

Multiparameter IO Module TMR

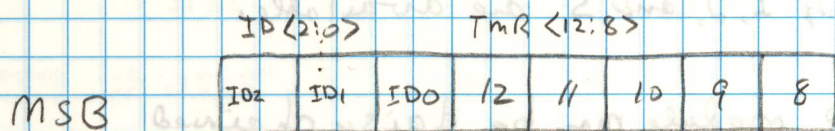
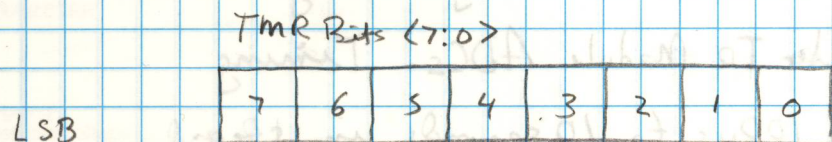
This USB powered module is designed to provide Multi channel Scaling timing for Multiparameter IO Module ADCs. Timing intervals of 100 μ s to 10 seconds in steps multipliers of 1, 2, and 5 are available.

The IO module may be daisy chained to include up to 8 IO modules. IO modules may be configured for independent or multiparameter acquisition. In independent mode each module transfer data through its independent USB interface. In Multiparameter mode the data transfers are synchronized and use the USB interface of the first (lowest ID number) multiparameter configured module in the IO Module Chain. Both independent and multiparameter mode acquisitions may be simultaneously active in a chain of IO Modules.

27 June 2011

ARB

The data transfer rate is upto
1 MB per second, - 500 K events per second.
Data is transferred from the module as two
bytes per event with the LSB first followed
by the MSB. The Data Format is:



ID <2:0> contains the three bit code
identifying the ID module.

The ID of the first module is by default 0.

However, the ID can be changed by using
jumpers on the first module's daisy chain
cable as indicated by the legend on the

ID module. Module IDs increase from

Right to Left along the daisy chain of
ID modules.

The TMR bits <12:0> are a counter which increment by 1 at each time interval.

The TMR IO module control register determines the operating characteristics of the module:

<CP> Period

0	100 μ s
1	200 μ s
2	500 μ s
3	1 ms
4	2 ms
5	5 ms
6	10 ms
7	20 ms
8	50 ms
9	100 ms
10	200 ms
11	500 ms
12	1 sec
13	2 sec
14	5 sec
15	10 sec

CP3
7
CP2
6
CP1
5
CP0
4
3
2
1
0

Counter Clock Period

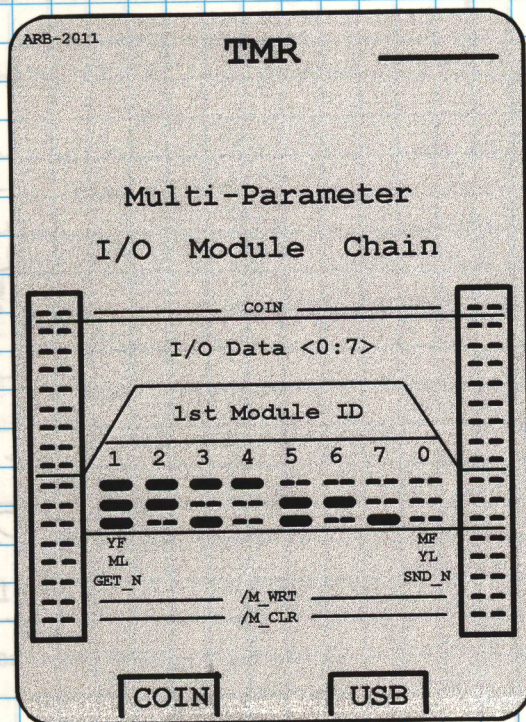
Single Transfer Test(1), auto cleared

Multiparameter(1), Single parameter(0)

Immediate USB transfer(1), Normal(0)

Module Enable(1), Disable(0)

for proper multiparameter operation all IO modules participating in the multiparameter IO must have the multiparameter AND enable bits set to 1.



The BNC COIN connector requires a 5 Volt pulse (or TTL level) to activate the multiparameter acquisition mode.

Only one (1) BNC COIN input is required to activate all multiparameter enabled ID Modules in the chain.

The COIN signal is routed through the daisy chain cable.

Parts List

68

1	Plastic Case	Hammond RL62IS	80x120mm
1	Isolated BNC Jack		
1	84 pin PLCC Through hole socket		M.II/Max
2	2x17 pin shrouded Header	Sullins SBH-PBPC-D17-ST-BH	
1	2x10 pin shrouded Header	Sullins SBH-PBPC-D10-ST-BH	
2	SN74LVC2G132 DCT	Dual 2 input Schmitt trigger NAND Gates	
1	CB3-3C-4M0000	4.0MHz 5.0V SMD Oscillator	CTS
1	XC95108	Xilinx Programmable CPLD (-15C)	
1	DLP-USB245M	USB to FIFO Parallel Interface Module	
1	IDC Cable HSC34H/AE34G/HSC34H	6" Recep-Recep 34pin	
1	IDC Cable HSC34H/AE34G/HPH34H	6" Recep-Plug 34pin	
3	10 pF Cap Ceramic	0805 SMD	
4	.1mF Cap Ceramic	0805 SMD	
5	.1mF Cap Ceramic	1206 SMD	
1	220 pF Cap Ceramic	0805 SMD	
1	270 pF Cap Ceramic	0805 SMD	
11	120 ohm 1/8 watt	0805 SMD	
3	330 ohm 1/8 watt	0805 SMD	
9	470 ohm 1/8 watt	0805 SMD	
5	4.7 K ohm 1/8 watt	0805 SMD	
1	10 K ohm 1/8 watt	0805 SMD	
2	47 K ohm 1/8 watt	0805 SMD	

27 June 2011

APB

External Coincidence

Multiple ADC Data Transfer Interface

MCS Clock Period Signals

USB Interface

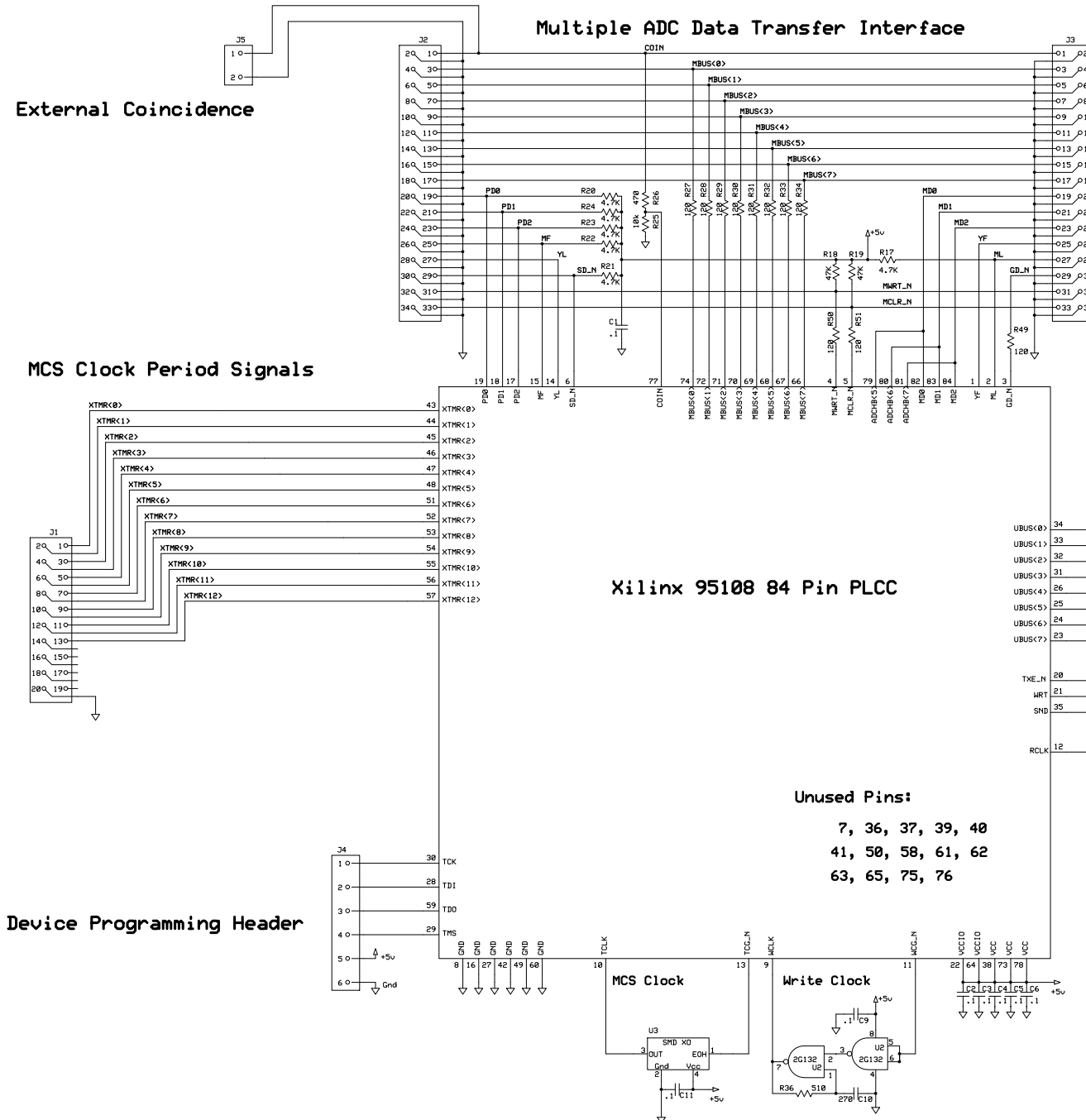
Xilinx 95108 84 Pin PLCC

Unused Pins:

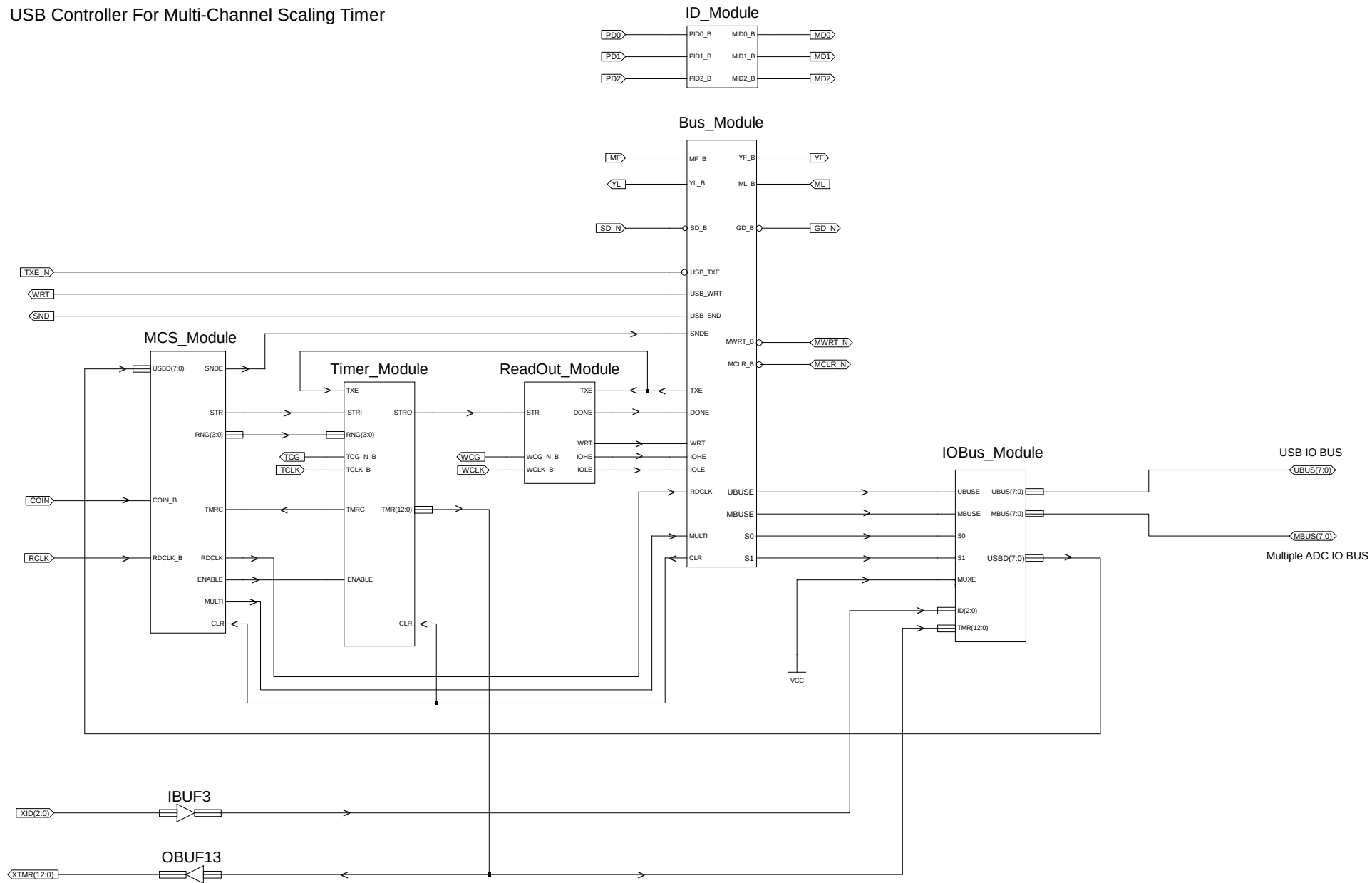
7, 36, 37, 39, 40
41, 50, 58, 61, 62
63, 65, 75, 76

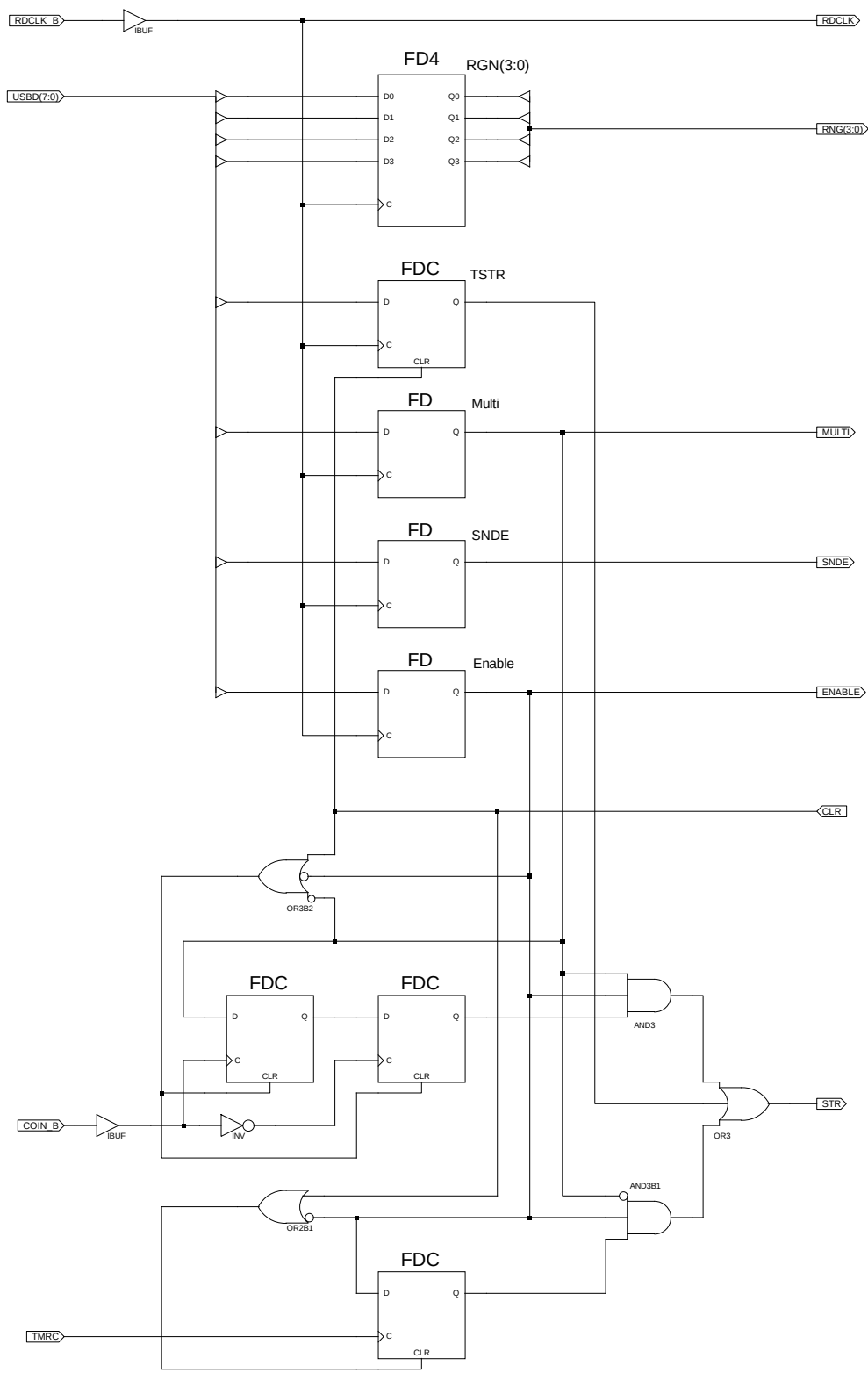
Device Programming Header

Read Clock



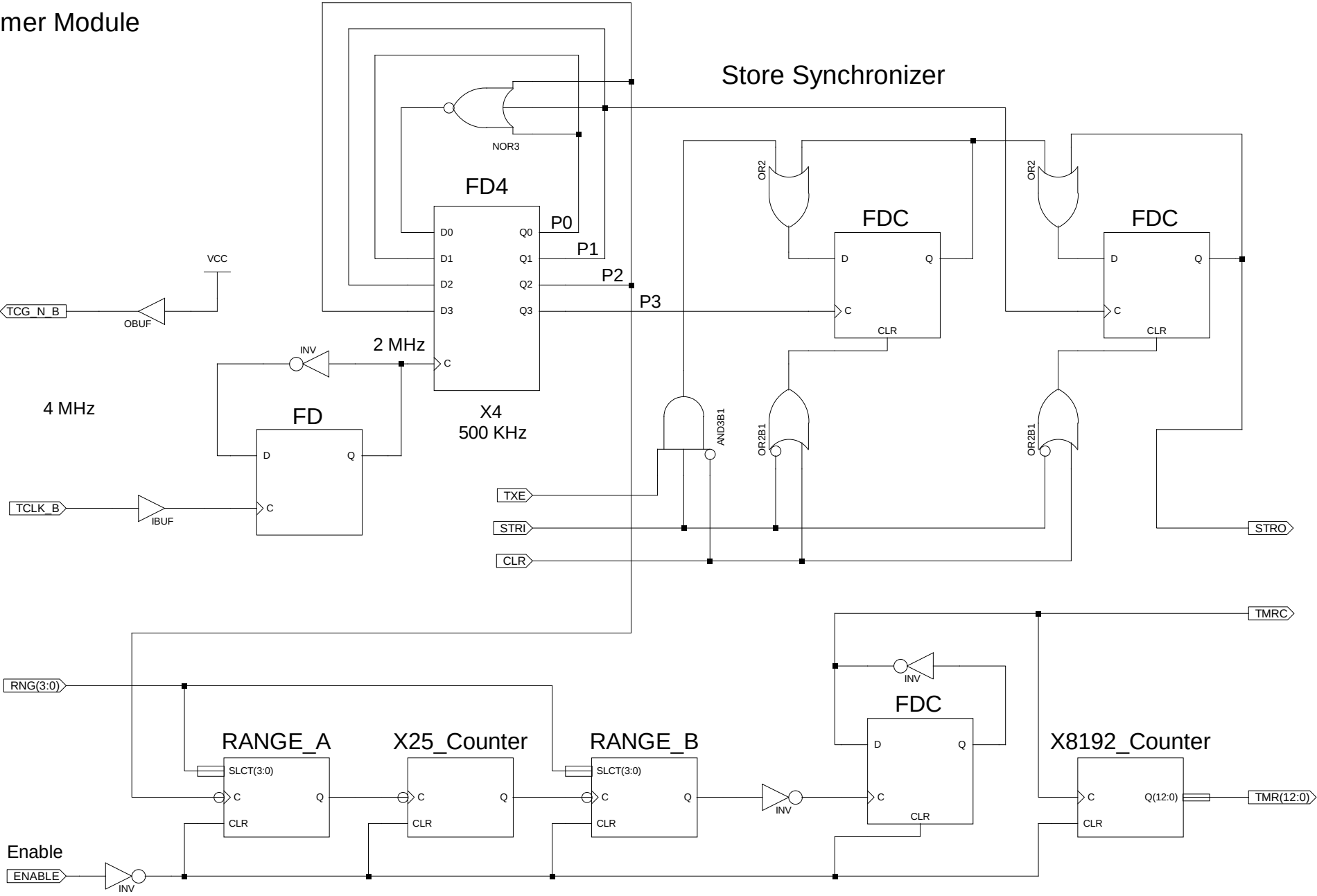
USB Controller For Multi-Channel Scaling Timer





Timer Module

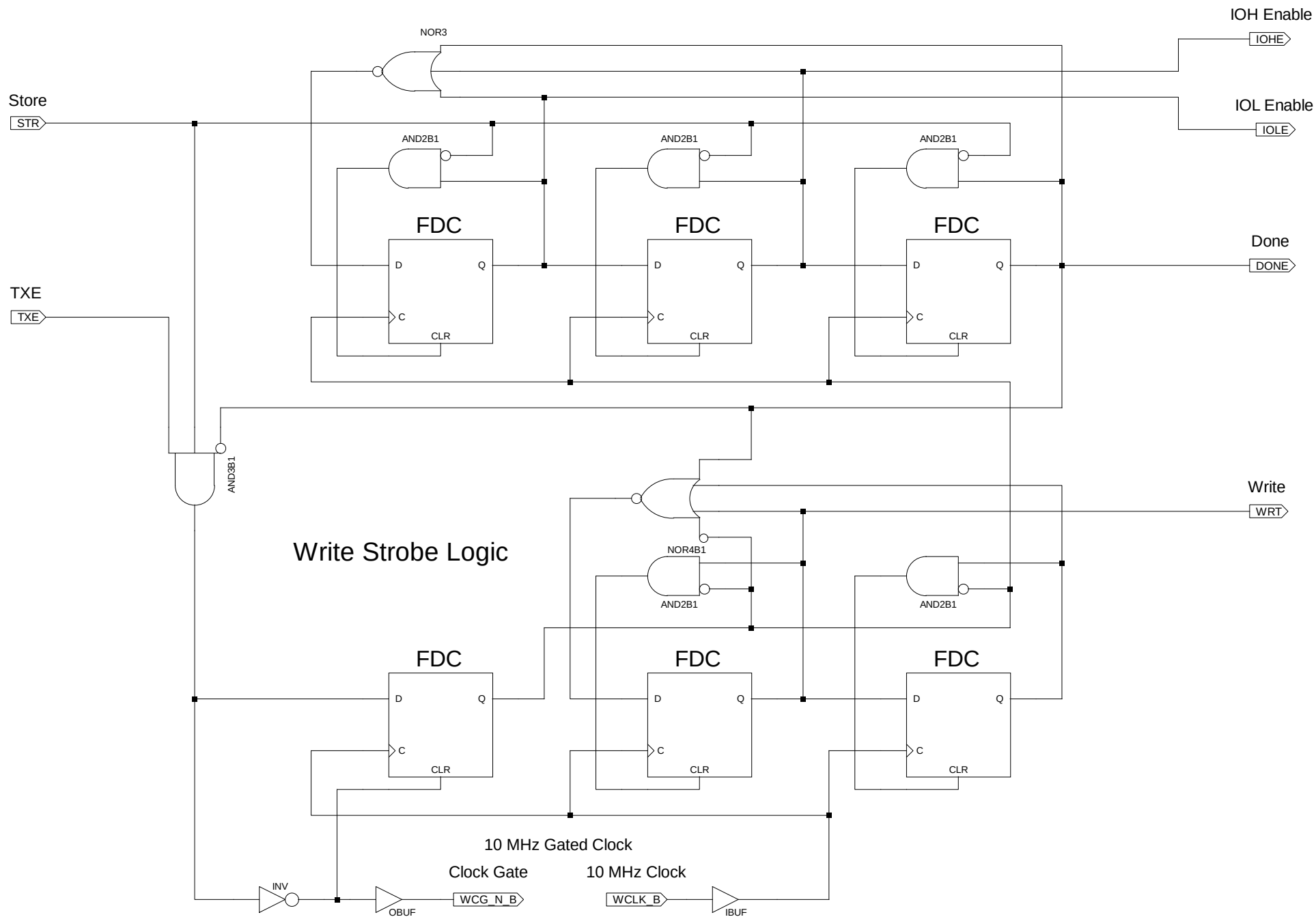
Store Synchronizer



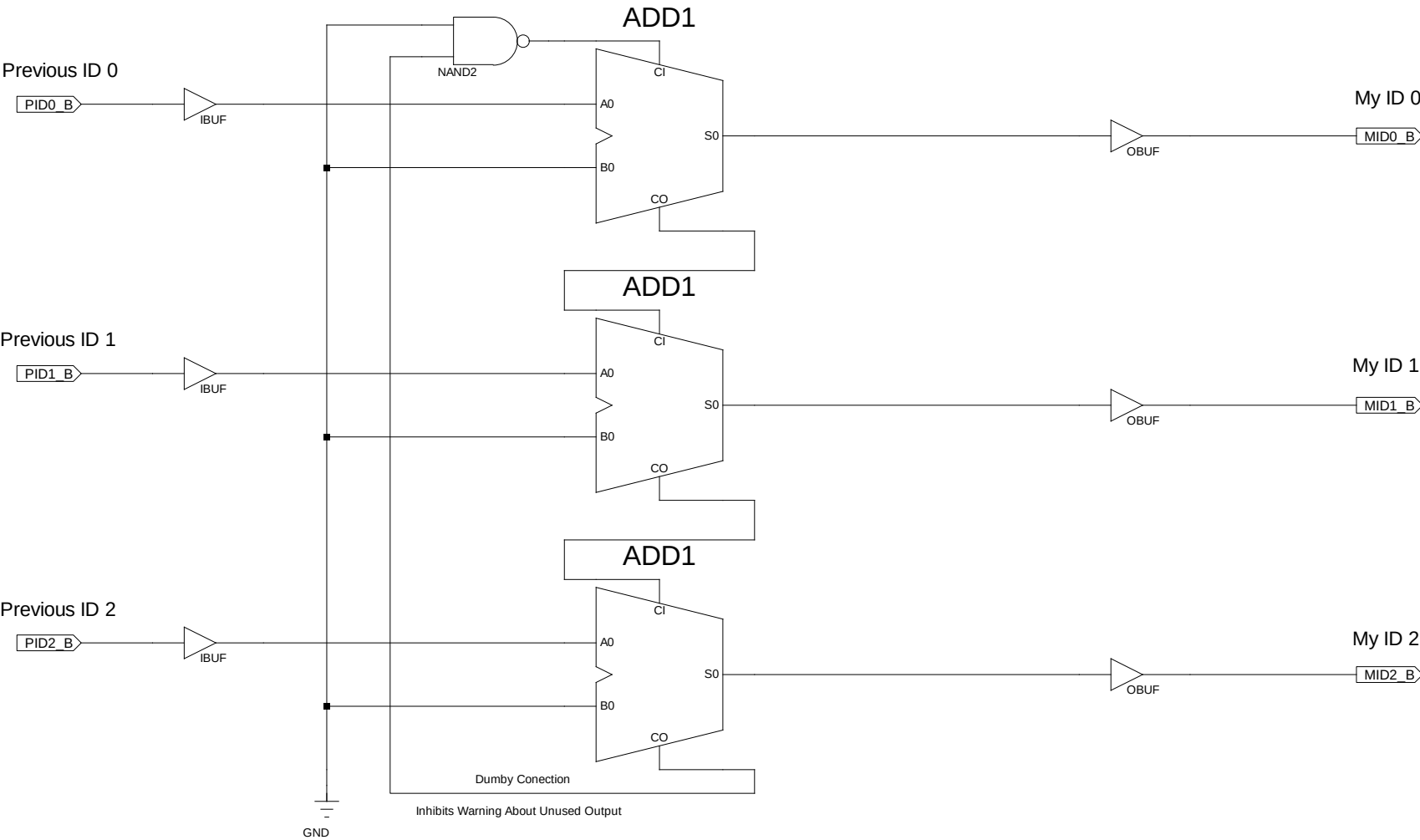
X1 - X100000 (1,2,5,10 steps) x X25

ReadOut Module

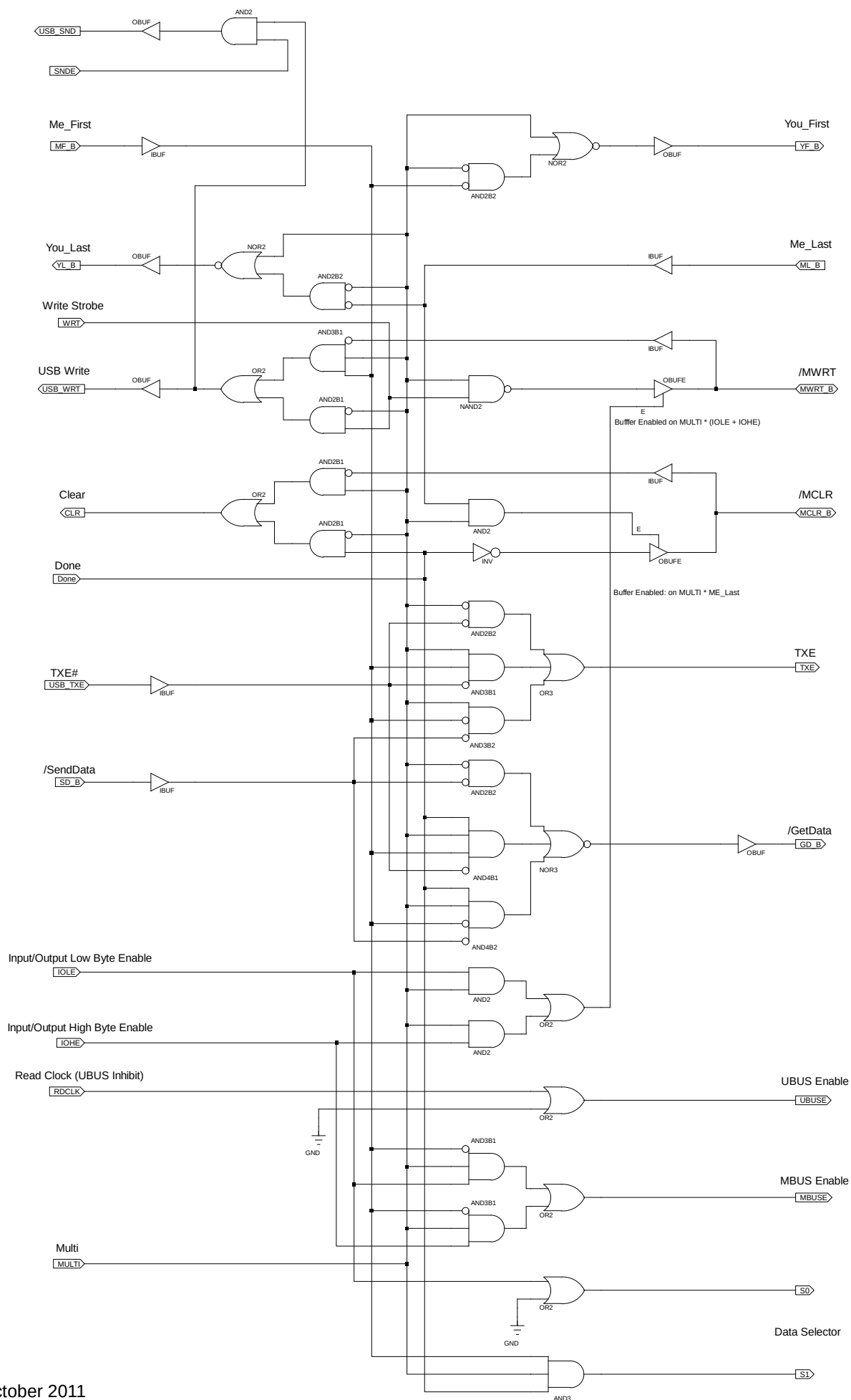
Readout Sequencer



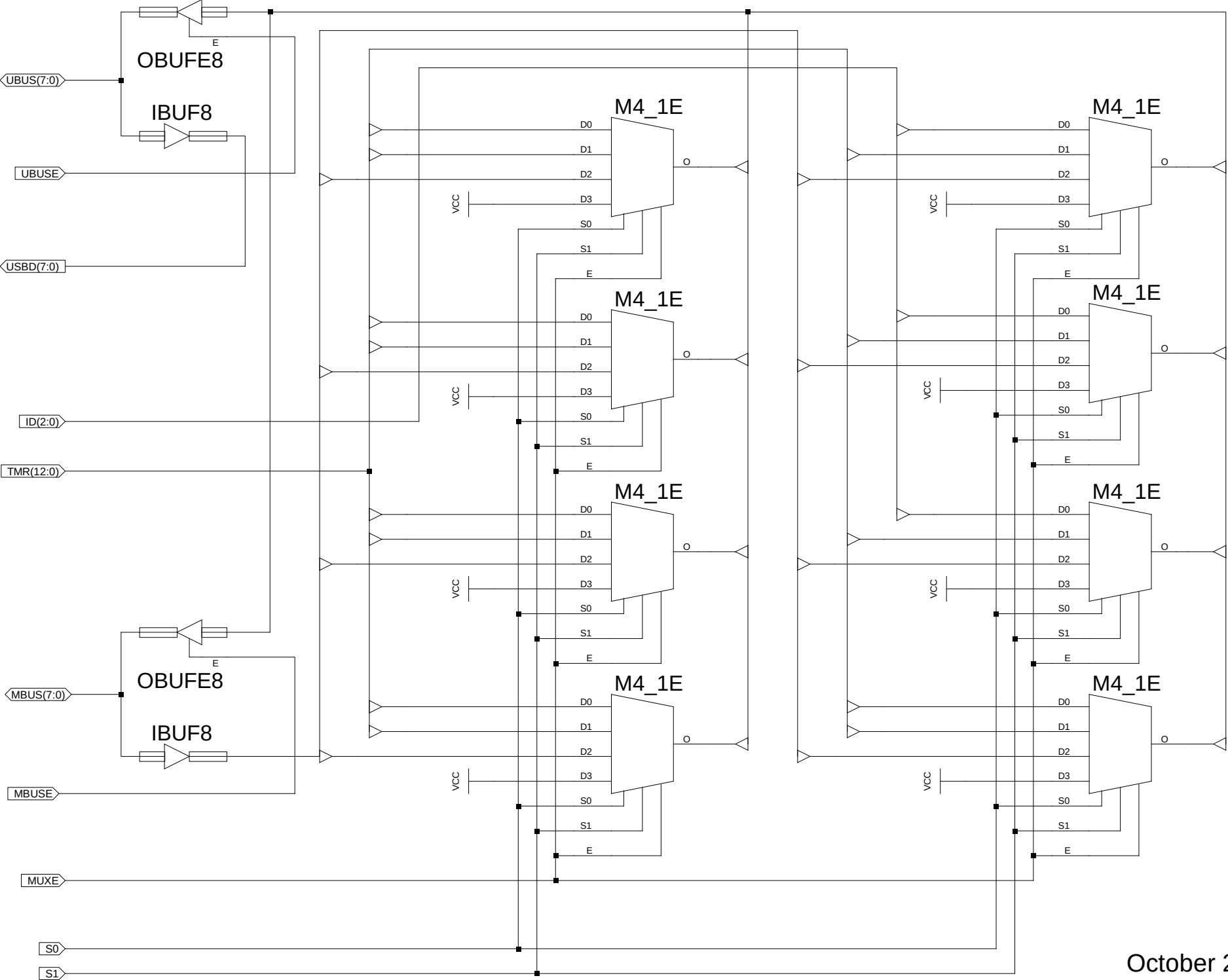
Interface ID Module



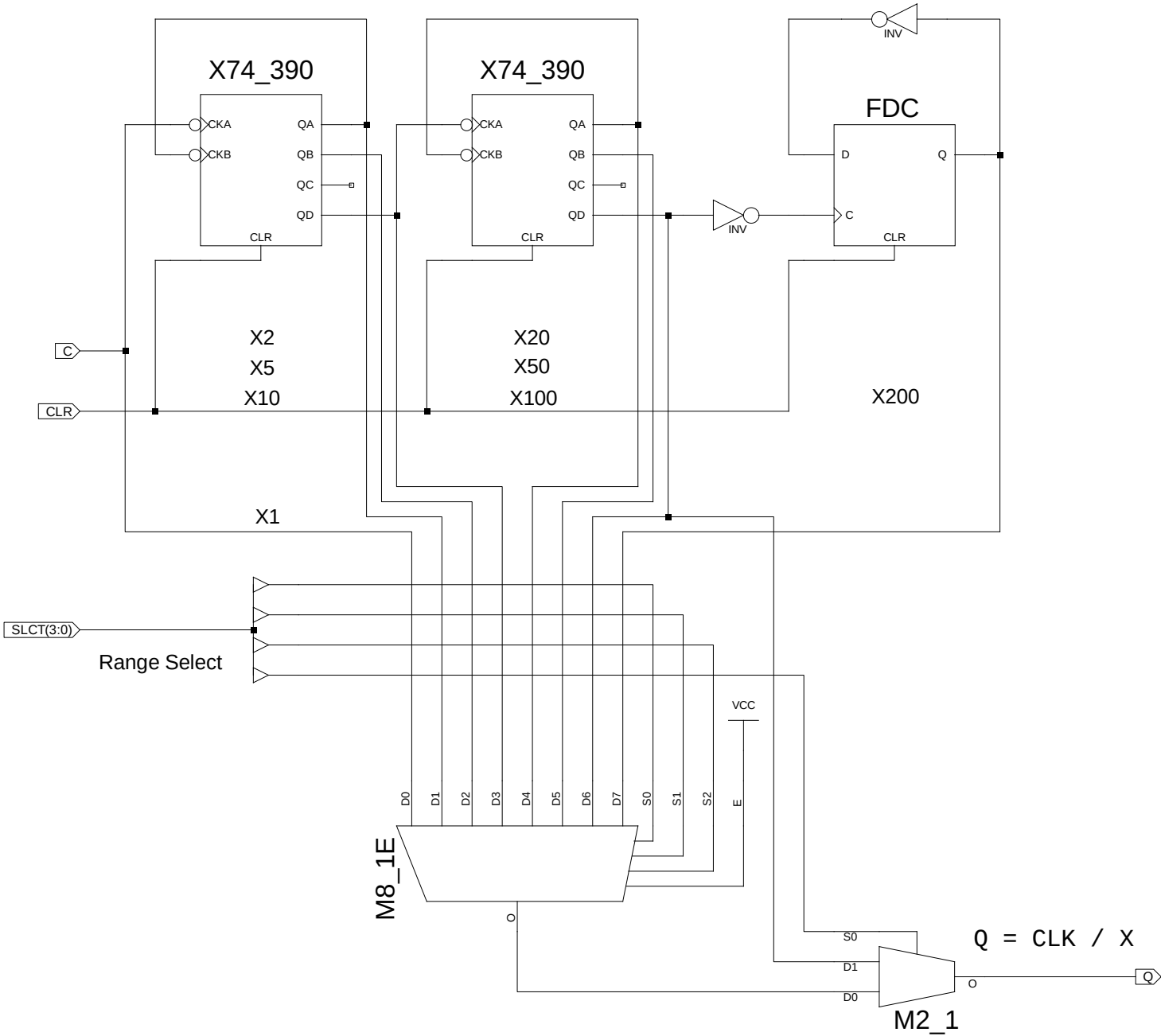
Multiple ADC Bus Module Control



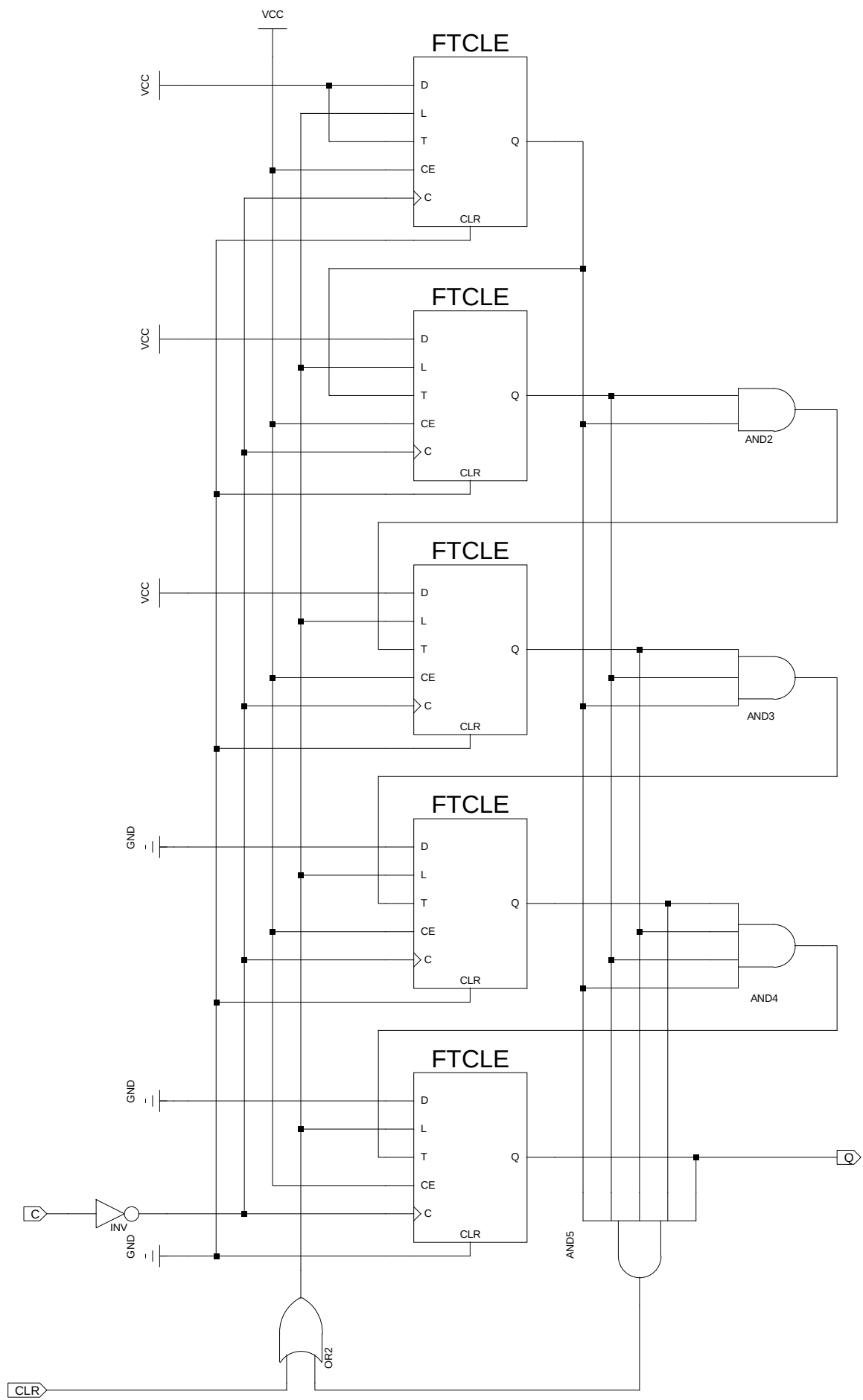
IO Bus Module



2 1/2 - Decade 1/2/5/10 Counter

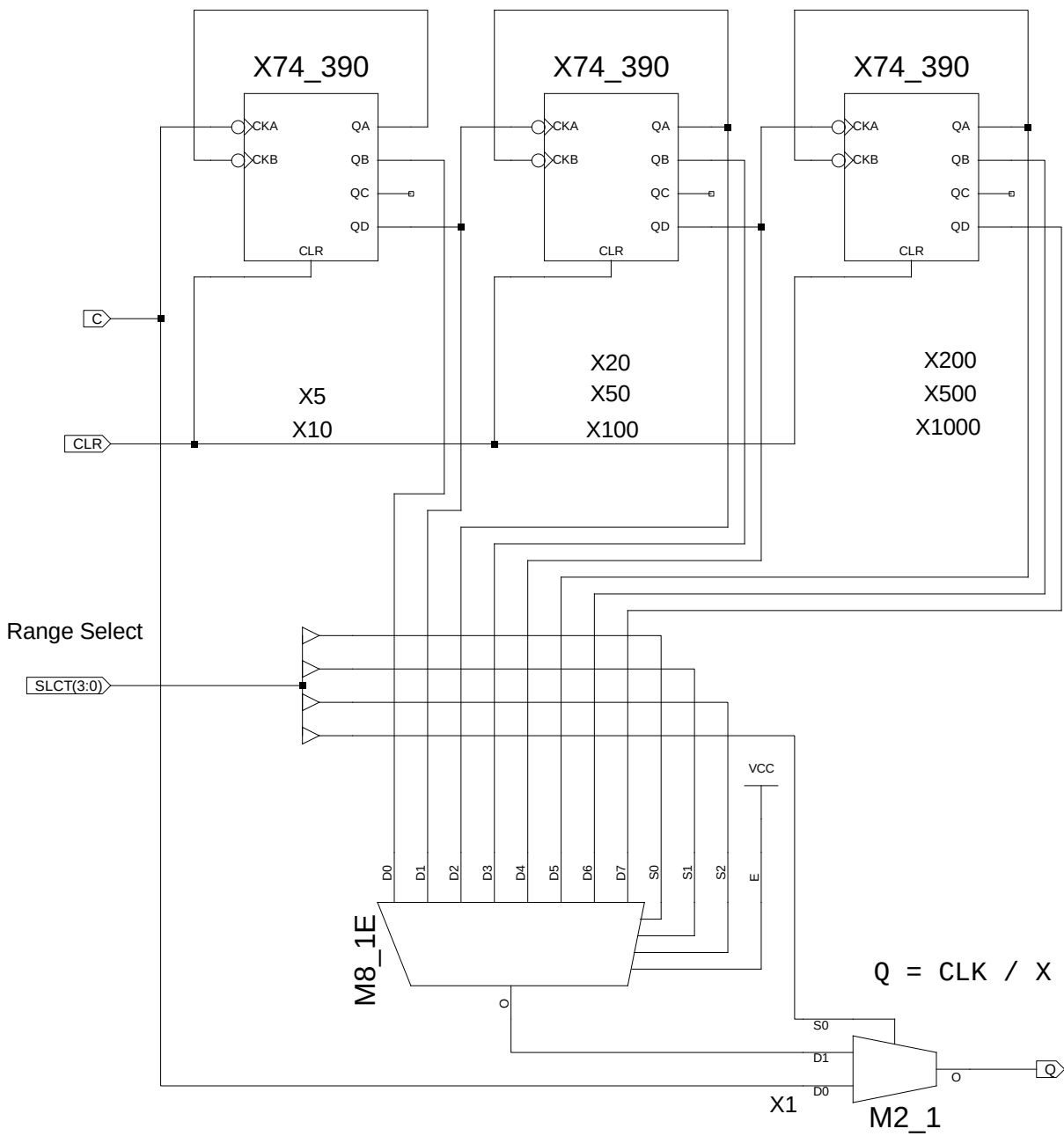


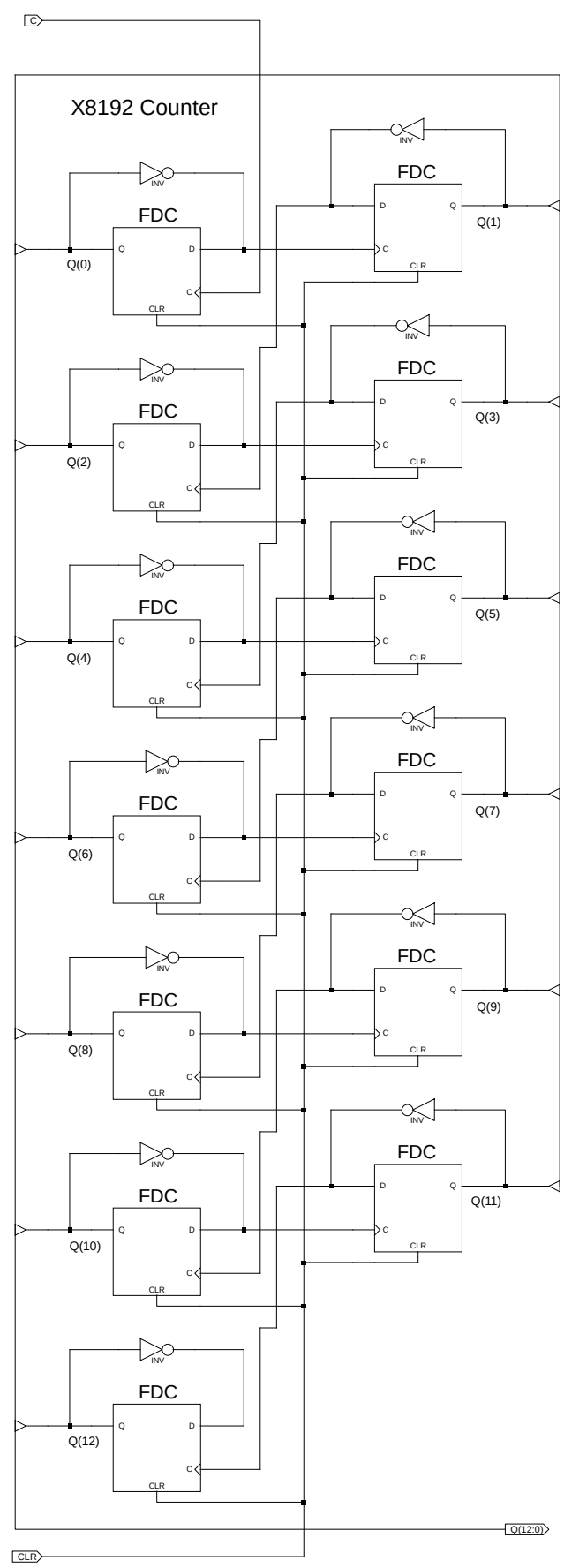
X25 Counter



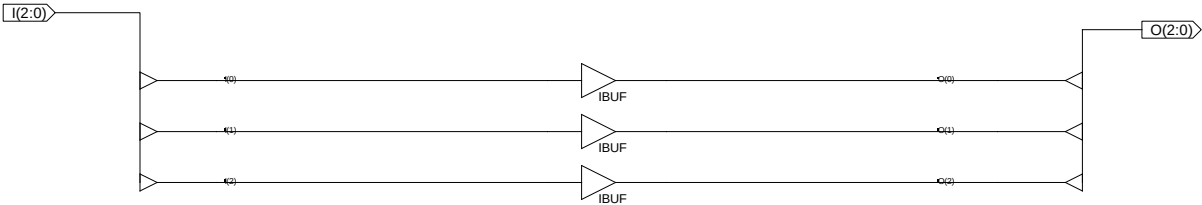
RANGE_B

2 1/2 - Decade 1/2/5/10 Counter

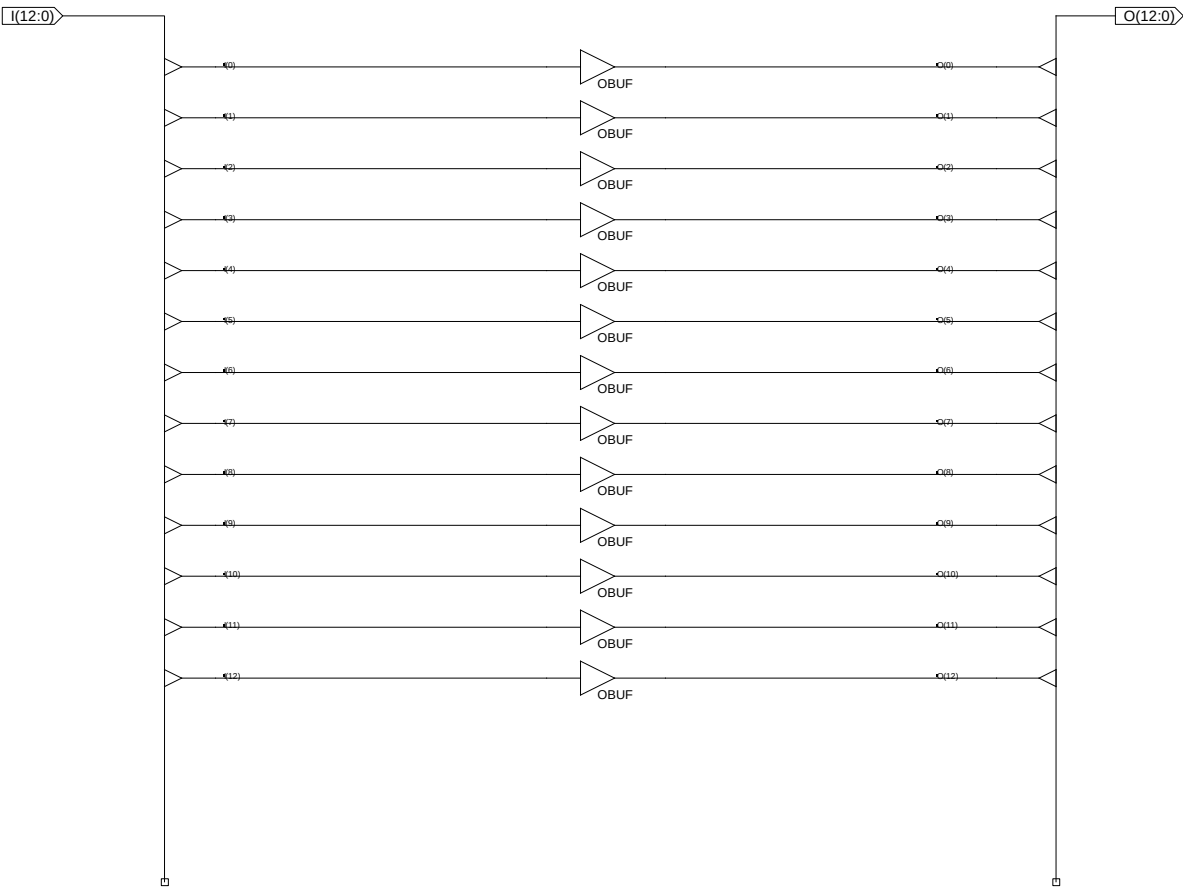




IBUF3



OBUF13



Summary

Design Name	USB_MCS_Timer_Multiple
Fitting Status	Successful
Software Version	O.40d
Device Used	XC95108-15-PC84
Date	10-13-2011, 5:46PM

RESOURCES SUMMARY

Macrocells Used	Pterms Used	Registers Used	Pins Used	Function Block Inputs Used
99/108 (92%)	321/540 (60%)	64/108 (60%)	55/69 (80%)	193/216 (90%)

PIN RESOURCES

Signal Type	Required	Mapped	Pin Type	Used	Total
Input	11	11	I/O	50	64
Output	23	23	GCK/IO	3	3
Bidirectional	18	18	GTS/IO	1	2
GCK	3	3	GSR/IO	1	1
GTS	0	0			
GSR	0	0			

GLOBAL RESOURCES

Signal mapped onto global clock net (GCK1)	WCLK
Signal mapped onto global clock net (GCK2)	TCLK
Signal mapped onto global clock net (GCK3)	RCLK

POWER DATA

Macrocells in high performance mode (MCHP)	0
Macrocells in low power mode (MCLP)	99
Total macrocells used (MC)	99

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[print page](#)

cpldfit: version 0.40d

Xilinx Inc.

Fitter Report

Design Name: USB_MCS_Timer_Multiple

Date: 10-13-2011, 5:46PM

Device Used: XC95108-15-PC84

Fitting Status: Successful

***** Mapped Resource Summary *****

Macrocells	Product Terms	Function Block	Registers	Pins
Used/Tot	Used/Tot	Inps Used/Tot	Used/Tot	Used/Tot
99 /108 (92%)	321 /540 (59%)	193/216 (89%)	64 /108 (59%)	55 /69 (80%)

** Function Block Resources **

Function Block	Mcells Used/Tot	FB Inps Used/Tot	Signals Used	Pterms Used/Tot	IO Used/Tot
FB1	12/18	32/36	32	41/90	6/12
FB2	16/18	29/36	29	52/90	6/12
FB3	17/18	33/36	33	61/90	7/12
FB4	18/18*	34/36	34	67/90	6/11
FB5	18/18*	34/36	34	57/90	6/11
FB6	18/18*	31/36	31	43/90	10/11
	-----	-----		-----	-----
	99/108	193/216		321/540	41/69

* - Resource is exhausted

** Global Control Resources **

Signal 'WCLK' mapped onto global clock net GCK1.
Signal 'TCLK' mapped onto global clock net GCK2.
Signal 'RCLK' mapped onto global clock net GCK3.
Global output enable net(s) unused.
Global set/reset net(s) unused.

** Pin Resources **

Signal Type	Required	Mapped	Pin Type	Used	Total
Input	: 11	11	I/O	: 50	63
Output	: 23	23	GCK/IO	: 3	3
Bidirectional	: 18	18	GTS/IO	: 1	2
GCK	: 3	3	GSR/IO	: 1	1
GTS	: 0	0			
GSR	: 0	0			
	----	----			
Total	55	55			

** Power Data **

There are 0 macrocells in high performance mode (MCHP).

There are 99 macrocells in low power mode (MCLP).

End of Mapped Resource Summary

***** Errors and Warnings *****

WARNING:Cpld - Unable to retrieve the path to the iSE Project Repository. Will use the default filename of 'USB_MCS_Timer_Multiple.ise'.

INFO:Cpld - Inferring BUFG constraint for signal 'XLXI_28/WCLK' based upon the LOC constraint 'P9'. It is recommended that you declare this BUFG

explicitly in your design. Note that for certain device families the output of a BUFG constraint can not drive a gated clock, and the BUFG constraint will be ignored.

INFO:Cpld - Inferring BUFG constraint for signal 'XLXI_21/RCLK' based upon the LOC constraint 'P12'. It is recommended that you declare this BUFG explicitly in your design. Note that for certain device families the output of a BUFG constraint can not drive a gated clock, and the BUFG constraint will be ignored.

INFO:Cpld - Inferring BUFG constraint for signal 'XLXI_24/TCLK' based upon the LOC constraint 'P10'. It is recommended that you declare this BUFG explicitly in your design. Note that for certain device families the output of a BUFG constraint can not drive a gated clock, and the BUFG constraint will be ignored.

□***** Summary of Mapped Logic *****

** 41 Outputs **

Signal Name	Total Pts	Total Inps	Loc	Pin No.	Pin Type	Pin Use
YF	1	2	FB1_2	1	I/O	O
GD_N	3	5	FB1_5	3	I/O	O
MWRT_N	2	3	FB1_6	4	I/O	I/O
MCLR_N	4	6	FB1_8	5	I/O	I/O
WCG	3	6	FB1_15	11	I/O	O
TCG	0	0	FB1_17	13	I/O	O
MBUS<2>	7	8	FB2_2	71	I/O	I/O
MBUS<1>	7	8	FB2_3	72	I/O	I/O
MBUS<0>	7	8	FB2_5	74	GSR/I/O	I/O
MD0	1	1	FB2_15	82	I/O	O
MD1	2	2	FB2_16	83	I/O	O
MD2	2	3	FB2_17	84	I/O	O
YL	1	2	FB3_2	14	I/O	O
WRT	2	4	FB3_11	21	I/O	O
UBUS<7>	7	8	FB3_12	23	I/O	I/O
UBUS<6>	7	8	FB3_14	24	I/O	I/O
UBUS<5>	7	8	FB3_15	25	I/O	I/O
UBUS<4>	7	8	FB3_16	26	I/O	I/O
UBUS<3>	7	8	FB3_17	31	I/O	I/O
XTMR<12>	2	2	FB4_2	57	I/O	O
MBUS<7>	7	8	FB4_11	66	I/O	I/O
MBUS<6>	7	8	FB4_12	67	I/O	I/O
MBUS<5>	7	8	FB4_14	68	I/O	I/O
MBUS<4>	7	8	FB4_15	69	I/O	I/O
MBUS<3>	7	8	FB4_17	70	I/O	I/O
UBUS<2>	7	8	FB5_2	32	I/O	I/O
UBUS<1>	7	8	FB5_3	33	I/O	I/O
UBUS<0>	7	8	FB5_5	34	I/O	I/O
SND	2	5	FB5_6	35	I/O	O
XTMR<0>	2	2	FB5_15	43	I/O	O
XTMR<1>	2	2	FB5_17	44	I/O	O
XTMR<2>	2	2	FB6_2	45	I/O	O
XTMR<3>	2	2	FB6_3	46	I/O	O
XTMR<4>	2	2	FB6_5	47	I/O	O
XTMR<5>	2	2	FB6_6	48	I/O	O
XTMR<6>	2	2	FB6_9	51	I/O	O
XTMR<7>	2	2	FB6_11	52	I/O	O
XTMR<8>	2	2	FB6_12	53	I/O	O
XTMR<9>	2	2	FB6_14	54	I/O	O
XTMR<10>	2	2	FB6_15	55	I/O	O

Signal Name	Total Pts	Total Inps	Loc	Pin No.	Pin Type	Pin Use
XTMR<11>	2	2	FB6_17	56	I/O	0

** 58 Buried Nodes **

Signal Name	Total Pts	Total Inps	Loc	Pwr Mode	Reg State	Init
XLXI_24/XLXI_81/XLXN_139	2	2	FB1_11	LOW	RESET	
XLXN_163	3	4	FB1_12	LOW	RESET	
XLXI_24/XLXI_81/XLXN_24	3	4	FB1_13	LOW	RESET	
XLXI_24/XLXI_81/XLXI_41/QC	3	4	FB1_14	LOW	RESET	
XLXI_24/XLXN_464	8	13	FB1_16	LOW	RESET	
XLXI_24/XLXI_88/Q3/XLXI_24/XLXI_88/Q3_CLKF	9	12	FB1_18	LOW		
XLXI_24/XLXN_284	0	0	FB2_6	LOW	RESET	
XLXI_24/XLXI_81/XLXN_184	2	2	FB2_7	LOW	RESET	
XLXI_24/XLXI_89/XLXN_92	3	5	FB2_8	LOW	RESET	
XLXI_24/XLXI_89/XLXN_253	3	4	FB2_9	LOW	RESET	
XLXI_24/XLXI_89/XLXI_41/QC	3	4	FB2_10	LOW	RESET	
XLXI_24/XLXI_81/XLXN_75	3	4	FB2_11	LOW	RESET	
XLXI_24/XLXI_81/XLXN_255	3	5	FB2_12	LOW	RESET	
XLXI_24/XLXI_81/XLXI_42/QC	3	4	FB2_13	LOW	RESET	
XLXI_21/XLXN_290	3	3	FB2_14	LOW	RESET	
XLXI_21/XLXN_27	3	3	FB2_18	LOW	RESET	
XLXN_169	1	1	FB3_1	LOW	RESET	
XLXN_157<3>	1	1	FB3_4	LOW	RESET	
XLXN_88	2	4	FB3_5	LOW	RESET	
XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST	2	3	FB3_6	LOW		
XLXI_28/XLXN_506	2	3	FB3_7	LOW	RESET	
XLXI_21/XLXN_360/XLXI_21/XLXN_360_RSTF	2	3	FB3_8	LOW		
XLXN_131	3	5	FB3_9	LOW	RESET	
XLXN_130	3	4	FB3_10	LOW	RESET	
XLXI_28/XLXN_595/XLXI_28/XLXN_595_RSTF__\$INT	3	6	FB3_13	LOW		
XLXI_28/XLXN_595	4	7	FB3_18	LOW	RESET	
XLXI_24/XLXI_88/Q2	5	7	FB4_1	LOW	RESET	
XLXI_24/XLXI_88/Q1	4	7	FB4_3	LOW	RESET	
XLXN_163/XLXN_163_RSTF__\$INT	4	7	FB4_4	LOW		
XLXI_24/XLXI_88/Q0	3	7	FB4_5	LOW	RESET	
XLXI_24/XLXI_88/Q3	3	6	FB4_6	LOW	RESET	
XLXI_24/XLXN_465	3	7	FB4_7	LOW	RESET	
XLXI_21/XLXN_389/XLXI_21/XLXN_389_RSTF__\$INT	2	4	FB4_8	LOW		
XLXI_24/XLXI_89/XLXN_139	2	2	FB4_9	LOW	RESET	
XLXI_21/XLXN_290/XLXI_21/XLXN_290_RSTF__\$INT	1	3	FB4_10	LOW		
XLXN_157<0>	1	1	FB4_13	LOW	RESET	
XLXN_157<1>	1	1	FB4_16	LOW	RESET	
XLXN_157<2>	1	1	FB4_18	LOW	RESET	
XLXN_149	1	1	FB5_1	LOW	RESET	
XLXN_123	1	1	FB5_4	LOW	RESET	

Signal Name	Total Pts	Total Inps	Loc	Pwr Mode	Reg State	Init
XLXI_24/XLXI_89/XLXN_288	2	2	FB5_7	LOW	RESET	
XLXI_24/XLXI_81/XLXN_136	2	2	FB5_8	LOW	RESET	
XLXI_24/XLXI_89/XLXN_287	3	4	FB5_9	LOW	RESET	
XLXI_24/XLXI_89/XLXN_286	3	5	FB5_10	LOW	RESET	
XLXI_24/XLXI_89/XLXN_248	3	5	FB5_11	LOW	RESET	
XLXI_24/XLXI_89/XLXN_245	3	4	FB5_12	LOW	RESET	
XLXI_24/XLXI_89/XLXI_63/QC	3	4	FB5_13	LOW	RESET	
XLXI_24/XLXI_89/XLXI_42/QC	3	4	FB5_14	LOW	RESET	
XLXI_24/XLXI_81/XLXN_92	3	5	FB5_16	LOW	RESET	

XLXI_21/XLXN_389	3	3	FB5_18	LOW	RESET
XLXI_24/XLXN_462	2	2	FB6_1	LOW	RESET
XLXI_24/XLXN_459	2	2	FB6_4	LOW	RESET
XLXI_24/XLXN_334	2	4	FB6_7	LOW	RESET
XLXI_24/XLXN_307	2	2	FB6_8	LOW	RESET
XLXI_24/XLXN_3	2	2	FB6_10	LOW	RESET
XLXI_24/XLXI_89/XLXN_244	2	2	FB6_13	LOW	RESET
XLXI_21/XLXN_360	2	2	FB6_16	LOW	RESET
XLXI_24/XLXN_462/XLXI_24/XLXN_462_CLKF	9	13	FB6_18	LOW	

** 14 Inputs **

Signal Name	Loc	Pin No.	Pin Type	Pin Use
ML	FB1_3	2	I/O	I
SD_N	FB1_9	6	I/O	I
WCLK	FB1_12	9	GCK/I/O	GCK
TCLK	FB1_14	10	GCK/I/O	GCK
RCLK	FB1_16	12	GCK/I/O	GCK/I
COIN	FB2_9	77	GTS/I/O	I
XID<0>	FB2_11	79	I/O	I
XID<1>	FB2_12	80	I/O	I
XID<2>	FB2_14	81	I/O	I
MF	FB3_3	15	I/O	I
PD2	FB3_5	17	I/O	I
PD1	FB3_6	18	I/O	I
PD0	FB3_8	19	I/O	I
TXE_N	FB3_9	20	I/O	I

Legend:

Pin No. - ~ - User Assigned

□***** Function Block Details *****

Legend:

Total Pt - Total product terms used by the macrocell signal

Imp Pt - Product terms imported from other macrocells

Exp Pt - Product terms exported to other macrocells
in direction shown

Unused Pt - Unused local product terms remaining in macrocell

Loc - Location where logic was mapped in device

Pin Type/Use - I - Input GCK - Global Clock
O - Output GTS - Global Output Enable
(b) - Buried macrocell GSR - Global Set/Reset

X(@) - Signal used as input (wire-AND input) to the macrocell logic.
The number of Signals Used may exceed the number of FB Inputs
Used due to wire-ANDing in the switch matrix.

Pin No. - ~ - User Assigned

□***** FB1 *****

Number of function block inputs used/remaining: 32/4

Number of signals used by logic mapping into function block: 32

Signal Name	Total Pt	Imp Pt	Exp Pt	Unused Pt	Loc	Pin #	Pin Type	Pin Use
(unused)	0	0	/\4	1	FB1_1		(b)	(b)
YF	1	0	0	4	FB1_2	1	I/O	O
(unused)	0	0	0	5	FB1_3	2	I/O	I
(unused)	0	0	0	5	FB1_4		(b)	
GD_N	3	0	0	2	FB1_5	3	I/O	O
MWRT_N	2	0	0	3	FB1_6	4	I/O	I/O
(unused)	0	0	0	5	FB1_7		(b)	
MCLR_N	4	0	0	1	FB1_8	5	I/O	I/O
(unused)	0	0	0	5	FB1_9	6	I/O	I

(unused)	0	0	0	5	FB1_10	(b)	
XLXI_24/XLXI_81/XLXN_139	2	0	0	3	FB1_11	7	I/O (b)
XLXN_163	3	0	0	2	FB1_12	9	GCK/I/O GCK
XLXI_24/XLXI_81/XLXN_24	3	0	0	2	FB1_13		(b) (b)
XLXI_24/XLXI_81/XLXI_41/QC	3	0	0	2	FB1_14	10	GCK/I/O GCK
WCG	3	0	\2	0	FB1_15	11	I/O O
XLXI_24/XLXN_464	8	3<-	0	0	FB1_16	12	GCK/I/O GCK/I
TCG	0	0	/\1	4	FB1_17	13	I/O O
XLXI_24/XLXI_88/Q3/XLXI_24/XLXI_88/Q3_CLKF	9	4<-	0	0	FB1_18		(b) (b)

Signals Used by Logic in Function Block

1: XLXI_21/XLXN_290	12: XLXI_24/XLXN_307	23: XL
2: XLXI_21/XLXN_360	13: XLXI_24/XLXN_459	24: XL
3: XLXI_21/XLXN_389	14: XLXI_24/XLXN_464.LFBK	25: XL
4: XLXI_24/XLXI_81/XLXN_136	15: XLXI_28/XLXN_595	26: XL
5: XLXI_24/XLXI_81/XLXN_139.LFBK	16: MCLR_N.PIN	27: XL
6: XLXI_24/XLXI_81/XLXN_184	17: ML	28: XL
7: XLXI_24/XLXI_81/XLXN_24.LFBK	18: XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST	29: XL
8: XLXI_24/XLXI_81/XLXN_255	19: TXE_N	30: XL
9: XLXI_24/XLXI_81/XLXN_75	20: MF	31: XL
10: XLXI_24/XLXI_81/XLXN_92	21: XLXI_6/XLXN_599.LFBK	32: XL
11: XLXI_24/XLXN_3	22: SD_N	

Signal Name	1	2	3	4	Signals Used	FB Inputs
YF	0-----+-----0-----+-----0-----+-----0-----+-----0	X..X			2	2
GD_N	.....	XXXXX			5	5
MWRT_N	.....	X...X	X		3	3
MCLR_N	.....	X.X...X	XX	X	6	6
XLXI_24/XLXI_81/XLXN_139	.....	X		X	2	2
XLXN_163	.....	X.X		XX	4	4
XLXI_24/XLXI_81/XLXN_24	....	X.X...X		X	4	4
XLXI_24/XLXI_81/XLXI_41/QC	....	X.X..X		X	4	4
WCG	.....	XXXXXX		X	6	6
XLXI_24/XLXN_464	XXX.....	XX.X	XXXXXX	XX	13	13
TCG	.....				0	0
XLXI_24/XLXI_88/Q3/XLXI_24/XLXI_88/Q3_CLKF	...XXXXXXXX		XXXX		12	12
	0-----+-----1-----+-----2-----+-----3-----+-----4					
	0	0	0	0		

□***** FB2 *****

Number of function block inputs used/remaining: 29/7

Number of signals used by logic mapping into function block: 29

Signal Name	Total Pt	Imp Pt	Exp Pt	Unused Pt	Loc	Pin #	Pin Type	Pin Use
(unused)	0	0	\2	3	FB2_1		(b)	(b)
MBUS<2>	7	2<-	0	0	FB2_2	71	I/O	I/O
MBUS<1>	7	2<-	0	0	FB2_3	72	I/O	I/O
(unused)	0	0	/\2	3	FB2_4		(b)	(b)
MBUS<0>	7	2<-	0	0	FB2_5	74	GSR/I/O	I/O
XLXI_24/XLXN_284	0	0	/\2	3	FB2_6	75	I/O	(b)
XLXI_24/XLXI_81/XLXN_184	2	0	0	3	FB2_7		(b)	(b)

XLXI_24/XLXI_89/XLXN_92	3	0	0	2	FB2_8	76	GTS/I/O	(b)
XLXI_24/XLXI_89/XLXN_253	3	0	0	2	FB2_9	77	GTS/I/O	I
XLXI_24/XLXI_89/XLXI_41/QC	3	0	0	2	FB2_10		(b)	(b)
XLXI_24/XLXI_81/XLXN_75	3	0	0	2	FB2_11	79	I/O	I
XLXI_24/XLXI_81/XLXN_255	3	0	0	2	FB2_12	80	I/O	I
XLXI_24/XLXI_81/XLXI_42/QC	3	0	0	2	FB2_13		(b)	(b)
XLXI_21/XLXN_290	3	0	0	2	FB2_14	81	I/O	I
MD0	1	0	0	4	FB2_15	82	I/O	O
MD1	2	0	0	3	FB2_16	83	I/O	O
MD2	2	0	0	3	FB2_17	84	I/O	O
XLXI_21/XLXN_27	3	0	0	2	FB2_18		(b)	(b)

Signals Used by Logic in Function Block

1: MCLR_N	11: XLXI_24/XLXI_81/XLXN_75.LFBK
2: PD0	12: XLXI_24/XLXI_89/XLXI_41/QC.LF
3: PD1	13: XLXI_24/XLXI_89/XLXN_139
4: PD2	14: XLXI_24/XLXI_89/XLXN_253.LFBK
5: XLXI_21/XLXN_27.LFBK	15: XLXI_24/XLXI_89/XLXN_92.LFBK
6: XLXI_21/XLXN_290/XLXI_21/XLXN_290_RSTF__\$INT	16: MBUS<0>.PIN
7: COIN	17: MBUS<1>.PIN
8: XLXI_24/XLXI_81/XLXI_42/QC.LFBK	18: MBUS<2>.PIN
9: XLXI_24/XLXI_81/XLXN_136	19: XLXI_6/XLXN_334/XLXI_6/XLXN_3
10: XLXI_24/XLXI_81/XLXN_255.LFBK	20: MF

Signal Name	1	2	3	4	Signals Used	FB Inputs
MBUS<2>	X.....XXXXX..X.X.....				8	8
MBUS<1>	X.....X.XXXX..X..X.....				8	8
MBUS<0>	X.....X..XXXX.X..X.....				8	8
XLXI_24/XLXN_284	.....				0	0
XLXI_24/XLXI_81/XLXN_184	X.....X.....				2	2
XLXI_24/XLXI_89/XLXN_92	XXXX.....X.....				5	5
XLXI_24/XLXI_89/XLXN_253	XXX.....X.....				4	4
XLXI_24/XLXI_89/XLXI_41/QC	XXX.....X.....				4	4
XLXI_24/XLXI_81/XLXN_75	XXX.....X.....				4	4
XLXI_24/XLXI_81/XLXN_255	XXXX.....X.....				5	5
XLXI_24/XLXI_81/XLXI_42/QC	XXX.....X.....				4	4
XLXI_21/XLXN_290	XXX.....				3	3
MD0	.X.....				1	1
MD1	.XX.....				2	2
MD2	.XXX.....				3	3
XLXI_21/XLXN_27	XX.....X.....				3	3
	0-----1-----2-----3-----4					
	0	0	0	0		

***** FB3 *****

Number of function block inputs used/remaining: 33/3

Number of signals used by logic mapping into function block: 33

Signal Name	Total Pt	Imp Pt	Exp Pt	Unused Pt	Loc	Pin #	Pin Type	Pin Use
XLXN_169	1	0	/\2	2	FB3_1		(b)	(b)
YL	1	0	0	4	FB3_2	14	I/O	O
(unused)	0	0	0	5	FB3_3	15	I/O	I
XLXN_157<3>	1	0	0	4	FB3_4		(b)	(b)
XLXN_88	2	0	0	3	FB3_5	17	I/O	I
XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST	2	0	0	3	FB3_6	18	I/O	I
XLXI_28/XLXN_506	2	0	0	3	FB3_7		(b)	(b)
XLXI_21/XLXN_360/XLXI_21/XLXN_360_RSTF	2	0	0	3	FB3_8	19	I/O	I
XLXN_131	3	0	0	2	FB3_9	20	I/O	I
XLXN_130	3	0	\2	0	FB3_10		(b)	(b)
WRT	2	2<-	\5	0	FB3_11	21	I/O	O
UBUS<7>	7	5<-	\3	0	FB3_12	23	I/O	I/O
XLXI_28/XLXN_595/XLXI_28/XLXN_595_RSTF__\$INT	3	3<-	\5	0	FB3_13		(b)	(b)
UBUS<6>	7	5<-	\3	0	FB3_14	24	I/O	I/O
UBUS<5>	7	3<-	\1	0	FB3_15	25	I/O	I/O
UBUS<4>	7	2<-	0	0	FB3_16	26	I/O	I/O
UBUS<3>	7	3<-	/\1	0	FB3_17	31	I/O	I/O
XLXI_28/XLXN_595	4	2<-	/\3	0	FB3_18		(b)	(b)

Signals Used by Logic in Function Block

1: XID<0>	12: MBUS<7>.PIN	23: UB
2: XID<1>	13: MWRT_N.PIN	24: RC
3: XID<2>	14: MCLR_N.PIN	25: XL
4: MCLR_N	15: ML	26: XL
5: XLXI_28/XLXN_506.LFBK	16: TXE_N	27: XT
6: XLXI_28/XLXN_595.LFBK	17: MF	28: XT
7: XLXI_28/XLXN_595/XLXI_28/XLXN_595_RSTF__\$INT.LFBK	18: SD_N	29: XT
8: MBUS<3>.PIN	19: XLXN_123	30: XT
9: MBUS<4>.PIN	20: XLXN_130.LFBK	31: XT
10: MBUS<5>.PIN	21: XLXN_131.LFBK	32: XT
11: MBUS<6>.PIN	22: UBUS<0>.PIN	33: XT

Signal Name	1	2	3	4	Signals	FB
	0-----+-----0-----+-----0-----+-----0-----+-----0				Used	Inputs
XLXN_169	X.....				1	1
YL	X..X.....				2	2
XLXN_157<3>	X.....				1	1
XLXN_88	...XXX.....X.....				4	4
XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST	XXX.....				3	3
XLXI_28/XLXN_506	XX.....X.....				3	3
XLXI_21/XLXN_360/XLXI_21/XLXN_360_RSTF	...X.....X...X.....				3	3
XLXN_131	...X.X.....XX...X.....				5	5
XLXN_130	X.....XX...X.....				4	4
WRT	X...X.X.....X.....				4	4
UBUS<7>	..XX.....X...X.X.X.X.....X.....				8	8
XLXI_28/XLXN_595/XLXI_28/XLXN_595_RSTF__\$INT	...X.....XXXX.....X.....				6	6
UBUS<6>	.X.X.....X.....X.X.X.....X.....				8	8
UBUS<5>	X..X.....X.....X.X.X.....X.....				8	8
UBUS<4>	...X....X.....X.X.X.X.....X.X.....				8	8
UBUS<3>	...X...X.....X.X.X.X.....X.X.....				8	8
XLXI_28/XLXN_595	...X..X.....XXXX.....X.....				7	7
	0-----+-----1-----+-----2-----+-----3-----+-----4					


```

0          0          0          0
□***** FB4 *****
Number of function block inputs used/remaining: 34/2
Number of signals used by logic mapping into function block: 34
Signal      Total  Imp  Exp Unused  Loc      Pin  Pin  Pin
Name        Pt    Pt   Pt  Pt      #    #    Type Use
XLXI_24/XLXI_88/Q2      5      0      0  0      FB4_1      (b)  (b)
XTMR<12>                2      0      0  3      FB4_2     57  I/O  0
XLXI_24/XLXI_88/Q1      4      0      0  1      FB4_3     58  I/O  (b)
XLXN_163/XLXN_163_RSTF__$INT
4      0      0  1      FB4_4      (b)  (b)
XLXI_24/XLXI_88/Q0      3      0      0  2      FB4_5     61  I/O  (b)
XLXI_24/XLXI_88/Q3      3      0      0  2      FB4_6     62  I/O  (b)
XLXI_24/XLXN_465        3      0      0  2      FB4_7      (b)  (b)
XLXI_21/XLXN_389/XLXI_21/XLXN_389_RSTF__$INT
2      0      0  3      FB4_8     63  I/O  (b)
XLXI_24/XLXI_89/XLXN_139
2      0      0  3      FB4_9     65  I/O  (b)
XLXI_21/XLXN_290/XLXI_21/XLXN_290_RSTF__$INT
1      0  \2  2      FB4_10      (b)  (b)
MBUS<7>                7      2<-  0  0      FB4_11     66  I/O  I/O
MBUS<6>                7      2<-  0  0      FB4_12     67  I/O  I/O
XLXN_157<0>            1      0  /\2  2      FB4_13      (b)  (b)
MBUS<5>                7      2<-  0  0      FB4_14     68  I/O  I/O
MBUS<4>                7      4<-  /\2  0      FB4_15     69  I/O  I/O
XLXN_157<1>            1      0  /\4  0      FB4_16      (b)  (b)
MBUS<3>                7      2<-  0  0      FB4_17     70  I/O  I/O
XLXN_157<2>            1      0  /\2  2      FB4_18      (b)  (b)

```

Signals Used by Logic in Function Block

1: XID<0>	13: XLXI_24/XLXI_88/Q3/XLXI_24/XLXI_88/Q3_CLKF	24: XL
2: XID<1>	14: XLXI_24/XLXN_465.LFBK	25: UB
3: XID<2>	15: MBUS<3>.PIN	26: UB
4: MCLR_N	16: MBUS<4>.PIN	27: UB
5: TMR<12>.LFBK	17: MBUS<5>.PIN	28: XL
6: XLXI_21/XLXN_290	18: MBUS<6>.PIN	29: XT
7: XLXI_21/XLXN_360	19: MBUS<7>.PIN	30: XT
8: XLXI_21/XLXN_389	20: MCLR_N.PIN	31: XT
9: XLXI_24/XLXI_88/Q0.LFBK	21: XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST	32: XT
10: XLXI_24/XLXI_88/Q1.LFBK	22: MF	33: XT
11: XLXI_24/XLXI_88/Q2.LFBK	23: XLXN_123	34: XT
12: XLXI_24/XLXI_88/Q3.LFBK		

```

Signal      1          2          3          4 Signals FB
Name        0-----0-----0-----0-----0 Used  Inputs
XLXI_24/XLXI_88/Q2      .....XXXXXX.....X..... 7      7
XTMR<12>                .....XX..... 2      2
XLXI_24/XLXI_88/Q1      .....XXXXXX.....X..... 7      7
XLXN_163/XLXN_163_RSTF__$INT
...X.XXX.....X..X...X..... 7      7
XLXI_24/XLXI_88/Q0      .....XXXXXX.....X..... 7      7
XLXI_24/XLXI_88/Q3      .....XXXXXX.....X..... 6      6
XLXI_24/XLXN_465        .....XXXXXX.....X..... 7      7
XLXI_21/XLXN_389/XLXI_21/XLXN_389_RSTF__$INT
...X.....X..X...X..... 4      4
XLXI_24/XLXI_89/XLXN_139
.....X.....X..... 2      2
XLXI_21/XLXN_290/XLXI_21/XLXN_290_RSTF__$INT
.....X..X...X..... 3      3
MBUS<7>                ..XX.....X.XXXX.....X..... 8      8

```

```

MBUS<6>          .X.X.....X..XXXX.....X..... 8      8
XLXN_157<0>      .....X..... 1      1
MBUS<5>          X..X.....X..XXXX.....X..... 8      8
MBUS<4>          ...XX.....X....XXXX.....X..... 8      8
XLXN_157<1>      .....X..... 1      1
MBUS<3>          ...X.....X....XXXX....XX..... 8      8
XLXN_157<2>      .....X..... 1      1
0-----+-----1-----+-----2-----+-----3-----+-----4
0              0              0              0              0

```

□***** FB5 *****

Number of function block inputs used/remaining: 34/2

Number of signals used by logic mapping into function block: 34

Signal Name	Total Pt	Imp Pt	Exp Pt	Unused Pt	Loc	Pin #	Pin Type	Pin Use
XLXN_149	1	0	\2	2	FB5_1		(b)	(b)
UBUS<2>	7	2<-	0	0	FB5_2	32	I/O	I/O
UBUS<1>	7	2<-	0	0	FB5_3	33	I/O	I/O
XLXN_123	1	0	/\2	2	FB5_4		(b)	(b)
UBUS<0>	7	2<-	0	0	FB5_5	34	I/O	I/O
SND	2	0	/\2	1	FB5_6	35	I/O	O
XLXI_24/XLXI_89/XLXN_288	2	0	0	3	FB5_7		(b)	(b)
XLXI_24/XLXI_81/XLXN_136	2	0	0	3	FB5_8	36	I/O	(b)
XLXI_24/XLXI_89/XLXN_287	3	0	0	2	FB5_9	37	I/O	(b)
XLXI_24/XLXI_89/XLXN_286	3	0	0	2	FB5_10		(b)	(b)
XLXI_24/XLXI_89/XLXN_248	3	0	0	2	FB5_11	39	I/O	(b)
XLXI_24/XLXI_89/XLXN_245	3	0	0	2	FB5_12	40	I/O	(b)
XLXI_24/XLXI_89/XLXI_63/QC	3	0	0	2	FB5_13		(b)	(b)
XLXI_24/XLXI_89/XLXI_42/QC	3	0	0	2	FB5_14	41	I/O	(b)
XTMR<0>	2	0	0	3	FB5_15	43	I/O	O
XLXI_24/XLXI_81/XLXN_92	3	0	0	2	FB5_16		(b)	(b)
XTMR<1>	2	0	0	3	FB5_17	44	I/O	O
XLXI_21/XLXN_389	3	0	0	2	FB5_18		(b)	(b)

Signals Used by Logic in Function Block

1: MCLR_N	13: XLXI_24/XLXI_89/XLXN_248.LFBK
2: TMR<0>.LFBK	14: XLXI_24/XLXI_89/XLXN_286.LFBK
3: TMR<1>.LFBK	15: XLXI_24/XLXI_89/XLXN_287.LFBK
4: XLXI_21/XLXN_389/XLXI_21/XLXN_389_RSTF__\$INT	16: XLXI_24/XLXI_89/XLXN_288.LFBK
5: XLXI_24/XLXI_81/XLXI_41/QC	17: XLXI_24/XLXN_462
6: XLXI_24/XLXI_81/XLXN_139	18: MBUS<0>.PIN
7: XLXI_24/XLXI_81/XLXN_24	19: MBUS<1>.PIN
8: XLXI_24/XLXI_81/XLXN_92.LFBK	20: MBUS<2>.PIN
9: XLXI_24/XLXI_89/XLXI_42/QC.LFBK	21: MWRT_N.PIN
10: XLXI_24/XLXI_89/XLXI_63/QC.LFBK	22: MF
11: XLXI_24/XLXI_89/XLXN_244	23: XLXN_123.LFBK
12: XLXI_24/XLXI_89/XLXN_245.LFBK	

Signal Name	1	2	3	4	Signals Used	FB Inputs
XLXN_149	X.....				1	1
UBUS<2>	X.....X.XXX...X..XX.....				8	8

```

UBUS<1>          X.X.....X..XXX...X.....X..... 8      8
XLXN_123         .....X.....X.....X..... 1      1
UBUS<0>          XX.....X...XXX...X...X..... 8      8
SND              .....XXX...X..X..... 5      5
XLXI_24/XLXI_89/XLXN_288
.....X.....X..... 2      2
XLXI_24/XLXI_81/XLXN_136
.....X.....X..... 2      2
XLXI_24/XLXI_89/XLXN_287
.....XXX.....X..... 4      4
XLXI_24/XLXI_89/XLXN_286
.....X...XXX.....X..... 5      5
XLXI_24/XLXI_89/XLXN_248
.....X.XXX.....X..... 5      5
XLXI_24/XLXI_89/XLXN_245
.....XXX.....X..... 4      4
XLXI_24/XLXI_89/XLXI_63/QC
.....XXX.....X..... 4      4
XLXI_24/XLXI_89/XLXI_42/QC
.....XXX.....X..... 4      4
XTMR<0>          .....X.....X..... 2      2
XLXI_24/XLXI_81/XLXN_92
....XXXX.....X..... 5      5
XTMR<1>          .X.....X..... 2      2
XLXI_21/XLXN_389  ...X.....X.....X..... 3      3
0-----+---1-----+---2-----+---3-----+---4
0          0          0          0          0

```

□***** FB6 *****

Number of function block inputs used/remaining: 31/5

Number of signals used by logic mapping into function block: 31

Signal Name	Total Pt	Imp Pt	Exp Pt	Unused Pt	Loc	Pin #	Pin Type	Pin Use
XLXI_24/XLXN_462	2	0	/\1	2	FB6_1		(b)	(b)
XTMR<2>	2	0	0	3	FB6_2	45	I/O	O
XTMR<3>	2	0	0	3	FB6_3	46	I/O	O
XLXI_24/XLXN_459	2	0	0	3	FB6_4		(b)	(b)
XTMR<4>	2	0	0	3	FB6_5	47	I/O	O
XTMR<5>	2	0	0	3	FB6_6	48	I/O	O
XLXI_24/XLXN_334	2	0	0	3	FB6_7		(b)	(b)
XLXI_24/XLXN_307	2	0	0	3	FB6_8	50	I/O	(b)
XTMR<6>	2	0	0	3	FB6_9	51	I/O	O
XLXI_24/XLXN_3	2	0	0	3	FB6_10		(b)	(b)
XTMR<7>	2	0	0	3	FB6_11	52	I/O	O
XTMR<8>	2	0	0	3	FB6_12	53	I/O	O
XLXI_24/XLXI_89/XLXN_244	2	0	0	3	FB6_13		(b)	(b)
XTMR<9>	2	0	0	3	FB6_14	54	I/O	O
XTMR<10>	2	0	0	3	FB6_15	55	I/O	O
XLXI_21/XLXN_360	2	0	0	3	FB6_16		(b)	(b)
XTMR<11>	2	0	\3	0	FB6_17	56	I/O	O
XLXI_24/XLXN_462/XLXI_24/XLXN_462_CLKF	9	4<-	0	0	FB6_18		(b)	(b)

Signals Used by Logic in Function Block

1: TMR<10>.LFBK	12: XLXI_24/XLXI_89/XLXN_245	22: XLXI_
2: TMR<2>.LFBK	13: XLXI_24/XLXI_89/XLXN_248	23: XLXI_
3: TMR<3>.LFBK	14: XLXI_24/XLXI_89/XLXN_253	24: XLXI_
4: TMR<4>.LFBK	15: XLXI_24/XLXI_89/XLXN_286	25: UBUS<
5: TMR<5>.LFBK	16: XLXI_24/XLXI_89/XLXN_287	26: XLXN_
6: TMR<6>.LFBK	17: XLXI_24/XLXI_89/XLXN_288	27: XLXN_

```

7: TMR<7>.LFBK
8: TMR<8>.LFBK
9: TMR<9>.LFBK
10: XLXI_21/XLXN_360/XLXI_21/XLXN_360_RSTF
11: XLXI_24/XLXI_89/XLXN_244.LFBK
18: XLXI_24/XLXI_89/XLXN_92
19: XLXI_24/XLXN_284
20: XLXI_24/XLXN_3.LFBK
21: XLXI_24/XLXN_307.LFBK
28: XLXN_
29: XLXN_
30: XLXN_
31: XTMR<

```

Signal Name	1	2	3	4	Signals Used	FB Inputs
XLXI_24/XLXN_462	0----	0----	0----	0----	2	2
XTMR<2>	.....	.....	.....	.....	2	2
XTMR<3>	.X.....	.....	.....	.....	2	2
XLXI_24/XLXN_459	.....	.....	.....	.....	2	2
XTMR<4>	..X.....	.....	.....	.....	2	2
XTMR<5>	...X.....	.....	.....	.....	2	2
XLXI_24/XLXN_334	.....	.....	.....	.....	4	4
XLXI_24/XLXN_307	.....	.....	.....	.....	2	2
XTMR<6>	X.....	.....	.....	.....	2	2
XLXI_24/XLXN_3	.....	.....	.....	.....	2	2
XTMR<7>	X.....	.....	.....	.....	2	2
XTMR<8>	X.....	.....	.....	.....	2	2
XLXI_24/XLXI_89/XLXN_244	.....	.....	.....	.....	2	2
XTMR<9>	X.....	.....	.....	.....	2	2
XTMR<10>	X.....	.....	.....	.....	2	2
XLXI_21/XLXN_360	X.....	.....	.....	.....	2	2
XTMR<11>	X.....	.....	.....	.....	2	2
XLXI_24/XLXN_462/XLXI_24/XLXN_462_CLKF	.....	.....	.....	.....	13	13
	0----	1----	2----	3----	4	
	0	0	0	0		

□***** Equations *****

***** Mapped Logic *****

```

GD_N <= NOT (((NOT SD_N AND NOT XLXN_123)
OR (NOT MF AND NOT SD_N AND NOT XLXI_6/XLXN_599.LFBK)
OR (MF AND NOT TXE_N AND XLXN_123 AND NOT XLXI_6/XLXN_599.LFBK)));

```

```

MBUS_I(0) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(0).PIN)
OR (XTMR(0) AND XLXN_131)
OR (MCLR_N AND XTMR(8) AND NOT XLXN_131)
OR (NOT MF AND XTMR(8) AND NOT XLXN_131)
OR (XTMR(8) AND NOT XLXN_131 AND NOT XLXN_123));
MBUS(0) <= MBUS_I(0) when MBUS_OE(0) = '1' else 'Z';
MBUS_OE(0) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

```

```

MBUS_I(1) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(1).PIN)
OR (XTMR(1) AND XLXN_131)
OR (MCLR_N AND XTMR(9) AND NOT XLXN_131)

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```

        OR (NOT MF AND XTMR(9) AND NOT XLXN_131)
        OR (XTMR(9) AND NOT XLXN_131 AND NOT XLXN_123));
MBUS(1) <= MBUS_I(1) when MBUS_OE(1) = '1' else 'Z';
MBUS_OE(1) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

```

```

MBUS_I(2) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(2).PIN)
        OR (XTMR(2) AND XLXN_131)
        OR (MCLR_N AND XTMR(10) AND NOT XLXN_131)
        OR (NOT MF AND XTMR(10) AND NOT XLXN_131)
        OR (XTMR(10) AND NOT XLXN_131 AND NOT XLXN_123));
MBUS(2) <= MBUS_I(2) when MBUS_OE(2) = '1' else 'Z';
MBUS_OE(2) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

```

```

MBUS_I(3) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(3).PIN)
        OR (XTMR(3) AND XLXN_131)
        OR (MCLR_N AND XTMR(11) AND NOT XLXN_131)
        OR (NOT MF AND XTMR(11) AND NOT XLXN_131)
        OR (XTMR(11) AND NOT XLXN_131 AND NOT XLXN_123));
MBUS(3) <= MBUS_I(3) when MBUS_OE(3) = '1' else 'Z';
MBUS_OE(3) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

```

```

MBUS_I(4) <= ((NOT MF AND NOT XLXN_131 AND TMR(12).LFBK)
        OR (NOT XLXN_131 AND NOT XLXN_123 AND TMR(12).LFBK)
        OR (NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(4).PIN)
        OR (XTMR(4) AND XLXN_131)
        OR (MCLR_N AND NOT XLXN_131 AND TMR(12).LFBK));
MBUS(4) <= MBUS_I(4) when MBUS_OE(4) = '1' else 'Z';
MBUS_OE(4) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

```

```

MBUS_I(5) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(5).PIN)
        OR (XTMR(5) AND XLXN_131)
        OR (MCLR_N AND NOT XLXN_131 AND XID(0))
        OR (NOT MF AND NOT XLXN_131 AND XID(0))
        OR (NOT XLXN_131 AND NOT XLXN_123 AND XID(0)));
MBUS(5) <= MBUS_I(5) when MBUS_OE(5) = '1' else 'Z';
MBUS_OE(5) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

```

```

MBUS_I(6) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(6).PIN)
        OR (XTMR(6) AND XLXN_131)
        OR (MCLR_N AND NOT XLXN_131 AND XID(1))
        OR (NOT MF AND NOT XLXN_131 AND XID(1))
        OR (NOT XLXN_131 AND NOT XLXN_123 AND XID(1)));
MBUS(6) <= MBUS_I(6) when MBUS_OE(6) = '1' else 'Z';
MBUS_OE(6) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

```

```

MBUS_I(7) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(7).PIN)
        OR (XTMR(7) AND XLXN_131)
        OR (MCLR_N AND NOT XLXN_131 AND XID(2))

```

```

        OR (NOT MF AND NOT XLXN_131 AND XID(2))
        OR (NOT XLXN_131 AND NOT XLXN_123 AND XID(2)));
MBUS(7) <= MBUS_I(7) when MBUS_OE(7) = '1' else 'Z';
MBUS_OE(7) <= (NOT MF AND XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST);

FDCPE_MCLR_N: FDCPE port map (MCLR_N_I, NOT XLXN_130, XLXI_28/XLXN_595, '0', MCLR_N_PRE)
MCLR_N_PRE <= (NOT XLXI_6/XLXN_599.LFBK AND NOT XLXN_163.LFBK);
MCLR_N <= MCLR_N_I when MCLR_N_OE = '1' else 'Z';
MCLR_N_OE <= (XLXN_123 AND ML);

MD0 <= NOT PD0;

MD1 <= PD1
      XOR
MD1 <= PD0;

MD2 <= PD2
      XOR
MD2 <= (PD1 AND PD0);

MWRT_N_I <= NOT ((XLXN_88 AND XLXN_123));
MWRT_N <= MWRT_N_I when MWRT_N_OE = '1' else 'Z';
MWRT_N_OE <= XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST;

SND <= ((XLXN_88 AND NOT XLXN_123.LFBK AND XLXN_149.LFBK)
        OR (MF AND NOT MWRT_N.PIN AND XLXN_123.LFBK AND XLXN_149.LFBK));

TCG <= '1';

UBUS_I(0) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123.LFBK)
              OR (NOT MCLR_N AND MF AND MBUS(0).PIN AND XLXN_123.LFBK)
              OR (XLXN_131 AND TMR(0).LFBK)
              OR (MCLR_N AND XTMR(8) AND NOT XLXN_131)
              OR (NOT MF AND XTMR(8) AND NOT XLXN_131)
              OR (XTMR(8) AND NOT XLXN_131 AND NOT XLXN_123.LFBK));
UBUS(0) <= UBUS_I(0) when UBUS_OE(0) = '1' else 'Z';
UBUS_OE(0) <= RCLK;

UBUS_I(1) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123.LFBK)
              OR (NOT MCLR_N AND MF AND MBUS(1).PIN AND XLXN_123.LFBK)
              OR (XLXN_131 AND TMR(1).LFBK)
              OR (MCLR_N AND XTMR(9) AND NOT XLXN_131)
              OR (NOT MF AND XTMR(9) AND NOT XLXN_131)
              OR (XTMR(9) AND NOT XLXN_131 AND NOT XLXN_123.LFBK));
UBUS(1) <= UBUS_I(1) when UBUS_OE(1) = '1' else 'Z';
UBUS_OE(1) <= RCLK;

UBUS_I(2) <= ((NOT MCLR_N AND MF AND XLXN_131 AND XLXN_123.LFBK)
              OR (NOT MCLR_N AND MF AND MBUS(2).PIN AND XLXN_123.LFBK)
              OR (XTMR(2) AND XLXN_131)
              OR (MCLR_N AND XTMR(10) AND NOT XLXN_131)

```



```

        OR (NOT MF AND XTMR(10) AND NOT XLXN_131)
        OR (XTMR(10) AND NOT XLXN_131 AND NOT XLXN_123.LFBK));
UBUS(2) <= UBUS_I(2) when UBUS_OE(2) = '1' else 'Z';
UBUS_OE(2) <= RCLK;

UBUS_I(3) <= ((NOT MF AND XTMR(11) AND NOT XLXN_131.LFBK)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(3).PIN)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND XLXN_131.LFBK)
        OR (XTMR(3) AND XLXN_131.LFBK)
        OR (MCLR_N AND XTMR(11) AND NOT XLXN_131.LFBK)
        OR (XTMR(11) AND NOT XLXN_123 AND NOT XLXN_131.LFBK));
UBUS(3) <= UBUS_I(3) when UBUS_OE(3) = '1' else 'Z';
UBUS_OE(3) <= RCLK;

UBUS_I(4) <= ((NOT MCLR_N AND MF AND XLXN_123 AND XLXN_131.LFBK)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(4).PIN)
        OR (XTMR(4) AND XLXN_131.LFBK)
        OR (MCLR_N AND XTMR(12) AND NOT XLXN_131.LFBK)
        OR (NOT MF AND XTMR(12) AND NOT XLXN_131.LFBK)
        OR (XTMR(12) AND NOT XLXN_123 AND NOT XLXN_131.LFBK));
UBUS(4) <= UBUS_I(4) when UBUS_OE(4) = '1' else 'Z';
UBUS_OE(4) <= RCLK;

UBUS_I(5) <= ((NOT MF AND XID(0) AND NOT XLXN_131.LFBK)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(5).PIN)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND XLXN_131.LFBK)
        OR (XTMR(5) AND XLXN_131.LFBK)
        OR (MCLR_N AND XID(0) AND NOT XLXN_131.LFBK)
        OR (NOT XLXN_123 AND XID(0) AND NOT XLXN_131.LFBK));
UBUS(5) <= UBUS_I(5) when UBUS_OE(5) = '1' else 'Z';
UBUS_OE(5) <= RCLK;

UBUS_I(6) <= ((MCLR_N AND XID(1) AND NOT XLXN_131.LFBK)
        OR (NOT MF AND XID(1) AND NOT XLXN_131.LFBK)
        OR (NOT XLXN_123 AND XID(1) AND NOT XLXN_131.LFBK)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(6).PIN)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND XLXN_131.LFBK)
        OR (XTMR(6) AND XLXN_131.LFBK));
UBUS(6) <= UBUS_I(6) when UBUS_OE(6) = '1' else 'Z';
UBUS_OE(6) <= RCLK;

UBUS_I(7) <= ((MCLR_N AND XID(2) AND NOT XLXN_131.LFBK)
        OR (NOT MF AND XID(2) AND NOT XLXN_131.LFBK)
        OR (NOT XLXN_123 AND XID(2) AND NOT XLXN_131.LFBK)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND MBUS(7).PIN)
        OR (NOT MCLR_N AND MF AND XLXN_123 AND XLXN_131.LFBK)
        OR (XTMR(7) AND XLXN_131.LFBK));
UBUS(7) <= UBUS_I(7) when UBUS_OE(7) = '1' else 'Z';
UBUS_OE(7) <= RCLK;

WCG <= NOT ((MF AND NOT TXE_N AND XLXI_6/XLXN_599.LFBK AND
        XLXN_163.LFBK)
        OR (NOT TXE_N AND NOT XLXN_123 AND XLXI_6/XLXN_599.LFBK AND
        XLXN_163.LFBK)

```

```
OR (NOT MF AND NOT SD_N AND XLXN_123 AND XLXI_6/XLXN_599.LFBK AND
XLXN_163.LFBK));
```

```
WRT <= ((NOT XLXN_123 AND XLXN_88.LFBK)
OR (MF AND NOT MWRT_N.PIN AND XLXN_123));
```

```
FDCPE_XLXI_21/XLXN_27: FDCPE port map (XLXI_21/XLXN_27,XLXN_123,COIN,NOT XLXI_21/XLX
```

```
FDCPE_XLXI_21/XLXN_290: FDCPE port map (XLXI_21/XLXN_290,XLXI_21/XLXN_27.LFBK,NOT CO
```

```
XLXI_21/XLXN_290/XLXI_21/XLXN_290_RSTF__$INT <= (XLXN_169 AND XLXN_123 AND MCLR_N.PI
```

```
FDCPE_XLXI_21/XLXN_360: FDCPE port map (XLXI_21/XLXN_360,UBUS(3).PIN,RCLK,XLXI_21/XL
```

```
XLXI_21/XLXN_360/XLXI_21/XLXN_360_RSTF <= ((NOT MCLR_N AND NOT XLXN_123)
OR (XLXN_123 AND NOT MCLR_N.PIN));
```

```
FDCPE_XLXI_21/XLXN_389: FDCPE port map (XLXI_21/XLXN_389,XLXN_169,NOT XLXI_24/XLXN_4
```

```
XLXI_21/XLXN_389/XLXI_21/XLXN_389_RSTF__$INT <= ((MCLR_N AND XLXN_169 AND NOT XLXN_1
OR (XLXN_169 AND XLXN_123 AND MCLR_N.PIN));
```

```
FTCPE_XLXI_24/XLXI_81/XLXI_41/QC: FTCPE port map (XLXI_24/XLXI_81/XLXI_41/QC,XLXI_24
XLXI_24/XLXI_81/XLXI_41/QC_T <= (NOT XLXI_24/XLXI_81/XLXN_92 AND
XLXI_24/XLXI_81/XLXN_24.LFBK);
```

```
FTCPE_XLXI_24/XLXI_81/XLXI_42/QC: FTCPE port map (XLXI_24/XLXI_81/XLXI_42/QC,XLXI_24
XLXI_24/XLXI_81/XLXI_42/QC_T <= (NOT XLXI_24/XLXI_81/XLXN_255.LFBK AND
XLXI_24/XLXI_81/XLXN_75.LFBK);
```

```
FTCPE_XLXI_24/XLXI_81/XLXN_136: FTCPE port map (XLXI_24/XLXI_81/XLXN_136,'1',NOT XLX
```

```
FTCPE_XLXI_24/XLXI_81/XLXN_139: FTCPE port map (XLXI_24/XLXI_81/XLXN_139,'1',NOT XLX
```

```
FTCPE_XLXI_24/XLXI_81/XLXN_184: FTCPE port map (XLXI_24/XLXI_81/XLXN_184,'1',NOT XLX
```

```
FDCPE_XLXI_24/XLXI_81/XLXN_24: FDCPE port map (XLXI_24/XLXI_81/XLXN_24,XLXI_24/XLXI_
XLXI_24/XLXI_81/XLXN_24_D <= (NOT XLXI_24/XLXI_81/XLXN_92 AND
NOT XLXI_24/XLXI_81/XLXN_24.LFBK);
```

```
FDCPE_XLXI_24/XLXI_81/XLXN_255: FDCPE port map (XLXI_24/XLXI_81/XLXN_255,XLXI_24/XLX
XLXI_24/XLXI_81/XLXN_255_D <= (NOT XLXI_24/XLXI_81/XLXN_255.LFBK AND
XLXI_24/XLXI_81/XLXN_75.LFBK AND XLXI_24/XLXI_81/XLXI_42/QC.LFBK);
```

```
FDCPE_XLXI_24/XLXI_81/XLXN_75: FDCPE port map (XLXI_24/XLXI_81/XLXN_75,XLXI_24/XLXI_
XLXI_24/XLXI_81/XLXN_75_D <= (NOT XLXI_24/XLXI_81/XLXN_255.LFBK AND
NOT XLXI_24/XLXI_81/XLXN_75.LFBK);
```

```
FDCPE_XLXI_24/XLXI_81/XLXN_92: FDCPE port map (XLXI_24/XLXI_81/XLXN_92,XLXI_24/XLXI_
XLXI_24/XLXI_81/XLXN_92_D <= (XLXI_24/XLXI_81/XLXN_24 AND
XLXI_24/XLXI_81/XLXI_41/QC AND NOT XLXI_24/XLXI_81/XLXN_92.LFBK);
```

```
FTCPE_XLXI_24/XLXI_88/Q0: FTCPE port map (XLXI_24/XLXI_88/Q0,XLXI_24/XLXI_88/Q0_T,XL
XLXI_24/XLXI_88/Q0_T <= ((NOT XLXN_169 AND XLXI_24/XLXI_88/Q0.LFBK)
OR (XLXI_24/XLXN_465.LFBK AND XLXI_24/XLXI_88/Q0.LFBK AND
XLXI_24/XLXI_88/Q1.LFBK AND XLXI_24/XLXI_88/Q2.LFBK AND XLXI_24/XLXI_88/Q3.L
```

```

FTCPE_XLXI_24/XLXI_88/Q1: FTCPE port map (XLXI_24/XLXI_88/Q1,XLXI_24/XLXI_88/Q1_T,XL
XLXI_24/XLXI_88/Q1_T <= ((XLXN_169 AND NOT XLXI_24/XLXI_88/Q0.LFBK)
    OR (NOT XLXN_169 AND XLXI_24/XLXI_88/Q1.LFBK)
    OR (XLXI_24/XLXN_465.LFBK AND XLXI_24/XLXI_88/Q1.LFBK AND
    XLXI_24/XLXI_88/Q2.LFBK AND XLXI_24/XLXI_88/Q3.LFBK));

FDCPE_XLXI_24/XLXI_88/Q2: FDCPE port map (XLXI_24/XLXI_88/Q2,XLXI_24/XLXI_88/Q2_D,XL
XLXI_24/XLXI_88/Q2_D <= ((XLXN_169 AND NOT XLXI_24/XLXI_88/Q0.LFBK AND
    NOT XLXI_24/XLXI_88/Q2.LFBK)
    OR (XLXN_169 AND NOT XLXI_24/XLXI_88/Q1.LFBK AND
    NOT XLXI_24/XLXI_88/Q2.LFBK)
    OR (XLXN_169 AND NOT XLXI_24/XLXN_465.LFBK AND
    XLXI_24/XLXI_88/Q0.LFBK AND XLXI_24/XLXI_88/Q1.LFBK AND XLXI_24/XLXI_88/Q2.L
    OR (XLXN_169 AND XLXI_24/XLXI_88/Q0.LFBK AND
    XLXI_24/XLXI_88/Q1.LFBK AND XLXI_24/XLXI_88/Q2.LFBK AND NOT XLXI_24/XLXI_88/

FTCPE_XLXI_24/XLXI_88/Q3: FTCPE port map (XLXI_24/XLXI_88/Q3,XLXI_24/XLXI_88/Q3_T,XL
XLXI_24/XLXI_88/Q3_T <= ((NOT XLXN_169 AND XLXI_24/XLXI_88/Q3.LFBK)
    OR (XLXN_169 AND XLXI_24/XLXI_88/Q0.LFBK AND
    XLXI_24/XLXI_88/Q1.LFBK AND XLXI_24/XLXI_88/Q2.LFBK));

XLXI_24/XLXI_88/Q3/XLXI_24/XLXI_88/Q3_CLKF <= ((NOT XLXI_24/XLXI_81/XLXN_92 AND XLXN
XLXN_157(1) AND NOT XLXN_157(2) AND NOT XLXN_157(3))
    OR (NOT XLXI_24/XLXI_81/XLXN_136 AND NOT XLXN_157(0) AND
    NOT XLXN_157(1) AND XLXN_157(2) AND NOT XLXN_157(3))
    OR (NOT XLXI_24/XLXI_81/XLXN_75 AND XLXN_157(0) AND
    NOT XLXN_157(1) AND XLXN_157(2) AND NOT XLXN_157(3))
    OR (NOT XLXI_24/XLXI_81/XLXN_184 AND XLXN_157(0) AND
    XLXN_157(1) AND XLXN_157(2) AND NOT XLXN_157(3))
    OR (NOT XLXI_24/XLXI_81/XLXN_255 AND XLXN_157(3))
    OR (NOT XLXI_24/XLXI_81/XLXN_255 AND NOT XLXN_157(0) AND
    XLXN_157(1) AND XLXN_157(2))
    OR (XLXN_157(0) AND NOT XLXN_157(1) AND NOT XLXN_157(2) AND
    NOT XLXN_157(3) AND NOT XLXI_24/XLXI_81/XLXN_139.LFBK)
    OR (NOT XLXN_157(0) AND XLXN_157(1) AND NOT XLXN_157(2) AND
    NOT XLXN_157(3) AND NOT XLXI_24/XLXI_81/XLXN_24.LFBK)
    OR (NOT XLXN_157(0) AND NOT XLXN_157(1) AND NOT XLXI_24/XLXN_3 AND
    NOT XLXN_157(2) AND NOT XLXN_157(3)));

FTCPE_XLXI_24/XLXI_89/XLXI_41/QC: FTCPE port map (XLXI_24/XLXI_89/XLXI_41/QC,XLXI_24
XLXI_24/XLXI_89/XLXI_41/QC_T <= (NOT XLXI_24/XLXI_89/XLXN_92.LFBK AND
    XLXI_24/XLXI_89/XLXN_253.LFBK);

FTCPE_XLXI_24/XLXI_89/XLXI_42/QC: FTCPE port map (XLXI_24/XLXI_89/XLXI_42/QC,XLXI_24
XLXI_24/XLXI_89/XLXI_42/QC_T <= (NOT XLXI_24/XLXI_89/XLXN_248.LFBK AND
    XLXI_24/XLXI_89/XLXN_245.LFBK);

FTCPE_XLXI_24/XLXI_89/XLXI_63/QC: FTCPE port map (XLXI_24/XLXI_89/XLXI_63/QC,XLXI_24
XLXI_24/XLXI_89/XLXI_63/QC_T <= (NOT XLXI_24/XLXI_89/XLXN_286.LFBK AND
    XLXI_24/XLXI_89/XLXN_287.LFBK);

FTCPE_XLXI_24/XLXI_89/XLXN_139: FTCPE port map (XLXI_24/XLXI_89/XLXN_139,'1',NOT XLX

FTCPE_XLXI_24/XLXI_89/XLXN_244: FTCPE port map (XLXI_24/XLXI_89/XLXN_244,'1',NOT XLX

FDCPE_XLXI_24/XLXI_89/XLXN_245: FDCPE port map (XLXI_24/XLXI_89/XLXN_245,XLXI_24/XLX
XLXI_24/XLXI_89/XLXN_245_D <= (NOT XLXI_24/XLXI_89/XLXN_248.LFBK AND
    NOT XLXI_24/XLXI_89/XLXN_245.LFBK);

```

```

FDCPE_XLXI_24/XLXI_89/XLXN_248: FDCPE port map (XLXI_24/XLXI_89/XLXN_248,XLXI_24/XLX
XLXI_24/XLXI_89/XLXN_248_D <= (NOT XLXI_24/XLXI_89/XLXN_248.LFBK AND
XLXI_24/XLXI_89/XLXN_245.LFBK AND XLXI_24/XLXI_89/XLXI_42/QC.LFBK);

FDCPE_XLXI_24/XLXI_89/XLXN_253: FDCPE port map (XLXI_24/XLXI_89/XLXN_253,XLXI_24/XLX
XLXI_24/XLXI_89/XLXN_253_D <= (NOT XLXI_24/XLXI_89/XLXN_92.LFBK AND
NOT XLXI_24/XLXI_89/XLXN_253.LFBK);

FDCPE_XLXI_24/XLXI_89/XLXN_286: FDCPE port map (XLXI_24/XLXI_89/XLXN_286,XLXI_24/XLX
XLXI_24/XLXI_89/XLXN_286_D <= (NOT XLXI_24/XLXI_89/XLXN_286.LFBK AND
XLXI_24/XLXI_89/XLXN_287.LFBK AND XLXI_24/XLXI_89/XLXI_63/QC.LFBK);

FDCPE_XLXI_24/XLXI_89/XLXN_287: FDCPE port map (XLXI_24/XLXI_89/XLXN_287,XLXI_24/XLX
XLXI_24/XLXI_89/XLXN_287_D <= (NOT XLXI_24/XLXI_89/XLXN_286.LFBK AND
NOT XLXI_24/XLXI_89/XLXN_287.LFBK);

FTCPE_XLXI_24/XLXI_89/XLXN_288: FTCPE port map (XLXI_24/XLXI_89/XLXN_288,'1',NOT XLX

FDCPE_XLXI_24/XLXI_89/XLXN_92: FDCPE port map (XLXI_24/XLXI_89/XLXN_92,XLXI_24/XLXI_
XLXI_24/XLXI_89/XLXN_92_D <= (NOT XLXI_24/XLXI_89/XLXN_92.LFBK AND
XLXI_24/XLXI_89/XLXN_253.LFBK AND XLXI_24/XLXI_89/XLXI_41/QC.LFBK);

FTCPE_XLXI_24/XLXN_284: FTCPE port map (XLXI_24/XLXN_284,'1',TCLK,'0','0');

FDCPE_XLXI_24/XLXN_3: FDCPE port map (XLXI_24/XLXN_3,XLXI_24/XLXN_307.LFBK,XLXI_24/X

FDCPE_XLXI_24/XLXN_307: FDCPE port map (XLXI_24/XLXN_307,XLXI_24/XLXN_334.LFBK,XLXI_

FDCPE_XLXI_24/XLXN_334: FDCPE port map (XLXI_24/XLXN_334,XLXI_24/XLXN_334_D,XLXI_24/
XLXI_24/XLXN_334_D <= (NOT XLXI_24/XLXN_307.LFBK AND NOT XLXI_24/XLXN_334.LFBK AND
NOT XLXI_24/XLXN_3.LFBK);

FDCPE_XLXI_24/XLXN_459: FDCPE port map (XLXI_24/XLXN_459,XLXI_24/XLXN_3.LFBK,XLXI_24

FTCPE_XLXI_24/XLXN_462: FTCPE port map (XLXI_24/XLXN_462,'1',XLXI_24/XLXN_462/XLXI_2

XLXI_24/XLXN_462/XLXI_24/XLXN_462_CLKF <= ((NOT XLXI_24/XLXI_89/XLXN_288 AND XLXN_15
NOT XLXN_157(1) AND XLXN_157(2) AND XLXN_157(3))
OR (NOT XLXI_24/XLXI_89/XLXN_248 AND NOT XLXN_157(0) AND
NOT XLXN_157(1) AND XLXN_157(2) AND XLXN_157(3))
OR (NOT XLXI_24/XLXI_89/XLXN_286 AND XLXN_157(0) AND
XLXN_157(1) AND XLXN_157(2) AND XLXN_157(3))
OR (NOT XLXI_24/XLXI_89/XLXN_287 AND NOT XLXN_157(0) AND
XLXN_157(1) AND XLXN_157(2) AND XLXN_157(3))
OR (NOT XLXI_24/XLXN_465 AND NOT XLXN_157(3))
OR (NOT XLXI_24/XLXI_89/XLXN_92 AND XLXN_157(0) AND
NOT XLXN_157(1) AND NOT XLXN_157(2) AND XLXN_157(3))
OR (NOT XLXI_24/XLXI_89/XLXN_245 AND XLXN_157(0) AND
XLXN_157(1) AND NOT XLXN_157(2) AND XLXN_157(3))
OR (NOT XLXI_24/XLXI_89/XLXN_253 AND NOT XLXN_157(0) AND
NOT XLXN_157(1) AND NOT XLXN_157(2) AND XLXN_157(3))
OR (NOT XLXN_157(0) AND XLXN_157(1) AND NOT XLXN_157(2) AND
XLXN_157(3) AND NOT XLXI_24/XLXI_89/XLXN_244.LFBK));

FTCPE_XLXI_24/XLXN_464: FTCPE port map (XLXI_24/XLXN_464,XLXI_24/XLXN_464_T,XLXI_24/
XLXI_24/XLXN_464_T <= ((MF AND NOT TXE_N AND XLXI_21/XLXN_360 AND XLXN_123 AND
MCLR_N.PIN AND NOT XLXI_24/XLXN_464.LFBK)
OR (NOT MF AND NOT SD_N AND XLXI_21/XLXN_290 AND XLXN_169 AND

```

```

XLXN_123 AND MCLR_N.PIN AND NOT XLXI_24/XLXN_464.LFBK)
OR (MF AND NOT TXE_N AND XLXI_21/XLXN_290 AND XLXN_169 AND
XLXN_123 AND MCLR_N.PIN AND NOT XLXI_24/XLXN_464.LFBK)
OR (NOT TXE_N AND XLXI_21/XLXN_360 AND NOT XLXN_123 AND
XLXI_6/XLXN_599.LFBK AND NOT XLXI_24/XLXN_464.LFBK)
OR (NOT MF AND NOT SD_N AND XLXI_21/XLXN_360 AND XLXN_123 AND
MCLR_N.PIN AND NOT XLXI_24/XLXN_464.LFBK)
OR (NOT TXE_N AND XLXI_21/XLXN_389 AND XLXN_169 AND NOT XLXN_123 AND
XLXI_6/XLXN_599.LFBK AND NOT XLXI_24/XLXN_464.LFBK));

```

```

FTCPE_XLXI_24/XLXN_465: FTCPE port map (XLXI_24/XLXN_465,XLXI_24/XLXN_465_T,XLXI_24/
XLXI_24/XLXN_465_T <= ((NOT XLXN_169 AND XLXI_24/XLXN_465.LFBK)
OR (XLXN_169 AND XLXI_24/XLXI_88/Q0.LFBK AND
XLXI_24/XLXI_88/Q1.LFBK AND XLXI_24/XLXI_88/Q2.LFBK AND XLXI_24/XLXI_88/Q3.L

```

```

FDCPE_XLXI_28/XLXN_506: FDCPE port map (XLXI_28/XLXN_506,XLXN_88.LFBK,WCLK,XLXI_28/X
XLXI_28/XLXN_506_CLR <= (NOT XLXI_28/XLXN_595.LFBK AND XLXI_28/XLXN_506.LFBK);

```

```

FDCPE_XLXI_28/XLXN_595: FDCPE port map (XLXI_28/XLXN_595,XLXI_28/XLXN_595_D,WCLK,NOT
XLXI_28/XLXN_595_D <= ((MCLR_N AND NOT TXE_N AND XLXN_163 AND NOT XLXN_123)
OR (MCLR_N AND NOT MF AND NOT SD_N AND XLXN_163 AND XLXN_123)
OR (MCLR_N AND MF AND NOT TXE_N AND XLXN_163));

```

```

XLXI_28/XLXN_595/XLXI_28/XLXN_595_RSTF_$INT <= ((MCLR_N AND MF AND NOT TXE_N AND XL
OR (MCLR_N AND NOT TXE_N AND XLXN_163 AND NOT XLXN_123)
OR (MCLR_N AND NOT MF AND NOT SD_N AND XLXN_163 AND XLXN_123));

```

```

XLXI_6/XLXN_334/XLXI_6/XLXN_334_TRST <= ((XLXN_123 AND XLXN_131.LFBK)
OR (XLXN_123 AND XLXN_130.LFBK));

```

```

FDCPE_XLXN_123: FDCPE port map (XLXN_123,UBUS(2).PIN,RCLK,'0','0');

```

```

FDCPE_XLXN_130: FDCPE port map (XLXN_130,XLXN_131.LFBK,XLXI_28/XLXN_595.LFBK,XLXN_13
XLXN_130_CLR <= (NOT XLXN_163 AND XLXN_130.LFBK);

```

```

FDCPE_XLXN_131: FDCPE port map (XLXN_131,XLXN_131_D,XLXI_28/XLXN_595.LFBK,XLXN_131_C
XLXN_131_D <= (MCLR_N AND NOT XLXN_131.LFBK AND NOT XLXN_130.LFBK);
XLXN_131_CLR <= (NOT XLXN_163 AND XLXN_131.LFBK);

```

```

FDCPE_XLXN_149: FDCPE port map (XLXN_149,UBUS(1).PIN,RCLK,'0','0');

```

```

FDCPE_XLXN_1570: FDCPE port map (XLXN_157(0),UBUS(4).PIN,RCLK,'0','0');

```

```

FDCPE_XLXN_1571: FDCPE port map (XLXN_157(1),UBUS(5).PIN,RCLK,'0','0');

```

```

FDCPE_XLXN_1572: FDCPE port map (XLXN_157(2),UBUS(6).PIN,RCLK,'0','0');

```

```

FDCPE_XLXN_1573: FDCPE port map (XLXN_157(3),UBUS(7).PIN,RCLK,'0','0');

```

```

FDCPE_XLXN_163: FDCPE port map (XLXN_163,XLXN_163_D,XLXI_24/XLXN_307,NOT XLXN_163/XL
XLXN_163_D <= (NOT XLXN_163.LFBK AND NOT XLXI_24/XLXN_464.LFBK);

```

```

XLXN_163/XLXN_163_RSTF_$INT <= ((MCLR_N AND XLXI_21/XLXN_360 AND NOT XLXN_123)
OR (XLXI_21/XLXN_360 AND XLXN_123 AND MCLR_N.PIN)
OR (MCLR_N AND XLXI_21/XLXN_389 AND XLXN_169 AND NOT XLXN_123)
OR (XLXI_21/XLXN_290 AND XLXN_169 AND XLXN_123 AND
MCLR_N.PIN));

```

```

FDCPE_XLXN_169: FDCPE port map (XLXN_169,UBUS(0).PIN,RCLK,'0','0');

FDCPE_XLXN_88: FDCPE port map (XLXN_88,XLXN_88_D,WCLK,XLXN_88_CLR,'0');
XLXN_88_D <= (MCLR_N AND XLXI_28/XLXN_595.LFBK AND NOT XLXN_88.LFBK AND
             NOT XLXI_28/XLXN_506.LFBK);
XLXN_88_CLR <= (NOT XLXI_28/XLXN_595.LFBK AND XLXN_88.LFBK);

FTCPE_XTMR0: FTCPE port map (XTMR(0),'1',NOT XLXI_24/XLXN_462,NOT XLXN_169,'0');

FTCPE_XTMR1: FTCPE port map (XTMR(1),'1',NOT TMR(0).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR2: FTCPE port map (XTMR(2),'1',NOT XTMR(1),NOT XLXN_169,'0');

FTCPE_XTMR3: FTCPE port map (XTMR(3),'1',NOT TMR(2).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR4: FTCPE port map (XTMR(4),'1',NOT TMR(3).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR5: FTCPE port map (XTMR(5),'1',NOT TMR(4).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR6: FTCPE port map (XTMR(6),'1',NOT TMR(5).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR7: FTCPE port map (XTMR(7),'1',NOT TMR(6).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR8: FTCPE port map (XTMR(8),'1',NOT TMR(7).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR9: FTCPE port map (XTMR(9),'1',NOT TMR(8).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR10: FTCPE port map (XTMR(10),'1',NOT TMR(9).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR11: FTCPE port map (XTMR(11),'1',NOT TMR(10).LFBK,NOT XLXN_169,'0');

FTCPE_XTMR12: FTCPE port map (XTMR(12),'1',NOT XTMR(11),NOT XLXN_169,'0');

```

```
YF <= (MF AND NOT XLXN_123);
```

```
YL <= (NOT XLXN_123 AND ML);
```

Register Legend:

```
FDCPE (Q,D,C,CLR,PRE);
```

```
FTCPE (Q,D,C,CLR,PRE);
```

```
LDCP (Q,D,G,CLR,PRE);
```

```
□***** Device Pin Out *****
```

```
Device : XC95108-15-PC84
```

```

-----
/11 10 9  8  7  6  5  4  3  2  1  84 83 82 81 80 79 78 77 76 75 \
| 12                                     74 |
| 13                                     73 |
| 14                                     72 |
| 15                                     71 |
| 16                                     70 |
| 17                                     69 |
| 18                                     68 |
| 19                                     67 |

```

| 20		66 |
| 21	XC95108-15-PC84	65 |
| 22		64 |
| 23		63 |
| 24		62 |
| 25		61 |
| 26		60 |
| 27		59 |
| 28		58 |
| 29		57 |
| 30		56 |
| 31		55 |
| 32		54 |
\ 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 /		

Pin No.	Signal Name	Pin No.	Signal Name
1	YF	43	XTMR<0>
2	ML	44	XTMR<1>
3	GD_N	45	XTMR<2>
4	MWRT_N	46	XTMR<3>
5	MCLR_N	47	XTMR<4>
6	SD_N	48	XTMR<5>
7	PGND	49	GND
8	GND	50	PGND
9	WCLK	51	XTMR<6>
10	TCLK	52	XTMR<7>
11	WCG	53	XTMR<8>
12	RCLK	54	XTMR<9>
13	TCG	55	XTMR<10>
14	YL	56	XTMR<11>
15	MF	57	XTMR<12>
16	GND	58	PGND
17	PD2	59	TDO
18	PD1	60	GND
19	PD0	61	PGND
20	TXE_N	62	PGND
21	WRT	63	PGND
22	VCC	64	VCC
23	UBUS<7>	65	PGND
24	UBUS<6>	66	MBUS<7>
25	UBUS<5>	67	MBUS<6>
26	UBUS<4>	68	MBUS<5>
27	GND	69	MBUS<4>
28	TDI	70	MBUS<3>
29	TMS	71	MBUS<2>
30	TCK	72	MBUS<1>
31	UBUS<3>	73	VCC
32	UBUS<2>	74	MBUS<0>
33	UBUS<1>	75	PGND
34	UBUS<0>	76	PGND
35	SND	77	COIN
36	PGND	78	VCC
37	PGND	79	XID<0>
38	VCC	80	XID<1>
39	PGND	81	XID<2>
40	PGND	82	MD0
41	PGND	83	MD1

42 GND

84 MD2

Legend : NC = Not Connected, unbonded pin
 PGND = Unused I/O configured as additional Ground pin
 TIE = Unused I/O floating -- must tie to VCC, GND or other signal
 VCC = Dedicated Power Pin
 GND = Dedicated Ground Pin
 TDI = Test Data In, JTAG pin
 TDO = Test Data Out, JTAG pin
 TCK = Test Clock, JTAG pin
 TMS = Test Mode Select, JTAG pin

PROHIBITED = User reserved pin

□***** Compiler Options *****

Following is a list of all global compiler options used by the fitter run.

Device(s) Specified	: xc95108-15-PC84
Optimization Method	: SPEED
Multi-Level Logic Optimization	: ON
Ignore Timing Specifications	: OFF
Default Register Power Up Value	: LOW
Keep User Location Constraints	: ON
What-You-See-Is-What-You-Get	: OFF
Exhaustive Fitting	: OFF
Keep Unused Inputs	: OFF
Slew Rate	: SLOW
Power Mode	: LOW
Ground on Unused IOs	: ON
Global Clock Optimization	: ON
Global Set/Reset Optimization	: ON
Global Output Enable Optimization	: ON
FASTConnect/UIM optimization	: ON
Local Feedback	: ON
Pin Feedback	: ON
Input Limit	: 36
Pterm Limit	: 25

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The FT245BL is the lead free version of the 2nd generation of FTDI's popular USB FIFO I.C. This device not only adds extra functionality to its FT8U245AM predecessor and reduces external component count, but also maintains a high degree of pin compatibility with the original, making it easy to upgrade or cost reduce existing designs as well as increasing the potential for using the device in new application areas.

1.0 Features

HARDWARE FEATURES

- Single Chip USB ⇔ Parallel FIFO bi-directional Data Transfer
- Transfer Data rate to 1M Byte / Sec - D2XX Drivers
- Transfer Data rate to 300 Kilobyte / Sec - VCP Drivers
- Simple to interface to MCU / PLD/ FPGA logic with a 4 wire handshake interface
- Entire USB protocol handled on-chip... no USB-specific firmware programming required
- FTDI's royalty-free VCP and D2XX drivers eliminate the requirement for USB driver development in most cases.
- 384 Byte FIFO Tx buffer / 128 Byte FIFO Rx Buffer for high data throughput.
- New Send Immediate support via SI Pin for optimised data throughput.
- Support for USB Suspend / Resume through PWREN# and WAKEUP pins.
- Support for high power USB Bus powered devices through PWREN# pin
- Adjustable RX buffer timeout
- In-built support for event characters
- Integrated level converter on FIFO and control signals for interfacing to 5V and 3.3V logic
- Integrated 3.3V regulator for USB IO
- Integrated Power-On-Reset circuit
- Integrated 6MHz – 48Mhz clock multiplier PLL
- USB Bulk or Isochronous data transfer modes
- New Bit-Bang Mode allows the data bus to be used as an 8 bit general purpose IO Port without the need for MCU or other support logic.
- 4.35V to 5.25V single supply operation
- UHCI / OHCI / EHCI host controller compatible
- USB 1.1 and USB 2.0 compatible

- USB VID, PID , Serial Number and Product Description strings in external EEPROM
- EEPROM programmable on-board via USB
- Compact Lead free RoHS compliant 32-LD LQFP package

VIRTUAL COM PORT (VCP) DRIVERS for

- Windows 98 and Windows 98 SE
- Windows 2000 / ME / Server 2003 / XP
- Windows XP 64 Bit
- Windows XP Embedded
- Windows CE 4.2
- MAC OS-8 and OS-9
- MAC OS-X
- Linux 2.40 and greater

D2XX (USB Direct Drivers + DLL S/W Interface)

- Windows 98 and Windows 98 SE
- Windows 2000 / ME / Server 2003 / XP
- Windows XP 64 Bit
- Windows XP Embedded
- Windows CE 4.2
- Linux 2.4 and Greater

APPLICATION AREAS

- Easy MCU / PLD / FPGA interface to USB
- Upgrading Legacy Peripheral Designs to USB
- USB Instrumentation
- USB Industrial Control
- USB Audio and Low Bandwidth Video data transfer
- PDA ⇔ USB data transfer
- USB MP3 Player Interface
- USB FLASH Card Reader / Writers
- Set Top Box (S.T.B.) PC - USB interface
- USB Digital Camera Interface
- USB Hardware Modems
- USB Wireless Modems

1.1 General Description

The FT245BL provides an easy cost-effective method of transferring data to / from a peripheral and a host P.C. at up to 8 Million bits (1 Megabyte) per second. Its simple, FIFO-like design makes it easy to interface to any microcontroller or microprocessor via IO ports.

To send data from the peripheral to the host computer, simply write the byte-wide data into the module when TXE# is low. If the (384-byte) transmit buffer fills up or is busy storing the previously written byte, the device keeps TXE# high in order to stop further data from being written until some of the FIFO data has been transferred over USB to the host. TXE# goes high after every byte written.

When the host sends data to the peripheral over USB, the device will take RXF# low to let the peripheral know that at least one byte of data is available. The peripheral can read a data byte every time RXF# goes low. RXF# goes high after every byte read.

By using FTDI's virtual COM port drivers, the peripheral looks like a standard COM port to the application software. Commands to set the baud rate are ignored - the device always transfers data at its fastest rate regardless of the application's baud-rate setting. Alternatively, FTDI's D2XX drivers allow application software to access the device "directly" through a published DLL based API. Details of the current VCP and D2XX driver can be found on FTDI's web site (<http://www.ftdichip.com>)

2.0 Enhancements

This section summarises the enhancements of the 2nd generation device compared to its FT8U245AM predecessor. For further details, consult the device pin-out description and functional descriptions.

- **Integrated Power-On-Reset (POR) Circuit**

The device now incorporates an internal POR function. The existing RESET# pin is maintained in order to allow external logic to reset the device where required, however for many applications this pin can now be either left N/C or hard wired to VCC. In addition, a new reset output pin (RSTOUT#) is provided in order to allow the new POR circuit to provide a stable reset to external MCU and other devices. RSTOUT# was the TEST pin on the previous generation of devices.

- **Integrated RCCLK Circuit**

In the previous devices, an external RC circuit was required to ensure that the oscillator and clock multiplier PLL frequency was stable prior to enabling the clock internal to the device. This circuit is now embedded on-chip – the pin assigned to this function is now designated as the TEST pin and should be tied to GND for normal operation.

- **Integrated Level Converter on FIFO interface and control signals**

The previous devices would drive the FIFO and control signals at 5V CMOS logic levels. The new device has a separate VCCIO pin allowing the device to directly interface to 3.3V and other logic families without the need for external level converter I.C.'s

- **Power Management control for USB Bus Powered, high current devices**

A new PWREN# signal is provided which can be used to directly drive a transistor or P-Channel MOSFET in applications where power switching of external circuitry is required. A new EEPROM based option makes the device pull gently down its FIFO interface lines when the power is shut off (PWREN# is High). In this mode, any residual

voltage on external circuitry is bled to GND when power is removed thus ensuring that external circuitry controlled by PWREN# resets reliably when power is restored. PWREN# can also be used by external circuitry to determine when USB is in suspend mode (PWREN# goes high).

- **Send Immediate / WakeUp (SI / WU) signal**

The new Send Immediate / WakeUp signal combines two functions on a single pin. If USB is in suspend mode (and remote wakeup is enabled in the EEPROM), strobing this pin low will cause the device to request a resume from suspend (WakeUp) on the USB Bus. Normally, this can be used to wake up the Host PC. During normal operation, if this pin is strobed low any data in the device RX buffer will be sent out over USB on the next Bulk-IN request from the drivers regardless of the packet size. This can be used to optimise USB transfer speed for some applications.

- **Lower Suspend Current**

Integration of RCCLK within the device and internal design improvements reduce the suspend current of the FT245BL to under 100uA typical (excluding the 1.5K pull-up on USBDP) in USB suspend mode. This allows greater margin for peripherals to meet the USB Suspend current limit of 500uA.

- **Support for USB Isochronous Transfers**

Whilst USB Bulk transfer is usually the best choice for data transfer, the scheduling time of the data is not guaranteed. For applications where scheduling latency takes priority over data integrity such as transferring audio and low bandwidth video data, the new device now offers an option of USB Isochronous transfer via an option bit in the EEPROM.

- **Programmable FIFO TX Buffer Timeout**

In the previous device, the TX buffer timeout used to flush remaining data from the TX buffer

was fixed at 16ms timeout. This timeout is now programmable over USB in 1ms increments from 1ms to 255ms, thus allowing the device to be better optimised for protocols requiring faster response times from short data packets.

- **Relaxed VCC Decoupling**

The 2nd generation devices now incorporate a level of on-chip VCC decoupling. Though this does not eliminate the need for external decoupling capacitors, it significantly improves the ease of PCB design requirements to meet FCC, CE and other EMI related specifications.

- **Bit Bang Mode**

The 2nd generation device has a new option referred to as “Bit Bang” mode. In Bit Bang mode, the eight FIFO data lines can be switched between FIFO interface mode and an 8-bit Parallel IO port. Data packets can be sent to the device and they will be sequentially sent to the interface at a rate controlled by an internal timer (equivalent to the prescaler of the FT232BL device). As well as allowing the device to be used stand-alone as a general purpose IO controller for example controlling lights, relays and switches, some other interesting possibilities exist. For instance, it may be possible to connect the device to an SRAM configurable FPGA as supplied by vendors such as Altera and Xilinx. The FPGA device would normally be un-configured (i.e. have no defined function) at power-up. Application software on the PC could use Bit Bang Mode to download configuration data to the FPGA which would define its hardware function, then after the FPGA device is configured the FT245BL can switch back into FIFO interface mode to allow the programmed FPGA device to communicate with the PC over USB. This approach allows a customer to create a “generic” USB peripheral who’s hardware function can be defined under control of the application software.

The FPGA based hardware can be easily upgraded or totally changed simply by changing the FPGA configuration data file. Application notes, software and development modules for this application area will be available from FTDI and other 3rd party developers.

- **Less External Support Components**

As well as eliminating the RCCLK RC network, and for most applications the need for an external reset circuit, we have also eliminated the requirement for a 100K pull-up on EECS to select 6MHz operation. When the FT245BL is being used without the configuration EEPROM, EECS, EESK and EEDATA can now be left n/c. For circuits requiring a long reset time (where the device is reset externally using a reset generator I.C., or reset is controlled by the IO port of a MCU, FPGA or ASIC device) an external transistor circuit is no longer required as the 1.5K pull-up resistor on USBDP can be wired to the RSTOUT# pin instead of to 3.3V. Note : RSTOUT# drives out at 3.3V level, not at 5V VCC level. This is the preferred configuration for new designs.

- **Extended EEPROM Support**

The previous generation of devices only supported EEPROM of type 93C46 (64 x 16 bit). The new devices will also work with EEPROM type 93C56 (128 x 16 bit) and 93C66 (256 x 16 bit). The extra space is not used by the device, however it is available for use by other external MCU / logic whilst the FT245BL is being held in reset.

- **USB 2.0 (full speed option)**

A new EEPROM based option allows the FT245BL to return a USB 2.0 device descriptor as opposed to USB 1.1. Note : The device would be a USB 2.0 Full Speed device (12Mb/s) as opposed to a USB 2.0 High Speed device (480Mb/s).

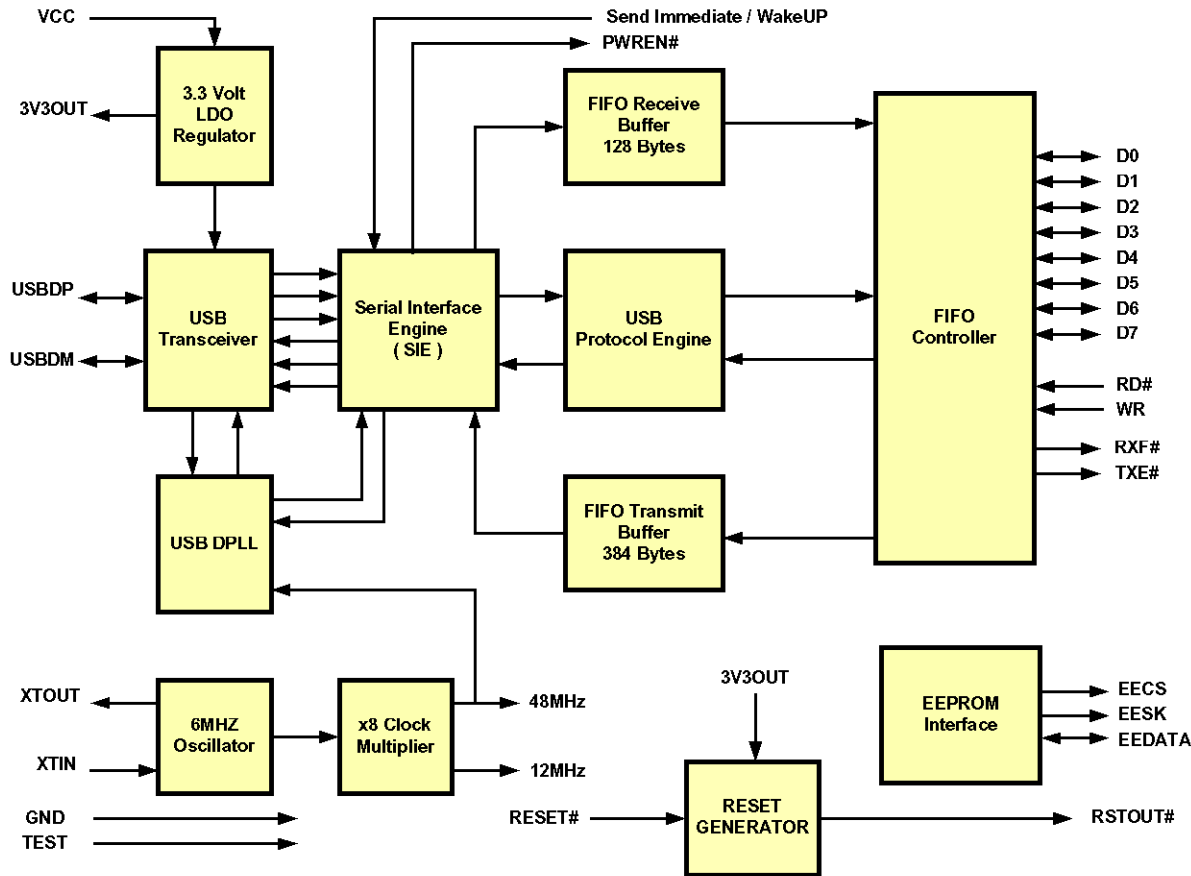
- **Multiple Device Support without EEPROM**

When no EEPROM (or a blank or invalid EEPROM) is attached to the device, the FT245BL no longer gives a serial number as part of its USB descriptor. This allows multiple devices to be simultaneously connected to the same PC. However, we still highly recommend that EEPROM is used, as without serial numbers a device can only be identified by which hub port in the USB tree it is connected to which can change if the end user re-plugs the device into a different USB port.

- **EEREQ# / EEGNT#**

These (FT8U245AM) pins are no longer supported on the FT245BL device. They have been replaced with the new SI / WU and PWREN# signals respectively.

3.0 Block Diagram (simplified)



3.1 Functional Block Descriptions

• 3.3V LDO Regulator

The 3.3V LDO Regulator generates the 3.3 volt reference voltage for driving the USB transceiver cell output buffers. It requires an external decoupling capacitor to be attached to the 3V3OUT regulator output pin. It also provides 3.3V power to the RSTOUT# pin. The main function of this block is to power the USB Transceiver and the Reset Generator Cells rather than to power external logic. However, external circuitry requiring 3.3V nominal at a current of not greater than 5mA could also draw its power from the 3V3OUT pin if required.

• USB Transceiver

The USB Transceiver Cell provides the USB 1.1 / USB 2.0 full-speed physical interface to the USB cable. The output drivers provide 3.3 volt level slew rate control signalling, whilst a differential receiver and two single ended receivers provide USB data in, SEO and USB Reset condition detection.

• USB DPLL

The USB DPLL cell locks on to the incoming NRZI USB data and provides separate recovered clock and data signals to the SIE block.

• 6MHz Oscillator

The 6MHz Oscillator cell generates a 6MHz reference clock input to the x8 Clock multiplier from an external 6MHz crystal or ceramic resonator.

• x8 Clock Multiplier

The x8 Clock Multiplier takes the 6MHz input from the Oscillator cell and generates a 12MHz reference clock for the SIE, USB Protocol Engine and FIFO controller blocks. It also generates a 48MHz reference clock for the USB DPLL.

- **Serial Interface Engine (SIE)**

The Serial Interface Engine (SIE) block performs the Parallel to Serial and Serial to Parallel conversion of the USB data. In accordance to the USB 2.0 specification, it performs bit stuffing / un-stuffing and CRC5 / CRC16 generation / checking on the USB data stream.

- **USB Protocol Engine**

The USB Protocol Engine manages the data stream from the device USB control endpoint. It handles the low level USB protocol (Chapter 9) requests generated by the USB host controller and the commands for controlling the functional parameters of the FIFO.

- **FIFO Receive Buffer (128 bytes)**

Data sent from the USB Host to the FIFO via the USB data out endpoint is stored in the FIFO Receive Buffer and is removed from the buffer by reading the FIFO contents using RD#.

- **FIFO Transmit Buffer (384 bytes)**

Data written into the FIFO using WR# is stored in the FIFO Transmit Buffer. The Host removes Data from the FIFO Transmit Data by sending a USB request for data from the device data in endpoint.

- **FIFO Controller**

The FIFO Controller handles the transfer of data between the external FIFO interface pins and the FIFO Transmit and Receive buffers.

- **RESET Generator**

The Reset Generator Cell provides a reliable power-on reset to the device internal circuitry on power up. An additional RESET# input and RSTOUT# output are provided to allow other devices to reset the FT245BL, or the FT245BL to reset other devices respectively. During reset, RSTOUT# is driven low, otherwise it drives out at the 3.3V provided by the onboard regulator. RSTOUT# can be used to control the 1.5K pull-up on USBDP directly where delayed USB

enumeration is required. RSTOUT# will be low for approximately 5ms after VCC has risen above 3.5V AND the device oscillator is running AND RESET# is high. RESET# should be tied to VCC unless it is a requirement to reset the device from external logic or an external reset generator I.C.

- **EEPROM Interface**

Though the FT245BL will work without the optional EEPROM, an external 93C46 (93C56 or 93C66) EEPROM can be used to customise the USB VID, PID, Serial Number, Product Description Strings and Power Descriptor value of the FT245BL for OEM applications. Other parameters controlled by the EEPROM include Remote Wake Up, Isochronous Transfer Mode, Soft Pull Down on Power-Off and USB 2.0 descriptor modes.

The EEPROM should be a 16 bit wide configuration such as a MicroChip 93LC46B or equivalent capable of a 1Mb/s clock rate at VCC = 4.35V to 5.25V. The EEPROM is programmable-on board over USB using a utility available from FTDI's web site (<http://www.ftdichip.com>). This allows a blank part to be soldered onto the PCB and programmed as part of the manufacturing and test process.

If no EEPROM is connected (or the EEPROM is blank), the FT245BL will use its built-in default VID, PID Product Description and Power Descriptor Value. In this case, the device will not have a serial number as part of the USB descriptor.

4.0 Device Pin-Out

Figure 1
Pin-Out

(Lead free LQFP-32 Package)

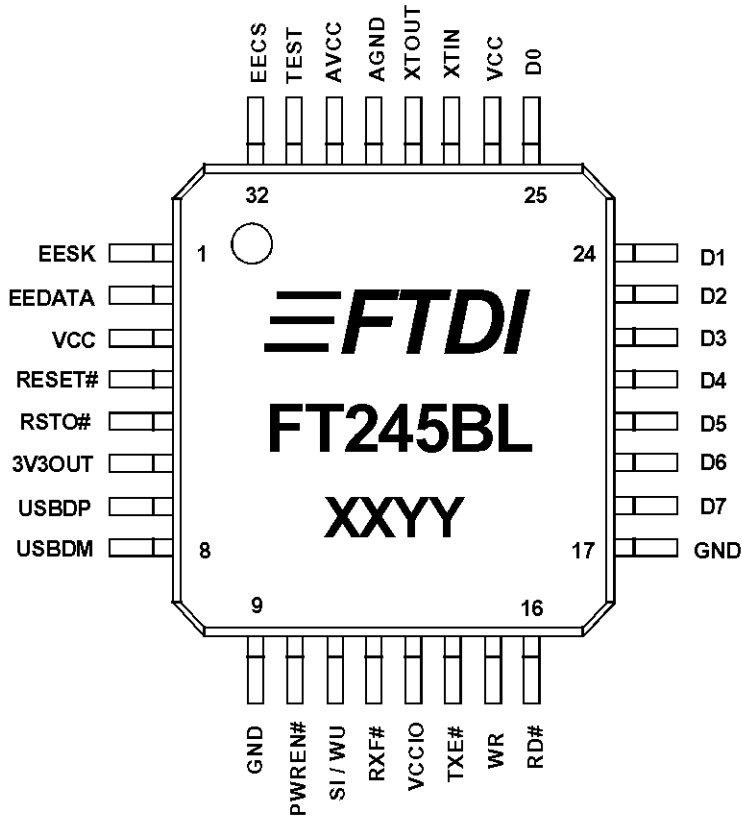
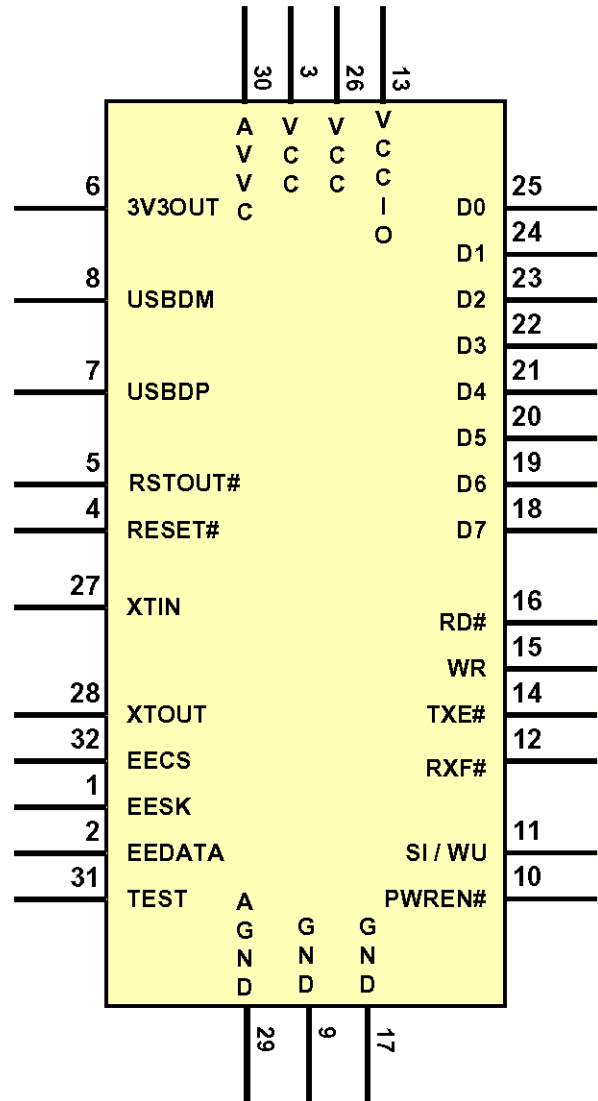


Figure 2
Pin-Out

(Schematic Symbol)



4.1 Signal Descriptions

Table 1 - FT245BL - PINOUT DESCRIPTION

FIFO DATA BUS GROUP (** Note 1)

Pin#	Signal	Type	Description
25	DO	I/O	FIFO Data Bus Bit 0
24	D1	I/O	FIFO Data Bus Bit 1
23	D2	I/O	FIFO Data Bus Bit 2
22	D3	I/O	FIFO Data Bus Bit 3
21	D4	I/O	FIFO Data Bus Bit 4
20	D5	I/O	FIFO Data Bus Bit 5
19	D6	I/O	FIFO Data Bus Bit 6
18	D7	I/O	FIFO Data Bus Bit 7

FIFO CONTROL INTERFACE GROUP

Pin#	Signal	Type	Description
16	RD#	IN	Enables Current FIFO Data Byte on D0..D7 when low. Fetches the next FIFO Data Byte (if available) from the Receive FIFO Buffer when RD# goes from low to high. *** Note 1
15	WR	IN	Writes the Data Byte on the D0..D7 into the Transmit FIFO Buffer when WR goes from high to low. *** Note 1
14	TXE#	OUT	When high, do not write data into the FIFO. When low, data can be written into the FIFO by strobing WR high then low. *** Note 2
12	RXF#	OUT	When high, do not read data from the FIFO. When low, there is data available in the FIFO which can be read by strobing RD# low then high again *** Note 2

USB INTERFACE GROUP

Pin#	Signal	Type	Description
7	USBDP	I/O	USB Data Signal Plus (Requires 1.5K pull-up to 3V3OUT or RSTOUT#)
8	USBDM	I/O	USB Data Signal Minus

EEPROM INTERFACE GROUP

Pin#	Signal	Type	Description
32	EECS	I/O	EEPROM – Chip Select. For 48MHz operation pull EECS to GND using a 10K resistor. For 6MHz operation no resistor is required. *** Note 3
1	EESK	OUT	Clock signal to EEPROM. Adding a 10K pull down resistor onto EESK will cause the FT245BL to use USB Product ID 6005 (hex) instead of 6001 (hex). All of the other USB device descriptors are unchanged. *** Note 3
2	EEDATA	I/O	EEPROM – Data I/O Connect directly to Data-In of the EEPROM and to Data-Out of the EEPROM via a 2.2K resistor. Also pull Data-Out of the EEPROM to VCC via a 10K resistor for correct operation. *** Note 3

POWER CONTROL GROUP

Pin#	Signal	Type	Description
10	PWREN#	OUT	Goes Low after the device is configured via USB, then high during USB suspend. Can be used to control power to external logic using a P-Channel Logic Level MOSFET switch. Enable the Interface Pull-Down Option in EEPROM when using the PWREN# pin in this way.
11	SI / WU	IN	The Send Immediate / WakeUp signal combines two functions on a single pin. If USB is in suspend mode (PWREN# = 1) and remote wakeup is enabled in the EEPROM, strobing this pin low will cause the device to request a resume on the USB Bus. Normally, this can be used to wake up the Host PC. During normal operation (PWREN# = 0), if this pin is strobed low any data in the device TX buffer will be sent out over USB on the next Bulk-IN request from the drivers regardless of the pending packet size. This can be used to optimise USB transfer speed for some applications. Tie this pin to VCCIO if not used.

MISCELLANEOUS SIGNAL GROUP

Pin#	Signal	Type	Description
4	RESET#	IN	Can be used by an external device to reset the FT245BL. If not required, tie to VCC.
5	RSTOUT#	OUT	Output of the internal Reset Generator. Stays high impedance for ~ 5ms after VCC > 3.5V and the internal clock starts up, then clamps its output to the 3.3V output of the internal regulator. Taking RESET# low will also force RSTOUT# to drive low. RSTOUT# is NOT affected by a USB Bus Reset.
27	XTIN	IN	Input to 6MHz Crystal Oscillator Cell. This pin can also be driven by an external 6MHz clock if required. Note : Switching threshold of this pin is VCC/2, so if driving from an external source, the source must be driving at 5V CMOS level or a.c. coupled to centre around VCC/2.
28	XTOUT	OUT	Output from 6MHz Crystal Oscillator Cell. XTOUT stops oscillating during USB suspend, so take care if using this signal to clock external logic.
31	TEST	IN	Puts device in I.C. test mode – must be tied to GND for normal operation.

POWER AND GND GROUP

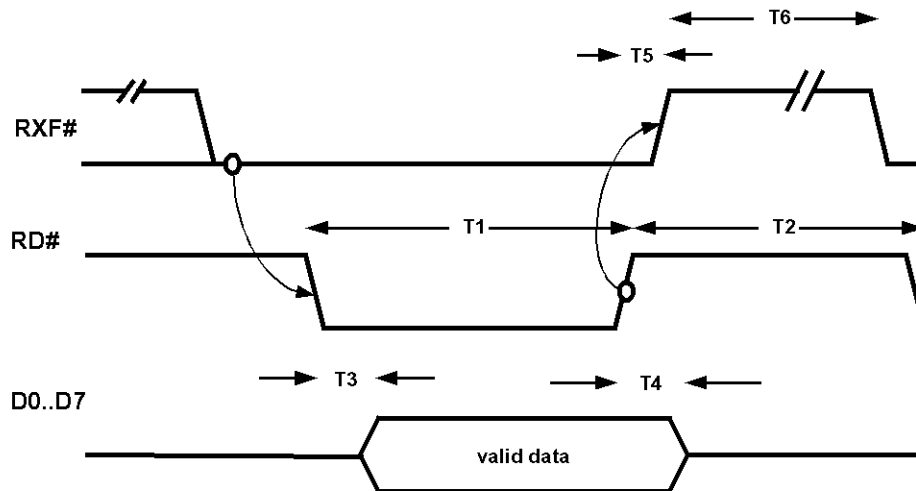
Pin#	Signal	Type	Description
6	3V3OUT	OUT	3.3 volt Output from the integrated L.D.O. regulator This pin should be decoupled to GND using a 33nF ceramic capacitor in close proximity to the device pin. Its prime purpose is to provide the internal 3.3V supply to the USB transceiver cell and the RSTOUT# pin. A small amount of current ($\leq 5\text{mA}$) can be drawn from this pin to power external 3.3V logic if required.
3,26	VCC	PWR	+4.35 volt to +5.25 volt VCC to the device core, LDO and none-FIFO interface pins.
13	VCCIO	PWR	+3.0 volt to +5.25 volt VCC to the FIFO interface pins 10..12, 14..16 and 18..25. When interfacing with 3.3V external logic in a bus powered design connect VCCIO to a 3.3V supply generated from the USB bus. When interfacing with 3.3V external logic in a self powered design connect VCCIO to the 3.3V supply of the external logic. Otherwise connect to VCC to drive out at 5V CMOS level.
9,17	GND	PWR	Device - Ground Supply Pins
30	AVCC	PWR	Device - Analog Power Supply for the internal x8 clock multiplier
29	AGND	PWR	Device - Analog Ground Supply for the internal x8 clock multiplier

Note 1 : In Input Mode, these pins are pulled to VCCIO via internal 200K resistors. These can be programmed to gently pull low during USB suspend (PWREN# = "1") by setting this option in the EEPROM.

Note 2: During device reset, these pins are tri-state but pulled up to VCCIO via internal 200K resistors.

Note 3: During device reset, these pins are tri-state but pulled up to VCC via internal 200K resistors.

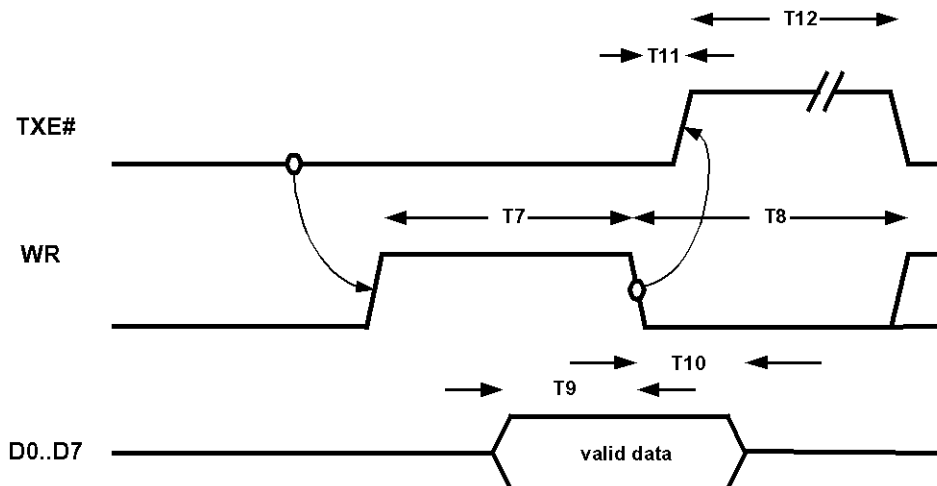
FT245BL TIMING DIAGRAM – FIFO READ CYCLE



Time	Description	Min	Max	Unit
T1	RD Active Pulse Width	50		ns
T2	RD to RD Pre-Charge Time	50 + T6		ns
T3	RD Active to Valid Data *** Note 4	20	50	ns
T4	Valid Data Hold Time from RD Inactive *** Note 4	0		ns
T5	RD Inactive to RXF#	0	25	ns
T6	RXF inactive after RD cycle	80		ns

*** Note 4 - Load 30 pF

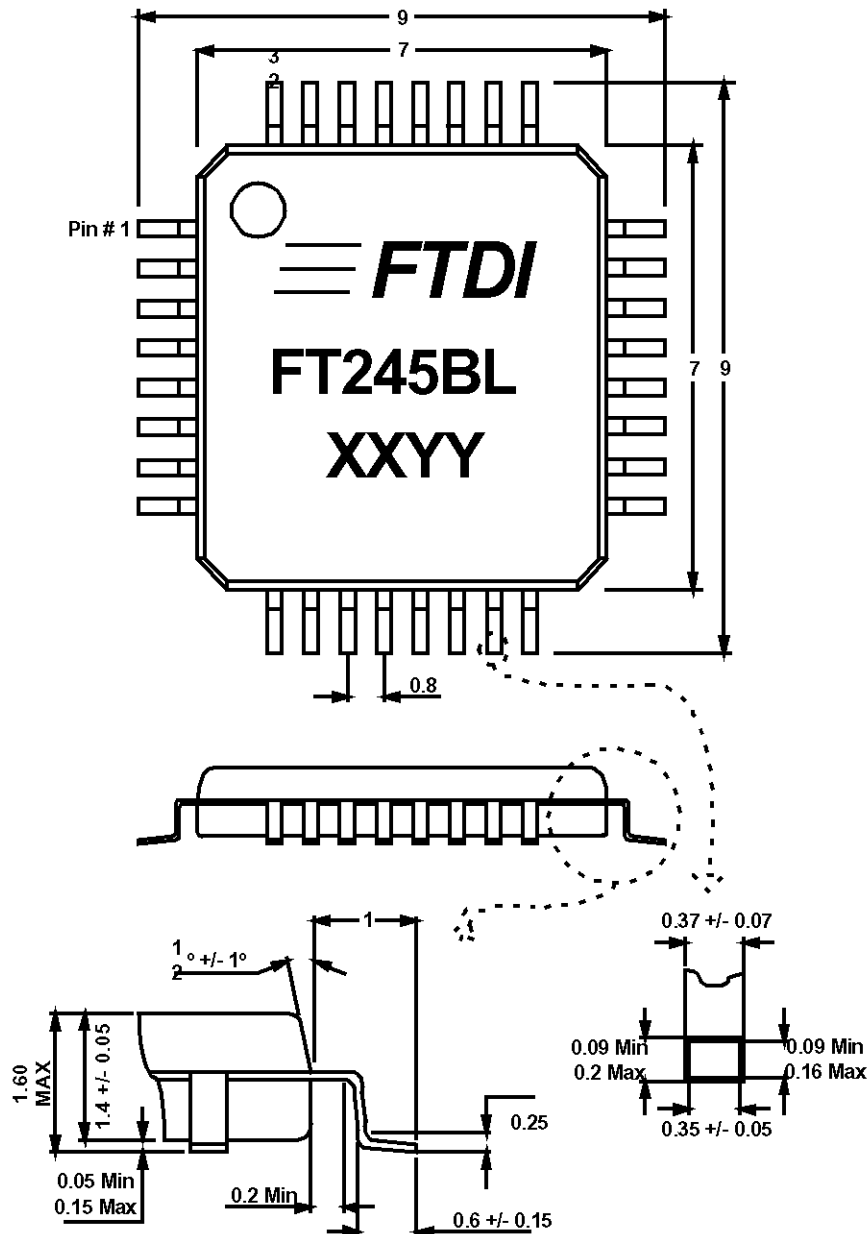
FT245BL TIMING DIAGRAM – FIFO WRITE CYCLE



Time	Description	Min	Max	Unit
T7	WR Active Pulse Width	50		ns
T8	WR to WR Pre-Charge Time	50		ns
T9	Data Setup Time before WR inactive	20		ns
T10	Data Hold Time from WR inactive	0		ns
T11	WR Inactive to TXE#	5	25	ns
T12	TXE inactive after WR cycle	80		ns

5.0 Package Outline

Figure 3 – 32 LD Lead free LQFP Package Dimensions



The FT245BL is supplied in a 32 pin lead free LQFP package as standard. This package has a 7mm x 7mm body (9mm x 9mm including leads) with leads on a 0.8mm pitch. The above drawing shows the LQFP-32 package – all dimensions are in millimetres. Note that there are two date code formats used - XXYY = Date Code where XX = 1 or 2 digit year number, YY = 2 digit week number); or XYY-1 where X = 1 digit year number, YY = 2 digit week number.

The FT245BL is fully compliant with the European Union RoHS directive.

An alternative 5mm x 5mm leadless QFN is also available for projects where package area is critical. Part number for this version is FT245BQ. The FT245BQ is also a lead free package. See the separate datasheet for package dimensions.

6.0 Absolute Maximum Ratings

These are the absolute maximum ratings for the FT245BL device in accordance with the Absolute Maximum Rating System (IEC 60134). Exceeding these may cause permanent damage to the device.

Parameter	Value	Units
Storage Temperature	-65°C to + 150°C	Degrees C
Floor Life (Out of Bag) at Factory Ambient (30°C/60% Relative Humidity)	192 Hours (Level 3 Compliant) **Note 5	
Ambient Temperature (Power Applied)	0°C to + 70°C	Degrees C
M.T.B.F. (at 35°C)	247484 Hours ≈ 28 Years	
VCC Supply Voltage	-0.5 to +6.00	V
D.C. Input Voltage - USBDP and USBDM	-0.5 to +3.8	V
D.C. Input Voltage - High Impedance Bidirectionals	-0.5 to +(Vcc +0.5)	V
D.C. Input Voltage - All other Inputs	-0.5 to +(Vcc +0.5)	V
DC Output Current – Outputs	24	mA
DC Output Current – Low Impedance Bidirectionals	24	mA
Power Dissipation (VCC = 5.25V)	500	mW
Electrostatic Discharge Voltage (Human Body Model) (I < 1uA)	+/- 3000	V
Latch Up Current (Vi = +/- 10V maximum, for 10 ms)	+/-200	mA

***** Note 5** - If devices are stored out of the packaging beyond this time limit the devices should be baked before use.
The devices should be ramped up to a temperature of 110°C and baked for 8 to 10 hours.

6.1 D.C. Characteristics

DC Characteristics (Ambient Temperature = 0 to 70°C)

Operating Voltage and Current

Parameter	Description	Min	Typ	Max	Units	Conditions
Vcc1	VCC Operating Supply Voltage	4.35	5.0	5.25	V	
Vcc2	VCCIO Operating Supply Voltage	3.0	-	5.25	V	
Icc1	Operating Supply Current	-	25	-	mA	Normal Operation
Icc2	Operating Supply Current	-	100	200	uA	USB Suspend *** Note 6

*****Note 6** – Supply current excludes the 200uA nominal drawn by the external pull-up resistor on USBDP.

FIFO Data / Control Bus IO Pin Characteristics (VCCIO = 5.0V)

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	3.2	4.1	4.9	V	I source = 2mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 2 mA
Vin	Input Switching Threshold	1.3	1.6	1.9	V	*** Note 7
VHys	Input Switching Hysteresis	50	55	60	mV	

FIFO Data / Control Bus IO Pin Characteristics (VCCIO = 3V to 3.6V)

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	2.2	2.7	3.2	V	I source = 2mA
Vol	Output Voltage Low	0.3	0.4	0.5	V	I sink = 4 mA
Vin	Input Switching Threshold	1.0	1.2	1.5	V	*** Note 7
VHys	Input Switching Hysteresis	20	25	30	mV	

***Note 7 – Inputs or IO Pins in Input Mode have an internal 200K pull-up resistor to VCCIO.

XTIN / XTOUT Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	4.0	-	5.0	V	Fosc = 6MHz
Vol	Output Voltage Low	0.1	-	1.0	V	Fosc = 6MHz
Vin	Input Switching Threshold	1.8	2.5	3.2	V	

RESET#, TEST, EECS, EESK, EEDATA, IO Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	3.2	4.1	4.9	V	I source = 2mA
Vol	Output Voltage Low	0.3	0.4	0.6	V	I sink = 2 mA
Vin	Input Switching Threshold	1.3	1.6	1.9	V	*** Note 8
VHys	Input Switching Hysteresis	50	55	60	mV	

***Note 8 – EECS, EESK and EEDATA pins have an internal 200K pull-up resistor to VCC

RSTOUT Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	3.0	-	3.6	V	I source = 2mA
Vol	Output Voltage Low	0.3	-	0.6	V	I sink = 2 mA

USB IO Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
UVoh	IO Pins Static Output (High)	2.8		3.6	V	RI = 1.5K to 3V3Out (D+) RI = 15K to GND (D-)
UVol	IO Pins Static Output (Low)	0		0.3	V	RI = 1.5K to 3V3Out (D+) RI = 15K to GND (D-)
UVse	Single Ended Rx Threshold	0.8		2.0	V	
UCom	Differential Common Mode	0.8		2.5	V	
UVDif	Differential Input Sensitivity	0.2			V	
UDrvZ	Driver Output Impedance	29		44	Ohm	*** Note 9

Note 9 – Driver Output Impedance includes the external 27R series resistors on USBDP and USBDM pins.

7.0 Device Configuration Examples

7.1 Oscillator Configurations

Figure 4
3 Pin Ceramic Resonator Configuration

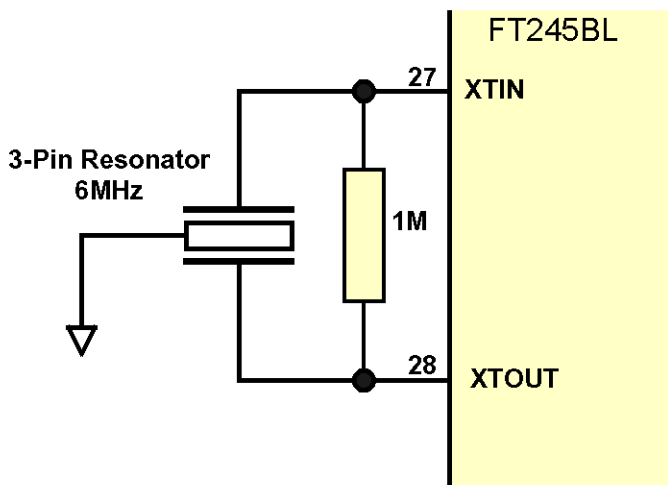


Figure 5
Crystal or 2-Pin Ceramic Resonator Configuration

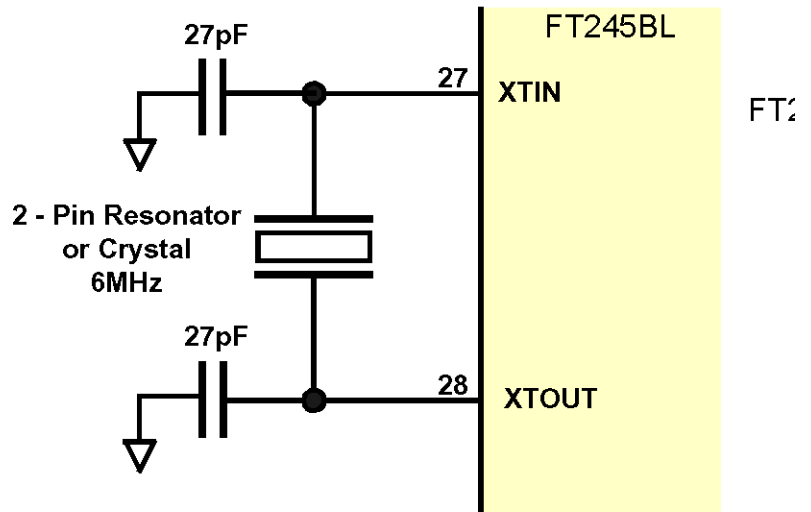


Figure 4 illustrates how to use the FT245BL with a 3-Pin Ceramic Resonator. A suitable part would be a ceramic resonator from Murata's CERALOCK range. (Murata Part Number CSTCR6M00G15), or equivalent. 3-Pin ceramic resonators have the load capacitors built into the resonator so no external loading capacitors are required. This makes for an economical configuration. The accuracy of this Murata ceramic resonator is $\pm 0.1\%$ and it is specifically designed for USB full speed applications. A 1 MOhm loading resistor across XTIN and XTOUT is recommended in order to guarantee this level of accuracy.

Other ceramic resonators with a lesser degree of accuracy (typically $\pm 0.5\%$) are technically outwith the USB specification, but it has been calculated that using such a device will work satisfactorily in practice with a FT245BL design.

Figure 5 illustrates how to use the FT245BL with a 6MHz Crystal or 2-Pin Ceramic Resonator. In this case, these devices do not have in-built loading capacitors so these have to be added between XTIN, XTOUT and GND as shown. A value of 27pF is shown as the capacitor in the example – this will be good for many crystals and some resonators but do select the value based on the manufacturers recommendations wherever possible. If using a crystal, use a parallel cut type. If using a resonator, see the previous note on frequency accuracy.

7.2 EEPROM Configuration

Figure 6
EEPROM Configuration

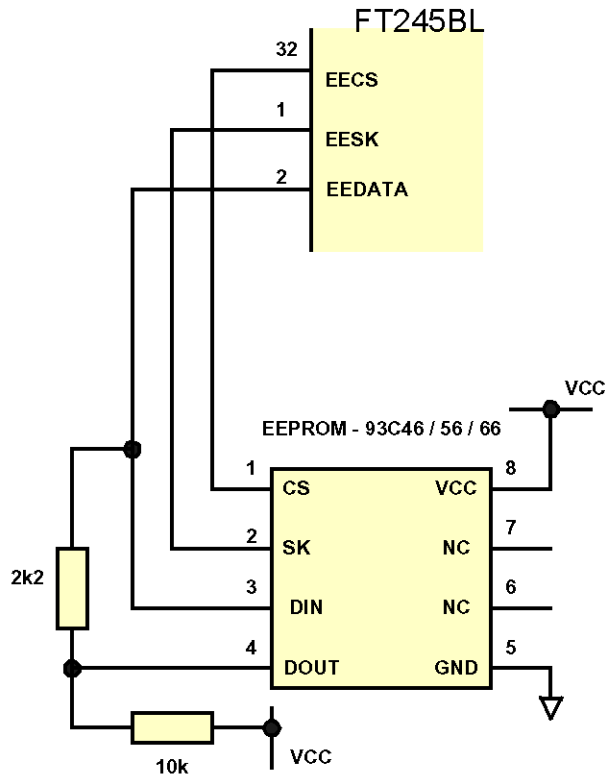


Figure 6 illustrates how to connect the FT245BL to the 93C46 (93C56 or 93C66) EEPROM. EECS (pin 32) is directly connected to the chip select (CS) pin of the EEPROM. EESK (pin 1) is directly connected to the clock (SK) pin of the EEPROM. EEDATA (pin 2) is directly connected to the Data In (Din) pin of the EEPROM. There is a potential condition whereby both the Data Output (Dout) of the EEPROM can drive out at the same time as the EEDATA pin of the FT245BL. To prevent potential data clash in this situation, the Dout of the EEPROM is connected to EEDATA of the FT245BL via a 2.2 K resistor.

Following a power-on reset or a USB reset, the FT245BL will scan the EEPROM to find out a) if an EEPROM is attached to the Device and b) if the data in the device is valid. If both of these are the case, then the FT245BL will use the data in the EEPROM, otherwise it will use its built-in default values. When a valid command is issued to the EEPROM from the FT245BL, the EEPROM will acknowledge the command by pulling its Dout pin low. In order to check for this condition, it is necessary to pull Dout high using a 10K resistor. If the command acknowledge doesn't happen then EEDATA will be pulled high by the 10K resistor during this part of the cycle and the device will detect an invalid command or no EEPROM present.

There are two varieties of these EEPROM's on the market – one is configured as being 16 bits wide, the other is configured as being 8 bits wide. These are available from many sources such as Microchip, ST Micro, ISSI etc. The FT245BL requires EEPROM's with a 16-bit wide configuration such as the Microchip 93LC46B device. The EEPROM must be capable of reading data at a 1Mb clock rate at a supply voltage of 4.35V to 5.25V. Most available parts are capable of this.

Check the manufacturers data sheet to find out how to connect pins 6 and 7 of the EEPROM. Some devices specify these as no-connect, others use them for selecting 8 / 16 bit mode or for test functions. Some other parts have their pinout rotated by 90° so please select the required part and its options carefully.

It is possible to "share" the EEPROM between the FT245BL and another external device such as an MCU. However, this can only be done when the FT245BL is in its reset condition as it tri-states its EEPROM interface at that time. A typical configuration would use four bits of an MCU IO Port. One bit would be used to hold the FT245BL reset (using RESET#) on power-up, the other three would connect to the EECS, EESK and EEDATA pins of the FT245BL in order to read / write data to the EEPROM at this time. Once the MCU has read / written the EEPROM, it would take RESET# high to allow the FT245BL to configure itself and enumerate over USB.

7.3 USB Bus Powered and Self Powered Configuration

Figure 7
USB Bus Powered Configuration

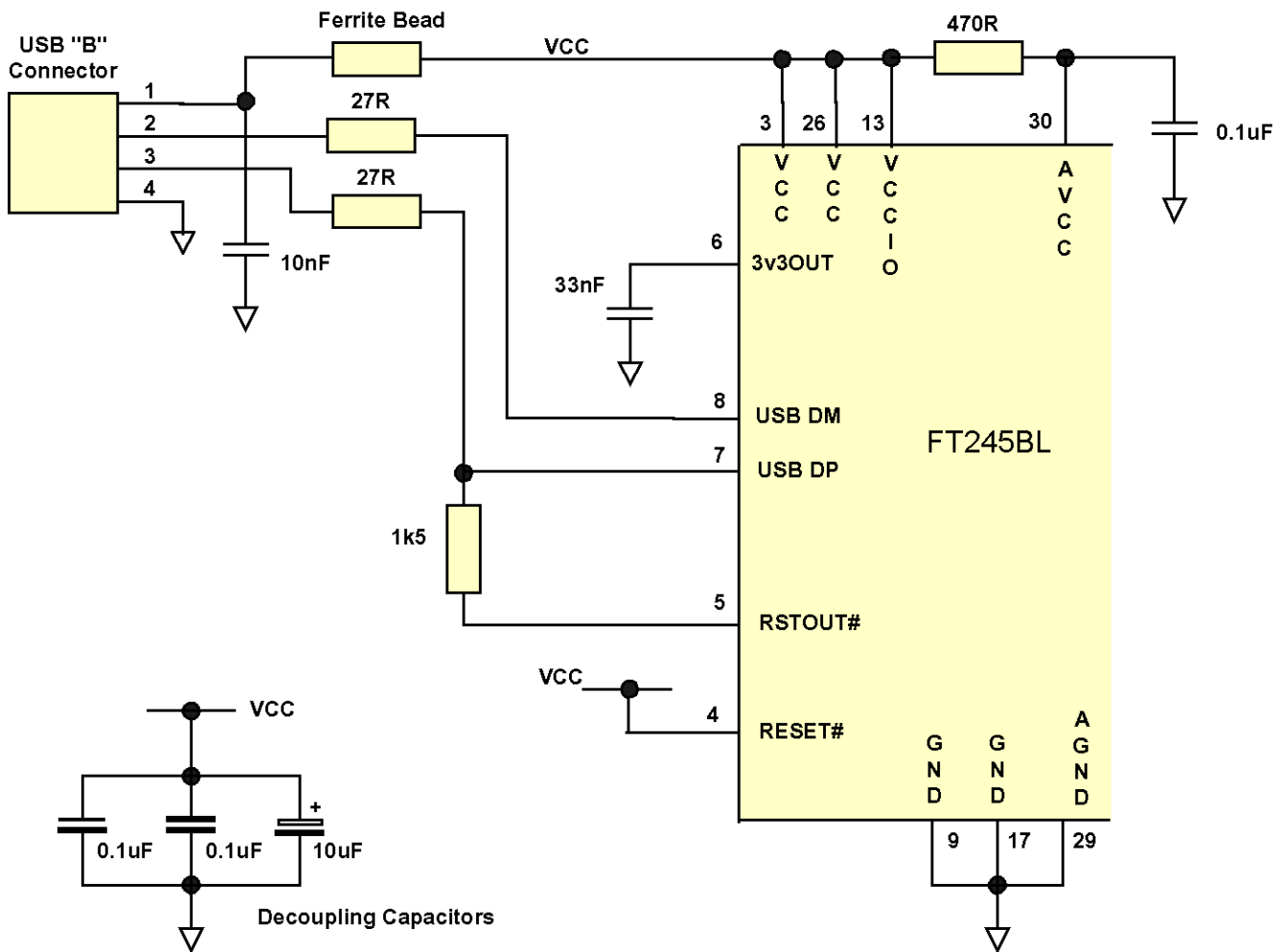


Figure 7 illustrates a typical USB bus powered configuration. A USB Bus Powered device gets its power from the USB bus. Basic rules for USB Bus power devices are as follows –

- a) On plug-in, the device must draw no more than 100mA
- b) On USB Suspend the device must draw no more than 500uA.
- c) A Bus Powered High Power Device (one that draws more than 100mA) should use the PWREN# pin to keep the current below 100mA on plug-in and 500uA on USB suspend.
- d) A device that consumes more than 100mA can not be plugged into a USB Bus Powered Hub
- e) No device can draw more that 500mA from the USB Bus.

The power descriptor in the EEPROM should be programmed to match the current draw of the device.

A Ferrite Bead is connected in series with USB power to prevent noise from the device and associated circuitry (EMI) being radiated down the USB cable to the Host. The value of the Ferrite Bead depends on the total current required by the circuit – a suitable range of Ferrite Beads is available from Steward (www.steward.com) for example Steward Part # MI0805K400R-00 also available as DigiKey Part # 240-1035-1.

Figure 8
USB Self Powered Configuration

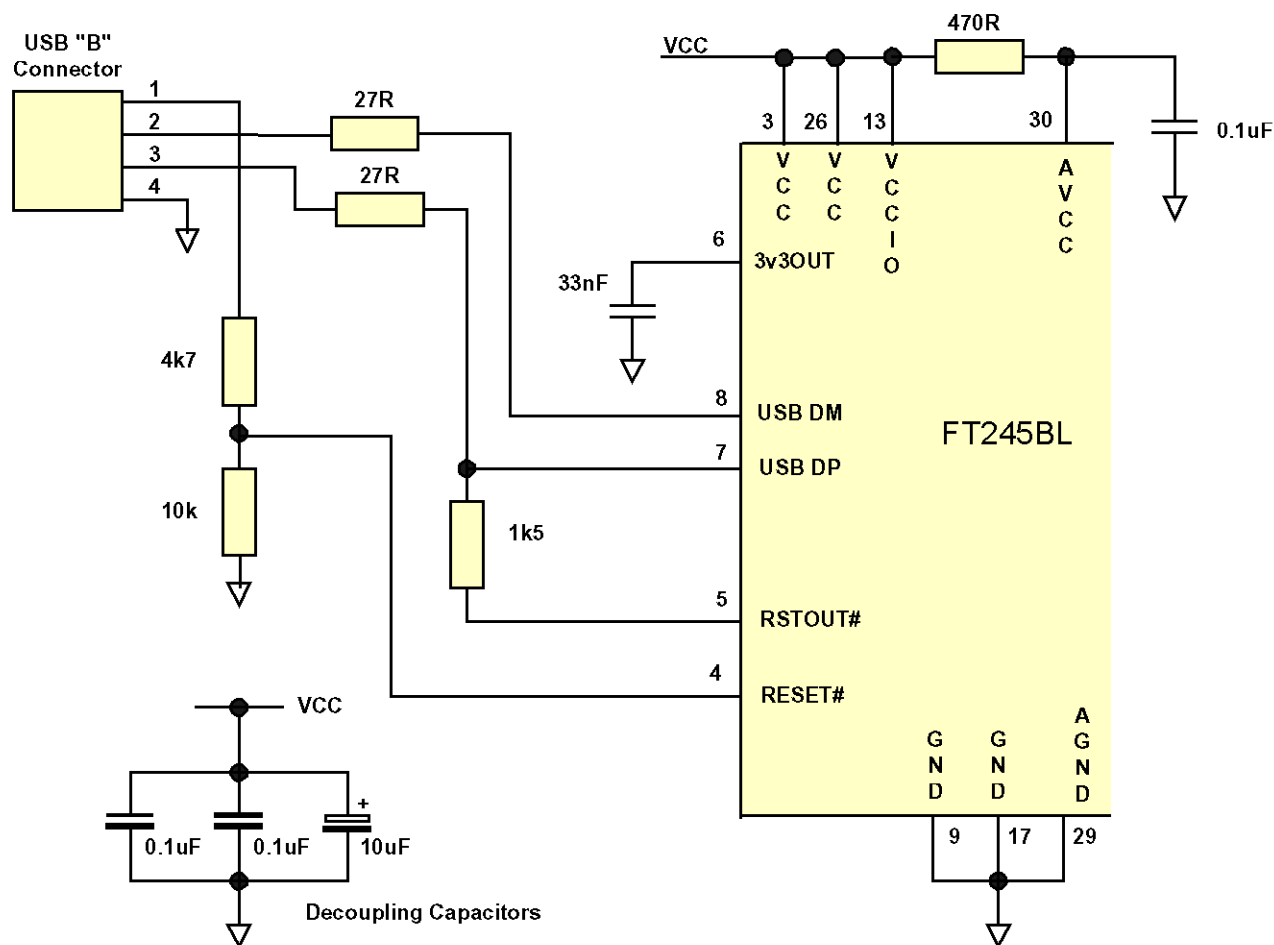


Figure 8 illustrates a typical USB self powered configuration. A USB Self Powered device gets its power from its own POWER SUPPLY and does not draw current from the USB bus. The basic rules for USB Self power devices are as follows –

- a) A Self-Powered device should not force current down the USB bus when the USB Host or Hub Controller is powered down.
- b) A Self Powered Device can take as much current as it likes during normal operation and USB suspend as it has its own POWER SUPPLY.
- c) A Self Powered Device can be used with any USB Host and both Bus and Self Powered USB Hubs

The USB power descriptor option in the EEPROM should be programmed to a value of zero (self powered).

To meet requirement a) the 1.5K pull-up resistor on USB DP is connected to RSTOUT# as per the bus-power circuit. However, the USB Bus Power is used to control the RESET# Pin of the FT245BL device. When the USB Host or Hub is powered up RSTOUT# will pull the 1.5K resistor on USB DP to 3.3V, thus identifying the device as a full speed device to USB. When the USB Host or Hub power is off, RESET# will go low and the device will be held in reset. As RESET# is low, RSTOUT# will also be low, so no current will be forced down USB DP via the 1.5K pull-up resistor when the host or hub is powered down. Failure to do this may cause some USB host or hub controllers to power up erratically.

Note : When the FT245BL is in reset, the FIFO interface pins all go tri-state. These pins have internal 200K pull-up resistors to VCCIO so they will gently pull high unless driven by some external logic.

Figure 9

Bus Powered Circuit with 3.3V logic drive / supply voltage

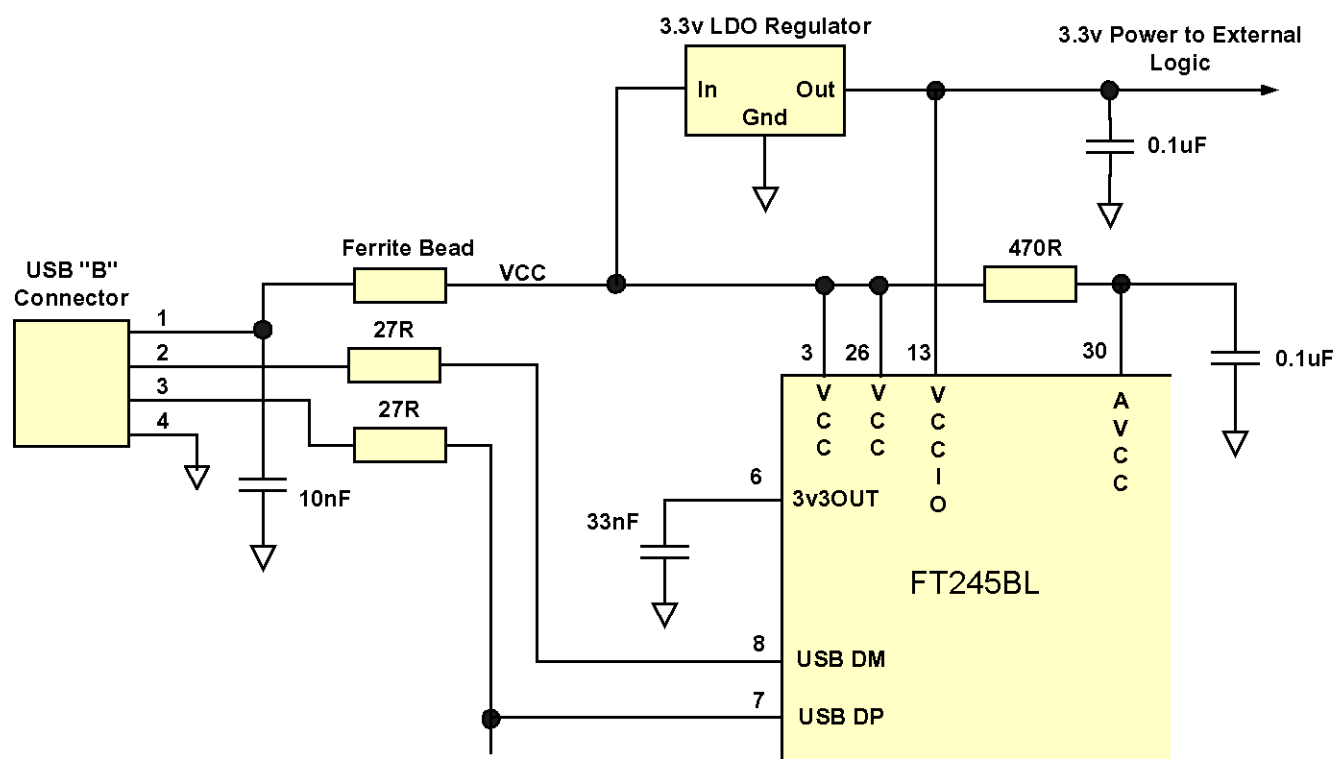


Figure 9 shows how to configure the FT245BL to interface with a 3.3V logic device. In this example, a discrete 3.3V regulator is used to supply the 3.3V logic from the USB supply. VCCIO is connected to the output of the 3.3V regulator, which in turn will cause the FIFO interface IO pins to drive out at 3.3V level. For USB bus powered circuits some considerations have to be taken into account when selecting the regulator –

- The regulator must be capable of sustaining its output voltage with an input voltage of 4.35 volts. A Low Drop Out (LDO) regulator must be selected.
- The quiescent current of the regulator must be low in order to meet the USB suspend total current requirement of $\leq 500\mu\text{A}$ during USB suspend.

An example of a regulator family that meets these requirements is the MicroChip (Telcom) TC55 Series. These devices can supply up to 250mA current and have a quiescent current of under 1uA.

In some cases, where only a small amount of current is required ($< 5\text{mA}$), it may be possible to use the in-built regulator of the FT245BL to supply the 3.3V without any other components being required. In this case, connect VCCIO to the 3V3OUT pin of the FT245BL.

Note : It should be emphasised that the 3.3V supply for VCCIO in a bus powered design with a 3.3V logic interface should come from an LDO which is supplied by USB bus, or from the 3V3OUT pin of the FT245BL, and not from any other source.

Figure 10
Self Powered Circuit with 3.3 V logic drive / supply voltage

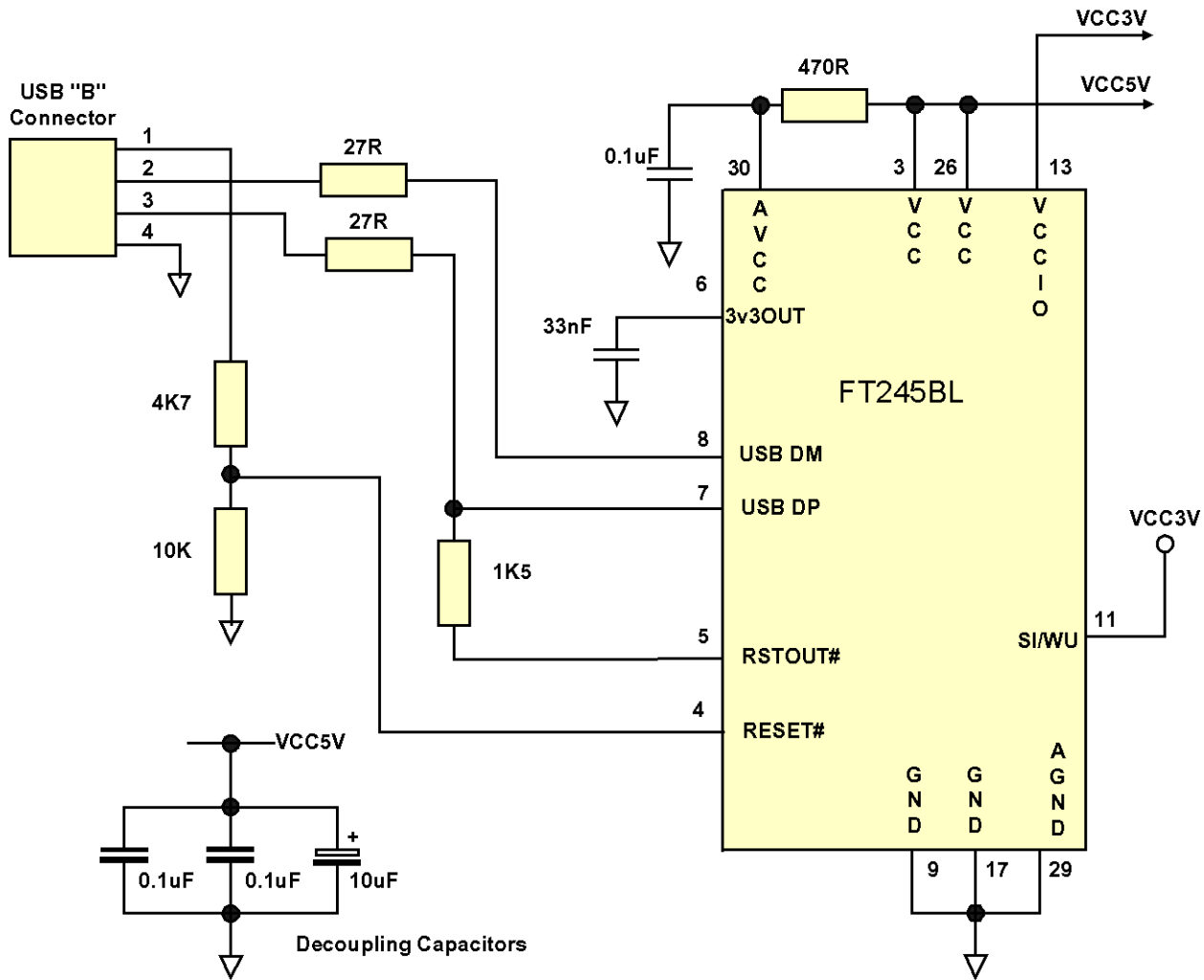


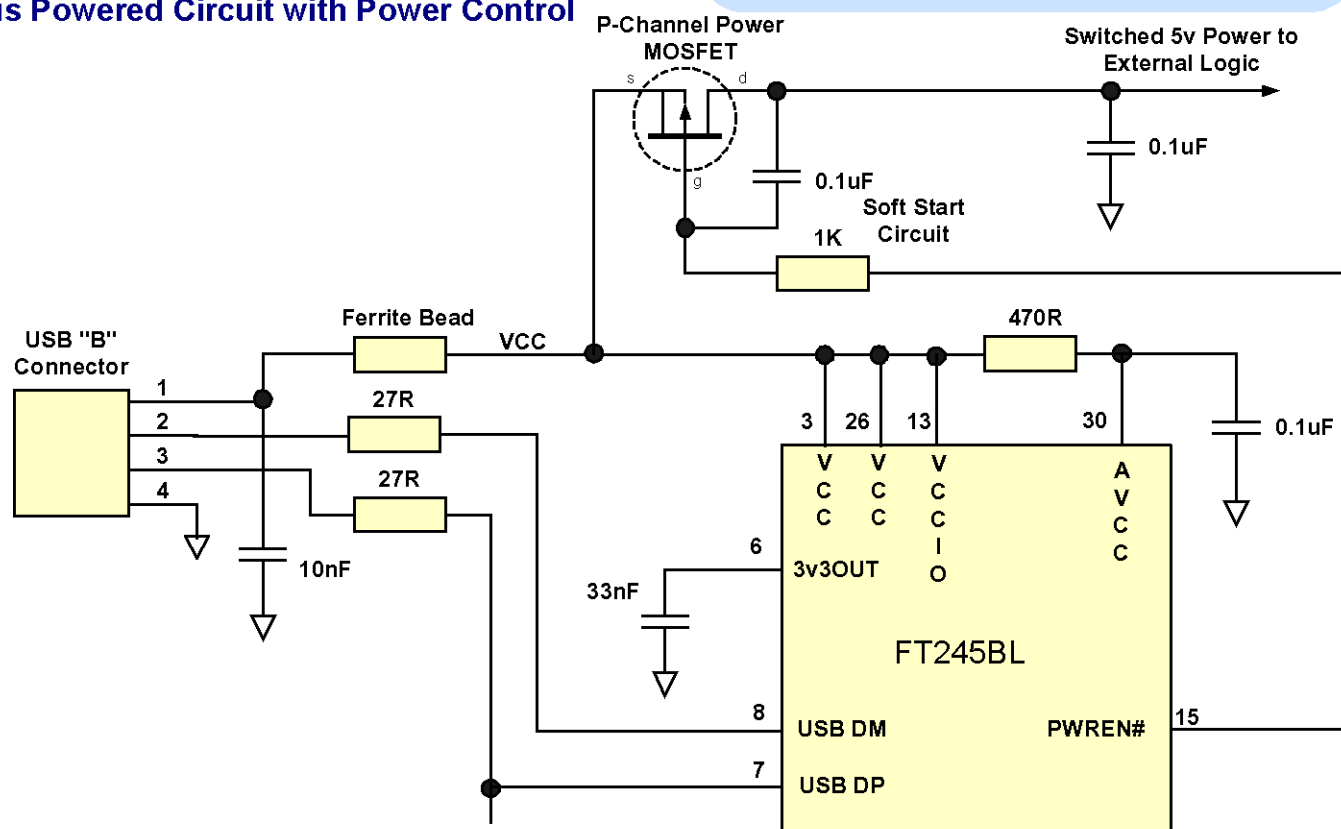
Figure 10 is an example of a USB self powered design with 3.3V interface. In this case VCCIO is supplied by an external 3.3V supply in order to make the device IO pins drive out at 3.3V logic level, thus allowing it to be connected to a 3.3V MCU or other external logic. A USB self powered design uses its own power supplies, and does not draw any of its power from the USB bus. In such cases, no special care need be taken to meet the USB suspend current (0.5 mA) as the device does not get its power from the USB port.

As with bus powered 3.3V interface designs, in some cases, where only a small amount of current is required (<5mA), it may be possible to use the in-built regulator of the FT245BL to supply the 3.3V without any other components being required. In this case, connect VCCIO to the 3v3OUT pin of the FT245BL.

Note that if SI/WU is not being used it should be pulled up to VCCIO.

Figure 11
Bus Powered Circuit with Power Control

FT245BL USB FIFO (USB - Parallel) I.C.



USB Bus powered circuits need to be able to power down in USB suspend mode in order to meet the $\leq 500\mu\text{A}$ total suspend current requirement (including external logic). Some external logic can power itself down into a low current state by monitoring the PWREN# pin. For external logic that cannot power itself down in that way, the FT245BL provides a simple but effective way of turning off power to external circuitry during USB suspend.

Figure 11 shows how to use a discrete P-Channel Logic Level MOSFET to control the power to external logic circuits. A suitable device could be a Fairchild NDT456P, or International Rectifier IRLML6402, or equivalent. It is recommended that a "soft start" circuit consisting of a 1K series resistor and a 0.1 μF capacitor are used to limit the current surge when the MOSFET turns on. Without the soft start circuit there is a danger that the transient power surge of the MOSFET turning on will reset the FT245BL, or the USB host / hub controller. The values used here allow attached circuitry to power up with a slew rate of $\sim 12.5\text{ V}$ per millisecond, in other words the output voltage will transition from GND to 5 V in approximately 400 microseconds.

Alternatively, a dedicated power switch I.C. with inbuilt "soft-start" can be used instead of a MOSFET. A suitable power switch i.c. for such an application would be a Micrel (www.micrel.com) MIC2025-2BL or equivalent.

Please note the following points in connection with power controlled designs –

- The logic to be controlled must have its own reset circuitry so that it will automatically reset itself when power is re-applied on coming out of suspend.
- Set the Pull-down on Suspend option in the FT245BL's EEPROM.
- For USB high-power bus powered device (one that consumes greater than 100 mA, and up to 500 mA of current from the USB bus), the power consumption of the device should be set in the max power field in the EEPROM. A high-power bus powered device must use this descriptor in the EEPROM to inform the system of its power requirements.
- For 3.3V power controlled circuits VCCIO must not be powered down with the external circuitry (PWREN# gets its VCC supply from VCCIO). Either connect the power switch between the output of the 3.3V regulator and the external 3.3V logic OR if appropriate power VCCIO from the 3v3OUT pin of the FT245BL.

Figure 12
Microprocessor Interface Example

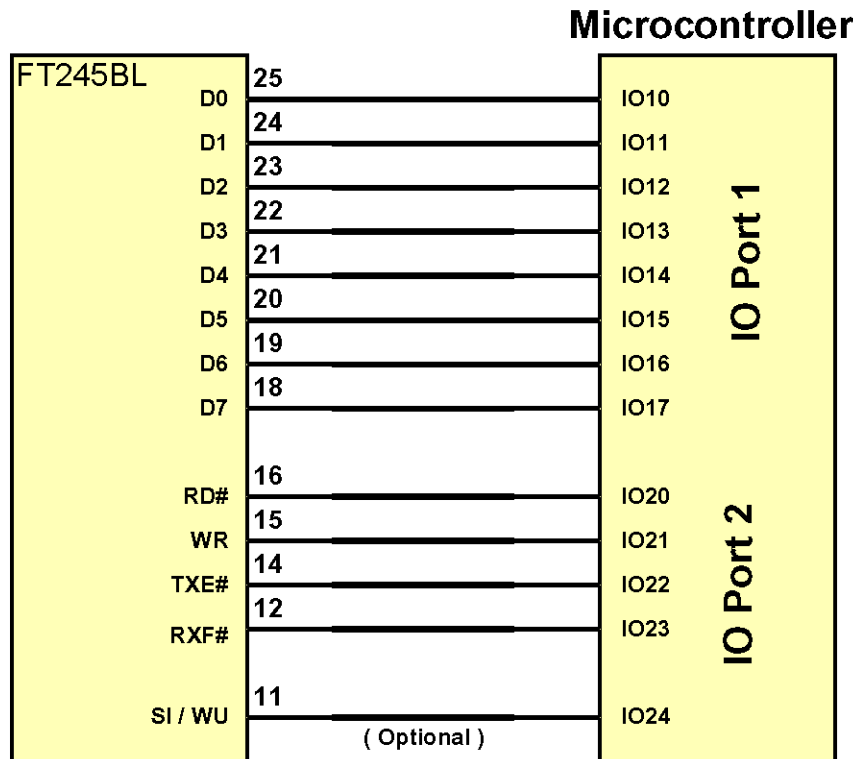


Figure 12 illustrates a typical interface between the FT245BL and a MicroController (MCU). This examples uses two IO Ports of the MCU, one port (8 bits) to transfer data and the other port (4 / 5 bits) to monitor the TXE# and RXF# status bits and generate the RD# and WR strobes to the FT245BL as required. Optionally, SI / WU can be connected to another IO pin if this function is required. If the SI / WU function is not required, tie this pin of the FT245BL to VCCIO. If the MCU is handling power management functions, then PWREN# should also be connected to an IO pin of the MCU.

The 8 data bits of Port 1 can be shared with other peripherals when the MCU is not accessing the FT245BL.

8.0 Document Revision History

DS245B Version 1.0 – Initial document created 8th August 2002.

DS245B Version 1.1 – Updated 23 October 2003

- Pin and package naming made consistent throughout data sheet.
- Section 1.0 Corrected data transfer rate for VCP drivers.
- Section 1.0 Amended to reflect availability of Mac OS X drivers.
- Section 1.1 Description of behaviour of TXE# and RXF# amended.
- Section 3.1 Minor changes to functional block descriptions.
- Section 2.0 Compatible EEPROM configurations corrected.
- Section 4.1 SI/WU Pin description amended.
- Section 4.1 RSTOUT# Pin description amended.
- Section 4.1 EEPROM interface Pin descriptions amended.
- Section 4.1 Note 2 should have referred to VCCIO, not VCC.
- Section 4.1 FIFO timing diagram amended.
- Section 6.1 Minimum Operating supply voltage adjusted.
- Section 7.1 Updated recommended ceramic resonator part number and circuit configuration.
- Section 7.3 *USB Self Powered Configuration (1) (original Figure 8) removed. Recommended circuit for USB self powered designs updated.
- Section 7.3 Self Powered Circuit with 3.3V logic drive / supply voltage added (new figure 8).
- Section 7.3 Figure 11 Bus powered circuit with power control updated to add soft start circuit on MOSFET. Circuit description amended.

DS245B Version 1.2 – Updated 20 November 2003.

- Section 6.1 FIFO Data control Bus IO pin characteristics amended
- Section 6.1 RESET#, TEST, EECS, EESK, and EEDATA pin characteristics amended.
- Section 6.1 RSTOUT# pin characteristics amended.

DS245B Version 1.3 – Updated 10 December 2003

- Section 5.0 Package drawing amended.
- Section 6.0 Floor Life / Relative Humidity specification added. ESD and Latch Up specifications amended.
- Section 7.1 Required accuracy of crystal / resonator corrected.

DS245B Version 1.4 – Updated 10 February 2004

- Grammar Corrections.
- Section 10.0 FTDI Address Updated
- Section 4.1 VCCIO Pin description amended.

DS245B Version 1.5 – Updated March 2004

- Section 4.1 FIFO EESK Pin Description amended.
- Section 4.1 FIFO WR timings and diagram amended.
- Section 7.3 Figure 10 SI/WU Pin number corrected
- Section 7.3 Figure 11 PWREN# Pin number corrected

DS245B Version 1.6 – Updated February 2005

- Section 1 - Win CE VCP drivers now available
- Section 1 - D2XX drivers for Win CE and Linux now available
- Section 5 FT245BL (lead free) and FT245BQ (lead free QFN package) now available

DS245B Version 1.6 – Updated February 2005

- Section 1 - Driver OS availability updated
- Section 6.1 - USB Data line absolute maximum rating added.

9.0 Disclaimer

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DLP-USB245M-G USB to FIFO Parallel Interface Module

The DLP-USB245M-G is the 2nd generation, lead free version of DLP Design's USB adapter. This device adds extra functionality to it's DLP-USB1 predecessor with a reduced component count and a new low price.

DLP-USB245M FEATURES

- Send / Receive Data over USB at up to 1 M Bytes / sec
- 384 byte FIFO Transmit buffer / 128 byte FIFO receive buffer for high data throughput
- Simple interface to CPU or MCU bus
- No in-depth knowledge of USB required as all USB
- Protocol is handled automatically within the module
- FTDI's Virtual COM port drivers eliminate the need for USB driver development in most cases.
- Integrated 3.3v Regulator – No External Regulator Required
- Integrated Power-On-Reset circuit
- Integrated 6MHz – 48Mhz clock multiplier PLL
- USB Bulk or Isocronous data transfer modes
- 4.4v - 5.25v Single Supply taken directly from the USB port
- UHCI / OHCI / EHCI host controller compatible
- USB 1.1 and USB 2.0 compatible
- USB VID, PID, Serial Number and Product Description
- Strings stored in on-board EEPROM.
- EEPROM programmable on-board via USB
- VIRTUAL COM PORT (VCP) DRIVERS for
 - Windows 98 and Windows 98 SE
 - Windows 2000 / ME / XP
 - Windows CE **
 - MAC OS-8 and OS-9
 - MAC OS-X
 - Linux 2.40 and greater
- D2XX (USB Direct Drivers + DLL S/W Interface)
 - Windows 98 and Windows 98 SE
 - Windows 2000 / ME / XP

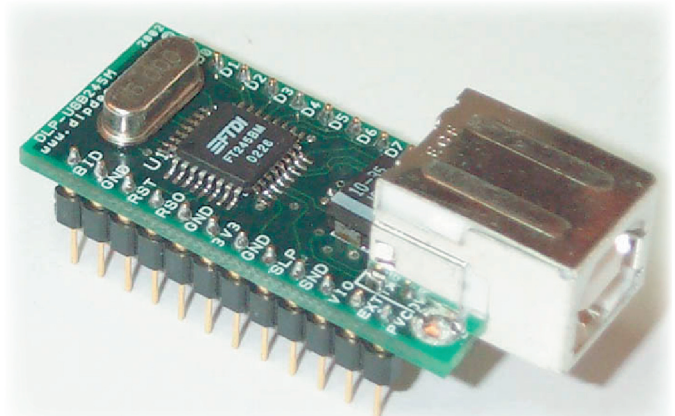
[** = In planning or under development]

APPLICATION AREAS

- Rapid Prototype Development
- USB ISDN and ADSL Modems
- High Speed USB PDA Interface
- USB Interface for Digital Cameras
- USB Interface for MP3 players
- High Speed USB Instrumentation
- USB Smart Card Readers
- Set Top Box (S.T.B.) PC-USB interface
- USB Hardware Modems
- USB Wireless Modems
- USB Bar Code Readers

GENERAL DESCRIPTION

The DLP-USB245M provides an easy cost-effective method of transferring data to / from a peripheral and a host at up to 8 Million bits (1-Megabyte) per second. Its simple FIFO-like design makes it easy to interface to any microcontroller or microprocessor via IO ports.



To send data from the peripheral to the host computer simply write the byte wide data into the module when TXE# is low. If the (384 byte) transmit buffer fills up or is busy storing the previously written byte, the device takes TXE# high in order to stop further data from being written until some of the FIFO data has been transferred over USB to the host.

When the host sends data to the peripheral over USB, the device will take RXF# low to let the peripheral know that at least one byte of data is available. The peripheral then reads the data until RXF# goes high indicating no more data is available to read.

By using FTDI's virtual COM Port drivers, the peripheral looks like a standard COM Port to the application software. Commands to set the baud rate are ignored – the device always transfers data at its fastest rate regardless of the application's baud rate setting. The latest versions of the drivers are available for download from DLP Design's website at <http://www.dlpdesign.com>.

APPLICATION NOTES

USB devices transfer data in packets. If data is to be sent from the PC, a packet is built up by the application program and is sent via the device driver to the USB scheduler. This scheduler puts a request onto the list of tasks for the USB host controller to perform. This will typically take at least 1 millisecond to execute because it will not pick up the new request until the next 'USB Frame' (the frame period is 1 millisecond).

There is therefore a sizeable overhead (depending on your required throughput) associated with moving the data from the application to the USB device. If data is sent 'byte at a time' by an application, this will severely limit the overall throughput of the system as a whole.

It must be stressed that in order to achieve maximum throughput, application programs should send or receive data using buffers and not individual characters.

DRIVER SOFTWARE

FTDI's VCP (Virtual COM Port) driver executable files are provided royalty-free on the condition that they are only used with designs incorporating an FTDI device (ie the FT245BM and DLP-USB245M). The latest version of the drivers can be downloaded from dlpdesign.com or ftdichip.com.

The VCP driver download file is a combined set of drivers for Windows '98, Windows ME and Windows 2000/XP. Unzip the file to a blank floppy disk or folder on your PC. The drivers can co-exist on the same floppy disk or folder since the INF files determine which set of drivers to load for each operating system version. Once loaded, the VCP drivers allow your application software, running on the host PC, to communicate with the DLP-USB245M as though it were connected to a COM (RS-232) port.

In addition to VCP drivers, FTDI's "D2XX Direct Drivers" for Windows offer an alternative solution to the VCP drivers that allows application software to interface with the FT245BM device using a DLL instead of a Virtual Com Port. The architecture of the D2XX drivers consists of a Windows WDM driver that communicates with the FT245BM device via the Windows USB Stack and a DLL that interfaces the Application Software (written in VC++, C++ Builder, Delphi, VB etc...) to the WDM driver. An INF installation file, uninstaller program and D2XX programmers guide complete the package

The D2XX Direct Drivers add support for simultaneous access and control of multiple FT245BM devices. The Extended Open function (FT_OpenEx) allows the device to be opened either by it's Product Description or by Serial Number, both of which can be programmed to be unique. The List Devices function (FT-ListDevices) allows the application software to determine which devices are currently available for use, again by product description or by serial number.

Several new features have been recently added to the D2XX drivers. Functions are provided to program the EEPROM (FT_EE_Program), and read the EEPROM (FT_EE_Read). Unused space in the EEPROM is called the User Area (EEUA), and functions are provided to access the EEUA. FT_EE_UASize gets its size, FT_EE_UAWrite writes data into it, and FT_EE_UARead is used to read its contents.

Download FTDI Application Notes AN232-03, AN232-05, AN232-06, and AN232-07 for detailed instructions on how to install and remove the drivers.

EEPROM WRITE UTILITY

The DLP-USB245M has the option to accept manufacturer-specific information that is written into the 93C46 EEPROM. Parameters that can be programmed include the VID and the PID identifiers, the manufacturer's product string and a serial number.

FTD2XXST is the latest EEPROM serializer and testing utility for the FT245BM device. It replaces the VCP based 232Prog utility. FTD2XXST is based on the new D2XX drivers and will work on Win '98, Win ME and Win 2000/XP platforms. You must install the latest release of the D2XX drivers in order to run this application. Refer to the SER200.PDF guide that is included in the EEPROM Write Utility's download zip file for details on how to use the serializer.

If you have VCP drivers installed on the PC that is to perform the EEPROM write process you must uninstall these drivers using the uninstaller program (included with the driver files) and install the D2XX drivers prior to running the serializer utility.

QUICK START GUIDE

This guide requires the use of a Windows 98/2000 PC that is equipped with a USB port.

1. Download the DLL version of the device drivers from either dlpdesign.com or ftdichip.com. Unzip the drivers onto a blank floppy disk or into a folder on the hard drive.
2. Download the serializer program from either dlpdesign.com or ftdichip.com. Unzip the package and place it in a folder on the hard drive.
3. Select a power source for the DLP-USB245M module via pins 10, 11, and 12. Be sure to pull the RESET# pin high (pin 3).
4. Connect the DLP-USB245M board to the PC via a standard, 6-foot USB cable. This action initiates the loading of the USB drivers. When prompted, select the folder where the DLL version of the device drivers were stored

in step one. Windows will then complete the installation of the device drivers for the DLP-USB245M board. The next time the DLP-USB245M module is attached, the host PC will immediately load the correct drivers without any prompting. Reboot the PC if prompted to do so.

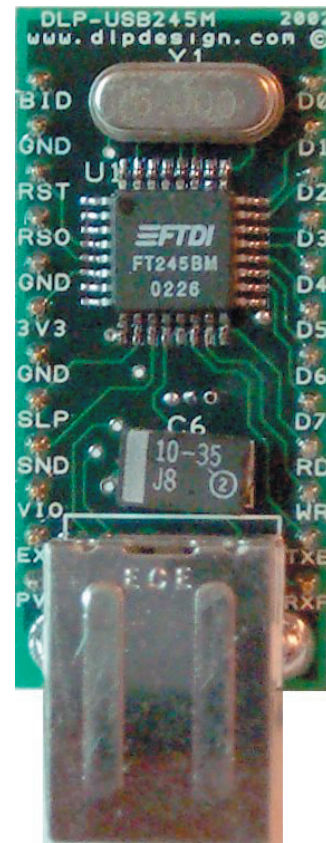
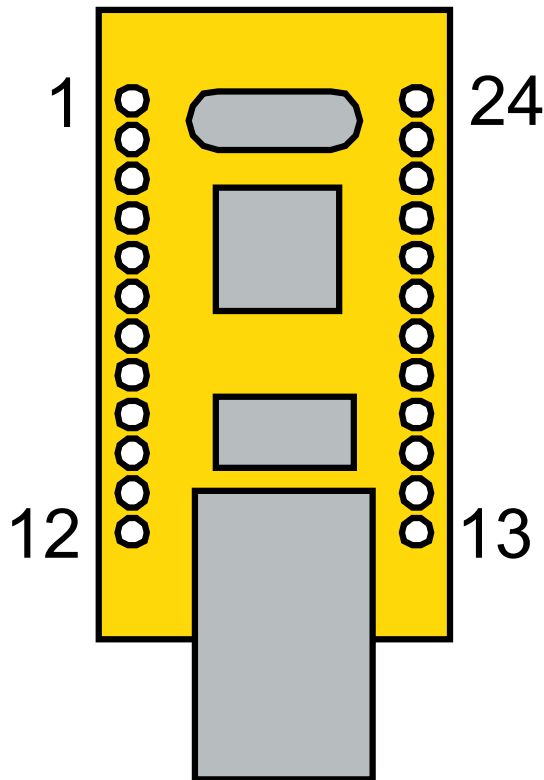
5. Run the serializer program and write the VID (0403), PID (6001), a description string of your choosing and manufacturers ID as instructed in the instruction manual that was downloaded with the serializer software. Terminate the serializer program and disconnect the DLP-USB245M board from the USB cable. Wait 10 seconds and reconnect the DLP-USB245M board. Reboot the PC if instructed to do so.

NOTE 1 - The DLP-USB245M comes pre-programmed with a default VID and PID. Step 5 is optional and only required if different VID/PID codes are required.

NOTE 2 – The “Test” button on the serializer program is intended for use with the DLP-USB232M module (and FT232BM device) and will fail if used with the DLP-USB245M module. The “Read” function will work and will present the contents of the EEPROM as well as the serial number and description strings stored in the EEPROM.

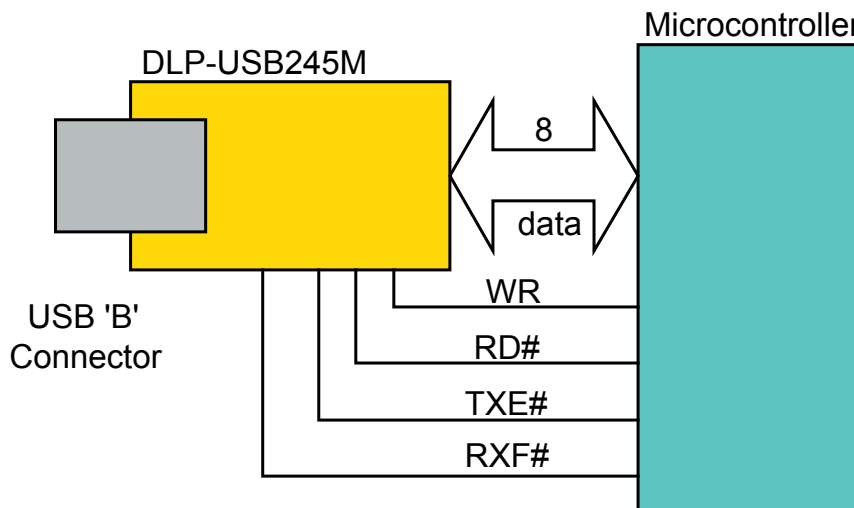
At this point the DLP-USB245M is ready for use. Note that the DLP-USB245M will appear non-responsive if data sent from the host PC is not read from the FT245BM device by an attached microcontroller/microprocessor/DSP/FPGA/ etc...

Table 1 - DLP-USB245M PINOUT DESCRIPTION



Pin#	Description
1	BOARD ID (Out) Identifies the board as either a DLP-USB245M or DLP-USB232M. High for DLP-USB232M and low for DLP-USB245M.
2	Ground
3	RESET# (In) Can be used by an external device to reset the FT245BM. If not required this pin must be tied to VCC.
4	RESET# (Out) Output of the internal Reset Generator. Stays high impedance for ~ 2ms after VCC > 3.5v and the internal clock starts up, then clamps it's output to the 3.3v output of the internal regulator. Taking RESET# low will also force RSTOUT# to go high impedance. RSTOUT# is NOT affected by a USB Bus Reset.
5	Ground
6	3V3OUT (Out) Output from the integrated L.D.O. regulator. It's primary purpose is to provide the internal 3.3v supply to the USB transceiver cell and the RSTOUT# pin. A small amount of current (<= 5mA) can be drawn from this pin to power external 3.3v logic if required.
7	Ground
8	SLEEP (Out) Goes Low after the device is configured via USB, then high during USB suspend. Can be used to control power to external logic using a P-Channel Logic Level MOSFET switch.

9	SND/WUP (In) If the DLP-USB245M is in USB suspend, a positive edge on this pin (WAKEUP) initiates a remote wakeup sequence. If the device is active (not in suspend) a positive edge on this pin (SEND) causes the data in the write buffer to be sent to the PC on the next USB Data-In request regardless of how many bytes are in the buffer.
10	VCC-IO (In) 3.0 volt to +5.25 volt VCC to the UART interface pins 10..12, 14..16 and 18..25. When interfacing with 3.3v external logic connect VCC-IO to the 3.3v supply of the external logic, otherwise connect to VCC to drive out at 5v CMOS level. This pin must be connected to VCC from the target electronics or EXTVCC.
11	EXTVCC – (In) Use for applying main power (4.4 to 5.25 Volts) to the module. Connect to PORTVCC if module is to be powered by the USB port (typical configuration)
12	PORTVCC - (Out) Power from USB port. Connect to EXTVCC if module is to be powered by the USB port (typical configuration). 500mA maximum current available to USB adapter and target electronics if USB device is configured for high power.
13	RXF# - (Out) When low, at least 1 byte is present in the FIFO's 128-byte receive buffer and is ready to be read with RD#. RXF# goes high when the receive buffer is empty.
14	TXE# - When high, the FIFO's 385 byte transmit buffer is full, or busy storing the last byte written. Do not attempt to write data to the transmit buffer when TXE# is high.
15	WR (In) When taken from a high to a low state, WR reads the 8 data lines and writes the byte into the FIFO's transmit buffer. Data written to the transmit buffer is sent to the host PC within the TX buffer timeout value (default 16mS) and placed in the RS-232 buffer opened by the application program. Note : The FT245BM allows the TX buffer timeout value to be reprogrammed to a value between 1 and 255mS depending on the applicaton requirement, also the SND pin can be used to send any remaining data in the TX buffer regardless of the timeout value.
16	RD# (In) When pulled low, RD# takes the 8 data lines from a high impedance state to the current byte in the FIFO's receive buffer. Taking RD# high returns the data pins to a high impedance state and prepares the next byte (if available) in the FIFO to be read.
17	D7 I/O Bi-directional Data Bus Bit # 7
18	D6 I/O Bi-directional Data Bus Bit # 6
19	D5 I/O Bi-directional Data Bus Bit # 5
20	D4 I/O Bi-directional Data Bus Bit # 4
21	D3 I/O Bi-directional Data Bus Bit # 3
22	D2 I/O Bi-directional Data Bus Bit # 2
23	D1 I/O Bi-directional Data Bus Bit # 1
24	D0 I/O Bi-directional Data Bus Bit # 0



Basic Connection to a Microcontroller

USB Bus Powered and Self Powered Configuration

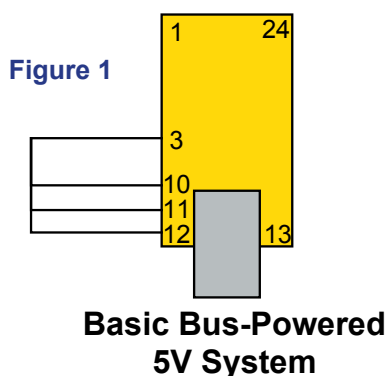


Figure 1 illustrates a typical USB bus powered configuration. A USB Bus Powered device gets its power from the USB bus. Basic rules for USB Bus power devices are as follows –

- a) On plug-in, the device must draw no more than 100mA
- b) On USB Suspend the device must draw no more than 500uA.
- c) A Bus Powered High Power Device (one that draws more than 100mA) should use the SLEEP# pin to keep the current below 100mA on plug-in and 500uA on USB suspend.
- d) A device that consumes more than 100mA can not be plugged into a USB

Bus Powered Hub

e) No device can draw more that 500mA from the USB Bus.

f) The power descriptor in the EEPROM should be programmed to a value of zero.

Figure 2 illustrates a typical USB self powered configuration. A USB Self Powered device gets its power from its own Power Supply and does not draw current from the USB bus.

Basic rules for USB Self power devices are as follows –

- a) A Self-Powered device should not force current down the USB bus when the USB Host or Hub Controller is powered down.
- b) A Self Powered Device can take as much current as it likes during normal operation and USB suspend as it has its own Power Supply.
- c) A Self Powered Device can be used with any USB Host and both Bus and Self Powered USB Hubs.

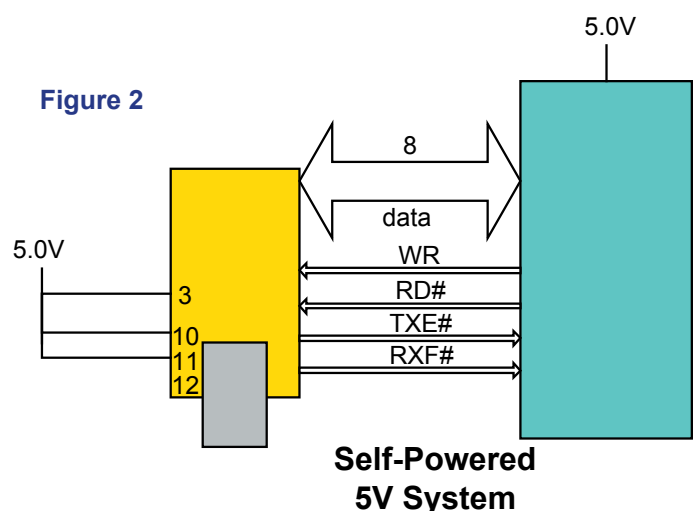


Figure 3

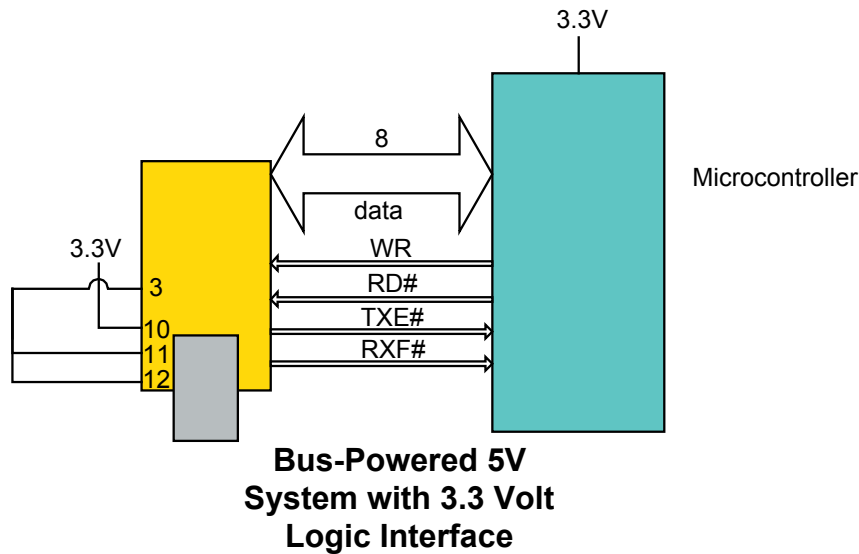


Figure 3 shows how to configure the DLP-USB245M to interface with a 3.3v logic device. In this example, the target electronics provides the 3.3 volts via the VCCIO line (pin 10) which in turn will cause the FIFO interface IO pins to drive out at 3.3v level.

Bus Powered Circuit with Power Control

USB Bus powered circuits need to be able to power down in USB suspend mode in order to meet the $\leq 500\mu\text{A}$ total suspend current requirement (including external logic).

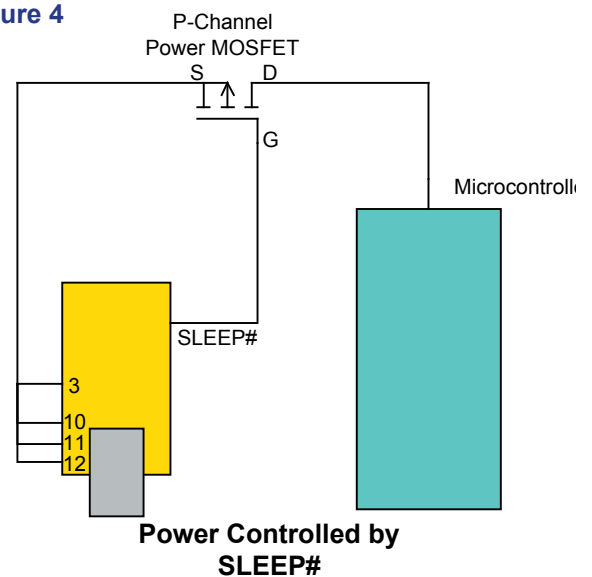
Figure 4 shows how to use a discrete P-Channel Logic Level MOSFET to control the power to external logic circuits. A suitable device could be a Fairchild NDT456P or equivalent. This configuration is suitable for powering external logic where the normal supply current is $\leq 100\text{mA}$ and the logic to be controlled does not generate an appreciable current surge at power-up. For power switching external logic that takes over 100mA or generates a current surge on powerup we

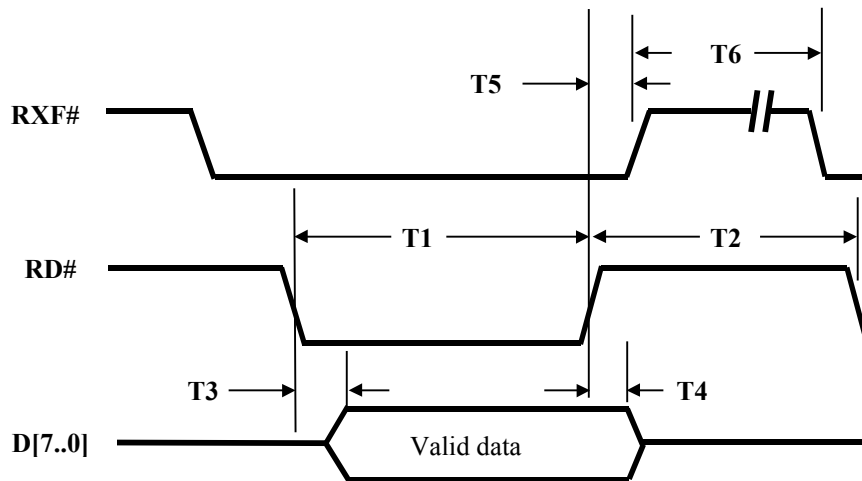
recommend that a dedicated power switch i.c with inbuilt “soft-start” is used instead of a MOSFET. A suitable power switch i.c. for such an application would be a Micrel (www.micrel.com) MIC2025-2BM or equivalent.

Please note the following points in connection with power controlled designs –

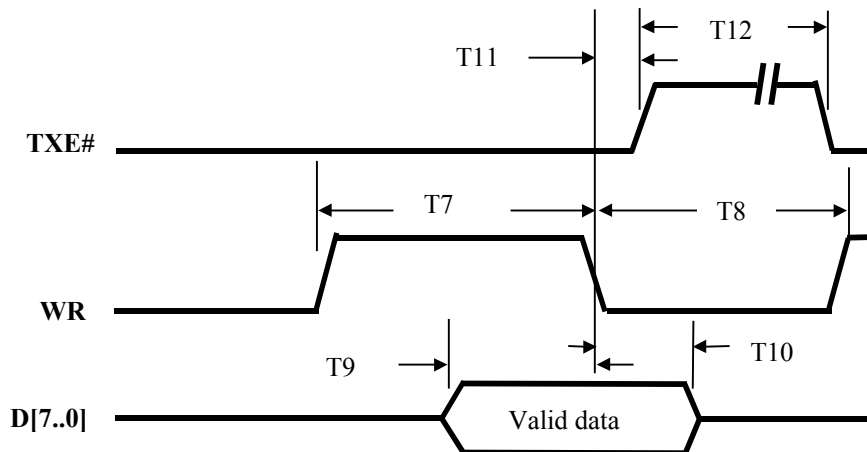
- The logic to be controlled must have it's own reset circuitry so that it will automatically reset itself when power is re-applied on coming out of suspend.
- Set the soft pull-down option bit in the FT232BM EEPROM.
- For 3.3v power controlled circuits VCCIO must not be powered down with the external circuitry (PWREN# gets it's VCC supply from VCCIO).

Figure 4



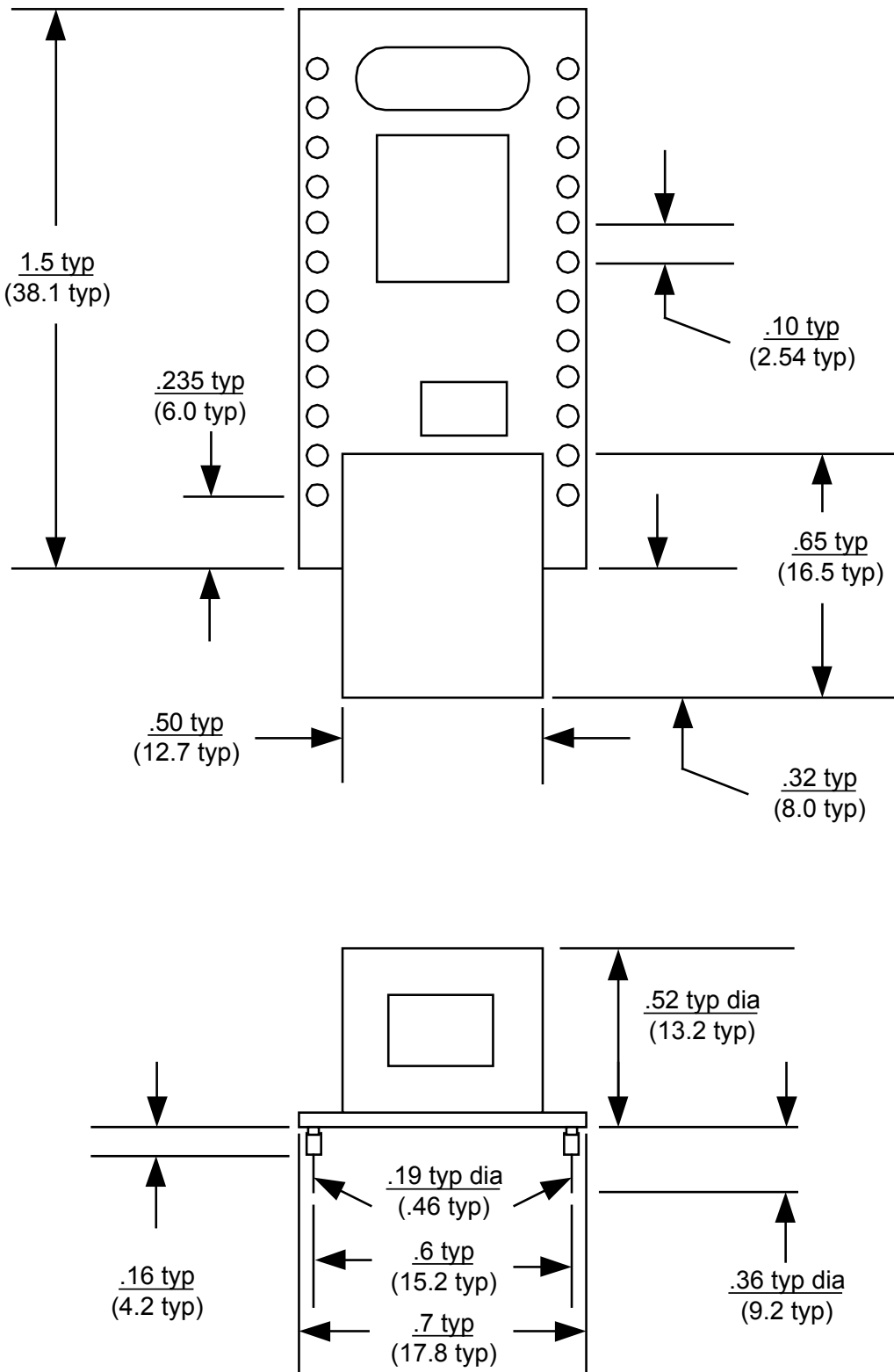
DLP-USB245M TIMING DIAGRAM – FIFO READ CYCLE

Time	Description	Min	Max	Unit
T1	RD Active Pulse Width	50		ns
T2	RD to RD Pre-Charge Time	50		ns
T3	RD Active to Valid Data		30	ns
T4	Valid Data Hold Time from RD Inactive	10		ns
T5	RD Inactive to RXF#	5	25	ns
T6	RXF inactive after RD cycle	80		ns

DLP-USB1 TIMING DIAGRAM – FIFO WRITE CYCLE

Time	Description	Min	Max	Unit
T7	WR Active Pulse Width	50		ns
T8	WR to WR Pre-Charge Time	50		ns
T9	Data Setup Time before WR inactive		20	ns
T10	Data Hold Time from WR inactive	10		ns
T11	WR Inactive to TXE#	5	25	ns
T12	TXE inactive after RD cycle	80		Ns

Mechanical Drawings (PRELIMINARY)
Inches(millimeters) unless otherwise noted



Absolute Maximum Ratings

These are the absolute maximum ratings for the FT245BM device in accordance with the Absolute Maximum Rating System (IEC 60134). Exceeding these may cause permanent damage to the device.

- Storage Temperature -65°C to + 150°C
- Ambient Temperature (Power Applied)..... 0°C to + 70°C
- VCC Supply Voltage -0.5v to +6.00v
- DC Input Voltage - Inputs -0.5v to VCC + 0.5v
- DC Input Voltage - High Impedance Bidirectionals -0.5v to VCC + 0.5v
- DC Output Current – Outputs 24mA
- DC Output Current – Low Impedance Bidirectionals 24mA
- Power Dissipation (VCC = 5.25v) 500mW
- Electrostatic Discharge Voltage (I < 1uA) +/- 2000v
- Latch Up Current (Vi < 0 or Vi > Vcc) 100mA

DC Characteristics (Ambient Temperature = 0 .. 70°C)

Operating Voltage and Current

Parameter	Description	Min	Typ	Max	Units	Conditions
Vcc1	VCC Operating Supply Voltage	4.4	5.0	5.25	V	
Vcc2	VCCIO Operating Supply Voltage	3.0	-	5.25	V	
Icc1	Operating Supply Current	-	25	-	mA	Normal Operation
Icc2	Operating Supply Current	-	350	400	uA	USB Suspend

FIFO IO Pin Characteristics (VCCIO = 5.0v)

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	4.4	-	4.9	V	I source = 2mA
Vol	Output Voltage Low	0.1	-	0.7	V	I sink = 4 mA
Vin	Input Switching Threshold	1.1	1.5	1.9	V	Note 1
VHys	Input Switching Hysteresis		200		mV	

FIFO IO Pin Characteristics (VCCIO = 3.3v)

Parameter	Description	Min	Typ	Max	Units	Conditions
Voh	Output Voltage High	2.7	-	3.2	V	I source = 2mA
Vol	Output Voltage Low	0.1	-	0.7	V	I sink = 4 mA
Vin	Input Switching Threshold	1.0	1.4	1.8	V	Note 1
VHys	Input Switching Hysteresis		200		mV	

RESET# Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
V_{in}	Input Switching Threshold	1.1	1.5	1.9	V	Note 1
V_{Hys}	Input Switching Hysteresis		200		mV	

Note 1 – Inputs have an internal 200k pull-up resistor to VCCIO.

RSTOUT Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
V_{oh}	Output Voltage High	3.0	-	3.6	V	I source = 2mA
I_{ol}	Leakage Current Tri-State	-	-	5	uA	

USB IO Pin Characteristics

Parameter	Description	Min	Typ	Max	Units	Conditions
UV_{oh}	IO Pins Static Output (High)	2.8		3.6v	V	RI = 1k5 to 3V3Out (D+) RI = 15k to GND (D-)
UV_{ol}	IO Pins Static Output (Low)	0		0.3	V	RI = 1k5 to 3V3Out (D+) RI = 15k to GND (D-)
UV_{se}	Single Ended Rx Threshold	0.8		2.0	V	
UCom	Differential Common Mode	0.8		2.5	V	
UV_{Dif}	Differential Input Sensitivity	0.2			V	
UDrvZ	Driver Output Impedance	29		44	ohm	Note 2

Note 2 – Driver Output Impedance includes the external 27R series resistors on USBDP and USBDM pins.

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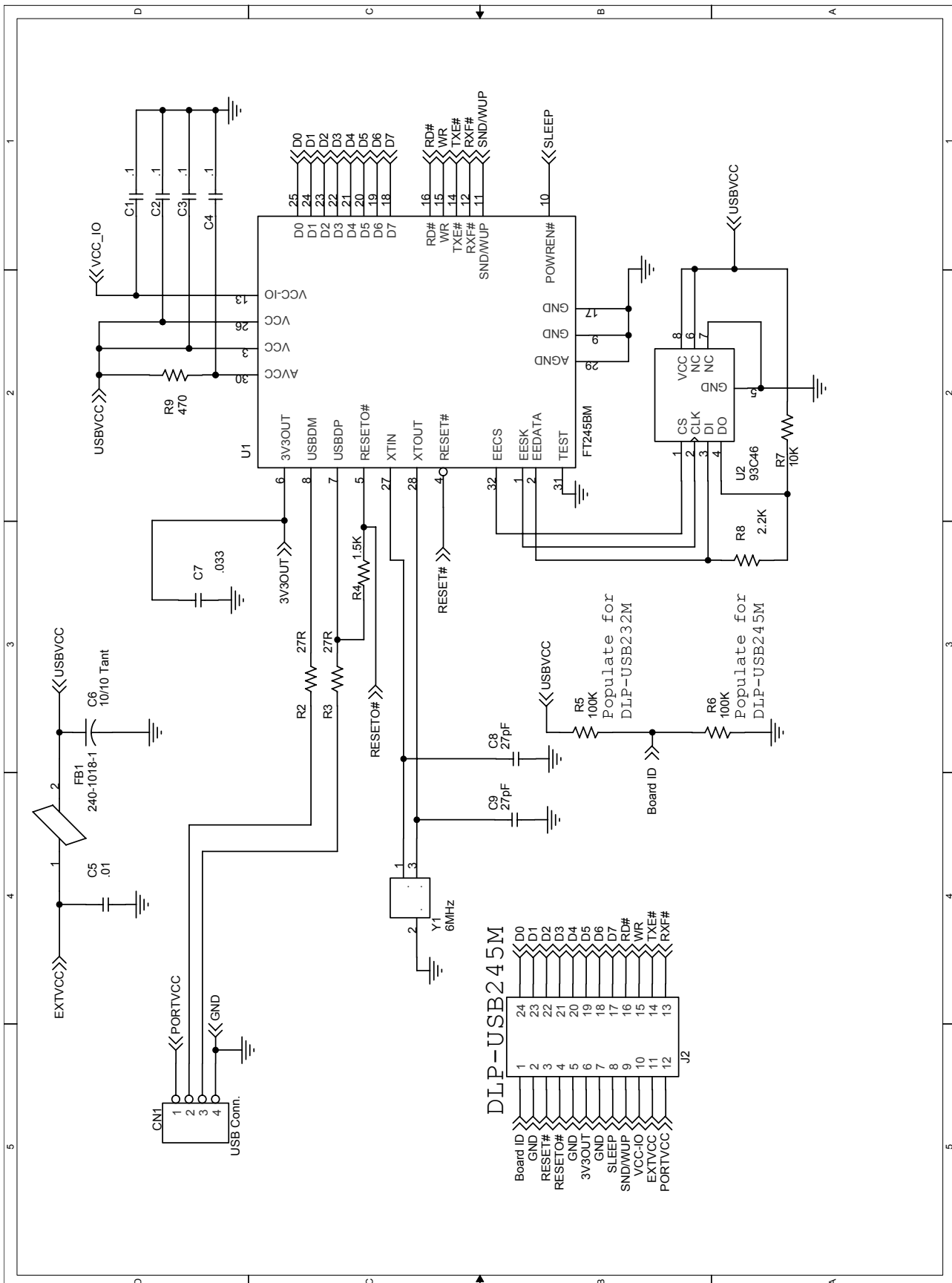
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Appendix A – DLP USB245M Schematic





Future Technology Devices International Ltd.

Software Application Development D2XX Programmer's Guide

Document Reference No.: FT_000071

Version 1.2

Issue Date: 2011-04-25

FTDI provides DLL and virtual COM port (VCP) application interfaces to its drivers. This document provides the application programming interface (API) for the FTD2XX DLL function library.

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1 Preface

The D2XX interface is a proprietary interface specifically for FTDI devices. This document provides an explanation of the functions available to application developers via the FTD2XX library

Any software code examples given in this document are for information only. The examples are not guaranteed and are not supported by FTDI.

1.1 Acronyms and Abbreviations

Terms	Description
CDM	Combined Driver Model. Windows driver package which incorporates both D2XX and VCP drivers.
D2XX	FTDI's proprietary "direct" driver interface via FTD2XX.DLL
VCP	Virtual COM Port

Table 1.1 Acronyms and Abbreviations

2 Introduction

FTDI provides two alternative software interfaces for its range of USB-UART and USB-FIFO ICs. One interface provides a Virtual COM Port (VCP) which appears to the system as a legacy COM port. The second interface, D2XX, is provided via a proprietary DLL (FTD2XX.DLL). The D2XX interface provides special functions that are not available in standard operating system COM port APIs, such as setting the device into a different mode or writing data into the device EEPROM.

In the case of the FTDI drivers for Windows, the D2XX driver and VCP driver are distributed in the same driver package, called the Combined Driver Model (CDM) package. Figure 2.1 Windows CDM Driver Architecture illustrates the architecture of the Windows CDM driver.

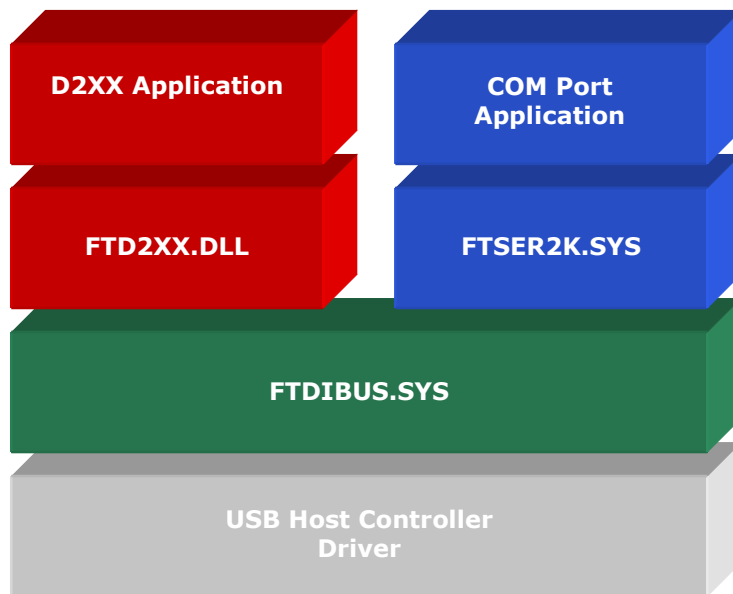


Figure 2.1 Windows CDM Driver Architecture

For Linux, Mac OS X (10.4 and later) and Windows CE (4.2 and later) the D2XX driver and VCP driver are mutually exclusive options as only one driver type may be installed at a given time for a given device ID. In the case of a Windows system running the CDM driver, applications may use either the D2XX or VCP interface without installing a different driver but may not use both interfaces at the same time.

As the VCP driver interface is designed to emulate a legacy COM port, FTDI does not provide documentation on how to communicate with the VCP driver from an application; the developer is referred to the large amount of material available on the Internet regarding serial communication.

The D2XX interface is a proprietary interface specifically for FTDI devices. This document provides an explanation of the functions available to application developers via the FTD2XX library.

3 D2XX Classic Functions

The functions listed in this section are compatible with all FTDI devices.

3.1 FT_SetVIDPID

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Summary

A command to include a custom VID and PID combination within the internal device list table. This will allow the driver to load for the specified VID and PID combination.

Definition

FT_STATUS **FT_SetVIDPID** (DWORD *dwVID*, DWORD *dwPID*)

Parameters

dwVID Device Vendor ID (VID)

dwPID Device Product ID (PID)

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

By default, the driver will support a limited set of VID and PID matched devices (VID 0x0403 with PIDs 0x6001, 0x6010, 0x6006 only).

In order to use the driver with other VID and PID combinations the FT_SetVIDPID function must be used prior to calling [FT_ListDevices](#), [FT_Open](#), [FT_OpenEx](#) or [FT_CreateDeviceInfoList](#).

3.2 FT_GetVIDPID

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Summary

A command to retrieve the current VID and PID combination from within the internal device list table.

Definition

FT_STATUS **FT_GetVIDPID** (DWORD * *pdwVID*, DWORD * *pdwPID*)

Parameters

pdwVID Pointer to DWORD that will contain the internal VID

pdwPID Pointer to DWORD that will contain the internal PID

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

See [FT_SetVIDPID](#).

3.3 FT_CreateDeviceInfoList

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function builds a device information list and returns the number of D2XX devices connected to the system. The list contains information about both unopen and open devices.

Definition

FT_STATUS **FT_CreateDeviceInfoList** (LPDWORD *lpdwNumDevs*)

Parameters

<i>lpdwNumDevs</i>	Pointer to unsigned long to store the number of devices connected.
--------------------	--

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

An application can use this function to get the number of devices attached to the system. It can then allocate space for the device information list and retrieve the list using [FT_GetDeviceInfoList](#) or [FT_GetDeviceInfoDetail](#).

If the devices connected to the system change, the device info list will not be updated until FT_CreateDeviceInfoList is called again.

Example

```
FT_STATUS ftStatus;  
DWORD numDevs;  
  
// create the device information list  
ftStatus = FT_CreateDeviceInfoList(&numDevs);  
if (ftStatus == FT_OK) {  
    printf("Number of devices is %d\n", numDevs);  
}  
else {  
    // FT_CreateDeviceInfoList failed  
}
```


3.4 FT_GetDeviceInfoList

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function returns a device information list and the number of D2XX devices in the list.

Definition

FT_STATUS **FT_GetDeviceInfoList** (FT_DEVICE_LIST_INFO_NODE *pDest,
LPDWORD lpdwNumDevs)

Parameters

*pDest	Pointer to an array of FT_DEVICE_LIST_INFO_NODE structures.
lpdwNumDevs	Pointer to the number of elements in the array.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function should only be called after calling [FT_CreateDeviceInfoList](#). If the devices connected to the system change, the device info list will not be updated until [FT_CreateDeviceInfoList](#) is called again.

Location ID information is not returned for devices that are open when [FT_CreateDeviceInfoList](#) is called.

Information is not available for devices which are open in other processes. In this case, the *Flags* parameter of the [FT_DEVICE_LIST_INFO_NODE](#) will indicate that the device is open, but other fields will be unpopulated.

The flag value is a 4-byte bit map containing miscellaneous data as defined [Appendix A – Type Definitions](#). Bit 0 (least significant bit) of this number indicates if the port is open (1) or closed (0). Bit 1 indicates if the device is enumerated as a high-speed USB device (2) or a full-speed USB device (0). The remaining bits (2 - 31) are reserved.

The array of [FT_DEVICE_LIST_INFO_NODES](#) contains all available data on each device. The structure of [FT_DEVICE_LIST_INFO_NODES](#) is given in the Appendix. The storage for the list must be allocated by the application. The number of devices returned by [FT_CreateDeviceInfoList](#) can be used to do this.

When programming in Visual Basic, LabVIEW or similar languages, [FT_GetDeviceInfoDetail](#) may be required instead of this function.

Please note that Linux, Mac OS X and Windows CE do not support location IDs. As such, the Location ID parameter in the structure will be empty under these operating systems.

Example

```
FT_STATUS ftStatus;
FT_DEVICE_LIST_INFO_NODE *devInfo;
DWORD numDevs;

// create the device information list
ftStatus = FT_CreateDeviceInfoList(&numDevs);

if (ftStatus == FT_OK) {
    printf("Number of devices is %d\n", numDevs);
}

if (numDevs > 0) {
    // allocate storage for list based on numDevs
    devInfo =
    (FT_DEVICE_LIST_INFO_NODE*)malloc(sizeof(FT_DEVICE_LIST_INFO_NODE)*numDevs);
    // get the device information list
    ftStatus = FT_GetDeviceInfoList(devInfo, &numDevs);
    if (ftStatus == FT_OK) {
        for (int i = 0; i < numDevs; i++) {
            printf("Dev %d:\n", i);
            printf("  Flags=0x%x\n", devInfo[i].Flags);
            printf("  Type=0x%x\n", devInfo[i].Type);
            printf("  ID=0x%x\n", devInfo[i].ID);
            printf("  LocId=0x%x\n", devInfo[i].LocId);
            printf("  SerialNumber=%s\n", devInfo[i].SerialNumber);
            printf("  Description=%s\n", devInfo[i].Description);
            printf("  ftHandle=0x%x\n", devInfo[i].ftHandle);
        }
    }
}
```

3.5 FT_GetDeviceInfoDetail

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function returns an entry from the device information list.

Definition

FT_STATUS **FT_GetDeviceInfoDetail** (DWORD *dwIndex*, LPDWORD *lpdwFlags*,
LPDWORD *lpdwType*,
LPDWORD *lpdwID*, LPDWORD *lpdwLocId*,
PCHAR *pcSerialNumber*, PCHAR *pcDescription*,
FT_HANDLE **ftHandle*)

Parameters

<i>dwIndex</i>	Index of the entry in the device info list.
<i>lpdwFlags</i>	Pointer to unsigned long to store the flag value.
<i>lpdwType</i>	Pointer to unsigned long to store device type.

<i>lpdwID</i>	Pointer to unsigned long to store device ID.
<i>lpdwLocId</i>	Pointer to unsigned long to store the device location ID.
<i>pcSerialNumber</i>	Pointer to buffer to store device serial number as a null-terminated string.
<i>pcDescription</i>	Pointer to buffer to store device description as a null-terminated string.
<i>*ftHandle</i>	Pointer to a variable of type FT_HANDLE where the handle will be stored.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function should only be called after calling [FT_CreateDeviceInfoList](#). If the devices connected to the system change, the device info list will not be updated until [FT_CreateDeviceInfoList](#) is called again.

The index value is zero-based.

The flag value is a 4-byte bit map containing miscellaneous data as defined [Appendix A – Type Definitions](#). Bit 0 (least significant bit) of this number indicates if the port is open (1) or closed (0). Bit 1 indicates if the device is enumerated as a high-speed USB device (2) or a full-speed USB device (0). The remaining bits (2 - 31) are reserved.

Location ID information is not returned for devices that are open when [FT_CreateDeviceInfoList](#) is called.

Information is not available for devices which are open in other processes. In this case, the *lpdwFlags* parameter will indicate that the device is open, but other fields will be unpopulated.

To return the whole device info list as an array of [FT_DEVICE_LIST_INFO_NODE](#) structures, use [FT_CreateDeviceInfoList](#).

Please note that Linux, Mac OS X and Windows CE do not support location IDs. As such, the Location ID parameter in the structure will be empty under these operating systems.

Example

```
FT_STATUS ftStatus;
FT_HANDLE ftHandleTemp;
DWORD numDevs;
DWORD Flags;
DWORD ID;
DWORD Type;
DWORD LocId;
char SerialNumber[16];
char Description[64];

// create the device information list
ftStatus = FT_CreateDeviceInfoList(&numDevs);
if (ftStatus == FT_OK) {
    printf("Number of devices is %d\n", numDevs);
}

if (numDevs > 0) {
    // get information for device 0
    ftStatus = FT_GetDeviceInfoDetail(0, &Flags, &Type, &ID, &LocId, SerialNumber,
    Description, &ftHandleTemp);
    if (ftStatus == FT_OK) {
        printf("Dev 0:\n");
        printf("  Flags=0x%x\n", Flags);
        printf("  Type=0x%x\n", Type);
    }
}
```

```
printf(" ID=0x%x\n", ID);  
printf(" LocId=0x%x\n", LocId);  
printf(" SerialNumber=%s\n", SerialNumber);  
printf(" Description=%s\n", Description);  
printf(" ftHandle=0x%x\n", ftHandleTemp);  
}  
}
```

3.6 FT_ListDevices

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Gets information concerning the devices currently connected. This function can return information such as the number of devices connected, the device serial number and device description strings, and the location IDs of connected devices.

Definition

FT_STATUS **FT_ListDevices** (PVOID *pvArg1*, PVOID *pvArg2*, DWORD *dwFlags*)

Parameters

<i>pvArg1</i>	Meaning depends on <i>dwFlags</i> .
<i>pvArg2</i>	Meaning depends on <i>dwFlags</i> .
<i>dwFlags</i>	Determines format of returned information.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function can be used in a number of ways to return different types of information. A more powerful way to get device information is to use the [FT_CreateDeviceInfoList](#), [FT_GetDeviceInfoList](#) and [FT_GetDeviceInfoDetail](#) functions as they return all the available information on devices.

In its simplest form, it can be used to return the number of devices currently connected. If [FT_LIST_NUMBER_ONLY](#) bit is set in *dwFlags*, the parameter *pvArg1* is interpreted as a pointer to a DWORD location to store the number of devices currently connected.

It can be used to return device information: if [FT_OPEN_BY_SERIAL_NUMBER](#) bit is set in *dwFlags*, the serial number string will be returned; if [FT_OPEN_BY_DESCRIPTION](#) bit is set in *dwFlags*, the product description string will be returned; if [FT_OPEN_BY_LOCATION](#) bit is set in *dwFlags*, the Location ID will be returned; if none of these bits is set, the serial number string will be returned by default.

It can be used to return device string information for a single device. If [FT_LIST_BY_INDEX](#) and [FT_OPEN_BY_SERIAL_NUMBER](#) or [FT_OPEN_BY_DESCRIPTION](#) bits are set in *dwFlags*, the parameter *pvArg1* is interpreted as the index of the device, and the parameter *pvArg2* is interpreted as a pointer to

a buffer to contain the appropriate string. Indexes are zero-based, and the error code [FT_DEVICE_NOT_FOUND](#) is returned for an invalid index.

It can be used to return device string information for all connected devices. If [FT_LIST_ALL](#) and [FT_OPEN_BY_SERIAL_NUMBER](#) or [FT_OPEN_BY_DESCRIPTION](#) bits are set in *dwFlags*, the parameter *pvArg1* is interpreted as a pointer to an array of pointers to buffers to contain the appropriate strings and the parameter *pvArg2* is interpreted as a pointer to a DWORD location to store the number of devices currently connected. Note that, for *pvArg1*, the last entry in the array of pointers to buffers should be a NULL pointer so the array will contain one more location than the number of devices connected.

The location ID of a device is returned if [FT_LIST_BY_INDEX](#) and [FT_OPEN_BY_LOCATION](#) bits are set in *dwFlags*. In this case the parameter *pvArg1* is interpreted as the index of the device, and the parameter *pvArg2* is interpreted as a pointer to a variable of type long to contain the location ID. Indexes are zero-based, and the error code [FT_DEVICE_NOT_FOUND](#) is returned for an invalid index. Please note that Windows CE and Linux do not support location IDs.

The location IDs of all connected devices are returned if [FT_LIST_ALL](#) and [FT_OPEN_BY_LOCATION](#) bits are set in *dwFlags*. In this case, the parameter *pvArg1* is interpreted as a pointer to an array of variables of type long to contain the location IDs, and the parameter *pvArg2* is interpreted as a pointer to a DWORD location to store the number of devices currently connected.

Examples

The examples that follow use these variables.

```
FT_STATUS ftStatus;  
DWORD numDevs;
```

1. Get the number of devices currently connected

```
ftStatus = FT_ListDevices(&numDevs, NULL, FT_LIST_NUMBER_ONLY);  
if (ftStatus == FT_OK) {  
    // FT_ListDevices OK, number of devices connected is in numDevs  
}  
else {  
    // FT_ListDevices failed  
}
```

2. Get serial number of first device

```
DWORD devIndex = 0; // first device  
char Buffer[64]; // more than enough room!  
  
ftStatus =  
FT_ListDevices((PVOID)devIndex, Buffer, FT_LIST_BY_INDEX|FT_OPEN_BY_SERIAL_NUMBER);  
if (ftStatus == FT_OK) {  
    // FT_ListDevices OK, serial number is in Buffer  
}  
else {  
    // FT_ListDevices failed  
}
```

Note that indexes are zero-based. If more than one device is connected, incrementing *devIndex* will get the serial number of each connected device in turn.

3. Get device descriptions of all devices currently connected

```
char *BufPtrs[3];           // pointer to array of 3 pointers  
char Buffer1[64];           // buffer for description of first device  
char Buffer2[64];           // buffer for description of second device  
  
// initialize the array of pointers  
BufPtrs[0] = Buffer1;  
BufPtrs[1] = Buffer2;  
BufPtrs[2] = NULL;         // last entry should be NULL
```

```
ftStatus = FT_ListDevices (BufPtrs, &numDevs, FT_LIST_ALL|FT_OPEN_BY_DESCRIPTION);  
if (ftStatus == FT_OK) {  
    // FT_ListDevices OK, product descriptions are in Buffer1 and Buffer2, and  
    // numDevs contains the number of devices connected  
}  
else {  
    // FT_ListDevices failed  
}
```

Note that this example assumes that two devices are connected. If more devices are connected, then the size of the array of pointers must be increased and more description buffers allocated.

4. Get locations of all devices currently connected

```
long locIdBuf[16];  
  
ftStatus = FT_ListDevices (locIdBuf, &numDevs, FT_LIST_ALL|FT_OPEN_BY_LOCATION);  
if (ftStatus == FT_OK) {  
    // FT_ListDevices OK, location IDs are in locIdBuf, and  
    // numDevs contains the number of devices connected  
}  
else {  
    // FT_ListDevices failed  
}
```

Note that this example assumes that no more than 16 devices are connected. If more devices are connected, then the size of the array of pointers must be increased.

3.7 FT_Open

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Open the device and return a handle which will be used for subsequent accesses.

Definition

FT_STATUS **FT_Open** (int *iDevice*, FT_HANDLE **ftHandle*)

Parameters

<i>iDevice</i>	Index of the device to open. Indices are 0 based.
<i>ftHandle</i>	Pointer to a variable of type FT_HANDLE where the handle will be stored. This handle must be used to access the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

Although this function can be used to open multiple devices by setting *iDevice* to 0, 1, 2 etc. there is no ability to open a specific device. To open named devices, use the function [FT_OpenEx](#).

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0,&ftHandle);
if (ftStatus == FT_OK) {
    // FT_Open OK, use ftHandle to access device
}
else {
    // FT_Open failed
}
```

3.8 FT_OpenEx

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Open the specified device and return a handle that will be used for subsequent accesses. The device can be specified by its serial number, device description or location.

This function can also be used to open multiple devices simultaneously. Multiple devices can be specified by serial number, device description or location ID (location information derived from the physical location of a device on USB). Location IDs for specific USB ports can be obtained using the utility USBView and are given in hexadecimal format. Location IDs for devices connected to a system can be obtained by calling [FT_GetDeviceInfoList](#) or [FT_ListDevices](#) with the appropriate flags.

Definition

FT_STATUS **FT_OpenEx** (PVOID *pvArg1*, DWORD *dwFlags*, FT_HANDLE **ftHandle*)

Parameters

<i>pvArg1</i>	Pointer to an argument whose type depends on the value of <i>dwFlags</i> . It is normally be interpreted as a pointer to a null terminated string.
<i>dwFlags</i>	FT_OPEN_BY_SERIAL_NUMBER , FT_OPEN_BY_DESCRIPTION or FT_OPEN_BY_LOCATION .
<i>ftHandle</i>	Pointer to a variable of type FT_HANDLE where the handle will be stored. This handle must be used to access the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

The parameter specified in *pvArg1* depends on *dwFlags*: if *dwFlags* is [FT_OPEN_BY_SERIAL_NUMBER](#), *pvArg1* is interpreted as a pointer to a null-terminated string that represents the serial number of the device; if *dwFlags* is [FT_OPEN_BY_DESCRIPTION](#), *pvArg1* is interpreted as a pointer to a null-terminated string that represents the device description; if *dwFlags* is [FT_OPEN_BY_LOCATION](#), *pvArg1* is interpreted as a long value that contains the location ID of the device. Please note that Windows CE and Linux do not support location IDs.

ftHandle is a pointer to a variable of type *FT_HANDLE* where the handle is to be stored. This handle must be used to access the device.

Examples

The examples that follow use these variables.

```
FT_STATUS ftStatus;  
FT_STATUS ftStatus2;  
FT_HANDLE ftHandle1;  
FT_HANDLE ftHandle2;  
long dwLoc;
```

1. Open a device with serial number "FT000001"

```
ftStatus = FT_OpenEx("FT000001", FT_OPEN_BY_SERIAL_NUMBER, &ftHandle1);  
if (ftStatus == FT_OK) {  
    // success - device with serial number "FT000001" is open  
}  
else {  
    // failure  
}
```

2. Open a device with device description "USB Serial Converter"

```
ftStatus = FT_OpenEx("USB Serial Converter", FT_OPEN_BY_DESCRIPTION, &ftHandle1);  
if (ftStatus == FT_OK) {  
    // success - device with device description "USB Serial Converter" is open  
}  
else {  
    // failure  
}
```

3. Open 2 devices with serial numbers "FT000001" and "FT999999"

```
ftStatus = FT_OpenEx("FT000001", FT_OPEN_BY_SERIAL_NUMBER, &ftHandle1);  
ftStatus2 = FT_OpenEx("FT999999", FT_OPEN_BY_SERIAL_NUMBER, &ftHandle2);  
if (ftStatus == FT_OK && ftStatus2 == FT_OK) {  
    // success - both devices are open  
}  
else {  
    // failure - one or both of the devices has not been opened  
}
```

4. Open 2 devices with descriptions "USB Serial Converter" and "USB Pump Controller"

```
ftStatus = FT_OpenEx("USB Serial Converter", FT_OPEN_BY_DESCRIPTION, &ftHandle1);  
ftStatus2 = FT_OpenEx("USB Pump Controller", FT_OPEN_BY_DESCRIPTION, &ftHandle2);  
if (ftStatus == FT_OK && ftStatus2 == FT_OK) {  
    // success - both devices are open  
}  
else {  
    // failure - one or both of the devices has not been opened  
}
```


5. Open a device at location 23

```
dwLoc = 0x23;
ftStatus = FT_OpenEx(dwLoc, FT_OPEN_BY_LOCATION, &ftHandle1);
if (ftStatus == FT_OK) {
    // success - device at location 23 is open
}
else {
    // failure
}
```

6. Open 2 devices at locations 23 and 31

```
dwLoc = 0x23;
ftStatus = FT_OpenEx(dwLoc, FT_OPEN_BY_LOCATION, &ftHandle1);
dwLoc = 0x31;
ftStatus2 = FT_OpenEx(dwLoc, FT_OPEN_BY_LOCATION, &ftHandle2);
if (ftStatus == FT_OK && ftStatus2 == FT_OK) {
    // success - both devices are open
}
else {
    // failure - one or both of the devices has not been opened
}
```

3.9 FT_Close

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Close an open device.

Definition

FT_STATUS **FT_Close** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if (ftStatus == FT_OK) {
    // FT_Open OK, use ftHandle to access device
}
```

```
// when finished, call FT_Close
FT_Close(ftHandle);
}
else {
    // FT_Open failed
}
```

3.10 FT_Read

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Read data from the device.

Definition

FT_STATUS **FT_Read** (FT_HANDLE *ftHandle*, LPVOID *lpBuffer*, DWORD *dwBytesToRead*,
LPDWORD *lpdwBytesReturned*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpBuffer</i>	Pointer to the buffer that receives the data from the device.
<i>dwBytesToRead</i>	Number of bytes to be read from the device.
<i>lpdwBytesReturned</i>	Pointer to a variable of type DWORD which receives the number of bytes read from the device.

Return Value

FT_OK if successful, FT_IO_ERROR otherwise.

Remarks

FT_Read always returns the number of bytes read in *lpdwBytesReturned*.

This function does not return until *dwBytesToRead* bytes have been read into the buffer. The number of bytes in the receive queue can be determined by calling [FT_GetStatus](#) or [FT_GetQueueStatus](#), and passed to FT_Read as *dwBytesToRead* so that the function reads the device and returns immediately.

When a read timeout value has been specified in a previous call to [FT_SetTimeouts](#), FT_Read returns when the timer expires or *dwBytesToRead* have been read, whichever occurs first. If the timeout occurred, FT_Read reads available data into the buffer and returns FT_OK.

An application should use the function return value and *lpdwBytesReturned* when processing the buffer. If the return value is FT_OK, and *lpdwBytesReturned* is equal to *dwBytesToRead* then FT_Read has completed normally. If the return value is FT_OK, and *lpdwBytesReturned* is less than *dwBytesToRead* then a timeout has occurred and the read has been partially completed. Note that if a timeout occurred and no data was read, the return value is still FT_OK.

A return value of FT_IO_ERROR suggests an error in the parameters of the function, or a fatal error like a USB disconnect has occurred.

Examples

1. This sample shows how to read all the data currently available.

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
DWORD EventDWord;
DWORD TxBytes;
DWORD RxBytes;
DWORD BytesReceived;
char RxBuffer[256];

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

FT_GetStatus(ftHandle, &RxBytes, &TxBytes, &EventDWord);
if (RxBytes > 0) {
    ftStatus = FT_Read(ftHandle, RxBuffer, RxBytes, &BytesReceived);
    if (ftStatus == FT_OK) {
        // FT_Read OK
    }
    else {
        // FT_Read Failed
    }
}

FT_Close(ftHandle);
```

2. This sample shows how to read with a timeout of 5 seconds.

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
DWORD RxBytes = 10;
DWORD BytesReceived;
char RxBuffer[256];

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

FT_SetTimeouts(ftHandle, 5000, 0);
ftStatus = FT_Read(ftHandle, RxBuffer, RxBytes, &BytesReceived);
if (ftStatus == FT_OK) {
    if (BytesReceived == RxBytes) {
        // FT_Read OK
    }
    else {
        // FT_Read Timeout
    }
}

else {
    // FT_Read Failed
}

FT_Close(ftHandle);
```

3.11 FT_Write

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Write data to the device.

Definition

FT_STATUS **FT_Write** (FT_HANDLE *ftHandle*, LPVOID *lpBuffer*, DWORD *dwBytesToWrite*, LPDWORD *lpdwBytesWritten*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpBuffer</i>	Pointer to the buffer that contains the data to be written to the device.
<i>dwBytesToWrite</i>	Number of bytes to write to the device.
<i>lpdwBytesWritten</i>	Pointer to a variable of type DWORD which receives the number of bytes written to the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
DWORD BytesWritten;
char TxBuffer[256]; // Contains data to write to device

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_Write(ftHandle, TxBuffer, sizeof(TxBuffer), &BytesWritten);
if (ftStatus == FT_OK) {
    // FT_Write OK
}
else {
    // FT_Write Failed
}
FT_Close(ftHandle);
```

3.12 FT_SetBaudRate

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function sets the baud rate for the device.

Definition

FT_STATUS **FT_SetBaudRate** (FT_HANDLE *ftHandle*, DWORD *dwBaudRate*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwBaudRate</i>	Baud rate.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_SetBaudRate(ftHandle, 115200); // Set baud rate to 115200
if (ftStatus == FT_OK) {
    // FT_SetBaudRate OK
}
else {
    // FT_SetBaudRate Failed
}

FT_Close(ftHandle);
```

3.13 FT_SetDivisor

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function sets the baud rate for the device. It is used to set non-standard baud rates.

Definition

FT_STATUS **FT_SetDivisor** (FT_HANDLE *ftHandle*, USHORT *usDivisor*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>usDivisor</i>	Divisor.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function is no longer required as [FT_SetBaudRate](#) will now automatically calculate the required divisor for a requested baud rate. The application note "Setting baud rates for the FT8U232AM" is available from the Application Notes section of the FTDI website describes how to calculate the divisor for a non-standard baud rate.

3.14 FT_SetDataCharacteristics

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function sets the data characteristics for the device.

Definition

FT_STATUS **FT_SetDataCharacteristics** (FT_HANDLE *ftHandle*, UCHAR *uWordLength*,
UCHAR *uStopBits*, UCHAR *uParity*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>uWordLength</i>	Number of bits per word - must be FT_BITS_8 or FT_BITS_7 .
<i>uStopBits</i>	Number of stop bits - must be FT_STOP_BITS_1 or FT_STOP_BITS_2 .
<i>uParity</i>	Parity - must be FT_PARITY_NONE , FT_PARITY_ODD , FT_PARITY_EVEN , FT_PARITY_MARK or FT_PARITY_SPACE .

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

// Set 8 data bits, 1 stop bit and no parity
ftStatus = FT_SetDataCharacteristics(ftHandle, FT_BITS_8, FT_STOP_BITS_1,
FT_PARITY_NONE);
    if (ftStatus == FT_OK) {
        // FT_SetDataCharacteristics OK
    }
    else {
        // FT_SetDataCharacteristics Failed
    }
}

FT_Close(ftHandle);
```

3.15 FT_SetTimeouts

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function sets the read and write timeouts for the device.

Definition

FT_STATUS **FT_SetTimeouts** (FT_HANDLE *ftHandle*, DWORD *dwReadTimeout*,
DWORD *dwWriteTimeout*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwReadTimeout</i>	Read timeout in milliseconds.
<i>dwWriteTimeout</i>	Write timeout in milliseconds.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}
// Set read timeout of 5sec, write timeout of 1sec
ftStatus = FT_SetTimeouts(ftHandle, 5000, 1000);
if (ftStatus == FT_OK) {
    // FT_SetTimeouts OK
}
else {
    // FT_SetTimeouts failed
}

FT_Close(ftHandle);
```

3.16 FT_SetFlowControl

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function sets the flow control for the device.

Definition

FT_STATUS **FT_SetFlowControl** (FT_HANDLE *ftHandle*, USHORT *usFlowControl*,
UCHAR *uXon*, UCHAR *uXoff*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>usFlowControl</i>	Must be one of FT_FLOW_NONE , FT_FLOW_RTS_CTS , FT_FLOW_DTR_DSR or FT_FLOW_XON_XOFF .

uXon Character used to signal Xon. Only used if flow control is [FT_FLOW_XON_XOFF](#).

uXoff Character used to signal Xoff. Only used if flow control is [FT_FLOW_XON_XOFF](#).

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

// Set RTS/CTS flow control
ftStatus = FT_SetFlowControl(ftHandle, FT_FLOW_RTS_CTS, 0x11, 0x13);
if (ftStatus == FT_OK) {
    // FT_SetFlowControl OK
}
else {
    // FT_SetFlowControl Failed
}

FT_Close(ftHandle);
```

3.17 FT_SetDtr

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function sets the Data Terminal Ready (DTR) control signal.

Definition

FT_STATUS **FT_SetDtr** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function asserts the Data Terminal Ready (DTR) line of the device.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}
ftStatus = FT_SetDtr(ftHandle);
if (ftStatus == FT_OK) {
    // FT_SetDtr OK
}
else {
    // FT_SetDtr failed
}

FT_Close(ftHandle);
```

3.18 FT_ClrDtr

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function clears the Data Terminal Ready (DTR) control signal.

Definition

FT_STATUS **FT_ClrDtr** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function de-asserts the Data Terminal Ready (DTR) line of the device.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
```

```
ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_ClrDtr(ftHandle);
if (ftStatus == FT_OK) {
    // FT_ClrDtr OK
}
else {
    // FT_ClrDtr failed
}

FT_Close(ftHandle);
```

3.19 FT_SetRts

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function sets the Request To Send (RTS) control signal.

Definition

FT_STATUS **FT_SetRts** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function asserts the Request To Send (RTS) line of the device.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}
```

```
ftStatus = FT_SetRts(ftHandle);  
if (ftStatus == FT_OK) {  
    // FT_SetRts OK  
}  
else {  
    // FT_SetRts failed  
}  
  
FT_Close(ftHandle);
```

3.20 FT_ClrRts

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function clears the Request To Send (RTS) control signal.

Definition

FT_STATUS **FT_ClrRts** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function de-asserts the Request To Send (RTS) line of the device.

Example

```
FT_HANDLE ftHandle;  
FT_STATUS ftStatus;  
  
ftStatus = FT_Open(0, &ftHandle);  
if (ftStatus != FT_OK) {  
    // FT_Open failed  
    return;  
}  
  
ftStatus = FT_ClrRts(ftHandle);  
if (ftStatus == FT_OK) {  
    // FT_ClrRts OK  
}  
else {  
    // FT_ClrRts failed
```

```
}  
  
FT_Close(ftHandle);
```

3.21 FT_GetModemStatus

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Gets the modem status and line status from the device.

Definition

FT_STATUS **FT_GetModemStatus** (FT_HANDLE *ftHandle*, LPDWORD *lpdwModemStatus*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwModemStatus</i>	Pointer to a variable of type DWORD which receives the modem status and line status from the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

The least significant byte of the *lpdwModemStatus* value holds the modem status. On Windows and Windows CE, the line status is held in the second least significant byte of the *lpdwModemStatus* value.

The modem status is bit-mapped as follows: Clear To Send ([CTS](#)) = 0x10, Data Set Ready ([DSR](#)) = 0x20, Ring Indicator ([RI](#)) = 0x40, Data Carrier Detect ([DCD](#)) = 0x80.

The line status is bit-mapped as follows: Overrun Error ([OE](#)) = 0x02, Parity Error ([PE](#)) = 0x04, Framing Error ([FE](#)) = 0x08, Break Interrupt ([BI](#)) = 0x10.

Example

```
FT_HANDLE ftHandle;  
FT_STATUS ftStatus;  
DWORD dwModemStatus = 0;  
DWORD dwLineStatus = 0;  
  
ftStatus = FT_Open(0, &ftHandle);  
if(ftStatus != FT_OK) {  
    // FT_Open failed  
    return;  
}
```

```
ftStatus = FT_GetModemStatus(ftHandle, &dwModemStatus);
if (ftStatus == FT_OK) {
    // FT_GetModemStatus OK
    // Line status is the second byte of the dwModemStatus value
    dwLineStatus = ((dwModemStatus >> 8) & 0x000000FF);
    // Now mask off the modem status byte
    dwModemStatus = (dwModemStatus & 0x000000FF);
}
else {
    // FT_GetModemStatus failed
}

FT_Close(ftHandle);
```

3.22 FT_GetQueueStatus

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Gets the number of bytes in the receive queue.

Definition

FT_STATUS **FT_GetQueueStatus** (FT_HANDLE *ftHandle*, LPDWORD *lpdwAmountInRxQueue*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwAmountInRxQueue</i>	Pointer to a variable of type DWORD which receives the number of bytes in the receive queue.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
DWORD RxBytes;
DWORD BytesReceived;
char RxBuffer[256];

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

FT_GetQueueStatus(ftHandle, &RxBytes);
if (RxBytes > 0) {
    ftStatus = FT_Read(ftHandle, RxBuffer, RxBytes, &BytesReceived);
```

```
    if (ftStatus == FT_OK) {  
        // FT_Read OK  
    }  
    else {  
        // FT_Read Failed  
    }  
}  
  
FT_Close(ftHandle);
```

3.23 FT_GetDeviceInfo

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Get device information for an open device.

Definition

FT_STATUS **FT_GetDeviceInfo** (FT_HANDLE *ftHandle*, FT_DEVICE **pftType*,
LPDWORD *lpdwID*, PCHAR *pcSerialNumber*,
PCHAR *pcDescription*, PVOID *pvDummy*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pftType</i>	Pointer to unsigned long to store device type.
<i>lpdwID</i>	Pointer to unsigned long to store device ID.
<i>pcSerialNumber</i>	Pointer to buffer to store device serial number as a null-terminated string.
<i>pcDescription</i> string.	Pointer to buffer to store device description as a null-terminated string.
<i>pvDummy</i>	Reserved for future use - should be set to NULL.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function is used to return the device type, device ID, device description and serial number.

The device ID is encoded in a DWORD - the most significant word contains the vendor ID, and the least significant word contains the product ID. So the returned ID 0x04036001 corresponds to the device ID VID_0403&PID_6001.

Example

```
FT_HANDLE ftHandle;
FT_DEVICE ftDevice;
FT_STATUS ftStatus;
DWORD deviceID;
char SerialNumber[16];
char Description[64];

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_GetDeviceInfo(
    ftHandle,
    &ftDevice,
    &deviceID,
    SerialNumber,
    Description,
    NULL
);

if (ftStatus == FT_OK) {
    if (ftDevice == FT_DEVICE_232H)
        ; // device is FT232H
    else if (ftDevice == FT_DEVICE_4232H)
        ; // device is FT4232H
    else if (ftDevice == FT_DEVICE_2232H)
        ; // device is FT2232H
    else if (ftDevice == FT_DEVICE_232R)
        ; // device is FT232R
    else if (ftDevice == FT_DEVICE_2232C)
        ; // device is FT2232C/L/D
    else if (ftDevice == FT_DEVICE_BM)
        ; // device is FTU232BM
    else if (ftDevice == FT_DEVICE_AM)
        ; // device is FT8U232AM
    else
        ; // unknown device (this should not happen!)
    // deviceID contains encoded device ID
    // SerialNumber, Description contain 0-terminated strings
}
else {
    // FT_GetDeviceType FAILED!
}

FT_Close(ftHandle);
```

3.24 FT_GetDriverVersion

Supported Operating Systems

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function returns the D2XX driver version number.

Definition

FT_STATUS **FT_GetDriverVersion** (FT_HANDLE *ftHandle*, LPDWORD *lpdwDriverVersion*)

Parameters

ftHandle Handle of the device.
lpdwDriverVersion Pointer to the driver version number.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

A version number consists of major, minor and build version numbers contained in a 4-byte field (unsigned long). Byte0 (least significant) holds the build version, Byte1 holds the minor version, and Byte2 holds the major version. Byte3 is currently set to zero.

For example, driver version "2.04.06" is represented as 0x00020406. Note that a device has to be opened before this function can be called.

Example

```
FT_HANDLE ftHandle;  
FT_STATUS ftStatus;  
DWORD dwDriverVer;  
  
// Get driver version  
ftStatus = FT_Open(0,&ftHandle);  
if (ftStatus == FT_OK) {  
    ftStatus = FT_GetDriverVersion(ftHandle,&dwDriverVer);  
    if (ftStatus == FT_OK)  
        printf("Driver version = 0x%x\n",dwDriverVer);  
    else  
        printf("error reading driver version\n");  
    FT_Close(ftHandle);  
}
```

3.25 FT_GetLibraryVersion

Supported Operating Systems

Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function returns D2XX DLL version number.

Definition

FT_STATUS **FT_GetLibraryVersion** (LPDWORD *lpdwDLLVersion*)

Parameters

lpdwDLLVersion Pointer to the DLL version number.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

A version number consists of major, minor and build version numbers contained in a 4-byte field (unsigned long). Byte0 (least significant) holds the build version, Byte1 holds the minor version, and Byte2 holds the major version. Byte3 is currently set to zero.

For example, D2XX DLL version "3.01.15" is represented as 0x00030115. Note that this function does not take a handle, and so it can be called without opening a device.

Example

```
FT_STATUS ftStatus;  
DWORD dwLibraryVer;  
  
// Get DLL version  
ftStatus = FT_GetLibraryVersion(&dwLibraryVer);  
if (ftStatus == FT_OK)  
    printf("Library version = 0x%x\n", dwLibraryVer);  
else  
    printf("error reading library version\n");
```

3.26 FT_GetComPortNumber

Supported Operating Systems

Windows (2000 and later)

Summary

Retrieves the COM port associated with a device.

Definition

FT_STATUS **FT_GetComPortNumber** (FT_HANDLE *ftHandle*, LPLONG *lplComPortNumber*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lplComPortNumber</i>	Pointer to a variable of type LONG which receives the COM port number associated with the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function is only available when using the Windows CDM driver as both the D2XX and VCP drivers can be installed at the same time.

If no COM port is associated with the device, *lplComPortNumber* will have a value of -1.

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx  
FT_STATUS ftStatus;  
LONG lComPortNumber;
```

```
ftStatus = FT_GetComPortNumber(ftHandle, &lComPortNumber);  
if (status == FT_OK) {  
    if (lComPortNumber == -1) {  
        // No COM port assigned  
    }  
    else {  
        // COM port assigned with number held in lComPortNumber  
    }  
}  
else {  
    // FT_GetComPortNumber FAILED!  
}  
FT_Close(ftHandle);
```

3.27 FT_GetStatus

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Gets the device status including number of characters in the receive queue, number of characters in the transmit queue, and the current event status.

Definition

FT_STATUS **FT_GetStatus** (FT_HANDLE *ftHandle*, LPDWORD *lpdwAmountInRxQueue*,
LPDWORD *lpdwAmountInTxQueue*, LPDWORD *lpdwEventStatus*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwAmountInRxQueue</i>	Pointer to a variable of type DWORD which receives the number of characters in the receive queue.
<i>lpdwAmountInTxQueue</i>	Pointer to a variable of type DWORD which receives the number of characters in the transmit queue.
<i>lpdwEventStatus</i> the event status.	Pointer to a variable of type DWORD which receives the current state of

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

For an example of how to use this function, see the sample code in [FT_SetEventNotification](#).

3.28 FT_SetEventNotification

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Sets conditions for event notification.

Definition

FT_STATUS **FT_SetEventNotification** (FT_HANDLE *ftHandle*, DWORD *dwEventMask*, PVOID *pvArg*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwEventMask</i>	Conditions that cause the event to be set.
<i>pvArg</i>	Interpreted as the handle of an event.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

An application can use this function to setup conditions which allow a thread to block until one of the conditions is met. Typically, an application will create an event, call this function, then block on the event. When the conditions are met, the event is set, and the application thread unblocked.

dwEventMask is a bit-map that describes the events the application is interested in. *pvArg* is interpreted as the handle of an event which has been created by the application. If one of the event conditions is met, the event is set.

If [FT_EVENT_RXCHAR](#) is set in *dwEventMask*, the event will be set when a character has been received by the device.

If [FT_EVENT_MODEM_STATUS](#) is set in *dwEventMask*, the event will be set when a change in the modem signals has been detected by the device.

If [FT_EVENT_LINE_STATUS](#) is set in *dwEventMask*, the event will be set when a change in the line status has been detected by the device.

Examples

1. This example is valid for Windows and Windows CE and shows how to wait for a character to be received or a change in modem status.

```
// First, create the event and call FT_SetEventNotification.
FT_HANDLE ftHandle; // handle of an open device
FT_STATUS ftStatus;
HANDLE hEvent;
DWORD EventMask;

hEvent = CreateEvent(
    NULL,
    false, // auto-reset event
    false, // non-signalled state
```

```
        ""
    );
EventMask = FT_EVENT_RXCHAR | FT_EVENT_MODEM_STATUS;
ftStatus = FT_SetEventNotification(ftHandle, EventMask, hEvent);

// Sometime later, block the application thread by waiting on the event, then when the
// event has
// occurred, determine the condition that caused the event, and process it accordingly.
WaitForSingleObject(hEvent, INFINITE);

DWORD EventDWord;
DWORD RxBytes;
DWORD TxBytes;

FT_GetStatus(ftHandle, &RxBytes, &TxBytes, &EventDWord);
if (EventDWord & FT_EVENT_MODEM_STATUS) {
    // modem status event detected, so get current modem status
    FT_GetModemStatus(ftHandle, &Status);
    if (Status & 0x00000010) {
        // CTS is high
    }
    else {
        // CTS is low
    }
    if (Status & 0x00000020) {
        // DSR is high
    }
    else {
        // DSR is low
    }
}
if (RxBytes > 0) {
    // call FT_Read() to get received data from device
}
```

2. This example is valid for Linux and shows how to wait for a character to be received or a change in modem status.

```
// First, create the event and call FT_SetEventNotification.
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
EVENT_HANDLE eh;
DWORD EventMask;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

pthread_mutex_init(&eh.eMutex, NULL);
pthread_cond_init(&eh.eCondVar, NULL);

EventMask = FT_EVENT_RXCHAR | FT_EVENT_MODEM_STATUS;
ftStatus = FT_SetEventNotification(ftHandle, EventMask, (PVOID)&eh);

// Sometime later, block the application thread by waiting on the event, then when the
// event has
// occurred, determine the condition that caused the event, and process it accordingly.

pthread_mutex_lock(&eh.eMutex);
pthread_cond_wait(&eh.eCondVar, &eh.eMutex);
pthread_mutex_unlock(&eh.eMutex);

DWORD EventDWord;
DWORD RxBytes;
```

```
DWORD TxBytes;  
DWORD Status;  
FT_GetStatus(ftHandle, &RxBytes, &TxBytes, &EventDWord);  
if (EventDWord & FT_EVENT_MODEM_STATUS) {  
    // modem status event detected, so get current modem status  
    FT_GetModemStatus(ftHandle, &Status);  
    if (Status & 0x00000010) {  
        // CTS is high  
    }  
    else {  
        // CTS is low  
    }  
    if (Status & 0x00000020) {  
        // DSR is high  
    }  
    else {  
        // DSR is low  
    }  
}  
if (RxBytes > 0) {  
    // call FT_Read() to get received data from device  
}  
  
FT_Close(ftHandle);
```

3.29 FT_SetChars

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function sets the special characters for the device.

Definition

FT_STATUS **FT_SetChars** (FT_HANDLE *ftHandle*, UCHAR *uEventCh*, UCHAR *uEventChEn*, UCHAR *uErrorCh*, UCHAR *uErrorChEn*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>uEventCh</i>	Event character.
<i>uEventChEn</i>	0 if event character disabled, non-zero otherwise.
<i>uErrorCh</i>	Error character.
<i>uErrorChEn</i>	0 if error character disabled, non-zero otherwise.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function allows for inserting specified characters in the data stream to represent events firing or errors occurring.

3.30 FT_SetBreakOn

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Sets the BREAK condition for the device.

Definition

FT_STATUS **FT_SetBreakOn** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx
FT_STATUS ftStatus;

ftStatus = FT_SetBreakOn(ftHandle);
if (ftStatus == FT_OK) {
    // FT_SetBreakOn OK
}
else {
    // FT_SetBreakOn failed
}

FT_Close(ftHandle);
```

3.31 FT_SetBreakOff

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Resets the BREAK condition for the device.

Definition

FT_STATUS **FT_SetBreakOff** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx
FT_STATUS ftStatus;

ftStatus = FT_SetBreakOff(ftHandle);
if (ftStatus == FT_OK) {
    // FT_SetBreakOff OK
}
else {
    // FT_SetBreakOff failed
}

FT_Close(ftHandle);
```

3.32 FT_Purge

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function purges receive and transmit buffers in the device.

Definition

FT_STATUS **FT_Purge** (FT_HANDLE *ftHandle*, DWORD *dwMask*)

Parameters

ftHandle Handle of the device.

uEventCh Combination of [FT_PURGE_RX](#) and [FT_PURGE_TX](#).

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx
FT_STATUS ftStatus;

ftStatus = FT_Purge(ftHandle, FT_PURGE_RX | FT_PURGE_TX); // Purge both Rx and Tx buffers
if (ftStatus == FT_OK) {
    // FT_Purge OK
}
else {
    // FT_Purge failed
}
FT_Close(ftHandle);
```

3.33 FT_ResetDevice

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function sends a reset command to the device.

Definition

FT_STATUS **FT_ResetDevice** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx
FT_STATUS ftStatus;

ftStatus = FT_ResetDevice(ftHandle);
if (ftStatus == FT_OK) {
    // FT_ResetDevice OK
}
else {
    // FT_ResetDevice failed
}
FT_Close(ftHandle);
```

3.34 FT_ResetPort

Supported Operating Systems

Windows (2000 and later)

Summary

Send a reset command to the port.

Definition

FT_STATUS **FT_ResetPort** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function is used to attempt to recover the port after a failure. It is not equivalent to an unplug-replug event. For the equivalent of an unplug-replug event, use [FT_CyclePort](#).

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx
FT_STATUS ftStatus;

ftStatus = FT_ResetPort(ftHandle);
if (ftStatus == FT_OK) {
    // Port has been reset
}
else {
    // FT_ResetPort FAILED!
}
```

3.35 FT_CyclePort

Supported Operating Systems

Windows (2000 and later)

Summary

Send a cycle command to the USB port.

Definition

FT_STATUS **FT_CyclePort** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

The effect of this function is the same as disconnecting then reconnecting the device from USB. Possible use of this function is situations where a fatal error has occurred and it is difficult, or not possible, to recover without unplugging and replugging the USB cable. This function can also be used after re-programming the EEPROM to force the FTDI device to read the new EEPROM contents which would otherwise require a physical disconnect-reconnect.

As the current session is not restored when the driver is reloaded, the application must be able to recover after calling this function. It is the responsibility of the application to close the handle after successfully calling FT_CyclePort.

For FT4232H, FT2232H and FT2232 devices, FT_CyclePort will only work under Windows XP and later.

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx
FT_STATUS ftStatus;

ftStatus = FT_CyclePort(ftHandle);
if (ftStatus == FT_OK) {
    // Port has been cycled.
    // Close the handle.
    ftStatus = FT_Close(ftHandle);
}
else {
    // FT_CyclePort FAILED!
}
```

3.36 FT_Rescan

Supported Operating Systems

Windows (2000 and later)

Summary

This function can be of use when trying to recover devices programmatically.

Definition

FT_STATUS **FT_Rescan** ()

Parameters

None

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

Calling FT_Rescan is equivalent to clicking the "Scan for hardware changes" button in the Device Manager. Only USB hardware is checked for new devices. All USB devices are scanned, not just FTDI devices.

Example

```
FT_STATUS ftstatus;  
  
ftStatus = FT_Rescan();  
if(ftStatus != FT_OK) {  
    // FT_Rescan failed!  
    return;  
}
```

3.37 FT_Reload

Supported Operating Systems

Windows (2000 and later)

Summary

This function forces a reload of the driver for devices with a specific VID and PID combination.

Definition

FT_STATUS **FT_Reload** (WORD *wVID*, WORD *wPID*)

Parameters

<i>wVID</i>	Vendor ID of the devices to reload the driver for.
<i>wPID</i>	Product ID of the devices to reload the driver for.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

Calling FT_Reload forces the operating system to unload and reload the driver for the specified device IDs. If the VID and PID parameters are null, the drivers for USB root hubs will be reloaded, causing all USB devices connected to reload their drivers. Please note that this function will not work correctly on 64-bit Windows when called from a 32-bit application.

Examples

1. This example shows how to call FT_Reload to reload the driver for a standard FT232R device (VID 0x0403, PID 0x6001).

```
FT_STATUS ftstatus;  
WORD wVID = 0x0403;  
WORD wPID = 0x6001;
```

```
ftStatus = FT_Reload(wVID,wPID);  
if(ftStatus != FT_OK) {  
    // FT_Reload failed!  
    return;  
}
```

2. This example shows how to call FT_Reload to reload the drivers for all USB devices.

```
FT_STATUS ftstatus;  
WORD wVID = 0x0000;  
WORD wPID = 0x0000;  
  
ftStatus = FT_Reload(wVID,wPID);  
if(ftStatus != FT_OK) {  
    // FT_Reload failed!  
    return;  
}
```

3.38 FT_SetResetPipeRetryCount

Supported Operating Systems

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Set the ResetPipeRetryCount value.

Definition

FT_STATUS **FT_SetResetPipeRetryCount** (FT_HANDLE *ftHandle*, DWORD *dwCount*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwCount</i>	Unsigned long containing required ResetPipeRetryCount.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function is used to set the ResetPipeRetryCount. ResetPipeRetryCount controls the maximum number of times that the driver tries to reset a pipe on which an error has occurred. ResetPipeRequestRetryCount defaults to 50. It may be necessary to increase this value in noisy environments where a lot of USB errors occur.

Example

```
FT_HANDLE ftHandle; // valid handle returned from FT_OpenEx  
FT_STATUS ftStatus;
```

```
DWORD dwRetryCount;  
  
dwRetryCount = 100;  
ftStatus = FT_SetResetPipeRetryCount(ftHandle, dwRetryCount);  
if (ftStatus == FT_OK) {  
    // ResetPipeRetryCount set to 100  
}  
else {  
    // FT_SetResetPipeRetryCount FAILED!  
}
```

3.39 FT_StopInTask

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Stops the driver's IN task.

Definition

FT_STATUS **FT_StopInTask** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function is used to put the driver's IN task (read) into a wait state. It can be used in situations where data is being received continuously, so that the device can be purged without more data being received. It is used together with [FT_RestartInTask](#) which sets the IN task running again.

Example

```
FT_HANDLE ftHandle;  
FT_STATUS ftStatus;  
  
ftStatus = FT_Open(0, &ftHandle);  
if(ftStatus != FT_OK) {  
    // FT_Open failed  
    return;  
}  
  
do {  
    ftStatus = FT_StopInTask(ftHandle);  
} while (ftStatus != FT_OK);
```

```
//  
// Do something - for example purge device  
//  
  
do {  
    ftStatus = FT_RestartInTask(ftHandle);  
} while (ftStatus != FT_OK);  
  
FT_Close(ftHandle);
```

3.40 FT_RestartInTask

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Restart the driver's IN task.

Definition

FT_STATUS **FT_RestartInTask** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function is used to restart the driver's IN task (read) after it has been stopped by a call to [FT_StopInTask](#).

Example

```
FT_HANDLE ftHandle;  
FT_STATUS ftStatus;  
  
ftStatus = FT_Open(0, &ftHandle);  
if(ftStatus != FT_OK) {  
    // FT_Open failed  
    return;  
}  
  
do {  
    ftStatus = FT_StopInTask(ftHandle);  
} while (ftStatus != FT_OK);  
  
//
```



```
// Do something - for example purge device
//

do {
    ftStatus = FT_RestartInTask(ftHandle);
} while (ftStatus != FT_OK);

FT_Close(ftHandle);
```

3.41 FT_SetDeadmanTimeout

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function allows the maximum time in milliseconds that a USB request can remain outstanding to be set.

Definition

FT_STATUS **FT_SetDeadmanTimeout** (FT_HANDLE *ftHandle*, DWORD *dwDeadmanTimeout*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwDeadmanTimeout</i>	Deadman timeout value in milliseconds. Default value is 5000.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

The deadman timeout is referred to in application note AN232B-10 Advanced Driver Options from the FTDI web site as the USB timeout. It is unlikely that this function will be required by most users.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
DWORD dwDeadmanTimeout = 6000;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_SetDeadmanTimeout(ftHandle, dwDeadmanTimeout);
if (ftStatus == FT_OK) {
```

```
        // Set Deadman Timer to 6 seconds  
    }  
    else {  
        // FT_SetDeadmanTimeout FAILED!  
    }  
  
    FT_Close(ftHandle);
```

3.42 FT_IoCtl

Undocumented function.

3.43 FT_SetWaitMask

Undocumented function.

3.44 FT_WaitOnMask

Undocumented function.

4 EEPROM Programming Interface Functions

FTDI device EEPROMs can be both read and programmed using the functions listed in this section.

4.1 FT_ReadEE

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Read a value from an EEPROM location.

Definition

FT_STATUS **FT_ReadEE** (FT_HANDLE *ftHandle*, DWORD *dwWordOffset*, LPWORD *lpwValue*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwWordOffset</i>	EEPROM location to read from.
<i>lpwValue</i>	Pointer to the WORD value read from the EEPROM.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

EEPROMs for FTDI devices are organised by WORD, so each value returned is 16-bits wide.

4.2 FT_WriteEE

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Write a value to an EEPROM location.

Definition

FT_STATUS **FT_WriteEE** (FT_HANDLE *ftHandle*, DWORD *dwWordOffset*, WORD *wValue*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwWordOffset</i>	EEPROM location to read from.
<i>wValue</i>	The WORD value write to the EEPROM.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

EEPROMs for FTDI devices are organised by WORD, so each value written to the EEPROM is 16-bits wide.

4.3 FT_EraseEE

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Erases the device EEPROM.

Definition

FT_STATUS **FT_EraseEE** (FT_HANDLE *ftHandle*)

Parameters

<i>ftHandle</i>	Handle of the device.
-----------------	-----------------------

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function will erase the entire contents of an EEPROM, including the user area. Note that the FT232R and FT245R devices have an internal EEPROM that cannot be erased.

4.4 FT_EE_Read

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Read the contents of the EEPROM.

Definition

FT_STATUS **FT_EE_Read** (FT_HANDLE *ftHandle*, PFT_PROGRAM_DATA *pData*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pData</i>	Pointer to structure of type FT_PROGRAM_DATA.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function interprets the parameter *pData* as a pointer to a structure of type *FT_PROGRAM_DATA* that contains storage for the data to be read from the EEPROM.

The function does not perform any checks on buffer sizes, so the buffers passed in the *FT_PROGRAM_DATA* structure must be big enough to accommodate their respective strings (including null terminators). The sizes shown in the following example are more than adequate and can be rounded down if necessary. The restriction is that the *Manufacturer* string length plus the *Description* string length is less than or equal to 40 characters.

Note that the DLL must be informed which version of the *FT_PROGRAM_DATA* structure is being used. This is done through the *Signature1*, *Signature2* and *Version* elements of the structure. *Signature1* should always be *0x00000000*, *Signature2* should always be *0xFFFFFFFF* and *Version* can be set to use whichever version is required. For compatibility with all current devices *Version* should be set to the latest version of the *FT_PROGRAM_DATA* structure which is defined in FTD2XX.h.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus = FT_Open(0, &ftHandle);
if (ftStatus != FT_OK) {
    // FT_Open FAILED!
}

FT_PROGRAM_DATA ftData;
char ManufacturerBuf[32];
char ManufacturerIdBuf[16];
char DescriptionBuf[64];
char SerialNumberBuf[16];

ftData.Signature1 = 0x00000000;
ftData.Signature2 = 0xffffffff;
ftData.Version = 0x00000005;           // EEPROM structure with FT232H extensions
ftData.Manufacturer = ManufacturerBuf;
ftData.ManufacturerId = ManufacturerIdBuf;
```

```
ftData.Description = DescriptionBuf;  
ftData.SerialNumber = SerialNumberBuf;  
  
ftStatus = FT_EE_Read(ftHandle, &ftData);  
if (ftStatus == FT_OK) {  
    // FT_EE_Read OK, data is available in ftData  
}  
else {  
    // FT_EE_Read FAILED!  
}  
FT_Close(ftHandle);
```

4.5 FT_EE_ReadEx

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Read the contents of the EEPROM and pass strings separately.

Definition

FT_STATUS **FT_EE_ReadEx** (FT_HANDLE *ftHandle*, PFT_PROGRAM_DATA *pData*,
char **Manufacturer*, char **ManufacturerId*, char **Description*,
char **SerialNumber*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pData</i>	Pointer to structure of type FT_PROGRAM_DATA.
* <i>Manufacturer</i>	Pointer to a null-terminated string containing the manufacturer name.
* <i>ManufacturerId</i>	Pointer to a null-terminated string containing the manufacturer ID.
* <i>Description</i>	Pointer to a null-terminated string containing the device description.
* <i>SerialNumber</i>	Pointer to a null-terminated string containing the device serial number.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This variation of the standard [FT_EE_Read](#) function was included to provide support for languages such as LabVIEW where problems can occur when string pointers are contained in a structure.

This function interprets the parameter *pData* as a pointer to a structure of type *FT_PROGRAM_DATA* that contains storage for the data to be read from the EEPROM.

The function does not perform any checks on buffer sizes, so the buffers passed in the *FT_PROGRAM_DATA* structure must be big enough to accommodate their respective strings (including null terminators).

Note that the DLL must be informed which version of the *FT_PROGRAM_DATA* structure is being used. This is done through the *Signature1*, *Signature2* and *Version* elements of the structure. *Signature1* should always be *0x00000000*, *Signature2* should always be *0xFFFFFFFF* and *Version* can be set to use whichever version is required. For compatibility with all current devices *Version* should be set to the latest version of the *FT_PROGRAM_DATA* structure which is defined in FTD2XX.h.

The string parameters in the *FT_PROGRAM_DATA* structure should be passed as DWORDs to avoid overlapping of parameters. All string pointers are passed out separately from the *FT_PROGRAM_DATA* structure.

4.6 FT_EE_Program

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Program the EEPROM.

Definition

FT_STATUS **FT_EE_Program** (FT_HANDLE *ftHandle*, PFT_PROGRAM_DATA *pData*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pData</i>	Pointer to structure of type FT_PROGRAM_DATA.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function interprets the parameter *pData* as a pointer to a structure of type *FT_PROGRAM_DATA* that contains the data to write to the EEPROM. The data is written to EEPROM, then read back and verified.

If the *SerialNumber* field in *FT_PROGRAM_DATA* is NULL, or *SerialNumber* points to a NULL string, a serial number based on the *ManufacturerId* and the current date and time will be generated. The *Manufacturer* string length plus the *Description* string length must be less than or equal to 40 characters.

Note that the DLL must be informed which version of the *FT_PROGRAM_DATA* structure is being used. This is done through the *Signature1*, *Signature2* and *Version* elements of the structure. *Signature1* should always be *0x00000000*, *Signature2* should always be *0xFFFFFFFF* and *Version* can be set to use whichever version is required. For compatibility with all current devices *Version* should be set to the latest version of the *FT_PROGRAM_DATA* structure which is defined in FTD2XX.h.

If *pData* is NULL, the structure version will default to 0 (original BM series) and the device will be programmed with the default data:

Example

This example shows how to program the EEPROM of an FT232B device. Other parameters would need to be set up for other device types.

```
// Version 4 structure for programming a BM device.  
// Other elements would need non-zero values for FT2232, FT232R, FT245R, FT2232H or  
// FT4232H devices.
```

```
FT_PROGRAM_DATA ftData = {  
    0x00000000,           // Header - must be 0x00000000  
    0xFFFFFFFF,           // Header - must be 0xffffffff  
    0x00000004,           // Header - FT_PROGRAM_DATA version  
    0x0403,               // VID  
    0x6001,               // PID  
    "FTDI",               // Manufacturer  
    "FT",                 // Manufacturer ID  
    "USB HS Serial Converter", // Description  
    "FT000001",           // Serial Number  
    44,                   // MaxPower  
    1,                    // PnP  
    0,                    // SelfPowered  
    1,                    // RemoteWakeup  
    1,                    // non-zero if Rev4 chip, zero otherwise  
    0,                    // non-zero if in endpoint is isochronous  
    0,                    // non-zero if out endpoint is isochronous  
    0,                    // non-zero if pull down enabled  
    1,                    // non-zero if serial number to be used  
    0,                    // non-zero if chip uses USBVersion  
    0x0110                // BCD (0x0200 => USB2)  
    //  
    // FT2232C extensions (Enabled if Version = 1 or greater)  
    //  
    0,                    // non-zero if Rev5 chip, zero otherwise  
    0,                    // non-zero if in endpoint is isochronous  
    0,                    // non-zero if in endpoint is isochronous  
    0,                    // non-zero if out endpoint is isochronous  
    0,                    // non-zero if out endpoint is isochronous  
    0,                    // non-zero if pull down enabled  
    0,                    // non-zero if serial number to be used  
    0,                    // non-zero if chip uses USBVersion  
    0x0,                 // BCD (0x0200 => USB2)  
    0,                    // non-zero if interface is high current  
    0,                    // non-zero if interface is high current  
    0,                    // non-zero if interface is 245 FIFO  
    0,                    // non-zero if interface is 245 FIFO CPU target  
    0,                    // non-zero if interface is Fast serial  
    0,                    // non-zero if interface is to use VCP drivers  
    0,                    // non-zero if interface is 245 FIFO  
    0,                    // non-zero if interface is 245 FIFO CPU target  
    0,                    // non-zero if interface is Fast serial  
    0,                    // non-zero if interface is to use VCP drivers  
    //  
    // FT232R extensions (Enabled if Version = 2 or greater)  
    //  
    0,                    // Use External Oscillator  
    0,                    // High Drive I/Os  
    0,                    // Endpoint size  
    0,                    // non-zero if pull down enabled  
    0,                    // non-zero if serial number to be used  
    0,                    // non-zero if invert TXD  
    0,                    // non-zero if invert RXD  
    0,                    // non-zero if invert RTS  
    0,                    // non-zero if invert CTS  
    0,                    // non-zero if invert DTR  
    0,                    // non-zero if invert DSR  
}
```



```
0, // non-zero if invert DCD
0, // non-zero if invert RI
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // non-zero if using D2XX drivers
//
// Rev 7 (FT2232H) Extensions (Enabled if Version = 3 or greater)
//
0, // non-zero if pull down enabled
0, // non-zero if serial number to be used
0, // non-zero if AL pins have slow slew
0, // non-zero if AL pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if AH pins have slow slew
0, // non-zero if AH pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if BL pins have slow slew
0, // non-zero if BL pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if BH pins have slow slew
0, // non-zero if BH pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if interface is 245 FIFO
0, // non-zero if interface is 245 FIFO CPU target
0, // non-zero if interface is Fast serial
0, // non-zero if interface is to use VCP drivers
0, // non-zero if interface is 245 FIFO
0, // non-zero if interface is 245 FIFO CPU target
0, // non-zero if interface is Fast serial
0, // non-zero if interface is to use VCP drivers
0, // non-zero if using BCBUS7 to save power for self-
    // powered designs
//
// Rev 8 (FT4232H) Extensions (Enabled if Version = 4)
//
0, // non-zero if pull down enabled
0, // non-zero if serial number to be used
0, // non-zero if AL pins have slow slew
0, // non-zero if AL pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if AH pins have slow slew
0, // non-zero if AH pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if BL pins have slow slew
0, // non-zero if BL pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if BH pins have slow slew
0, // non-zero if BH pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if port A uses RI as RS485 TXDEN
0, // non-zero if port B uses RI as RS485 TXDEN
0, // non-zero if port C uses RI as RS485 TXDEN
0, // non-zero if port D uses RI as RS485 TXDEN
0, // non-zero if interface is to use VCP drivers
0, // non-zero if interface is to use VCP drivers
0, // non-zero if interface is to use VCP drivers
0, // non-zero if interface is to use VCP drivers
//
// Rev 9 (FT232H) Extensions (Enabled if Version = 5)
//
0, // non-zero if pull down enabled
0, // non-zero if serial number to be used
0, // non-zero if AC pins have slow slew
0, // non-zero if AC pins are Schmitt input
```

```
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // non-zero if AD pins have slow slew
0, // non-zero if AD pins are Schmitt input
0, // valid values are 4mA, 8mA, 12mA, 16mA
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // Cbus Mux control
0, // non-zero if interface is 245 FIFO
0, // non-zero if interface is 245 FIFO CPU target
0, // non-zero if interface is Fast serial
0, // non-zero if interface is FT1248
0, // FT1248 clock polarity - clock idle high (1) or
    // clock idle low (0)
0, // FT1248 data is LSB (1) or MSB (0)
0, // FT1248 flow control enable
0, // non-zero if interface is to use VCP drivers
0, // non-zero if using ACBUS7 to save power for
    // self-powered designs

};
FT_HANDLE ftHandle;

FT_STATUS ftStatus = FT_Open(0, &ftHandle);
if (ftStatus == FT_OK) {
    ftStatus = FT_EE_Program(ftHandle, &ftData);
    if (ftStatus == FT_OK) {
        // FT_EE_Program OK!
    }
    else {
        // FT_EE_Program FAILED!
    }
    FT_Close(ftHandle);
}
```

4.7 FT_EE_ProgramEx

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Program the EEPROM and pass strings separately.

Definition

FT_STATUS **FT_EE_ProgramEx** (FT_HANDLE *ftHandle*, PFT_PROGRAM_DATA *pData*,
char *Manufacturer, char *ManufacturerId,
char *Description, char *SerialNumber)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pData</i>	Pointer to structure of type FT_PROGRAM_DATA.
<i>*Manufacturer</i>	Pointer to a null-terminated string containing the manufacturer name.
<i>*ManufacturerId</i>	Pointer to a null-terminated string containing the manufacturer ID.
<i>*Description</i>	Pointer to a null-terminated string containing the device description.
<i>*SerialNumber</i>	Pointer to a null-terminated string containing the device serial number.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This variation of the [FT_EE_Program](#) function was included to provide support for languages such as LabVIEW where problems can occur when string pointers are contained in a structure.

This function interprets the parameter *pData* as a pointer to a structure of type FT_PROGRAM_DATA that contains the data to write to the EEPROM. The data is written to EEPROM, then read back and verified.

The string pointer parameters in the FT_PROGRAM_DATA structure should be allocated as DWORDs to avoid overlapping of parameters. The string parameters are then passed in separately.

If the *SerialNumber* field is NULL, or *SerialNumber* points to a NULL string, a serial number based on the *ManufacturerId* and the current date and time will be generated. The *Manufacturer* string length plus the *Description* string length must be less than or equal to 40 characters.

Note that the DLL must be informed which version of the FT_PROGRAM_DATA structure is being used. This is done through the *Signature1*, *Signature2* and *Version* elements of the structure. *Signature1* should always be 0x00000000, *Signature2* should always be 0xFFFFFFFF and *Version* can be set to use whichever version is required. For compatibility with all current devices *Version* should be set to the latest version of the FT_PROGRAM_DATA structure which is defined in FTD2XX.h.

If *pData* is NULL, the structure version will default to 0 (original BM series) and the device will be programmed with the default data:

4.8 FT_EE_UASize

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Get the available size of the EEPROM user area.

Definition

FT_STATUS FT_EE_UASizeWrite (FT_HANDLE *ftHandle*, LPDWORD *lpdwSize*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwSize</i>	Pointer to a DWORD that receives the available size, in bytes, of the EEPROM user area.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

The user area of an FTDI device EEPROM is the total area of the EEPROM that is unused by device configuration information and descriptors. This area is available to the user to store information specific to their application. The size of the user area depends on the length of the *Manufacturer*, *ManufacturerId*, *Description* and *SerialNumber* strings programmed into the EEPROM.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus = FT_Open(0, &ftHandle);

if (ftStatus != FT_OK) {
    // FT_Open FAILED!
}

DWORD EEUA_Size;

ftStatus = FT_EE_UASize(ftHandle, &EEUA_Size);
if (ftStatus == FT_OK) {
    // FT_EE_UASize OK
    // EEUA_Size contains the size, in bytes, of the EEUA
}
else {
    // FT_EE_UASize FAILED!
}
FT_Close(ftHandle);
```

4.9 FT_EE_UARead

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Read the contents of the EEPROM user area.

Definition

FT_STATUS **FT_EE_UARead** (FT_HANDLE *ftHandle*, PCHAR *pucData*, DWORD *dwDataLen*, LPDWORD *lpdwBytesRead*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pucData</i>	Pointer to a buffer that contains storage for data to be read.
<i>dwDataLen</i>	Size, in bytes, of buffer that contains storage for the data to be read.
<i>lpdwBytesRead</i>	Pointer to a DWORD that receives the number of bytes read.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function interprets the parameter *pucData* as a pointer to an array of bytes of size *dwDataLen* that contains storage for the data to be read from the EEPROM user area. The actual number of bytes read is stored in the DWORD referenced by *lpdwBytesRead*.

If *dwDataLen* is less than the size of the EEPROM user area, then *dwDataLen* bytes are read into the buffer. Otherwise, the whole of the EEPROM user area is read into the buffer. The available user area size can be determined by calling [FT_EE_UASize](#).

An application should check the function return value and *lpdwBytesRead* when FT_EE_UARead returns.

Example

```
FT_HANDLE ftHandle;  
FT_STATUS ftStatus = FT_Open(0, &ftHandle);  
  
if (ftStatus != FT_OK) {  
    // FT_Open FAILED!  
}  
  
unsigned char Buffer[64];  
DWORD BytesRead;  
  
ftStatus = FT_EE_UARead(ftHandle, Buffer, 64, &BytesRead);  
if (ftStatus == FT_OK) {  
    // FT_EE_UARead OK  
    // User Area data stored in Buffer  
    // Number of bytes read from EEUA stored in BytesRead  
}  
else {  
    // FT_EE_UARead FAILED!  
}  
FT_Close(ftHandle);
```

4.10 FT_EE_UAWrite

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Write data into the EEPROM user area.

Definition

FT_STATUS **FT_EE_UAWrite** (FT_HANDLE *ftHandle*, PCHAR *pucData*, DWORD *dwDataLen*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pucData</i>	Pointer to a buffer that contains the data to be written.
<i>dwDataLen</i>	Size, in bytes, of buffer that contains storage for the data to be read.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function interprets the parameter *pucData* as a pointer to an array of bytes of size *dwDataLen* that contains the data to be written to the EEPROM user area. It is a programming error for *dwDataLen* to be greater than the size of the EEPROM user area. The available user area size can be determined by calling [FT_EE_UASize](#).

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus = FT_Open(0, &ftHandle);

if (ftStatus != FT_OK) {
    // FT_Open FAILED!
}

char *buffer = "Hello, World";

ftStatus = FT_EE_UAWrite(ftHandle, (unsigned char*)buffer, 12);
if(ftStatus != FT_OK) {
    // FT_EE_UAWRITE failed
}
else {
    // FT_EE_UAWRITE failed
}

FT_Close(ftHandle);
```

5 Extended API Functions

The extended API functions do not apply to FT8U232AM or FT8U245AM devices. FTDI's other USB-UART and USB-FIFO ICs (the FT2232H, FT4232H, FT232R, FT245R, FT2232, FT232B and FT245B) do support these functions. Note that there is device dependence in some of these functions.

5.1 FT_SetLatencyTimer

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Set the latency timer value.

Definition

FT_STATUS **FT_SetLatencyTimer** (FT_HANDLE *ftHandle*, UCHAR *ucTimer*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>ucTimer</i>	Required value, in milliseconds, of latency timer. Valid range is 2 – 255.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

In the FT8U232AM and FT8U245AM devices, the receive buffer timeout that is used to flush remaining data from the receive buffer was fixed at 16 ms. In all other FTDI devices, this timeout is programmable and can be set at 1 ms intervals between 2ms and 255 ms. This allows the device to be better optimized for protocols requiring faster response times from short data packets.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
UCHAR LatencyTimer = 10;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}
```



```
ftStatus = FT_SetLatencyTimer(ftHandle, LatencyTimer);  
if (ftStatus == FT_OK) {  
    // LatencyTimer set to 10 milliseconds  
}  
else {  
    // FT_SetLatencyTimer FAILED!  
}  
  
FT_Close(ftHandle);
```

5.2 FT_GetLatencyTimer

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Get the current value of the latency timer.

Definition

FT_STATUS **FT_GetLatencyTimer** (FT_HANDLE *ftHandle*, PCHAR *pucTimer*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pucTimer</i>	Pointer to unsigned char to store latency timer value.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

In the FT8U232AM and FT8U245AM devices, the receive buffer timeout that is used to flush remaining data from the receive buffer was fixed at 16 ms. In all other FTDI devices, this timeout is programmable and can be set at 1 ms intervals between 2ms and 255 ms. This allows the device to be better optimized for protocols requiring faster response times from short data packets.

Example

```
FT_HANDLE ftHandle;  
FT_STATUS ftStatus;  
UCHAR LatencyTimer;  
  
ftStatus = FT_Open(0, &ftHandle);  
if(ftStatus != FT_OK) {  
    // FT_Open failed
```

```
        return;
    }

    ftStatus = FT_GetLatencyTimer(ftHandle, &LatencyTimer);
    if (ftStatus == FT_OK) {
        // LatencyTimer contains current value
    }
    else {
        // FT_GetLatencyTimer FAILED!
    }

    FT_Close(ftHandle);
```

5.3 FT_SetBitMode

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Enables different chip modes.

Definition

FT_STATUS **FT_SetBitmode** (FT_HANDLE *ftHandle*, UCHAR *ucMask*, UCHAR *ucMode*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>ucMask</i>	Required value for bit mode mask. This sets up which bits are inputs and outputs. A bit value of 0 sets the corresponding pin to an input, a bit value of 1 sets the corresponding pin to an output. In the case of CBUS Bit Bang, the upper nibble of this value controls which pins are inputs and outputs, while the lower nibble controls which of the outputs are high and low.
<i>ucMode</i>	Mode value. Can be one of the following:
0x0	Reset
0x1	Asynchronous Bit Bang
0x2	MPSSE (FT2232, FT2232H, FT4232H and FT232H devices only)
0x4	Synchronous Bit Bang (FT232R, FT245R, FT2232, FT2232H, FT4232H and FT232H devices only)
0x8	MCU Host Bus Emulation Mode (FT2232, FT2232H, FT4232H and FT232H devices only)
0x10	Fast Opto-Isolated Serial Mode (FT2232, FT2232H, FT4232H and FT232H devices only)
0x20	CBUS Bit Bang Mode (FT232R and FT232H devices only)
0x40	Single Channel Synchronous 245 FIFO Mode (FT2232H and FT232H devices only)

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

For a description of available bit modes for the FT232R, see the application note "Bit Bang Modes for the FT232R and FT245R".

For a description of available bit modes for the FT2232, see the application note "Bit Mode Functions for the FT2232".

For a description of Bit Bang Mode for the FT232B and FT245B, see the application note "FT232B/FT245B Bit Bang Mode".

Application notes are available for download from the FTDI website.

Note that to use CBUS Bit Bang for the FT232R, the CBUS must be configured for CBUS Bit Bang in the EEPROM.

Note that to use Single Channel Synchronous 245 FIFO mode for the FT2232H, channel A must be configured for FT245 FIFO mode in the EEPROM.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
UCHAR Mask = 0xff;
UCHAR Mode = 1; // Set asynchronous bit-bang mode

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_SetBitMode(ftHandle, Mask, Mode);
if (ftStatus == FT_OK) {
    // 0xff written to device
}
else {
    // FT_SetBitMode FAILED!
}

FT_Close(ftHandle);
```

5.4 FT_GetBitMode

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Gets the instantaneous value of the data bus.

Definition

FT_STATUS **FT_GetBitmode** (FT_HANDLE *ftHandle*, PCHAR *pucMode*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>pucMode</i>	Pointer to unsigned char to store the instantaneous data bus value.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

For a description of available bit modes for the FT232R, see the application note "Bit Bang Modes for the FT232R and FT245R".

For a description of available bit modes for the FT2232, see the application note "Bit Mode Functions for the FT2232".

For a description of bit bang modes for the FT232B and FT245B, see the application note "FT232B/FT245B Bit Bang Mode".

For a description of bit modes supported by the FT4232H and FT2232H devices, please see the IC data sheets.

These application notes are available for download from the FTDI website.

Example

```
FT_HANDLE ftHandle;
UCHAR BitMode;
FT_STATUS ftStatus;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_GetBitMode(ftHandle, &BitMode);
if (ftStatus == FT_OK) {
    // BitMode contains current value
}
else {
    // FT_GetBitMode FAILED!
}

FT_Close(ftHandle);
```

5.5 FT_SetUSBParameters

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Set the USB request transfer size.

Definition

FT_STATUS **FT_SetUSBParameters** (FT_HANDLE *ftHandle*, DWORD *dwInTransferSize*, DWORD *dwOutTransferSize*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwInTransferSize</i>	Transfer size for USB IN request.
<i>dwOutTransferSize</i>	Transfer size for USB OUT request.

Return Value

FT_OK if successful, otherwise the return value is an FT error code.

Remarks

This function can be used to change the transfer sizes from the default transfer size of 4096 bytes to better suit the application requirements. Transfer sizes must be set to a multiple of 64 bytes between 64 bytes and 64k bytes.

When FT_SetUSBParameters is called, the change comes into effect immediately and any data that was held in the driver at the time of the change is lost.

Note that, at present, only *dwInTransferSize* is supported.

Example

```
FT_HANDLE ftHandle;
FT_STATUS ftStatus;
DWORD InTransferSize = 16384;

ftStatus = FT_Open(0, &ftHandle);
if(ftStatus != FT_OK) {
    // FT_Open failed
    return;
}

ftStatus = FT_SetUSBParameters(ftHandle, InTransferSize, 0);
if (ftStatus == FT_OK) {
    // In transfer size set to 16 Kbytes
}
else {
    // FT_SetUSBParameters FAILED!
}

FT_Close(ftHandle);
```

6 FT-Win32 API Functions

The functions in this section are supplied to ease porting from a Win32 serial port application. These functions are supported under non-Windows platforms to assist with porting existing applications from Windows. Note that classic D2XX functions and the Win32 D2XX functions should not be mixed unless stated.

6.1 FT_W32_CreateFile

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Opens the specified device and return a handle which will be used for subsequent accesses. The device can be specified by its serial number, device description, or location.

This function must be used if overlapped I/O is required.

Definition

FT_HANDLE **FT_W32_CreateFile** (PVOID *pvArg1*, DWORD *dwAccess*, DWORD *dwShareMode*, LPSECURITY_ATTRIBUTES *lpSecurityAttributes*, DWORD *dwCreate*, DWORD *dwAttrsAndFlags*, HANDLE *hTemplate*)

Parameters

pvArg1 Meaning depends on the value of *dwAttrsAndFlags*. Can be a pointer to a null terminated string that contains the description or serial number of the device, or can be the location of the device. These values can be obtained from the [FT_CreateDeviceInfoList](#), [FT_GetDeviceInfoDetail](#) or [FT_ListDevices](#) functions.

<i>dwAccess</i>	Type of access to the device. Access can be GENERIC_READ, GENERIC_WRITE or both. Ignored in Linux.
<i>dwShareMode</i>	How the device is shared. This value must be set to 0.
<i>lpSecurityAttributes</i>	This parameter has no effect and should be set to NULL.
<i>dwCreate</i>	This parameter must be set to OPEN_EXISTING. Ignored in Linux.
<i>dwAttrsAndFlags</i>	File attributes and flags. This parameter is a combination of FILE_ATTRIBUTE_NORMAL, FILE_FLAG_OVERLAPPED if overlapped I/O is used, FT_OPEN_BY_SERIAL_NUMBER if <i>lp.szName</i> is the device's serial number, and FT_OPEN_BY_DESCRIPTION if <i>lp.szName</i> is the device's description.
<i>hTemplate</i>	This parameter must be NULL.

Return Value

If the function is successful, the return value is a handle.

If the function is unsuccessful, the return value is the Win32 error code INVALID_HANDLE_VALUE.

Remarks

The meaning of pvArg1 depends on dwAttrsAndFlags: if [FT_OPEN_BY_SERIAL_NUMBER](#) or [FT_OPEN_BY_DESCRIPTION](#) is set in dwAttrsAndFlags, pvArg1 contains a pointer to a null terminated string that contains the device's serial number or description; if [FT_OPEN_BY_LOCATION](#) is set in dwAttrsAndFlags, pvArg1 is interpreted as a value of type long that contains the location ID of the device.

dwAccess can be GENERIC_READ, GENERIC_WRITE or both; dwShareMode must be set to 0; lpSecurityAttributes must be set to NULL; dwCreate must be set to OPEN_EXISTING; dwAttrsAndFlags is a combination of FILE_ATTRIBUTE_NORMAL, FILE_FLAG_OVERLAPPED if overlapped I/O is used, [FT_OPEN_BY_SERIAL_NUMBER](#) or [FT_OPEN_BY_DESCRIPTION](#) or [FT_OPEN_BY_LOCATION](#); hTemplate must be NULL.

Note that Linux, Mac OS X and Windows CE do not support overlapped IO or location IDs.

Examples

The examples that follow use these variables.

```
FT_STATUS ftStatus;  
FT_HANDLE ftHandle;  
char Buf[64];
```

1. Open a device for overlapped I/O using its serial number

```
ftStatus = FT_ListDevices(0, Buf, FT_LIST_BY_INDEX|FT_OPEN_BY_SERIAL_NUMBER);  
  
ftHandle = FT_W32_CreateFile(Buf, GENERIC_READ|GENERIC_WRITE, 0, 0,  
                             OPEN_EXISTING,  
                             FILE_ATTRIBUTE_NORMAL | FILE_FLAG_OVERLAPPED |  
                             FT_OPEN_BY_SERIAL_NUMBER,  
                             0);  
  
if (ftHandle == INVALID_HANDLE_VALUE)  
    ; // FT_W32_CreateDevice failed
```

2. Open a device for non-overlapped I/O using its description

```
ftStatus = FT_ListDevices(0, Buf, FT_LIST_BY_INDEX|FT_OPEN_BY_DESCRIPTION);  
  
ftHandle = FT_W32_CreateFile(Buf, GENERIC_READ|GENERIC_WRITE, 0, 0,  
                             OPEN_EXISTING,  
                             FILE_ATTRIBUTE_NORMAL | FT_OPEN_BY_DESCRIPTION,  
                             0);  
  
if (ftHandle == INVALID_HANDLE_VALUE)  
    ; // FT_W32_CreateDevice failed
```

3. Open a device for non-overlapped I/O using its location

```
long locID;  
  
ftStatus = FT_ListDevices(0, &locID, FT_LIST_BY_INDEX|FT_OPEN_BY_LOCATION);  
  
ftHandle = FT_W32_CreateFile((PVOID) locID, GENERIC_READ|GENERIC_WRITE, 0, 0,  
                             OPEN_EXISTING,  
                             FILE_ATTRIBUTE_NORMAL | FT_OPEN_BY_LOCATION,  
                             0);  
  
if (ftHandle == INVALID_HANDLE_VALUE)
```

```
; // FT_W32_CreateDevice failed
```

6.2 FT_W32_CloseHandle

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Close the specified device handle.

Definition

BOOL **FT_W32_CloseHandle** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Example

This example shows how to close a device after opening it for non-overlapped I/O using its description.

```
FT_STATUS ftStatus;  
FT_HANDLE ftHandle;  
char Buf[64];  
  
ftStatus = FT_ListDevices(0, Buf, FT_LIST_BY_INDEX | FT_OPEN_BY_DESCRIPTION);  
ftHandle = FT_W32_CreateFile (Buf, GENERIC_READ | GENERIC_WRITE, 0, 0,  
                             OPEN_EXISTING,  
                             FILE_ATTRIBUTE_NORMAL | FT_OPEN_BY_DESCRIPTION,  
                             0);  
if (ftHandle == INVALID_HANDLE_VALUE) {  
    // FT_W32_CreateDevice failed  
}  
else {  
    // FT_W32_CreateFile OK, so do some work, and eventually ...  
    FT_W32_CloseHandle(ftHandle);  
}
```

6.3 FT_W32_ReadFile

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Read data from the device.

Definition

BOOL **FT_W32_ReadFile** (FT_HANDLE *ftHandle*, LPVOID *lpBuffer*, DWORD *dwBytesToRead*, LPDWORD *lpdwBytesReturned*, LPOVERLAPPED *lpOverlapped*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpBuffer</i>	Pointer to a buffer that receives the data from the device.
<i>dwBytesToRead</i>	Number of bytes to read from the device.
<i>lpdwBytesReturned</i> the device.	Pointer to a variable that receives the number of bytes read from
<i>lpOverlapped</i>	Pointer to an overlapped structure.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

This function supports both non-overlapped and overlapped I/O, except under Linux, Mac OS X and Windows CE where only non-overlapped IO is supported.

Non-overlapped I/O

The parameter, *lpOverlapped*, must be NULL for non-overlapped I/O.

This function always returns the number of bytes read in *lpdwBytesReturned*.

This function does not return until *dwBytesToRead* have been read into the buffer. The number of bytes in the receive queue can be determined by calling [FT_GetStatus](#) or [FT_GetQueueStatus](#), and passed as *dwBytesToRead* so that the function reads the device and returns immediately.

When a read timeout has been setup in a previous call to [FT_W32_SetCommTimeouts](#), this function returns when the timer expires or *dwBytesToRead* have been read, whichever occurs first. If a timeout occurred, any available data is read into *lpBuffer* and the function returns a non-zero value.

An application should use the function return value and *lpdwBytesReturned* when processing the buffer. If the return value is non-zero and *lpdwBytesReturned* is equal to *dwBytesToRead* then the function has completed normally. If the return value is non-zero and *lpdwBytesReturned* is less than *dwBytesToRead* then a timeout has occurred, and the read request has been partially completed. Note that if a timeout occurred and no data was read, the return value is still non-zero.

A return value of *FT_IO_ERROR* suggests an error in the parameters of the function, or a fatal error like USB disconnect has occurred.

Overlapped I/O

When the device has been opened for overlapped I/O, an application can issue a request and perform some additional work while the request is pending. This contrasts with the case of non-overlapped I/O in which the application issues a request and receives control again only after the request has been completed.

The parameter, *lpOverlapped*, must point to an initialized OVERLAPPED structure.

If there is enough data in the receive queue to satisfy the request, the request completes immediately and the return code is non-zero. The number of bytes read is returned in *lpdwBytesReturned*.

If there is not enough data in the receive queue to satisfy the request, the request completes immediately, and the return code is zero, signifying an error. An application should call [FT_W32_GetLastError](#) to get the cause of the error. If the error code is ERROR_IO_PENDING, the overlapped operation is still in progress, and the application can perform other processing. Eventually, the application checks the result of the overlapped request by calling [FT_W32_GetOverlappedResult](#).

If successful, the number of bytes read is returned in *lpdwBytesReturned*.

Example

1. This example shows how to read 256 bytes from the device using non-overlapped I/O.

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile for non-overlapped i/o
char Buf[256];
DWORD dwToRead = 256;
DWORD dwRead;

if (FT_W32_ReadFile(ftHandle, Buf, dwToRead, &dwRead, &osRead)) {
    if (dwToRead == dwRead) {
        // FT_W32_ReadFile OK
    }
    else {
        // FT_W32_ReadFile timeout
    }
}
else {
    // FT_W32_ReadFile failed
}
```

2. This example shows how to read 256 bytes from the device using overlapped I/O.

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile for overlapped i/o
char Buf[256];
DWORD dwToRead = 256;
DWORD dwRead;
OVERLAPPED osRead = { 0 };
osRead.hEvent = CreateEvent (NULL, FALSE, FALSE, NULL);

if (!FT_W32_ReadFile(ftHandle, Buf, dwToRead, &dwRead, &osRead)) {
    if (FT_W32_GetLastError(ftHandle) == ERROR_IO_PENDING) {
        // write is delayed so do some other stuff until ...
        if (!FT_W32_GetOverlappedResult(ftHandle, &osRead, &dwRead, FALSE)) {
            // error
        }
        else {
            if (dwToRead == dwRead) {
                // FT_W32_ReadFile OK
            }
            else {
                // FT_W32_ReadFile timeout
            }
        }
    }
}
else {
    // FT_W32_ReadFile OK
}
```

```
CloseHandle (osRead.hEvent);
```

6.4 FT_W32_WriteFile

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Write data to the device.

Definition

BOOL **FT_W32_WriteFile** (FT_HANDLE *ftHandle*, LPVOID *lpBuffer*, DWORD *dwBytesToWrite*, LPDWORD *lpdwBytesWritten*, LPOVERLAPPED *lpOverlapped*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpBuffer</i>	Pointer to the buffer that contains the data to write to the device.
<i>dwBytesToWrite</i>	Number of bytes to be written to the device.
<i>lpdwBytesWritten</i>	Pointer to a variable that receives the number of bytes written to the device.
<i>lpOverlapped</i>	Pointer to an overlapped structure.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

This function supports both non-overlapped and overlapped I/O, except under Linux, Mac OS X and Windows CE where only non-overlapped IO is supported.

Non-overlapped I/O

The parameter, *lpOverlapped*, must be NULL for non-overlapped I/O.

This function always returns the number of bytes written in *lpdwBytesWritten*.

This function does not return until *dwBytesToWrite* have been written to the device.

When a write timeout has been setup in a previous call to [FT_W32_SetCommTimeouts](#), this function returns when the timer expires or *dwBytesToWrite* have been written, whichever occurs first. If a timeout occurred, *lpdwBytesWritten* contains the number of bytes actually written, and the function returns a non-zero value.

An application should always use the function return value and *lpdwBytesWritten*. If the return value is non-zero and *lpdwBytesWritten* is equal to *dwBytesToWrite* then the function has completed normally. If the return value is non-zero and *lpdwBytesWritten* is less than *dwBytesToWrite* then a timeout has occurred, and the write request has been partially completed. Note that if a timeout occurred and no data was written, the return value is still non-zero.

Overlapped I/O

When the device has been opened for overlapped I/O, an application can issue a request and perform some additional work while the request is pending. This contrasts with the case of non-overlapped I/O in which the application issues a request and receives control again only after the request has been completed.

The parameter, *lpOverlapped*, must point to an initialized OVERLAPPED structure.

This function completes immediately, and the return code is zero, signifying an error. An application should call [FT_W32_GetLastError](#) to get the cause of the error. If the error code is ERROR_IO_PENDING, the overlapped operation is still in progress, and the application can perform other processing. Eventually, the application checks the result of the overlapped request by calling [FT_W32_GetOverlappedResult](#).

If successful, the number of bytes written is returned in *lpdwBytesWritten*.

Example

1. This example shows how to write 128 bytes to the device using non-overlapped I/O.

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile for overlapped i/o
char Buf[128]; // contains data to write to the device
DWORD dwToWrite = 128;
DWORD dwWritten;

if (FT_W32_WriteFile(ftHandle, Buf, dwToWrite, &dwWritten, &osWrite)) {
    if (dwToWrite == dwWritten){
        // FT_W32_WriteFile OK
    }
    else{
        // FT_W32_WriteFile timeout
    }
}
else{
    // FT_W32_WriteFile failed
}
```

2. This example shows how to write 128 bytes to the device using overlapped I/O.

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile for overlapped i/o
char Buf[128]; // contains data to write to the device
DWORD dwToWrite = 128;
DWORD dwWritten;
OVERLAPPED osWrite = { 0 };

if (!FT_W32_WriteFile(ftHandle, Buf, dwToWrite, &dwWritten, &osWrite)) {
    if (FT_W32_GetLastError(ftHandle) == ERROR_IO_PENDING) {
        // write is delayed so do some other stuff until ...
        if (!FT_W32_GetOverlappedResult(ftHandle, &osWrite, &dwWritten, FALSE)){
            // error
        }
        else {
            if (dwToWrite == dwWritten){
                // FT_W32_WriteFile OK
            }
            else{
                // FT_W32_WriteFile timeout
            }
        }
    }
}
```

```
        }  
    }  
    else {  
        // FT_W32_WriteFile OK  
    }  
}
```

6.5 FT_W32_GetOverlappedResult

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Gets the result of an overlapped operation.

Definition

BOOL **FT_W32_GetOverlappedResult** (FT_HANDLE *ftHandle*, LPOVERLAPPED *lpOverlapped*, LPDWORD *lpdwBytesTransferred*, BOOL *bWait*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpOverlapped</i>	Pointer to an overlapped structure.
<i>lpdwBytesTransferred</i>	Pointer to a variable that receives the number of bytes transferred during the overlapped operation.
<i>bWait</i>	Set to TRUE if the function does not return until the operation has been completed.

Return Value

If the function is successful, the return value is nonzero.
If the function is unsuccessful, the return value is zero.

Remarks

This function is used with overlapped I/O and so is not supported in Linux, Mac OS X or Windows CE. For a description of its use, see [FT_W32_ReadFile](#) and [FT_W32_WriteFile](#).

6.6 FT_W32_EscapeCommFunction

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
~~Windows (2000 and later)~~

Windows CE (4.2 and later)

Summary

Perform an extended function.

Definition

BOOL **FT_W32_EscapeCommFunction** (FT_HANDLE *ftHandle*, DWORD *dwFunc*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwFunc</i>	The extended function to perform can be one of the following values: - CLRDTR – Clear the DTR signal - CLRRTS – Clear the RTS signal - SETDTR – Set the DTR signal - SETRTS – Set the RTS signal - SETBREAK – Set the BREAK condition - CLRBREAK – Clear the BREAK condition

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile

FT_W32_EscapeCommFunction(ftHandle,CLRDTR); // Clear the DTR signal
FT_W32_EscapeCommFunction(ftHandle,SETRTS); // Set the RTS signal
```

6.7 FT_W32_GetCommModemStatus

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function gets the current modem control value.

Definition

BOOL **FT_W32_GetCommModemStatus** (FT_HANDLE *ftHandle*, LPDWORD *lpdwStat*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwStat</i>	Pointer to a variable to contain modem control value. The modem control value can be a combination of the following: MS_CTS_ON – Clear To Send (CTS) is on MS_DSR_ON – Data Set Ready (DSR) is on MS_RING_ON – Ring Indicator (RI) is on MS_RLSD_ON – Receive Line Signal Detect (RLSD) is on

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile DWORD dwStatus;  
  
if (FT_W32_GetCommModemStatus(ftHandle,&dwStatus)) {  
    // FT_W32_GetCommModemStatus ok  
    if (dwStatus & MS_CTS_ON)  
        ; // CTS is on  
    if (dwStatus & MS_DSR_ON)  
        ; // DSR is on  
    if (dwStatus & MS_RI_ON)  
        ; // RI is on  
    if (dwStatus & MS_RLSD_ON)  
        ; // RLSD is on  
}  
else  
    ; // FT_W32_GetCommModemStatus failed
```

6.8 FT_W32_SetupComm

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function sets the read and write buffers.

Definition

BOOL **FT_W32_SetupComm** (FT_HANDLE *ftHandle*, DWORD *dwReadBufferSize*,
DWORD *dwWriteBufferSize*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwReadBufferSize</i>	Length, in bytes, of the read buffer.
<i>dwWriteBufferSize</i>	Length, in bytes, of the write buffer.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

This function has no effect. It is the responsibility of the driver to allocate sufficient storage for I/O requests.

6.9 FT_W32_SetCommState

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function sets the state of the device according to the contents of a device control block (DCB).

Definition

BOOL **FT_W32_SetCommState** (FT_HANDLE *ftHandle*, LPFTDCB *lpftDcb*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpftDcb</i>	Pointer to an FTDCB structure.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile
FTDCB ftDCB;

if (FT_W32_GetCommState(ftHandle, &ftDCB)) {
    // FT_W32_GetCommState ok, device state is in ftDCB
    ftDCB.BaudRate = 921600; // Change the baud rate
}
```



```
if (FT_W32_SetCommState(ftHandle,&ftDCB))
    ; // FT_W32_SetCommState ok
else
    ; // FT_W32_SetCommState failed
}
else
    ; // FT_W32_GetCommState failed
```

6.10 FT_W32_GetCommState

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function gets the current device state.

Definition

BOOL **FT_W32_GetCommState** (FT_HANDLE *ftHandle*, LPFTDCB *lpftDcb*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpftDcb</i>	Pointer to an FTDCB structure.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

The current state of the device is returned in a device control block.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile
FTDCB ftDCB;

if (FT_W32_GetCommState(ftHandle,&ftDCB))
    ; // FT_W32_GetCommState ok, device state is in ftDCB
else
    ; // FT_W32_GetCommState failed
```

6.11 FT_W32_SetCommTimeouts

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

This function sets the timeout parameters for I/O requests.

Definition

BOOL **FT_W32_SetCommTimeouts** (FT_HANDLE *ftHandle*, LPFTTIMEOUTS *lpftTimeouts*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpftTimeouts</i>	Pointer to an FTTIMEOUTS structure to store timeout information.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

Timeouts are calculated using the information in the FTTIMEOUTS structure.

For read requests, the number of bytes to be read is multiplied by the total timeout multiplier, and added to the total timeout constant. So, if TS is an FTTIMEOUTS structure and the number of bytes to read is *dwToRead*, the read timeout, *rdTO*, is calculated as follows.

$$rdTO = (dwToRead * TS.ReadTotalTimeoutMultiplier) + TS.ReadTotalTimeoutConstant$$

For write requests, the number of bytes to be written is multiplied by the total timeout multiplier, and added to the total timeout constant. So, if TS is an FTTIMEOUTS structure and the number of bytes to write is *dwToWrite*, the write timeout, *wrTO*, is calculated as follows.

$$wrTO = (dwToWrite * TS.WriteTotalTimeoutMultiplier) + TS.WriteTotalTimeoutConstant$$

Linux and Mac OS X currently ignore the *ReadIntervalTimeout*, *ReadTotalTimeoutMultiplier* and *WriteTotalTimeoutMultiplier*.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile
FTTIMEOUTS ftTS;

ftTS.ReadIntervalTimeout = 0;
ftTS.ReadTotalTimeoutMultiplier = 0;
ftTS.ReadTotalTimeoutConstant = 100;
ftTS.WriteTotalTimeoutMultiplier = 0;
ftTS.WriteTotalTimeoutConstant = 200;

if (FT_W32_SetCommTimeouts(ftHandle, &ftTS))
    ; // FT_W32_SetCommTimeouts OK
```

```
else  
    ; // FT_W32_SetCommTimeouts failed
```

6.12 FT_W32_GetCommTimeouts

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function gets the current read and write request timeout parameters for the specified device.

Definition

BOOL **FT_W32_GetCommTimeouts** (FT_HANDLE *ftHandle*, LPFTIMEOUTS *lpftTimeouts*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpftTimeouts</i>	Pointer to an FTIMEOUTS structure to store timeout information.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

For an explanation of how timeouts are used, see [FT_W32_SetCommTimeouts](#).

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile  
FTTIMEOUTS ftTS;  
  
if (FT_W32_GetCommTimeouts(ftHandle,&ftTS))  
    ; // FT_W32_GetCommTimeouts OK  
else  
    ; // FT_W32_GetCommTimeouts failed
```

6.13 FT_W32_SetCommBreak

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Puts the communications line in the BREAK state.

Definition

BOOL **FT_W32_SetCommBreak** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

If the function is successful, the return value is nonzero.
If the function is unsuccessful, the return value is zero.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile

if (!FT_W32_SetCommBreak(ftHandle))
    ; // FT_W32_SetCommBreak failed
else
    ; // FT_W32_SetCommBreak OK
```

6.14 FT_W32_ClearCommBreak

Supported Operating Systems

Linux
Mac OS X (10.4 and later)
Windows (2000 and later)
Windows CE (4.2 and later)

Summary

Puts the communications line in the non-BREAK state.

Definition

BOOL **FT_W32_ClearCommBreak** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile

if (!FT_W32_ClearCommBreak(ftHandle)){
    // FT_W32_ClearCommBreak failed
}
else{
    // FT_W32_ClearCommBreak OK
}
```

6.15 FT_W32_SetCommMask

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function specifies events that the device has to monitor.

Definition

BOOL **FT_W32_SetCommMask** (FT_HANDLE *ftHandle*, DWORD *dwMask*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>dwMask</i>	Mask containing events that the device has to monitor. This can be a combination of the following: - EV_BREAK – BREAK condition detected - EV_CTS – Change in Clear To Send (CTS) - EV_DSR – Change in Data Set Ready (DSR) - EV_ERR – Error in line status - EV_RING – Change in Ring Indicator (RI) - EV_RLSD – Change in Receive Line Signal Detect (RLSD) - EV_RXCHAR – Character received - EV_RXFLAG – Event character received - EV_TXEMPTY – Transmitter empty

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

This function specifies the events that the device should monitor. An application can call the function [FT_W32_WaitCommEvent](#) to wait for an event to occur.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile
DWORD dwMask = EV_CTS | EV_DSR;

if (!FT_W32_SetCommMask(ftHandle, dwMask))
    ; // FT_W32_SetCommMask failed
else
    ; // FT_W32_SetCommMask OK
```

6.16 FT_W32_GetCommMask

Supported Operating Systems

Windows (2000 and later)

Summary

Retrieves the events that are currently being monitored by a device.

Definition

BOOL **FT_W32_GetCommMask** (FT_HANDLE *ftHandle*, LPDWORD *lpdwEventMask*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwEventMask</i>	Pointer to a location that receives a mask that contains the events that are currently enabled. This parameter can be one or more of the following values: - EV_BREAK – BREAK condition detected - EV_CTS – Change in Clear To Send (CTS) - EV_DSR – Change in Data Set Ready (DSR) - EV_ERR – Error in line status - EV_RING – Change in Ring Indicator (RI) - EV_RLSD – Change in Receive Line Signal Detect (RLSD) - EV_RXCHAR – Character received - EV_RXFLAG – Event character received - EV_TXEMPTY – Transmitter empty

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

This function returns events currently being monitored by the device. Event monitoring for these events is enabled by the [FT_W32_SetCommMask](#) function.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile
DWORD dwMask;

if (!FT_W32_GetCommMask(ftHandle, &dwMask))
    ; // FT_W32_GetCommMask failed
else
    ; // FT_W32_GetCommMask OK
```

6.17 FT_W32_WaitCommEvent

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function waits for an event to occur.

Definition

BOOL **FT_W32_SetupComm** (FT_HANDLE *ftHandle*, LPDWORD *lpdwEvent*,
LPOVERLAPPED *lpOverlapped*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwEvent</i>	Pointer to a location that receives a mask that contains the events that occurred.
<i>lpOverlapped</i>	Pointer to an overlapped structure.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

This function supports both non-overlapped and overlapped I/O, except under Windows CE and Linux where only non-overlapped I/O is supported.

Non-overlapped I/O

The parameter, *lpOverlapped*, must be NULL for non-overlapped I/O.

This function does not return until an event that has been specified in a call to [FT_W32_SetCommMask](#) has occurred. The events that occurred and resulted in this function returning are stored in *lpdwEvent*.

Overlapped I/O

When the device has been opened for overlapped I/O, an application can issue a request and perform some additional work while the request is pending. This contrasts with the case of non-overlapped I/O in which the application issues a request and receives control again only after the request has been completed.

The parameter, *lpOverlapped*, must point to an initialized OVERLAPPED structure.

This function does not return until an event that has been specified in a call to [FT_W32_SetCommMask](#) has occurred.

If an event has already occurred, the request completes immediately, and the return code is non-zero. The events that occurred are stored in *lpdwEvent*.

If an event has not yet occurred, the request completes immediately, and the return code is zero, signifying an error. An application should call [FT_W32_GetLastError](#) to get the cause of the error. If the error code is ERROR_IO_PENDING, the overlapped operation is still in progress, and the application can perform other processing. Eventually, the application checks the result of the overlapped request by calling [FT_W32_GetOverlappedResult](#). The events that occurred and resulted in this function returning are stored in *lpdwEvent*.

Examples

1. This example shows how to write 128 bytes to the device using non-overlapped I/O.

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile for non-overlapped i/o
DWORD dwEvents;

if (FT_W32_WaitCommEvent(ftHandle, &dwEvents, NULL))
    ; // FT_W32_WaitCommEvents OK
else
    ; // FT_W32_WaitCommEvents failed
```

2. This example shows how to write 128 bytes to the device using overlapped I/O.

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile for overlapped i/o
DWORD dwEvents;
DWORD dwRes;
OVERLAPPED osWait = { 0 };

if (!FT_W32_WaitCommEvent(ftHandle, &dwEvents, &osWait)) {
    if (FT_W32_GetLastError(ftHandle) == ERROR_IO_PENDING) {
        // wait is delayed so do some other stuff until ...
        if (!FT_W32_GetOverlappedResult(ftHandle, &osWait, &dwRes, FALSE))
            ; // error
        else
            ; // FT_W32_WaitCommEvent OK
            // Events that occurred are stored in dwEvents
    }
}
else {
    // FT_W32_WaitCommEvent OK
    // Events that occurred are stored in dwEvents
}
```


6.18 FT_W32_PurgeComm

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

This function purges the device.

Definition

BOOL **FT_W32_PurgeComm** (FT_HANDLE *ftHandle*, DWORD *dwFlags*)

Parameters

ftHandle

Handle of the device.

dwFlags

Specifies the action to take. The action can be a combination of the following:

PURGE_TXABORT – Terminate outstanding overlapped writes

PURGE_RXABORT – Terminate outstanding overlapped reads

PURGE_TXCLEAR – Clear the transmit buffer

PURGE_RXCLEAR – Clear the receive buffer

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Example

```
FT_HANDLE ftHandle; // setup by FT_W32_CreateFile

if (FT_W32_PurgeComm(ftHandle, PURGE_TXCLEAR|PURGE_RXCLEAR))
    ; // FT_W32_PurgeComm OK
else
    ; // FT_W32_PurgeComm failed
```

6.19 FT_W32_GetLastError

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Gets the last error that occurred on the device.

Definition

DWORD **FT_W32_GetLastError** (FT_HANDLE *ftHandle*)

Parameters

ftHandle Handle of the device.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Remarks

This function is normally used with overlapped I/O and so is not supported in Windows CE. For a description of its use, see [FT_W32_ReadFile](#) and [FT_W32_WriteFile](#).

In Linux and Mac OS X, this function returns a DWORD that directly maps to the FT Errors (for example the FT_INVALID_HANDLE error number).

6.20 FT_W32_ClearCommError

Supported Operating Systems

Linux

Mac OS X (10.4 and later)

Windows (2000 and later)

Windows CE (4.2 and later)

Summary

Gets information about a communications error and get current status of the device.

Definition

BOOL **FT_W32_ClearCommError** (FT_HANDLE *ftHandle*, LPDWORD *lpdwErrors*, LPFTCOMSTAT *lpftComstat*)

Parameters

<i>ftHandle</i>	Handle of the device.
<i>lpdwErrors</i>	Variable that contains the error mask.
<i>lpftComstat</i>	Pointer to FTCOMSTAT structure.

Return Value

If the function is successful, the return value is nonzero.

If the function is unsuccessful, the return value is zero.

Example

```
static COMSTAT oldCS = {0};
static DWORD dwOldErrors = 0;

FT_HANDLE ftHandle; // setup by FT_W32_CreateFile
COMSTAT newCS;
DWORD dwErrors;
BOOL bChanged = FALSE;

if (!FT_W32_ClearCommError(ftHandle, &dwErrors, (FTCOMSTAT *)&newCS))
    ; // FT_W32_ClearCommError failed

if (dwErrors != dwOldErrors) {
    bChanged = TRUE;
    dwErrorsOld = dwErrors;
}

if (memcmp(&oldCS, &newCS, sizeof(FTCOMSTAT))) {
    bChanged = TRUE;
    oldCS = newCS;
}

if (bChanged) {
    if (dwErrors & CE_BREAK)
        ; // BREAK condition detected
    if (dwErrors & CE_FRAME)
        ; // Framing error detected
    if (dwErrors & CE_RXOVER)
        ; // Receive buffer has overflowed
    if (dwErrors & CE_TXFULL)
        ; // Transmit buffer full
    if (dwErrors & CE_OVERRUN)
        ; // Character buffer overrun
    if (dwErrors & CE_RXPARITY)
        ; // Parity error detected
    if (newCS.fCtsHold)
        ; // Transmitter waiting for CTS
    if (newCS.fDsrHold)
        ; // Transmitter is waiting for DSR
    if (newCS.fRltdHold)
        ; // Transmitter is waiting for RLSD
    if (newCS.fXoffHold)
        ; // Transmitter is waiting because XOFF was received
```

```
    if (newCS.fXoffSent)
        ; //
    if (newCS.fEof)
        ; // End of file character has been received
    if (newCS.fTxim)
        ; // Tx immediate character queued for transmission
    // newCS.cbInQue contains number of bytes in receive queue
    // newCS.cbOutQue contains number of bytes in transmit queue
}
```

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8 Appendix A - Type Definitions

UCHAR Unsigned char (1 byte)
e)
PUCHAR Pointer to unsigned char (4 bytes)
PCHAR Pointer to char (4 bytes)
DWORD Unsigned long (4 bytes)
LPDWORD Pointer to unsigned long (4 bytes)
FT_HANDLE DWORD

FT_STATUS (DWORD)

FT_OK = 0
FT_INVALID_HANDLE = 1
FT_DEVICE_NOT_FOUND = 2
FT_DEVICE_NOT_OPENED = 3
FT_IO_ERROR = 4
FT_INSUFFICIENT_RESOURCES = 5
FT_INVALID_PARAMETER = 6
FT_INVALID_BAUD_RATE = 7
FT_DEVICE_NOT_OPENED_FOR_ERASE = 8
FT_DEVICE_NOT_OPENED_FOR_WRITE = 9
FT_FAILED_TO_WRITE_DEVICE = 10
FT_EEPROM_READ_FAILED = 11
FT_EEPROM_WRITE_FAILED = 12
FT_EEPROM_ERASE_FAILED = 13
FT_EEPROM_NOT_PRESENT = 14
FT_EEPROM_NOT_PROGRAMMED = 15
FT_INVALID_ARGS = 16
FT_NOT_SUPPORTED = 17
FT_OTHER_ERROR = 18

Flags (see FT_ListDevices)

FT_LIST_NUMBER_ONLY = 0x80000000
FT_LIST_BY_INDEX = 0x40000000
FT_LIST_ALL = 0x20000000

Flags (see FT_OpenEx)

FT_OPEN_BY_SERIAL_NUMBER = 1
FT_OPEN_BY_DESCRIPTION = 2
FT_OPEN_BY_LOCATION = 4

FT_DEVICE (DWORD)

FT_DEVICE_232BM = 0
FT_DEVICE_232AM = 1
FT_DEVICE_100AX = 2
FT_DEVICE_UNKNOWN = 3
FT_DEVICE_2232C = 4
FT_DEVICE_232R = 5
FT_DEVICE_2232H = 6
FT_DEVICE_4232H = 7
FT_DEVICE_232H = 8

Word Length (see FT_SetDataCharacteristics)

FT_BITS_8 = 8
FT_BITS_7 = 7

Stop Bits (see FT_SetDataCharacteristics)

FT_STOP_BITS_1 = 0

FT_STOP_BITS_2 = 2

Parity (see FT_SetDataCharacteristics)

FT_PARITY_NONE = 0
FT_PARITY_ODD = 1
FT_PARITY_EVEN = 2
FT_PARITY_MARK = 3
FT_PARITY_SPACE = 4

Flow Control (see FT_SetFlowControl)

FT_FLOW_NONE = 0x0000
FT_FLOW_RTS_CTS = 0x0100
FT_FLOW_DTR_DSR = 0x0200
FT_FLOW_XON_XOFF = 0x0400

Purge RX and TX Buffers (see FT_Purge)

FT_PURGE_RX = 1
FT_PURGE_TX = 2

Notification Events (see FT_SetEventNotification)

FT_EVENT_RXCHAR = 1
FT_EVENT_MODEM_STATUS = 2
FT_EVENT_LINE_STATUS = 4

Modem Status (see

FT_GetModemStatus)

CTS = 0x10
DSR = 0x20
RI = 0x40
DCD = 0x80

Line Status (see

FT_GetModemStatus)

OE = 0x02
PE = 0x04
FE = 0x08
BI = 0x10

Bit Modes (see FT_SetBitMode)

FT_BITMODE_RESET = 0x00
FT_BITMODE_ASYNC_BITBANG = 0x01
FT_BITMODE_MPSSE = 0x02
FT_BITMODE_SYNC_BITBANG = 0x04
FT_BITMODE_MCU_HOST = 0x08
FT_BITMODE_FAST_SERIAL = 0x10
FT_BITMODE_CBUS_BITBANG = 0x20
FT_BITMODE_SYNC_FIFO = 0x40

FT232R CBUS EEPROM OPTIONS - Ignored for FT245R (see FT_EE_Program and FT_EE_Read)

FT_232R_CBUS_TXDEN = 0x00


```
FT_232R_CBUS_PWRON = 0x01
FT_232R_CBUS_RXLED = 0x02
FT_232R_CBUS_TXLED = 0x03
FT_232R_CBUS_TXRXLED = 0x04
FT_232R_CBUS_SLEEP = 0x05
FT_232R_CBUS_CLK48 = 0x06
FT_232R_CBUS_CLK24 = 0x07
FT_232R_CBUS_CLK12 = 0x08
FT_232R_CBUS_CLK6 = 0x09
FT_232R_CBUS_IOMODE = 0x0A
FT_232R_CBUS_BITBANG_WR = 0x0B
FT_232R_CBUS_BITBANG_RD = 0x0C
```

FT232H CBUS EEPROM OPTIONS (see FT_EE_Program and FT_EE_Read)

```
FT_232H_CBUS_TRISTATE = 0x00
FT_232H_CBUS_RXLED = 0x01
FT_232H_CBUS_TXLED = 0x02
FT_232H_CBUS_TXRXLED = 0x03
FT_232H_CBUS_PWREN = 0x04
FT_232H_CBUS_SLEEP = 0x05
FT_232H_CBUS_DRIVE_0 = 0x06
FT_232H_CBUS_DRIVE_1 = 0x07
FT_232H_CBUS_IOMODE = 0x08
FT_232H_CBUS_TXDEN = 0x09
FT_232H_CBUS_CLK30 = 0x0A
FT_232H_CBUS_CLK15 = 0x0B
FT_232H_CBUS_CLK7_5 = 0x0C
```

FT_DEVICE_LIST_INFO_NODE (see FT_GetDeviceInfoList and FT_GetDeviceInfoDetail)

```
typedef struct _ft_device_list_info_node {
    DWORD Flags;
    DWORD Type;
    DWORD ID;
    DWORD LocId;
    char SerialNumber[16];
    char Description[64];
    FT_HANDLE ftHandle;
} FT_DEVICE_LIST_INFO_NODE;
```

FT_FLAGS (see [FT_DEVICE_LIST_INFO_NODE](#))

```
FT_FLAGS_OPENED = 0x00000001
```

FT_PROGRAM_DATA_STRUCTURE

```
typedef struct ft_program_data {
    DWORD Signature1;           // Header - must be 0x00000000
    DWORD Signature2;           // Header - must be 0xffffffff
    DWORD Version;              // Header - FT_PROGRAM_DATA version
                                // 0 = original (FT232B)
                                // 1 = FT2232 extensions
                                // 2 = FT232R extensions
                                // 3 = FT2232H extensions
                                // 4 = FT4232H extensions
                                // 5 = FT232H extensions
    WORD VendorId;              // 0x0403
    WORD ProductId;             // 0x6001
    char *Manufacturer;         // "FTDI"
    char *ManufacturerId;       // "FT"
    char *Description;          // "USB HS Serial Converter"
    char *SerialNumber;         // "FT000001" if fixed, or NULL
    WORD MaxPower;              // 0 <= MaxPower <= 500
}
```

```
WORD PnP;                // 0 = disabled, 1 = enabled
WORD SelfPowered;        // 0 = bus powered, 1 = self powered
WORD RemoteWakeup;       // 0 = not capable, 1 = capable
//
// Rev4 (FT232B) extensions
//
UCHAR Rev4;              // non-zero if Rev4 chip, zero otherwise
UCHAR IsoIn;             // non-zero if in endpoint is isochronous
UCHAR IsoOut;            // non-zero if out endpoint is isochronous
UCHAR PullDownEnable;    // non-zero if pull down enabled
UCHAR SerNumEnable;      // non-zero if serial number to be used
UCHAR USBVersionEnable;  // non-zero if chip uses USBVersion
WORD USBVersion;         // BCD (0x0200 => USB2)
//
// Rev 5 (FT2232) extensions
//
UCHAR Rev5;              // non-zero if Rev5 chip, zero otherwise
UCHAR IsoInA;            // non-zero if in endpoint is isochronous
UCHAR IsoInB;            // non-zero if in endpoint is isochronous
UCHAR IsoOutA;           // non-zero if out endpoint is isochronous
UCHAR IsoOutB;           // non-zero if out endpoint is isochronous
UCHAR PullDownEnable5;   // non-zero if pull down enabled
UCHAR SerNumEnable5;     // non-zero if serial number to be used
UCHAR USBVersionEnable5; // non-zero if chip uses USBVersion
WORD USBVersion5;        // BCD (0x0200 => USB2)
UCHAR AIsHighCurrent;    // non-zero if interface is high current
UCHAR BIsHighCurrent;    // non-zero if interface is high current
UCHAR IFAIsFifo;         // non-zero if interface is 245 FIFO
UCHAR IFAIsFifoTar;      // non-zero if interface is 245 FIFO CPU target
UCHAR IFAIsFastSer;      // non-zero if interface is Fast serial
UCHAR AIsVCP;            // non-zero if interface is to use VCP drivers
UCHAR IFBIsFifo;         // non-zero if interface is 245 FIFO
UCHAR IFBIsFifoTar;      // non-zero if interface is 245 FIFO CPU target
UCHAR IFBIsFastSer;      // non-zero if interface is Fast serial
UCHAR BIsVCP;            // non-zero if interface is to use VCP drivers
//
// Rev 6 (FT232R) extensions
//
UCHAR UseExtOsc;          // Use External Oscillator
UCHAR HighDriveIOs;       // High Drive I/Os
UCHAR EndpointSize;      // Endpoint size
UCHAR PullDownEnableR;    // non-zero if pull down enabled
UCHAR SerNumEnableR;      // non-zero if serial number to be used
UCHAR InvertTXD;          // non-zero if invert TXD
UCHAR InvertRXD;          // non-zero if invert RXD
UCHAR InvertRTS;          // non-zero if invert RTS
UCHAR InvertCTS;          // non-zero if invert CTS
UCHAR InvertDTR;          // non-zero if invert DTR
UCHAR InvertDSR;          // non-zero if invert DSR
UCHAR InvertDCD;          // non-zero if invert DCD
UCHAR InvertRI;           // non-zero if invert RI
UCHAR Cbus0;              // Cbus Mux control
UCHAR Cbus1;              // Cbus Mux control
UCHAR Cbus2;              // Cbus Mux control
UCHAR Cbus3;              // Cbus Mux control
UCHAR Cbus4;              // Cbus Mux control
UCHAR RIsD2XX;            // non-zero if using D2XX driver
//
// Rev 7 (FT2232H) Extensions
//
UCHAR PullDownEnable7;    // non-zero if pull down enabled
UCHAR SerNumEnable7;      // non-zero if serial number to be used
UCHAR ALSlowSlew;         // non-zero if AL pins have slow slew
```

```
UCHAR ALSchmittInput;    // non-zero if AL pins are Schmitt input
UCHAR ALDriveCurrent;    // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR AHSlew;            // non-zero if AH pins have slow slew
UCHAR AHSchmittInput;    // non-zero if AH pins are Schmitt input
UCHAR AHDriveCurrent;    // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR BLSlew;            // non-zero if BL pins have slow slew
UCHAR BLSchmittInput;    // non-zero if BL pins are Schmitt input
UCHAR BLDriveCurrent;    // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR BHSlew;            // non-zero if BH pins have slow slew
UCHAR BHSchmittInput;    // non-zero if BH pins are Schmitt input
UCHAR BHDriveCurrent;    // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR IFAIsFifo7;        // non-zero if interface is 245 FIFO
UCHAR IFAIsFifoTar7;     // non-zero if interface is 245 FIFO CPU target
UCHAR IFAIsFastSer7;     // non-zero if interface is Fast serial
UCHAR AIsVCP7;           // non-zero if interface is to use VCP drivers
UCHAR IFBIsFifo7;        // non-zero if interface is 245 FIFO
UCHAR IFBIsFifoTar7;     // non-zero if interface is 245 FIFO CPU target
UCHAR IFBIsFastSer7;     // non-zero if interface is Fast serial
UCHAR BIsVCP7;           // non-zero if interface is to use VCP drivers
UCHAR PowerSaveEnable;   // non-zero if using BCBUS7 to save power for self-powered
```

designs

```
//
// Rev 8 (FT4232H) Extensions
//
UCHAR PullDownEnable8;   // non-zero if pull down enabled
UCHAR SerNumEnable8;     // non-zero if serial number to be used
UCHAR ASlew;             // non-zero if AL pins have slow slew
UCHAR ASchmittInput;     // non-zero if AL pins are Schmitt input
UCHAR ADriveCurrent;     // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR BSlew;             // non-zero if AH pins have slow slew
UCHAR BSchmittInput;     // non-zero if AH pins are Schmitt input
UCHAR BDriveCurrent;     // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR CSlew;             // non-zero if BL pins have slow slew
UCHAR CSchmittInput;     // non-zero if BL pins are Schmitt input
UCHAR CDriveCurrent;     // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR DSlew;             // non-zero if BH pins have slow slew
UCHAR DSchmittInput;     // non-zero if BH pins are Schmitt input
UCHAR DDriveCurrent;     // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR ARIIsTXDEN;        // non-zero if port A uses RI as RS485 TXDEN
UCHAR BRIIsTXDEN;        // non-zero if port B uses RI as RS485 TXDEN
UCHAR CRIIsTXDEN;        // non-zero if port C uses RI as RS485 TXDEN
UCHAR DRIIsTXDEN;        // non-zero if port D uses RI as RS485 TXDEN
UCHAR AIsVCP8;           // non-zero if interface is to use VCP drivers
UCHAR BIsVCP8;           // non-zero if interface is to use VCP drivers
UCHAR CIsVCP8;           // non-zero if interface is to use VCP drivers
UCHAR DIsVCP8;           // non-zero if interface is to use VCP drivers
//
// Rev 9 (FT232H) Extensions
//
UCHAR PullDownEnableH;   // non-zero if pull down enabled
UCHAR SerNumEnableH;     // non-zero if serial number to be used
UCHAR ACSlew;            // non-zero if AC pins have slow slew
UCHAR ACSchmittInputH;   // non-zero if AC pins are Schmitt input
UCHAR ACDriveCurrentH;   // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR ADSlew;            // non-zero if AD pins have slow slew
UCHAR ADSchmittInputH;   // non-zero if AD pins are Schmitt input
UCHAR ADDriveCurrentH;   // valid values are 4mA, 8mA, 12mA, 16mA
UCHAR Cbus0H;            // Cbus Mux control
UCHAR Cbus1H;            // Cbus Mux control
UCHAR Cbus2H;            // Cbus Mux control
UCHAR Cbus3H;            // Cbus Mux control
UCHAR Cbus4H;            // Cbus Mux control
UCHAR Cbus5H;            // Cbus Mux control
```

```

    UCHAR Cbus6H;           // Cbus Mux control
    UCHAR Cbus7H;           // Cbus Mux control
    UCHAR Cbus8H;           // Cbus Mux control
    UCHAR Cbus9H;           // Cbus Mux control
    UCHAR IsFifoH;          // non-zero if interface is 245 FIFO
    UCHAR IsFifoTarH;       // non-zero if interface is 245 FIFO CPU target
    UCHAR IsFastSerH;       // non-zero if interface is Fast serial
    UCHAR IsFT1248H;        // non-zero if interface is FT1248
    UCHAR FT1248CpolH;      // FT1248 clock polarity - clock idle high (1) or clock idle low (0)
    UCHAR FT1248LsbH;       // FT1248 data is LSB (1) or MSB (0)
    UCHAR FT1248FlowControlH; // FT1248 flow control enable
    UCHAR IsVCPH;           // non-zero if interface is to use VCP drivers
    UCHAR PowerSaveEnableH; // non-zero if using ACBUS7 to save power for self-powered

```

designs

```

} FT_PROGRAM_DATA, *PFT_PROGRAM_DATA;

```

Win32

```

OPEN_EXISTING = 3
FILE_ATTRIBUTE_NORMAL = 0x00000080
FILE_FLAG_OVERLAPPED = 0x40000000
GENERIC_READ = 0x80000000
GENERIC_WRITE = 0x40000000

```

```

OVERLAPPED structure
typedef struct _OVERLAPPED {
    ULONG_PTR Internal;
    ULONG_PTR InternalHigh;
    union {
        struct {
            DWORD Offset;
            DWORD OffsetHigh;
        };
        PVOID Pointer;
    };
    HANDLE hEvent;
} OVERLAPPED, *LPOVERLAPPED;

```

```

CLRDRTR = 6 - Clear the DTR signal
CLRRTS = 4 - Clear the RTS signal
SETDRTR = 5 - Set the DTR signal
SETRTS = 3 - Set the RTS signal
SETBREAK = 8 - Set the BREAK condition
CLRBREAK = 9 - Clear the BREAK condition

```

```

MS_CTS_ON = 0x0010 - Clear To Send (CTS) is on
MS_DSR_ON = 0x0020 - Data Set Ready (DSR) is on
MS_RING_ON = 0x0040 - Ring Indicator (RI) is on
MS_RLSD_ON = 0x0080 - Receive Line Signal Detect (RLSD) is on

```

```

FTDCB structure
typedef struct _FTDCB {
    DWORD DCBlength; // sizeof(FTDCB)
    DWORD BaudRate; // Baud rate at which running
    DWORD fBinary: 1; // Binary Mode (skip EOF check)
    DWORD fParity: 1; // Enable parity checking

```

```
DWORD fOutxCtsFlow:1; // CTS handshaking on output
DWORD fOutxDsrFlow:1; // DSR handshaking on output
DWORD fDtrControl:2; // DTR Flow control
DWORD fDsrSensitivity:1; // DSR Sensitivity
DWORD fTXContinueOnXoff: 1; // Continue TX when Xoff sent
DWORD fOutX: 1; // Enable output X-ON/X-OFF
DWORD fInX: 1; // Enable input X-ON/X-OFF
DWORD fErrorChar: 1; // Enable Err Replacement
DWORD fNull: 1; // Enable Null stripping
DWORD fRtsControl:2; // Rts Flow control
DWORD fAbortOnError:1; // Abort all reads and writes on Error
DWORD fDummy2:17; // Reserved
WORD wReserved; // Not currently used
WORD XonLim; // Transmit X-ON threshold
WORD XoffLim; // Transmit X-OFF threshold
BYTE ByteSize; // Number of bits/byte, 7-8
BYTE Parity; // 0-4=None,Odd,Even,Mark,Space
BYTE StopBits; // 0,2 = 1, 2
char XonChar; // Tx and Rx X-ON character
char XoffChar; // Tx and Rx X-OFF character
char ErrorChar; // Error replacement char
char EofChar; // End of Input character
char EvtChar; // Received Event character
WORD wReserved1; // Fill
} FTDCB, *LPFTDCB;

FTTIMEOUTS structure
typedef struct _FTTIMEOUTS {
    DWORD ReadIntervalTimeout; // Maximum time between read chars
    DWORD ReadTotalTimeoutMultiplier; // Multiplier of characters
    DWORD ReadTotalTimeoutConstant; // Constant in milliseconds
    DWORD WriteTotalTimeoutMultiplier; // Multiplier of characters
    DWORD WriteTotalTimeoutConstant; // Constant in milliseconds
} FTTIMEOUTS, *LPFTTIMEOUTS;

EV_BREAK = 0x0040 - BREAK condition detected
EV_CTS = 0x0008 - Change in Clear To Send (CTS)
EV_DSR = 0x0010 - Change in Data Set Ready (DSR)
EV_ERR = 0x0080 - Error in line status
EV_RING = 0x0100 - Change in Ring Indicator (RI)
EV_RLSD = 0x0020 - Change in Receive Line Signal Detect (RLSD)
EV_RXCHAR = 0x0001 - Character received
EV_RXFLAG = 0x0002 - Event character received
EV_TXEMPTY = 0x0004 - Transmitter empty

PURGE_TXABORT = 0x0001 - Terminate outstanding overlapped writes
PURGE_RXABORT = 0x0002 - Terminate outstanding overlapped reads
PURGE_TXCLEAR = 0x0004 - Clear the transmit buffer
PURGE_RXCLEAR = 0x0008 - Clear the receive buffer
```

```
FTCOMSTAT structure
typedef struct _FTCOMSTAT {
    DWORD fCtsHold : 1;
    DWORD fDsrHold : 1;
    DWORD fRlsdHold : 1;
    DWORD fXoffHold : 1;
    DWORD fXoffSent : 1;
    DWORD fEof : 1;
    DWORD fTxim : 1;
    DWORD fReserved : 25;
```

```
DWORD cbInQue;  
    DWORD cbOutQue;  
} FTCOMSTAT, *LPFTCOMSTAT;
```

9 Appendix B - Revision History

Revision History

Revision History

Version 1.00	Initial release in new format. Includes all functions in CDM driver 2.04.06	August, 2008
Version 1.01	Includes FT4232H and FT2232H. Updated addresses	January, 2009
Version 1.02	Page 65 – removed FT232R and FT245R reference from MCU host emulation and Fast Opto modes	January, 2010
Version 1.03	Corrected section 3.32 (FT_Purge) Updated Contact details	8th September 2010
Version 1.04	Added 245 Synchronous FIFO mode code in section 5.3	28th October 2010
Version 1.1	Corrected previous editing errors to the document by re-adding FT4232H and FT2232H extensions	4th November 2010
Version 1.2	Added references to FT232H including EEPROM format. Numerous formatting fixes. Expanded definitions in appendix to reflect updates in CDM 2.08.14 header file.	25 th April 2011

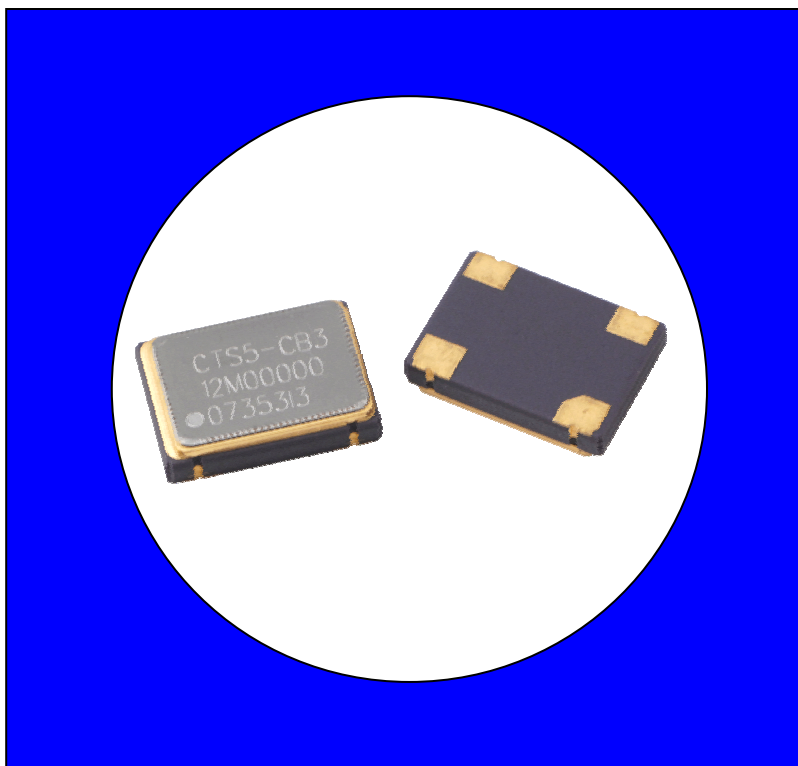


FEATURES

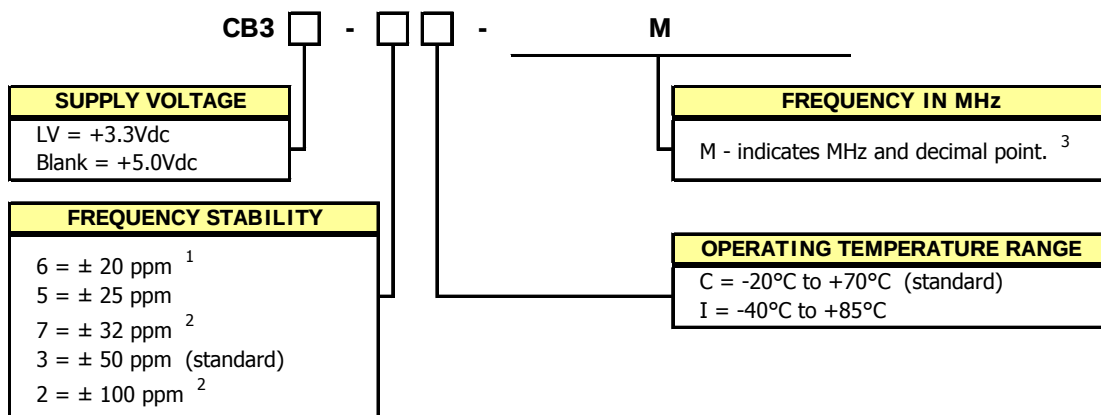
- Standard 7.0x5.0mm Surface Mount Footprint
- HCMOS/TTL Compatible
- **Fundamental and 3RD Overtone Crystals**
- Frequency Range 1.5 – 160 MHz
- Frequency Stability, ± 50 ppm Standard (± 25 ppm and ± 20 ppm available)
- +3.3Vdc or +5.0Vdc Operation
- Operating Temperature to -40°C to $+85^{\circ}\text{C}$
- Output Enable Standard
- Tape & Reel Packaging
- **RoHS/Green Compliant (6/6)**

DESCRIPTION

The CB3/CB3LV is a ceramic packaged Clock oscillator offering reduced size and enhanced stability. The small size means it is perfect for any application. The enhanced stability means it is the perfect choice for today's communications applications that require tight frequency control.



ORDERING INFORMATION



1] 6I Stability/Temperature combination is not available.

2] These stabilities are not recommended for new designs.

3] Frequency is recorded with only leading significant digits before the 'M' and 4 - 6 significant digits after the 'M' (including zeros).

[Ex. XMXXXXXX (3M579545), XXMXXXXX (14M31818), XXXMXXXX (125M0000)]

4] CTS Distributors may add a -T or -1 at the end of the part number to indicate Tape and Reel packaging.

**Not all performance combinations and frequencies may be available.
Contact your local CTS Representative or CTS Customer Service for availability.**

Example Part Number: CB3LV-3C-32M7680 or CB3-3I-32M7680

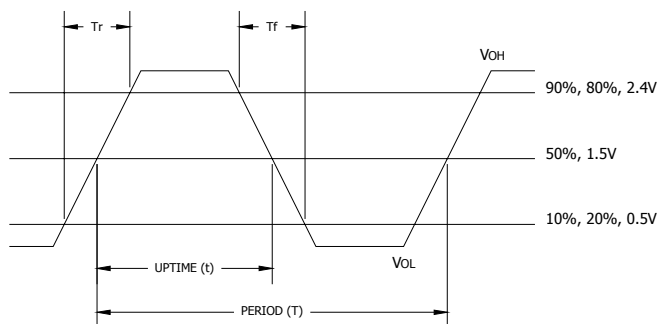
ELECTRICAL CHARACTERISTICS

	PARAMETER	SYMBOL	CONDITIONS	MIN	TYP	MAX	UNIT
Absolute Maximums	Maximum Supply Voltage	V_{CC}	-	-0.5	-	7.0	V
	Storage Temperature	T_{STG}	-	-55	-	125	°C
	Frequency Range	f_0	-	1.5	-	107	MHz
	CB3		-	1.5	-	160	
	Frequency Stability	$\Delta f/f_0$	See Note 1 and Ordering Information	-	-	20, 25 or 50	± ppm
	Aging	Δf	First year	-	3	5	± ppm
Electrical and Waveform Parameters	Operating Temperature	T_A	-	-20	25	70	°C
	Commercial			-40		85	
	Industrial						
	Supply Voltage	V_{CC}	± 10 %	4.5	5.0	5.5	V
	CB3			3.0	3.3	3.6	
	CB3LV						
	Supply Current	I_{CC}	Frequency Range, tested load condition noted for typical values.				
	CB3		1.5 MHz to 20 MHz $C_L=50pF$	-	10	25	
			20.1 MHz to 80 MHz $C_L=50pF$	-	30	50	
			80.1 MHz to 107 MHz $C_L=15pF$	-	40	80	
	CB3LV		1.5 MHz to 20 MHz $C_L=15pF$	-	7	12	
			20.1 MHz to 80 MHz $C_L=15pF$	-	20	40	
			80.1 MHz to 160 MHz $C_L=15pF$	-	30	60	
	Output Load	C_L	1.5 MHz to 50 MHz	-	-	50	
			50.1 MHz to 80 MHz	-	-	30	
			80.1 MHz to 160 MHz	-	-	15	
	Output Voltage Levels	V_{OH}	CMOS Load 10	0.9* V_{CC}	-	-	
	Logic '1' Level		TTL LOAD	$V_{CC}-0.6V$			
	Logic '0' Level	V_{OL}	CMOS	-	-	0.1* V_{CC}	
			Load			0.4	
	Output Current	I_{OH}	$V_{OH} = 3.9V/2.2V$ $V_{CC} = 4.5V/3.0V$	-	-	-16/-8	
	Logic '1' Level	I_{OL}	$V_{OL} = 0.4V$ $V_{CC} = 4.5V/3.0V$	-	-	+16/+8	
	Logic '0' Level						
	Output Duty Cycle	SYM	@ 50% Level	45	-	55	%
	Rise and Fall Time	T_{R, T_F}	@ 10% - 90% Levels, Tested load condition noted for typical values.				
	CB3		1.5 MHz to 20 MHz $C_L=50pF$	-	8	10	
			20.1 MHz to 80 MHz $C_L=50pF$	-	5	8	
			80.1 MHz to 160 MHz $C_L=15pF$	-	2.5	5	
	CB3LV		1.5 MHz to 20 MHz $C_L=15pF$	-	6	8	
			20.1 MHz to 80 MHz $C_L=15pF$	-	3	5	
			80.1 MHz to 160 MHz $C_L=15pF$	-	1.5	3	
	Start Up Time	T_S	Application of V_{CC}	-	-	10	ms
	Enable Function						
	Enable Input Voltage	V_{IH}	Pin 1 Logic '1', Output Enabled	2.0	-	-	V
	Disable Input Voltage	V_{IL}	Pin 1 Logic '0', Output Disabled	-	-	0.8	
	Enable Time	T_{PLZ}	Pin 1 Logic '1'	-	-	10	ms
	Standby Current	I_{ST}	Pin 1 Logic '0', Output Disabled	-	-	10	µA
	Period Jitter, Pk-Pk	-	-	-	-	50	
	Period Jitter, RMS	-	-	-	-	5	ps
	Phase Jitter, RMS	-	Bandwidth 12 kHz - 20 MHz	-	-	1	

Notes:

1. Inclusive of calibration @ 25°C, operating temperature range, supply voltage variation, load variation, and first year aging.

CMOS/TTL OUTPUT WAVEFORM

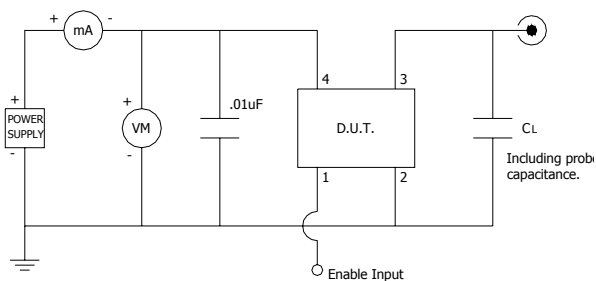


$$\text{DUTY CYCLE} = t/T \times 100 (\%)$$

ENABLE TRUTH TABLE

PIN 1	PIN 3
Logic '1'	Output
Open	Output
Logic '0'	High Imp.

TEST CIRCUIT, CMOS LOAD

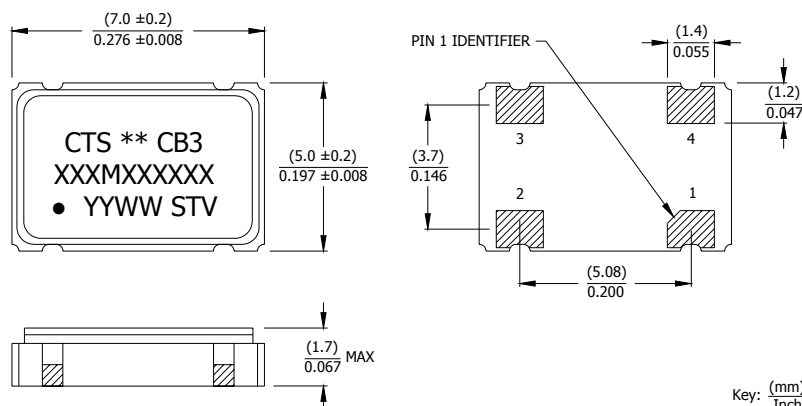


D.U.T. PIN ASSIGNMENTS

PIN	SYMBOL	DESCRIPTION
1	EOH	Enable Input
2	GND	Circuit & Package Ground
3	Output	RF Output
4	V _{CC}	Supply Voltage

MECHANICAL SPECIFICATIONS

PACKAGE DRAWING



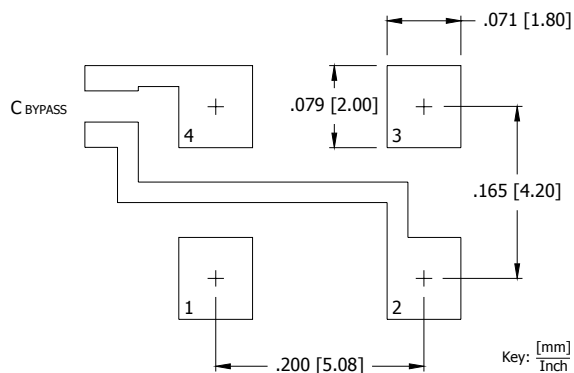
MARKING INFORMATION

- ** – Manufacturing Site Code.
[Note a dash may follow the site code and is acceptable.]
- XXXXMXXXXX – Frequency is marked with only leading significant digits before the 'M' and 4 - 6 digits after the 'M' (including zeros).
Ex. XMXXXXX (3M579545)
XXMXXXXX (14M31818)
XXXMXXXXX (125M0000)
- YYWW – Date code, YY – year, WW – week.
- ST – Frequency stability/temperature code.
(Refer to Ordering Information.)
- V – Voltage code. 3 = 3.3V, 5 = 5.0V.

NOTES

- Termination pads (e4). Barrier-plating is nickel (Ni) with gold (Au) flash plate.
- Reflow conditions per JEDEC J-STD-020.

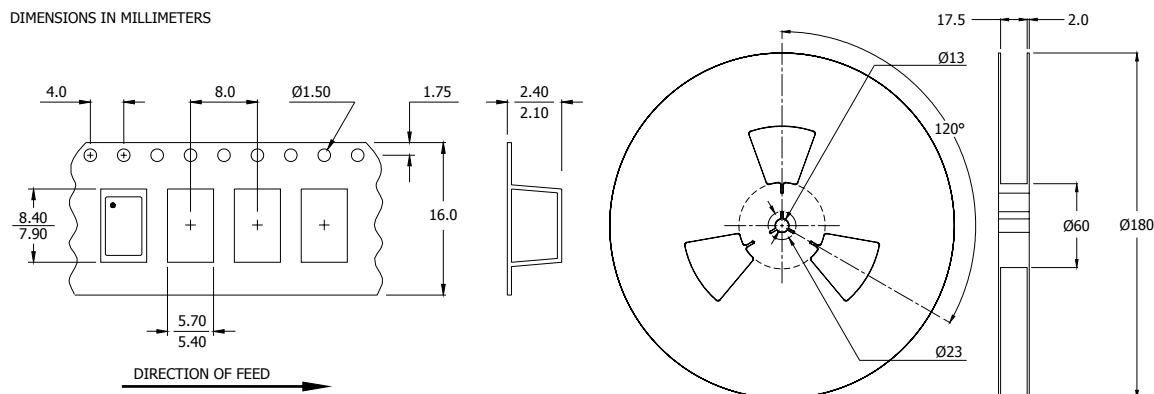
SUGGESTED SOLDER PAD GEOMETRY



C_{BYPASS} should be ≥ 0.01 uF.

TAPE AND REEL INFORMATION

Standard packaging is tape and reel for this product family. Device quantity is 1,000 pieces per 180mm reel.

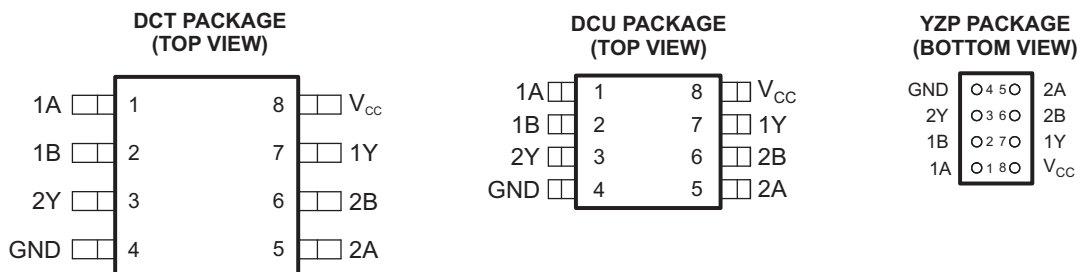


ENVIRONMENTAL SPECIFICATIONS

Temperature Cycle:	400 cycles from -55°C to +125°C, 10 minute dwell at each temperature, 1 minute transfer time between temperatures.
Mechanical Shock:	1,500g's, 0.5mS duration, ½ sinewave, 3 shocks each direction along 3 mutually perpendicular planes (18 total shocks).
Sinusoidal Vibration:	0.06 inches double amplitude, 10 to 55 Hz and 20g's, 55 to 2,000 Hz, 3 cycles each in 3 mutually perpendicular planes (9 times total).
Gross Leak:	No leak shall appear while immersed in an FC40 or equivalent liquid at +125°C for 20 seconds.
Fine Leak:	Mass spectrometer leak rates less than 2×10^{-8} ATM cc/sec air equivalent.
Resistance to Solder Heat:	Product must survive 3 reflows of +260°C peak, 10 seconds maximum.
High Temperature Operating Bias:	2,000 hours at +125°C, maximum bias, disregarding frequency shift.
Frequency Aging:	1,000 hours at +85°C, full bias, less than ± 5 ppm shift.
Moisture Sensitivity Level:	Level 1 per JEDEC J-STD-020.

FEATURES

- Available in Texas Instruments NanoFree™ Package
- Supports 5-V V_{CC} Operation
- Inputs Accept Voltages to 5.5 V
- Max t_{pd} of 5.3 ns at 3.3 V
- Low Power Consumption, 10- μ A Max I_{CC}
- ± 24 -mA Output Drive at 3.3 V
- Typical V_{OLP} (Output Ground Bounce) <0.8 V at $V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$
- Typical V_{OHV} (Output V_{OH} Undershoot) >2 V at $V_{CC} = 3.3$ V, $T_A = 25^\circ\text{C}$
- I_{off} Supports Partial-Power-Down Mode Operation
- Latch-Up Performance Exceeds 100 mA Per JESD 78, Class II
- ESD Protection Exceeds JESD 22
 - 2000-V Human-Body Model (A114-A)
 - 200-V Machine Model (A115-A)
 - 1000-V Charged-Device Model (C101)



See mechanical drawings for dimensions.

DESCRIPTION/ORDERING INFORMATION

This dual 2-input NAND gate with Schmitt-trigger inputs is designed for 1.65-V to 5.5-V V_{CC} operation.

The SN74LVC2G132 contains two inverters and performs the Boolean function $Y = \overline{A \cdot B}$ or $Y = \overline{A} + \overline{B}$ in positive logic. The device functions as two independent inverters, but because of Schmitt action, it has different input threshold levels for positive-going (V_{T+}) and negative-going (V_{T-}) signals.

NanoFree™ package technology is a major breakthrough in IC packaging concepts, using the die as the package.

This device can be triggered from the slowest of input ramps and still give clean jitter-free output signals.

This device is fully specified for partial-power-down applications using I_{off} . The I_{off} circuitry disables the outputs, preventing damaging current backflow through the device when it is powered down.

ORDERING INFORMATION

T_A	PACKAGE ⁽¹⁾		ORDERABLE PART NUMBER	TOP-SIDE MARKING ⁽²⁾
-40°C to 85°C	NanoFree™ – WCSP (DSBGA) 0.23-mm Large Bump – YZP (Pb-free)	Reel of 3000	SN74LVC2G132YZPR	__ _D5_
		Reel of 3000	SN74LVC2G132DCTR	C3B_ _ _
	SSOP – DCT	Reel of 3000	SN74LVC2G132DCUR	C3B_
		Reel of 250	SN74LVC2G132DCUT	

(1) Package drawings, standard packing quantities, thermal data, symbolization, and PCB design guidelines are available at www.ti.com/sc/package.

(2) DCT: The actual top-side marking has three additional characters that designate the year, month, and assembly/test site.

DCU: The actual top-side marking has one additional character that designates the assembly/test site.

YZP: The actual top-side marking has three preceding characters to denote year, month, and sequence code, and one following character to designate the assembly/test site. Pin 1 identifier indicates solder-bump composition (1 = SnPb, • = Pb-free).



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

NanoFree is a trademark of Texas Instruments.

SN74LVC2G132

DUAL 2-INPUT NAND GATE

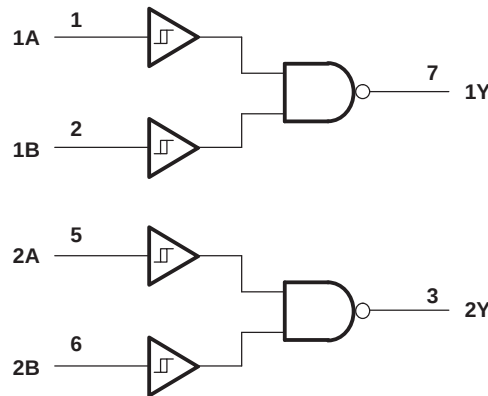
WITH SCHMITT-TRIGGER INPUTS

SCES547C—FEBRUARY 2004—REVISED JANUARY 2007

FUNCTION TABLE
(EACH GATE)

INPUTS		OUTPUT Y
A	B	
L	L	H
L	H	H
H	L	H
H	H	L

LOGIC DIAGRAM (POSITIVE LOGIC)



Absolute Maximum Ratings⁽¹⁾

over operating free-air temperature range (unless otherwise noted)

			MIN	MAX	UNIT
V _{CC}	Supply voltage range		−0.5	6.5	V
V _I	Input voltage range ⁽²⁾		−0.5	6.5	V
V _O	Voltage range applied to any output in the high-impedance or power-off state ⁽²⁾		−0.5	6.5	V
V _O	Voltage range applied to any output in the high or low state ⁽²⁾⁽³⁾		−0.5	V _{CC} + 0.5	V
I _{IK}	Input clamp current	V _I < 0	−50		mA
I _{OK}	Output clamp current	V _O < 0	−50		mA
I _O	Continuous output current		±50		mA
Continuous current through V _{CC} or GND			±100		mA
θ _{JA}	Package thermal impedance ⁽⁴⁾	DCT package	220		°C/W
		DCU package	227		
		YZP package	102		
T _{stg}	Storage temperature range		−65	150	°C

- (1) Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
- (2) The input and output negative-voltage ratings may be exceeded if the input and output current ratings are observed.
- (3) The value of V_{CC} is provided in the recommended operating conditions table.
- (4) The package thermal impedance is calculated in accordance with JESD 51-7

Recommended Operating Conditions⁽¹⁾

			MIN	MAX	UNIT
V _{CC}	Supply voltage	Operating	1.65	5.5	V
		Data retention only	1.5		
V _I	Input voltage		0	5.5	V
V _O	Output voltage		0	V _{CC}	V
I _{OH}	High-level output current	V _{CC} = 1.65 V		−4	mA
		V _{CC} = 2.3 V		−8	
		V _{CC} = 3 V		−16	
				−24	
		V _{CC} = 4.5 V		−32	
I _{OL}	Low-level output current	V _{CC} = 1.65 V		4	mA
		V _{CC} = 2.3 V		8	
		V _{CC} = 3 V		16	
				24	
		V _{CC} = 4.5 V		32	
T _A	Operating free-air temperature		−40	85	°C

- (1) All unused inputs of the device must be held at V_{CC} or GND to ensure proper device operation. Refer to the TI application report, *Implications of Slow or Floating CMOS Inputs*, literature number SCBA004.

SN74LVC2G132

DUAL 2-INPUT NAND GATE

WITH SCHMITT-TRIGGER INPUTS

SCES547C – FEBRUARY 2004 – REVISED JANUARY 2007

Electrical Characteristics

over recommended operating free-air temperature range (unless otherwise noted)

PARAMETER	TEST CONDITIONS	V _{CC}	MIN	TYP ⁽¹⁾	MAX	UNIT
V _{T+} Positive-going input threshold voltage		1.65 V	0.79		1.16	V
		2.3 V	1.11		1.56	
		3 V	1.5		1.87	
		4.5 V	2.16		2.74	
		5.5 V	2.61		3.33	
V _{T-} Negative-going input threshold voltage		1.65 V	0.39		0.62	V
		2.3 V	0.58		0.87	
		3 V	0.84		1.14	
		4.5 V	1.41		1.79	
		5.5 V	1.87		2.29	
ΔV_T Hysteresis (V _{T+} – V _{T-})		1.65 V	0.37		0.62	V
		2.3 V	0.48		0.77	
		3 V	0.56		0.87	
		4.5 V	0.71		1.04	
		5.5 V	0.71		1.11	
V _{OH}	I _{OH} = –100 μ A	1.65 V to 5.5 V	V _{CC} – 0.1			V
	I _{OH} = –4 mA	1.65 V	1.2			
	I _{OH} = –8 mA	2.3 V	1.9			
	I _{OH} = –16 mA	3 V	2.4			
	I _{OH} = –24 mA		2.3			
	I _{OH} = –32 mA	4.5 V	3.8			
V _{OL}	I _{OL} = 100 μ A	1.65 V to 5.5 V	0.1			V
	I _{OL} = 4 mA	1.65 V	0.45			
	I _{OL} = 8 mA	2.3 V	0.3			
	I _{OL} = 16 mA	3 V	0.4			
	I _{OL} = 24 mA		0.55			
	I _{OL} = 32 mA	4.5 V	0.55			
I _I	A or B inputs	V _I = 5.5 V or GND	1.65 V to 5.5 V	± 1		μ A
I _{off}	V _I or V _O = 5.5 V		0	± 10		μ A
I _{CC}	V _I = V _{CC} or GND, I _O = 0	1.65 V to 5.5 V	10			μ A
ΔI_{CC}	One input at V _{CC} – 0.6 V, Other inputs at V _{CC} or GND	3 V to 5.5 V	500			μ A
C _I	V _I = V _{CC} or GND	3.3 V	3.5			pF

(1) All typical values are at V_{CC} = 3.3 V, T_A = 25°C.

Switching Characteristics

over recommended operating free-air temperature range, $C_L = 15 \text{ pF}$ (unless otherwise noted) (see [Figure 1](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 1.8 \text{ V}$ $\pm 0.15 \text{ V}$		$V_{CC} = 2.5 \text{ V}$ $\pm 0.2 \text{ V}$		$V_{CC} = 3.3 \text{ V}$ $\pm 0.3 \text{ V}$		$V_{CC} = 5 \text{ V}$ $\pm 0.5 \text{ V}$		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{pd}	A or B	Y	4	16	2.5	7	2	5.3	1.5	4.4	ns

Switching Characteristics

over recommended operating free-air temperature range, $C_L = 30 \text{ pF}$ or 50 pF (unless otherwise noted) (see [Figure 2](#))

PARAMETER	FROM (INPUT)	TO (OUTPUT)	$V_{CC} = 1.8 \text{ V}$ $\pm 0.15 \text{ V}$		$V_{CC} = 2.5 \text{ V}$ $\pm 0.2 \text{ V}$		$V_{CC} = 3.3 \text{ V}$ $\pm 0.3 \text{ V}$		$V_{CC} = 5 \text{ V}$ $\pm 0.5 \text{ V}$		UNIT
			MIN	MAX	MIN	MAX	MIN	MAX	MIN	MAX	
t_{pd}	A or B	Y	4	16	3	7.5	2	6	2	5	ns

Operating Characteristics

$T_A = 25^\circ\text{C}$

PARAMETER		TEST CONDITIONS	$V_{CC} = 1.8 \text{ V}$	$V_{CC} = 2.5 \text{ V}$	$V_{CC} = 3.3 \text{ V}$	$V_{CC} = 5 \text{ V}$	UNIT
			TYP	TYP	TYP	TYP	
C_{pd}	Power dissipation capacitance	$f = 10 \text{ MHz}$	17	18	18	20	pF

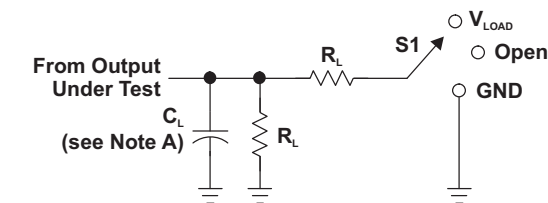
SN74LVC2G132

DUAL 2-INPUT NAND GATE

WITH SCHMITT-TRIGGER INPUTS

SCES547C—FEBRUARY 2004—REVISED JANUARY 2007

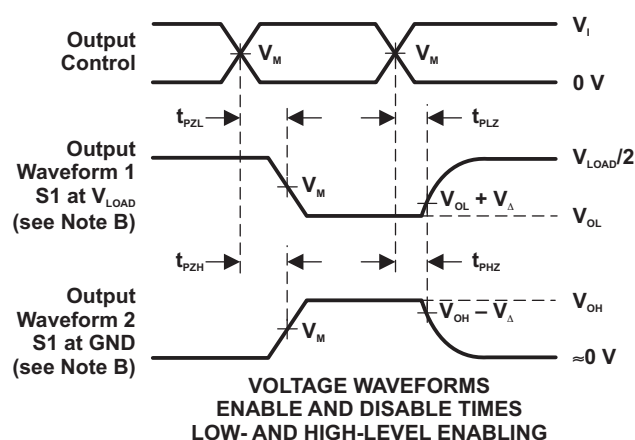
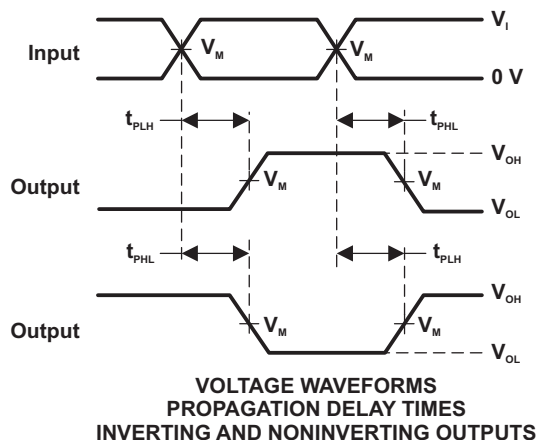
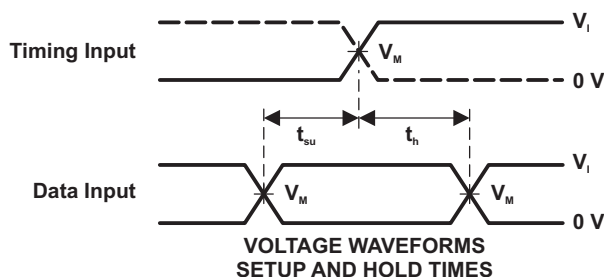
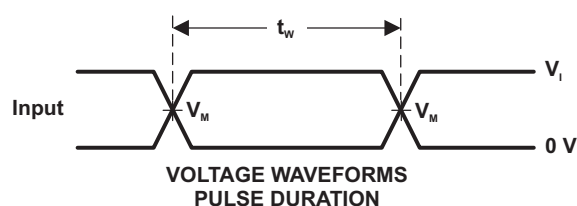
PARAMETER MEASUREMENT INFORMATION



LOAD CIRCUIT

TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	V_{LOAD}
t_{PHZ}/t_{PZH}	GND

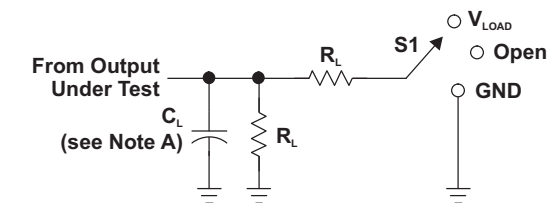
V_{CC}	INPUTS		V_M	V_{LOAD}	C_L	R_L	V_{Δ}
	V_I	t_i/t_f					
$1.8\text{ V} \pm 0.15\text{ V}$	V_{CC}	$\leq 2\text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	15 pF	1 M Ω	0.15 V
$2.5\text{ V} \pm 0.2\text{ V}$	V_{CC}	$\leq 2\text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	15 pF	1 M Ω	0.15 V
$3.3\text{ V} \pm 0.3\text{ V}$	3 V	$\leq 2.5\text{ ns}$	1.5 V	6 V	15 pF	1 M Ω	0.3 V
$5\text{ V} \pm 0.5\text{ V}$	V_{CC}	$\leq 2.5\text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	15 pF	1 M Ω	0.3 V



- NOTES:
- C_L includes probe and jig capacitance.
 - Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
 - All input pulses are supplied by generators having the following characteristics: $PRR \leq 10\text{ MHz}$, $Z_o = 50\ \Omega$.
 - The outputs are measured one at a time, with one transition per measurement.
 - t_{PLZ} and t_{PHZ} are the same as t_{dis} .
 - t_{PZL} and t_{PZH} are the same as t_{en} .
 - t_{PLH} and t_{PHL} are the same as t_{pd} .
 - All parameters and waveforms are not applicable to all devices.

Figure 1. Load Circuit and Voltage Waveforms

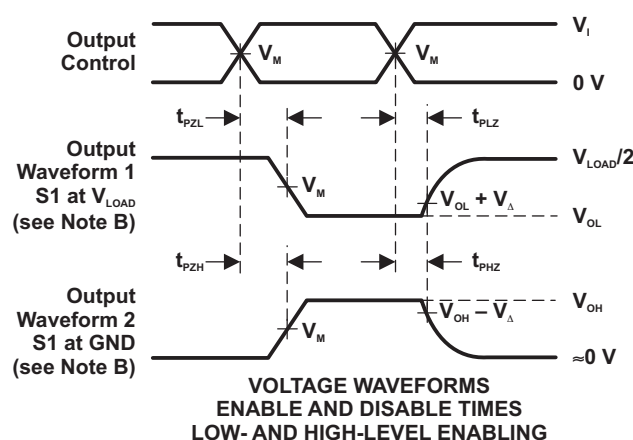
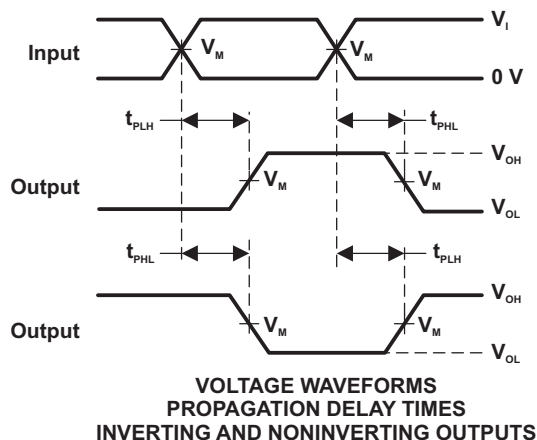
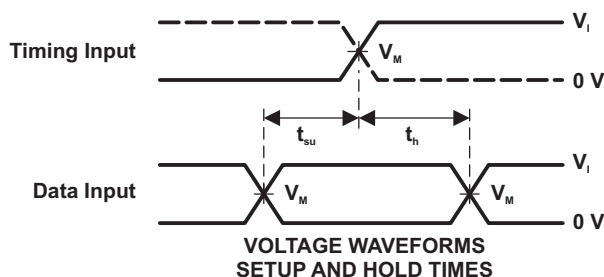
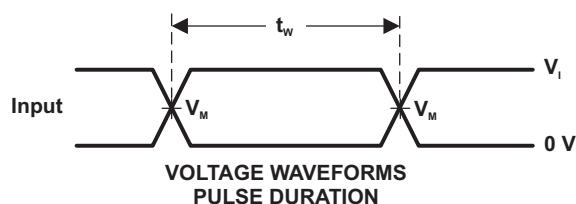
PARAMETER MEASUREMENT INFORMATION



LOAD CIRCUIT

TEST	S1
t_{PLH}/t_{PHL}	Open
t_{PLZ}/t_{PZL}	V_{LOAD}
t_{PHZ}/t_{PZH}	GND

V_{CC}	INPUTS		V_M	V_{LOAD}	C_L	R_L	V_{Δ}
	V_I	t_I/t_f					
$1.8\text{ V} \pm 0.15\text{ V}$	V_{CC}	$\leq 2\text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	30 pF	1 k Ω	0.15 V
$2.5\text{ V} \pm 0.2\text{ V}$	V_{CC}	$\leq 2\text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	30 pF	500 Ω	0.15 V
$3.3\text{ V} \pm 0.3\text{ V}$	3 V	$\leq 2.5\text{ ns}$	1.5 V	6 V	50 pF	500 Ω	0.3 V
$5\text{ V} \pm 0.5\text{ V}$	V_{CC}	$\leq 2.5\text{ ns}$	$V_{CC}/2$	$2 \times V_{CC}$	50 pF	500 Ω	0.3 V



- NOTES:
- C_L includes probe and jig capacitance.
 - Waveform 1 is for an output with internal conditions such that the output is low, except when disabled by the output control. Waveform 2 is for an output with internal conditions such that the output is high, except when disabled by the output control.
 - All input pulses are supplied by generators having the following characteristics: $PRR \leq 10\text{ MHz}$, $Z_o = 50\text{ }\Omega$.
 - The outputs are measured one at a time, with one transition per measurement.
 - t_{PLZ} and t_{PHZ} are the same as t_{dis} .
 - t_{PZL} and t_{PZH} are the same as t_{en} .
 - t_{PLH} and t_{PHL} are the same as t_{pd} .
 - All parameters and waveforms are not applicable to all devices.

Figure 2. Load Circuit and Voltage Waveforms

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
74LVC2G132DCTRE4	ACTIVE	SM8	DCT	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
74LVC2G132DCTRG4	ACTIVE	SM8	DCT	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
74LVC2G132DCURE4	ACTIVE	US8	DCU	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
74LVC2G132DCURG4	ACTIVE	US8	DCU	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
74LVC2G132DCUTE4	ACTIVE	US8	DCU	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LVC2G132DCTR	ACTIVE	SM8	DCT	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LVC2G132DCUR	ACTIVE	US8	DCU	8	3000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LVC2G132DCUT	ACTIVE	US8	DCU	8	250	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-1-260C-UNLIM
SN74LVC2G132YZPR	ACTIVE	DSBGA	YZP	8	3000	Green (RoHS & no Sb/Br)	SNAGCU	Level-1-260C-UNLIM

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBsolete: TI has discontinued the production of the device.

⁽²⁾ Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check <http://www.ti.com/productcontent> for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

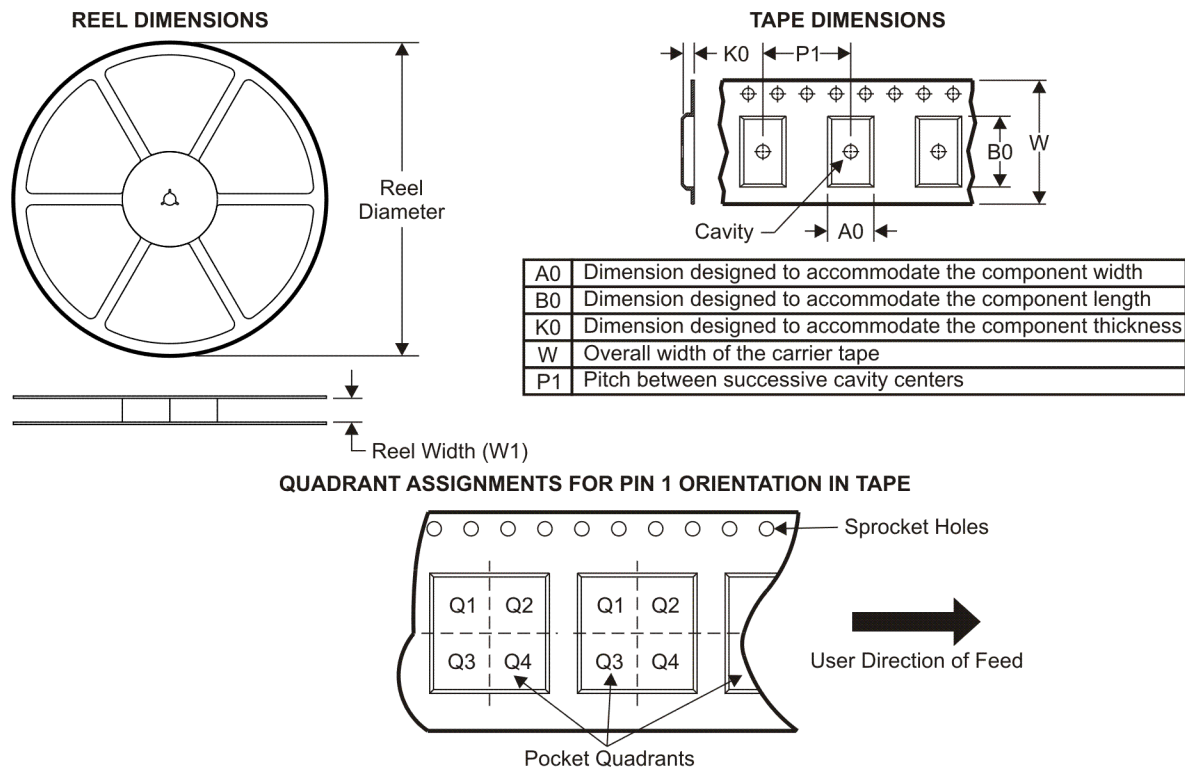
Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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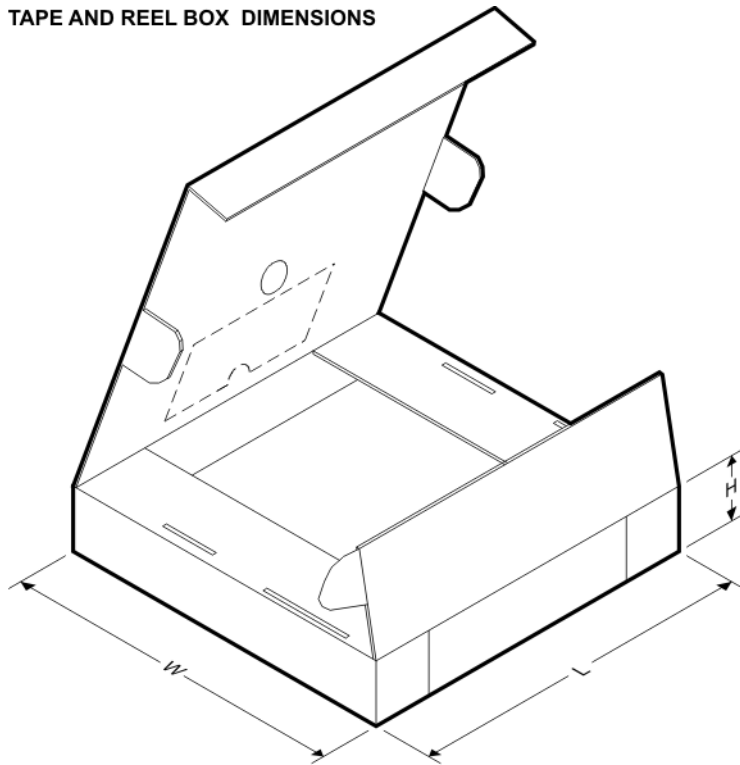
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TAPE AND REEL INFORMATION


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
SN74LVC2G132YZPR	DSBGA	YZP	8	3000	180.0	8.4	1.02	2.02	0.63	4.0	8.0	Q1

TAPE AND REEL BOX DIMENSIONS

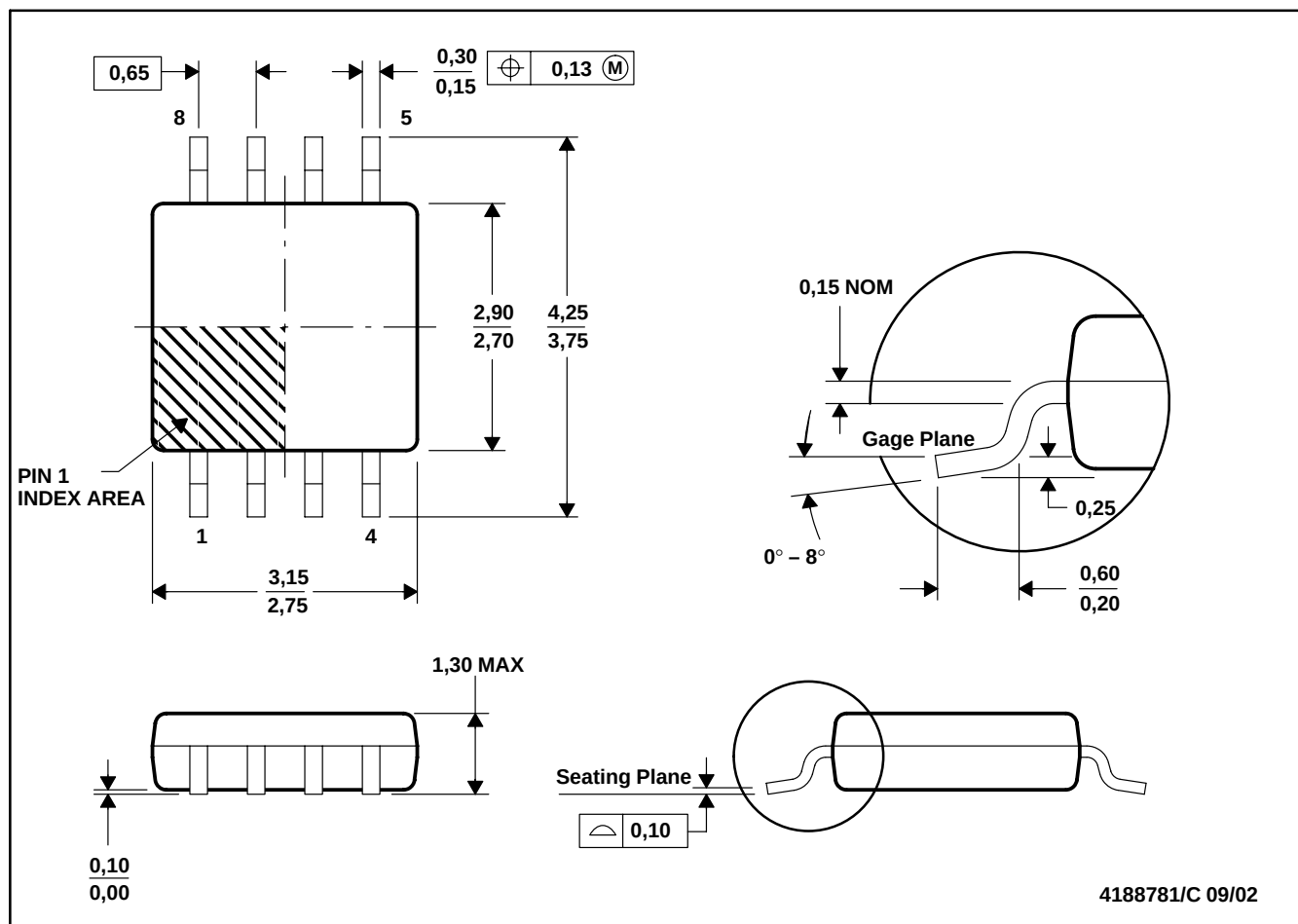


*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
SN74LVC2G132YZPR	DSBGA	YZP	8	3000	220.0	220.0	34.0

DCT (R-PDSO-G8)

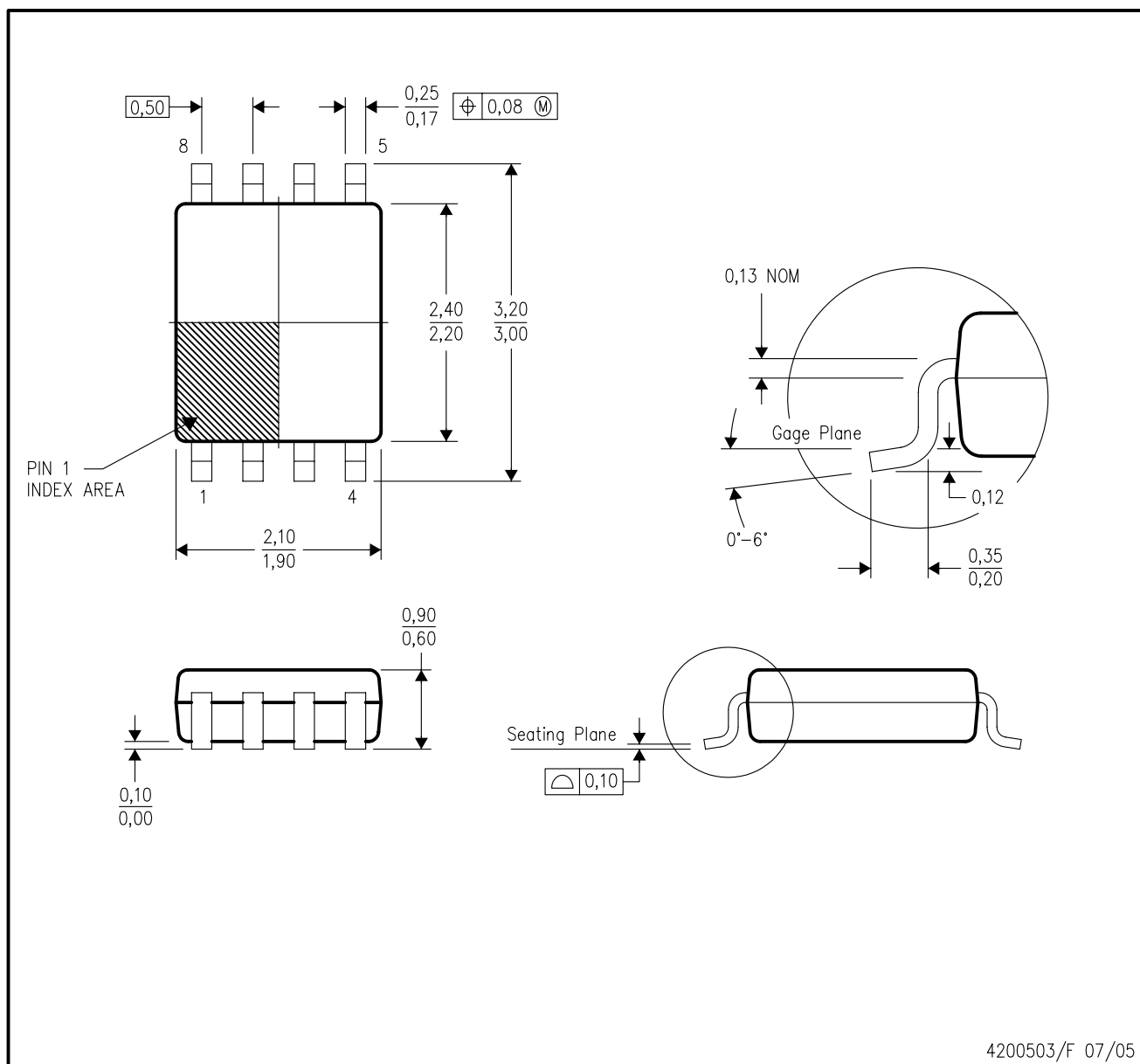
PLASTIC SMALL-OUTLINE PACKAGE



- NOTES:
- All linear dimensions are in millimeters.
 - This drawing is subject to change without notice.
 - Body dimensions do not include mold flash or protrusion.
 - Falls within JEDEC MO-187 variation DA.

DCU (R-PDSO-G8)

PLASTIC SMALL-OUTLINE PACKAGE (DIE DOWN)

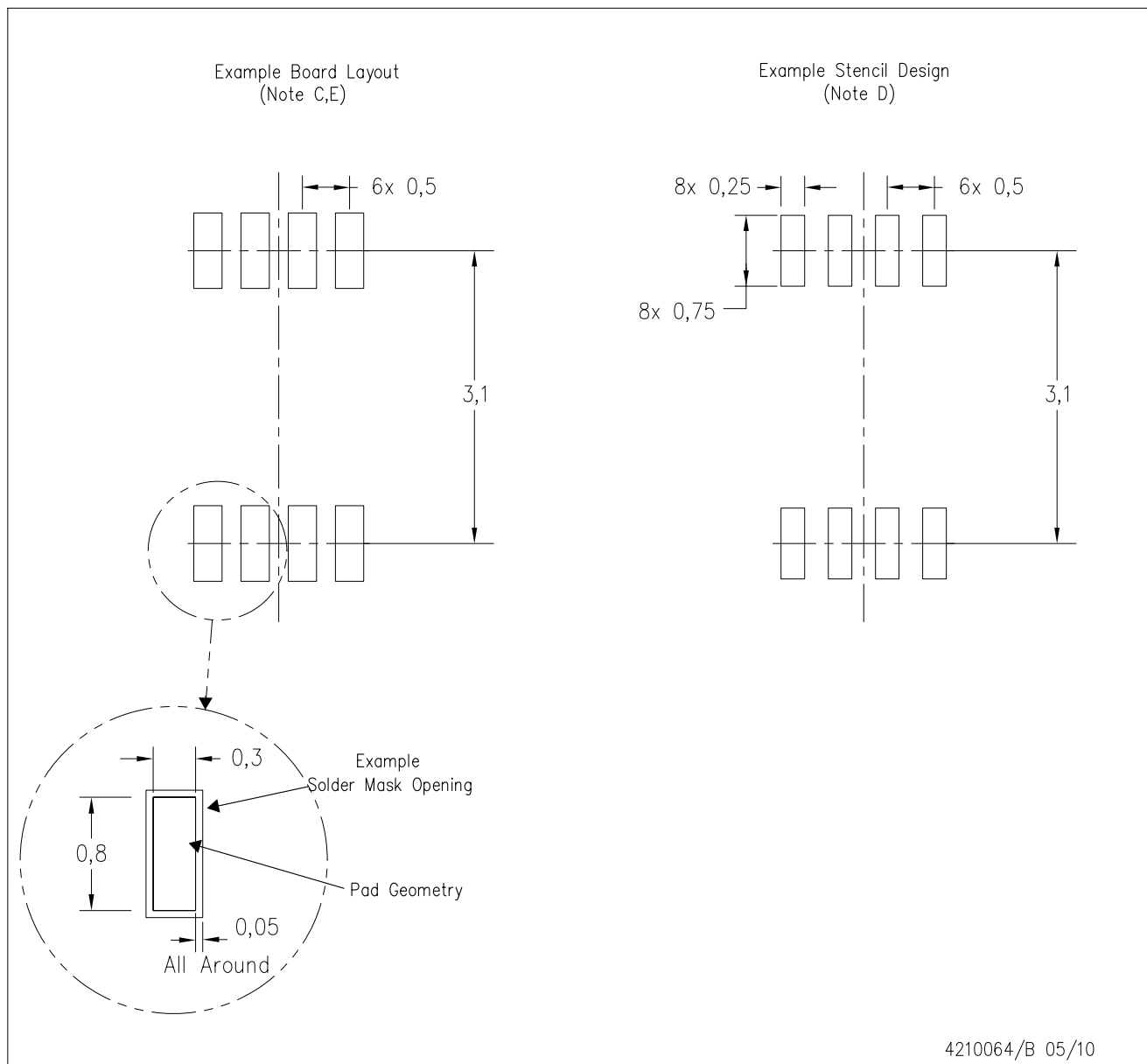


NOTES:

- All linear dimensions are in millimeters.
- This drawing is subject to change without notice.
- Body dimensions do not include mold flash or protrusion. Mold flash and protrusion shall not exceed 0.15 per side.
- Falls within JEDEC MO-187 variation CA.

DCU (S-PDSO-G8)

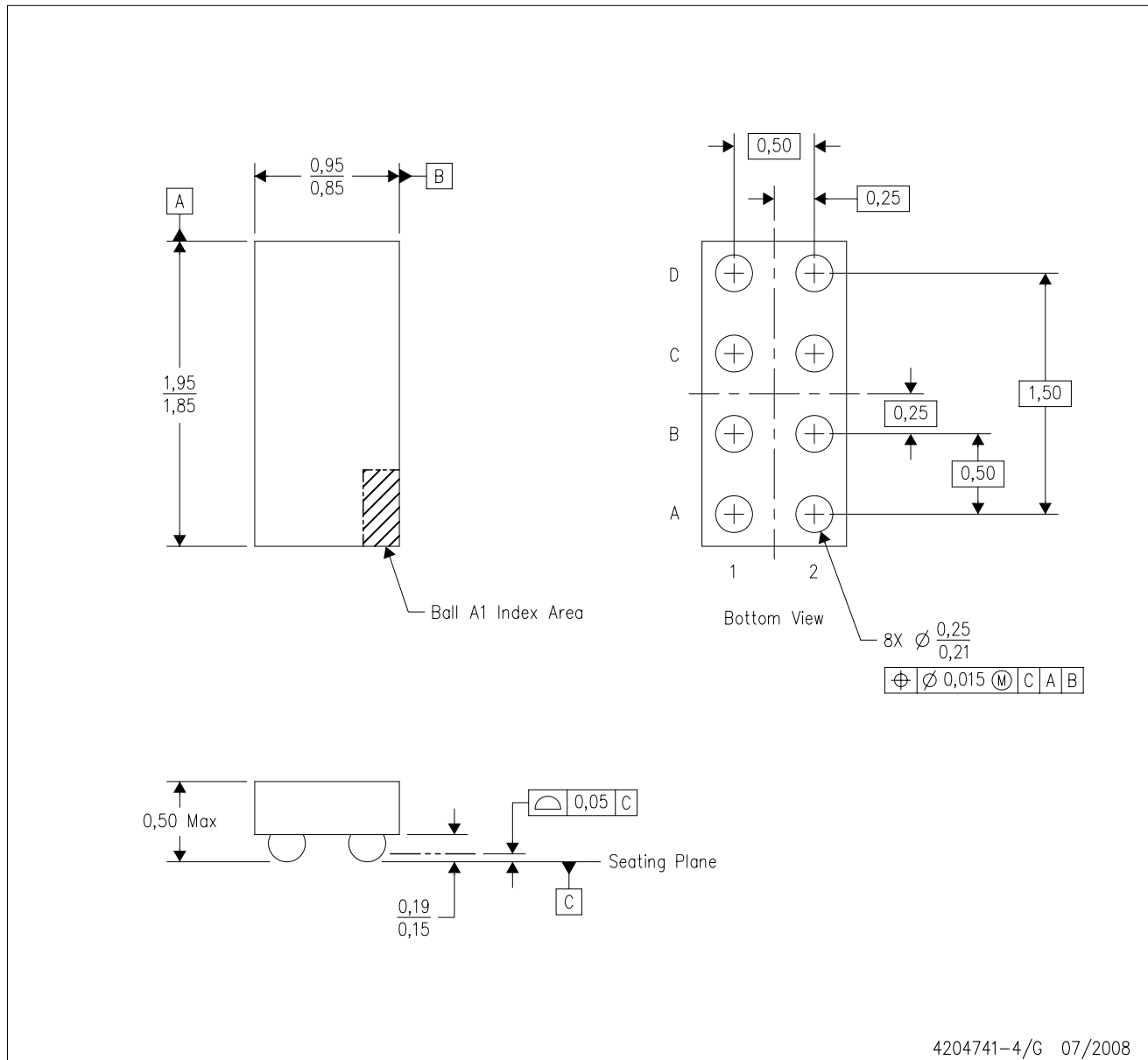
PLASTIC SMALL OUTLINE PACKAGE (DIE DOWN)



- NOTES:
- A. All linear dimensions are in millimeters.
 - B. This drawing is subject to change without notice.
 - C. Publication IPC-7351 is recommended for alternate designs.
 - D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525.
 - E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.

YZP (R-XBGA-N8)

DIE-SIZE BALL GRID ARRAY



- NOTES:
- A. All linear dimensions are in millimeters. Dimensioning and tolerancing per ASME Y14.5M-1994.
 - B. This drawing is subject to change without notice.
 - C. NanoFree™ package configuration.
 - D. This package is lead-free. Refer to the 8 YEP package (drawing 4204725) for tin-lead (SnPb).

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Features

- 7.5 ns pin-to-pin logic delays on all pins
- f_{CNT} to 125 MHz
- 108 macrocells with 2,400 usable gates
- Up to 108 user I/O pins
- 5V in-system programmable
 - Endurance of 10,000 program/erase cycles
 - Program/erase over full commercial voltage and temperature range
- Enhanced pin-locking architecture
- Flexible 36V18 Function Block
 - 90 product terms drive any or all of 18 macrocells within Function Block
 - Global and product term clocks, output enables, set and reset signals
- Extensive IEEE Std 1149.1 boundary-scan (JTAG) support
- Programmable power reduction mode in each macrocell
- Slew rate control on individual outputs
- User programmable ground pin capability
- Extended pattern security features for design protection
- High-drive 24 mA outputs
- 3.3V or 5V I/O capability
- Advanced CMOS 5V FastFLASH™ technology
- Supports parallel programming of more than one XC9500 concurrently
- Available in 84-pin PLCC, 100-pin PQFP, 100-pin TQFP, and 160-pin PQFP packages

Description

The XC95108 is a high-performance CPLD providing advanced in-system programming and test capabilities for general purpose logic integration. It is comprised of eight 36V18 Function Blocks, providing 2,400 usable gates with propagation delays of 7.5 ns. See Figure 2 for the architecture overview.

Power Management

Power dissipation can be reduced in the XC95108 by configuring macrocells to standard or low-power modes of operation. Unused macrocells are turned off to minimize power dissipation.

Operating current for each design can be approximated for specific operating conditions using the following equation:

$$I_{CC} \text{ (mA)} = MC_{HP} (1.7) + MC_{LP} (0.9) + MC (0.006 \text{ mA/MHz}) f$$

Where:

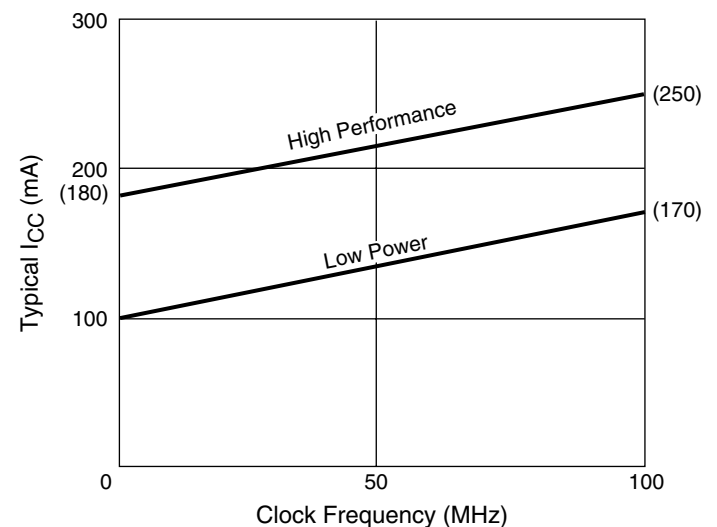
MC_{HP} = Macrocells in high-performance mode

MC_{LP} = Macrocells in low-power mode

MC = Total number of macrocells used

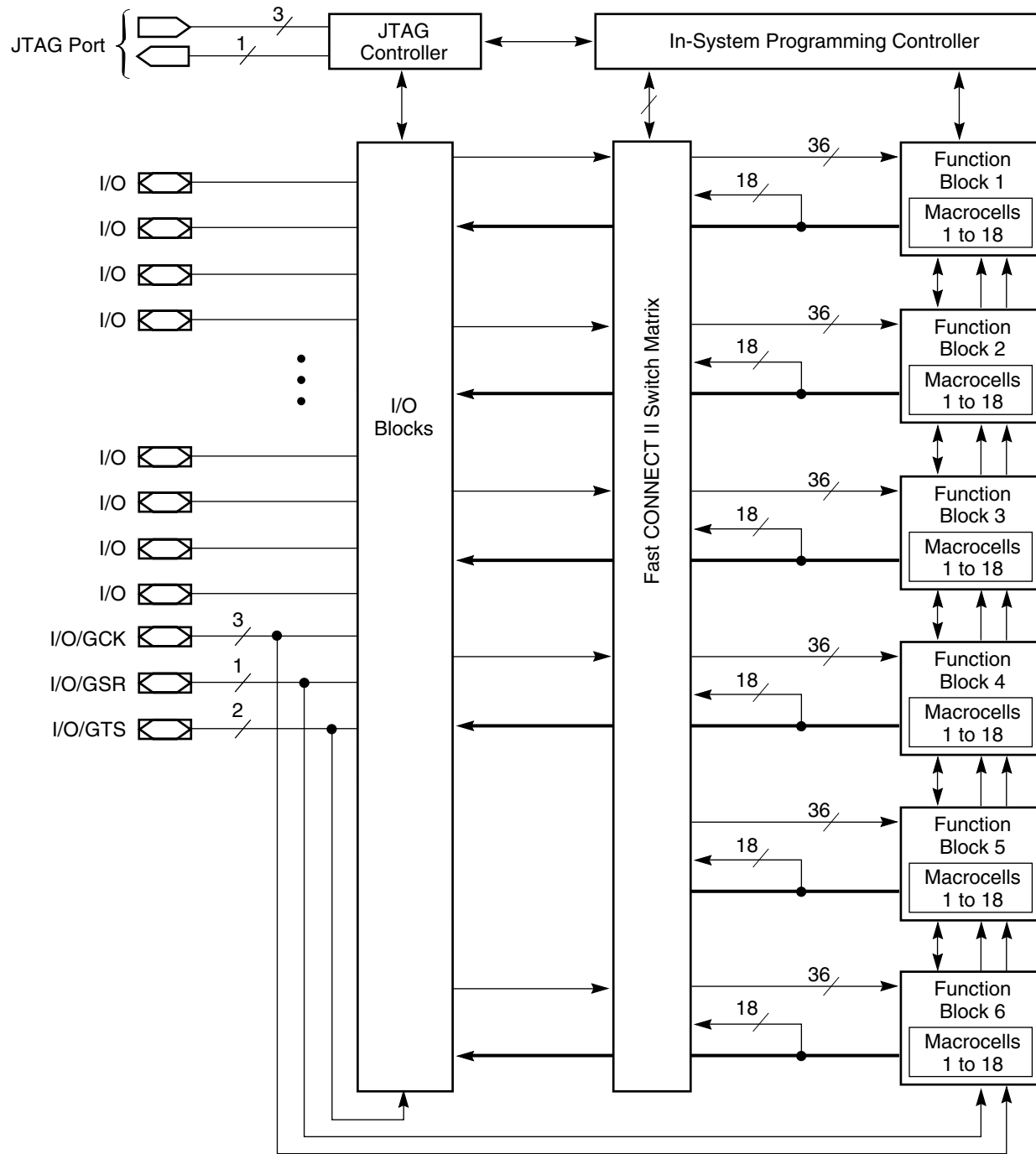
f = Clock frequency (MHz)

Figure 1 shows a typical calculation for the XC95108 device.



DS066_01_110501

Figure 1: Typical I_{CC} vs. Frequency for XC95108



DS066_02_110101

Figure 2: XC95108 Architecture

Function block outputs (indicated by the bold line) drive the I/O blocks directly.

Absolute Maximum Ratings

Symbol	Description	Value	Units
V_{CC}	Supply voltage relative to GND	–0.5 to 7.0	V
V_{IN}	Input voltage relative to GND	–0.5 to $V_{CC} + 0.5$	V
V_{TS}	Voltage applied to 3-state output	–0.5 to $V_{CC} + 0.5$	V
T_{STG}	Storage temperature (ambient)	–65 to +150	°C
T_J	Junction temperature	+150	°C

Notes:

- Stresses beyond those listed under Absolute Maximum Ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those listed under Operating Conditions is not implied. Exposure to Absolute Maximum Ratings conditions for extended periods of time may affect device reliability.

Recommended Operation Conditions

Symbol	Parameter		Min	Max	Units
V_{CCINT}	Supply voltage for internal logic and input buffers	Commercial $T_A = 0^{\circ}\text{C}$ to 70°C	4.75	5.25	V
		Industrial $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$	4.5	5.5	
V_{CCIO}	Supply voltage for output drivers for 5V operation	Commercial $T_A = 0^{\circ}\text{C}$ to 70°C	4.75	5.25	V
		Industrial $T_A = -40^{\circ}\text{C}$ to $+85^{\circ}\text{C}$	4.5	5.5	
	Supply voltage for output drivers for 3.3V operation		3.0	3.6	
V_{IL}	Low-level input voltage		0	0.80	V
V_{IH}	High-level input voltage		2.0	$V_{CCINT} + 0.5$	V
V_O	Output voltage		0	V_{CCIO}	V

Quality and Reliability Characteristics

Symbol	Parameter	Min	Max	Units
T_{DR}	Data Retention	20	-	Years
N_{PE}	Program/Erase Cycles (Endurance)	10,000	-	Cycles

DC Characteristic Over Recommended Operating Conditions

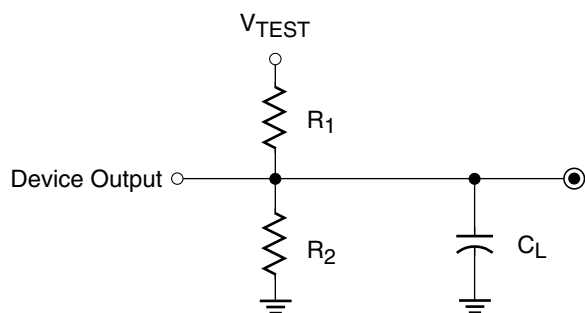
Symbol	Parameter	Test Conditions	Min	Max	Units
V_{OH}	Output high voltage for 5V outputs	$I_{OH} = -4.0\text{ mA}$, $V_{CC} = \text{Min}$	2.4	-	V
	Output high voltage for 3.3V outputs	$I_{OH} = -3.2\text{ mA}$, $V_{CC} = \text{Min}$	2.4	-	V
V_{OL}	Output low voltage for 5V outputs	$I_{OL} = 24\text{ mA}$, $V_{CC} = \text{Min}$	-	0.5	V
	Output low voltage for 3.3V outputs	$I_{OL} = 10\text{ mA}$, $V_{CC} = \text{Min}$	-	0.4	V
I_{IL}	Input leakage current	$V_{CC} = \text{Max}$ $V_{IN} = \text{GND or } V_{CC}$	-	± 10	μA
I_{IH}	I/O high-Z leakage current	$V_{CC} = \text{Max}$ $V_{IN} = \text{GND or } V_{CC}$	-	± 10	μA
C_{IN}	I/O capacitance	$V_{IN} = \text{GND}$ $f = 1.0\text{ MHz}$	-	10	pF
I_{CC}	Operating supply current (low power mode, active)	$V_I = \text{GND}$, No load $f = 1.0\text{ MHz}$	100 (Typical)		mA

AC Characteristics

Symbol	Parameter	XC95108-7		XC95108-10		XC95108-15		XC95108-20		Units
		Min	Max	Min	Max	Min	Max	Min	Max	
T_{PD}	I/O to output valid	-	7.5	-	10.0	-	15.0	-	20.0	ns
T_{SU}	I/O setup time before GCK	4.5	-	6.0	-	8.0	-	10.0	-	ns
T_H	I/O hold time after GCK	0	-	0	-	0	-	0	-	ns
T_{CO}	GCK to output valid	-	4.5	-	6.0	-	8.0	-	10.0	ns
$f_{CNT}^{(1)}$	16-bit counter frequency	125.0	-	111.1	-	95.2	-	83.3	-	MHz
$f_{SYSTEM}^{(2)}$	Multiple FB internal operating frequency	83.3	-	66.7	-	55.6	-	50.0	-	MHz
T_{PSU}	I/O setup time before p-term clock input	0.5	-	2.0	-	4.0	-	4.0	-	ns
T_{PH}	I/O hold time after p-term clock input	4.0	-	4.0	-	4.0	-	6.0	-	ns
T_{PCO}	P-term clock output valid	-	8.5	-	10.0	-	12.0	-	16.0	ns
T_{OE}	GTS to output valid	-	5.5	-	6.0	-	11.0	-	16.0	ns
T_{OD}	GTS to output disable	-	5.5	-	6.0	-	11.0	-	16.0	ns
T_{POE}	Product term OE to output enabled	-	9.5	-	10.0	-	14.0	-	18.0	ns
T_{POD}	Product term OE to output disabled	-	9.5	-	10.0	-	14.0	-	18.0	ns
T_{WLH}	GCK pulse width (High or Low)	4.0	-	4.5	-	5.5	-	5.5	-	ns
T_{APRPW}	Asynchronous preset/reset pulse width (High or Low)	7.0	-	7.5	-	8.0	-	8.0	-	ns

Notes:

- f_{CNT} is the fastest 16-bit counter frequency available, using the local feedback when applicable.
 f_{CNT} is also the Export Control Maximum flip-flop toggle rate, f_{TOG} .
- f_{SYSTEM} is the internal operating frequency for general purpose system designs spanning multiple FBs.



Output Type	VCCIO	VTEST	R1	R2	CL
	5.0V	5.0V	160Ω	120Ω	35 pF
	3.3V	3.3V	260Ω	360Ω	35 pF

DS067_03_110101

Figure 3: AC Load Circuit

Internal Timing Parameters

Symbol	Parameter	XC95108-7		XC95108-10		XC95108-15		XC95108-20		Units
		Min	Max	Min	Max	Min	Max	Min	Max	
Buffer Delays										
T _{IN}	Input buffer delay	-	2.5	-	3.5	-	4.5	-	6.5	ns
T _{GCK}	GCK buffer delay	-	1.5	-	2.5	-	3.0	-	3.0	ns
T _{GSR}	GSR buffer delay	-	4.5	-	6.0	-	7.5	-	9.5	ns
T _{GTS}	GTS buffer delay	-	5.5	-	6.0	-	11.0	-	16.0	ns
T _{OUT}	Output buffer delay	-	2.5	-	3.0	-	4.5	-	6.5	ns
T _{EN}	Output buffer enable/disable delay	-	0	-	0	-	0	-	0	ns
Product Term Control Delays										
T _{PTCK}	Product term clock delay	-	3.0	-	3.0	-	2.5	-	2.5	ns
T _{PTSR}	Product term set/reset delay	-	2.0	-	2.5	-	3.0	-	3.0	ns
T _{PTTS}	Product term 3-state delay	-	4.5	-	3.5	-	5.0	-	5.0	ns
Internal Register and Combinatorial Delays										
T _{PDI}	Combinatorial logic propagation delay	-	0.5	-	1.0	-	3.0	-	4.0	ns
T _{SUI}	Register setup time	1.5	-	2.5	-	3.5	-	3.5	-	ns
T _{HI}	Register hold time	3.0	-	3.5	-	4.5	-	6.5	-	ns
T _{COI}	Register clock to output valid time	-	0.5	-	0.5	-	0.5	-	0.5	ns
T _{AOI}	Register async. S/R to output delay	-	6.5	-	7.0	-	8.0	-	8.0	ns
T _{RAI}	Register async. S/R recover before clock	7.5	-	10.0	-	10.0	-	10.0	-	ns
T _{LOGI}	Internal logic delay	-	2.0	-	2.5	-	3.0	-	3.0	ns
T _{LOGILP}	Internal low power logic delay	-	10.0	-	11.0	-	11.5	-	11.5	ns
Feedback Delays										
T _F	FastCONNECT feedback delay	-	8.0	-	9.5	-	11.0	-	13.0	ns
T _{LF}	Function block local feedback delay	-	4.0	-	3.5	-	3.5	-	5.0	ns
Time Adders										
T _{PTA} ⁽¹⁾	Incremental product term allocator delay	-	1.0	-	1.0	-	1.0	-	1.5	ns
T _{SLEW}	Slew-rate limited delay	-	4.0	-	4.5	-	5.0	-	5.5	ns

Notes:

- T_{PTA} is multiplied by the span of the function as defined in the XC9500 family data sheet.

XC95108 I/O Pins

Function Block	Macro-cell	PC84	PQ100	TQ100	PQ160	BScan Order	Function Block	Macro-cell	PC84	PQ100	TQ100	PQ160	BScan Order
1	1	—	—	—	25	321	3	1	—	—	—	45	213
1	2	1	15	13	21	318	3	2	14	31	29	47	210
1	3	2	16	14	22	315	3	3	15	32	30	49	207
1	4	—	21	19	29	312	3	4	—	36	34	57	204
1	5	3	17	15	23	309	3	5	17	34	32	54	201
1	6	4	18	16	24	306	3	6	18	35	33	56	198
1	7	—	—	—	27	303	3	7	—	—	—	50	195
1	8	5	19	17	26	300	3	8	19	37	35	58	192
1	9	6	20	18	28	297	3	9	20	38	36	59	189
1	10	—	26	24	36	294	3	10	—	45	43	69	186
1	11	7	22	20	30	291	3	11	21	39	37	60	183
1	12	9 ^[1]	24 ^[1]	22 ^[1]	33 ^[1]	288 ^[1]	3	12	23	41	39	62	180
1	13	—	—	—	34	285	3	13	—	—	—	52	177
1	14	10 ^[1]	25 ^[1]	23 ^[1]	35 ^[1]	282 ^[1]	3	14	24	42	40	63	174
1	15	11	27	25	37	279	3	15	25	43	41	64	171
1	16	12 ^[1]	29 ^[1]	27 ^[1]	42 ^[1]	276 ^[1]	3	16	26	44	42	68	168
1	17	13	30	28	44	273	3	17	31	51	49	77	165
1	18	—	—	—	43	270	3	18	—	—	—	74	162
2	1	—	—	—	158	267	4	1	—	—	—	123	159
2	2	71	98	96	154	264	4	2	57	83	81	134	156
2	3	72	99	97	156	261	4	3	58	84	82	135	153
2	4	—	4	2	4	258	4	4	—	82	80	133	150
2	5	74 ^[1]	1 ^[1]	99 ^[1]	159 ^[1]	255 ^[1]	4	5	61	87	85	138	147
2	6	75	3	1	2	252	4	6	62	88	86	139	144
2	7	—	—	—	9	249	4	7	—	—	—	128	141
2	8	76 ^[1]	5 ^[1]	3 ^[1]	6 ^[1]	246 ^[1]	4	8	63	89	87	140	138
2	9	77 ^[1]	6 ^[1]	4 ^[1]	8 ^[1]	243 ^[1]	4	9	65	91	89	142	135
2	10	—	9	7	12	240	4	10	—	—	—	147	132
2	11	79	8	6	11	237	4	11	66	92	90	143	129
2	12	80	10	8	13	234	4	12	67	93	91	144	126
2	13	—	—	—	14	231	4	13	—	—	—	153	123
2	14	81	11	9	15	228	4	14	68	95	93	146	120
2	15	82	12	10	17	225	4	15	69	96	94	148	117
2	16	83	13	11	18	222	4	16	—	94	92	145	114
2	17	84	14	12	19	219	4	17	70	97	95	152	111
2	18	—	—	—	16	216	4	18	—	—	—	155	108

Notes:

1. Global control pin.

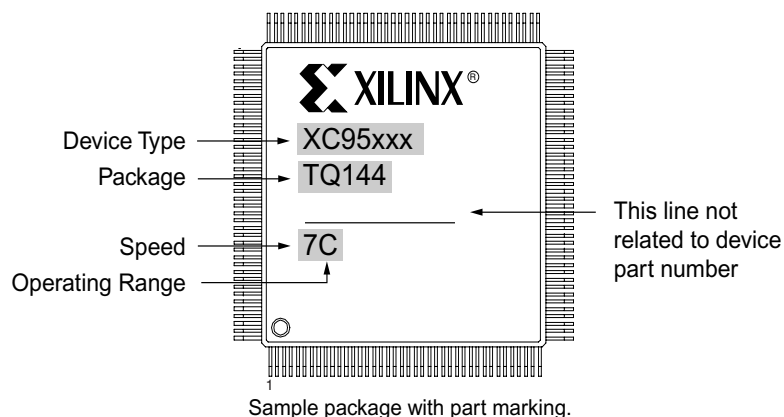
XC95108 I/O Pins (Continued)

Function Block	Macro-cell	PC84	PQ100	TQ100	PQ160	BScan Order	Function Block	Macro-cell	PC84	PQ100	TQ100	PQ160	BScan Order
5	1	—	—	—	76	105	6	1	—	—	—	91	51
5	2	32	52	50	79	102	6	2	45	67	65	103	48
5	3	33	54	52	82	99	6	3	46	68	66	104	45
5	4	—	48	46	72	96	6	4	—	75	73	116	42
5	5	34	55	53	86	93	6	5	47	69	67	106	39
5	6	35	56	54	88	90	6	6	48	70	68	108	36
5	7	—	—	—	78	87	6	7	—	—	—	105	33
5	8	36	57	55	90	84	6	8	50	72	70	111	30
5	9	37	58	56	92	81	6	9	51	73	71	113	27
5	10	—	—	—	84	78	6	10	—	—	—	107	24
5	11	39	60	58	95	75	6	11	52	74	72	115	21
5	12	40	62	60	97	72	6	12	53	76	74	117	18
5	13	—	—	—	87	69	6	13	—	—	—	112	15
5	14	41	63	61	98	66	6	14	54	78	76	122	12
5	15	43	65	63	101	63	6	15	55	79	77	124	9
5	16	—	61	59	96	60	6	16	—	81	79	129	6
5	17	44	66	64	102	57	6	17	56	80	78	126	3
5	18	—	—	—	89	54	6	18	—	—	—	114	0

XC95108 Global, JTAG, and Power Pins

Pin Type	PC84	PQ100	TQ100	PQ160
I/O/GCK1	9	24	22	33
I/O/GCK2	10	25	23	35
I/O/GCK3	12	29	27	42
I/O/GTS1	76	5	3	6
I/O/GTS2	77	6	4	8
I/O/GSR	74	1	99	159
TCK	30	50	48	75
TDI	28	47	45	71
TDO	59	85	83	136
TMS	29	49	47	73
V _{CCINT} 5V	38,73,78	7,59,100	5,57,98	10,46,94,157
V _{CCIO} 3.3V/5V	22,64	28,40,53,90	26,38,51,88	1,41,61,81,121,141
GND	8,16,27,42,49,60	2,23,33,46,64,71,77,86	100,21,31,44,62,69,75,84	20,31,40,51,70,80,99
GND	—	—	—	100,110,120,127,137
GND	—	—	—	160
No connects	—	—	—	3,5,7,32,38,39,48,53,55,65,66,67,83,85,93,109,118,119,125,130,131,132,149,150,151

Device Part Marking and Ordering Combination Information



Device Ordering and Part Marking Number	Speed (pin-to-pin delay)	Pkg. Symbol	No. of Pins	Package Type	Operating Range ⁽¹⁾
XC95108-7PC84C	7.5 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	C
XC95108-7PCG84C	7.5 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	C
XC95108-7PQ100C	7.5 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-7PQG100C	7.5 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-7TQ100C	7.5 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	C
XC95108-7TQG100C	7.5 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	C
XC95108-7PQ160C	7.5 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-7PQG160C	7.5 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-7PC84I	7.5 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	I
XC95108-7PCG84I	7.5 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	I
XC95108-7PQ100I	7.5 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-7PQG100I	7.5 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I
XC95108-7TQ100I	7.5 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	I
XC95108-7TQG100I	7.5 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	I
XC95108-7PQ160I	7.5 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-7PQG160I	7.5 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I
XC95108-10PC84C	10 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	C
XC95108-10PCG84C	10 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	C
XC95108-10PQ100C	10 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-10PQG100C	10 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-10TQ100C	10 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	C
XC95108-10TQG100C	10 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	C
XC95108-10PQ160C	10 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-10PQG160C	10 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-10PC84I	10 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	I
XC95108-10PCG84I	10 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	I
XC95108-10PQ100I	10 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-10PQG100I	10 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I
XC95108-10TQ100I	10 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	I
XC95108-10TQG100I	10 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	I
XC95108-10PQ160I	10 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-10PQG160I	10 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I
XC95108-15PC84C	15 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	C

Device Ordering and Part Marking Number	Speed (pin-to-pin delay)	Pkg. Symbol	No. of Pins	Package Type	Operating Range ⁽¹⁾
XC95108-15PCG84C	15 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	C
XC95108-15PQ100C	15 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-15PQG100C	15 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-15TQ100C	15 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	C
XC95108-15TQG100C	15 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	C
XC95108-15PQ160C	15 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-15PQG160C	15 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-15PC84I	15 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	I
XC95108-15PCG84I	15 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	I
XC95108-15PQ100I	15 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-15PQG100I	15 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I
XC95108-15TQ100I	15 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	I
XC95108-15TQG100I	15 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	I
XC95108-15PQ160I	15 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-15PQG160I	15 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I
XC95108-20PC84C	20 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	C
XC95108-20PCG84C	20 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	C
XC95108-20PQ100C	20 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-20PQG100C	20 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-20TQ100C	20 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	C
XC95108-20TQG100C	20 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	C
XC95108-20PQ160C	20 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	C
XC95108-20PQG160C	20 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	C
XC95108-20PC84I	20 ns	PC84	84-pin	Plastic Lead Chip Carrier (PLCC)	I
XC95108-20PCG84I	20 ns	PCG84	84-pin	Plastic Lead Chip Carrier (PLCC); Pb-Free	I
XC95108-20PQ100I	20 ns	PQ100	100-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-20PQG100I	20 ns	PQG100	100-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I
XC95108-20TQ100I	20 ns	TQ100	100-pin	Thin Quad Flat Pack (TQFP)	I
XC95108-20TQG100I	20 ns	TQG100	100-pin	Thin Quad Flat Pack (TQFP); Pb-Free	I
XC95108-20PQ160I	20 ns	PQ160	160-pin	Plastic Quad Flat Pack (PQFP)	I
XC95108-20PQG160I	20 ns	PQG160	160-pin	Plastic Quad Flat Pack (PQFP); Pb-Free	I

Notes:

1. C = Commercial: T_A = 0° to +70°C; I = Industrial: T_A = –40° to +85°C

Warranty Disclaimer

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Additional Information

[XC9500 Data Sheets and Application Notes](#)

[Online Store](#)

[Device Packaging](#)

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
12/04/98	3.0	Update AC characteristics and internal parameters.
06/18/03	4.0	Updated format.
08/21/03	4.1	Updated Package Device Marking Pin 1 orientation.
03/01/04	4.2	Updated table on page 8 for PQ160 pins.
04/15/05	4.3	Added asynchronous preset/reset pulse width specification (T_{APRPW}).
04/03/06	4.4	Added Warranty Disclaimer. Added Pb-Free package ordering information.

Features

- High-performance
 - 5 ns pin-to-pin logic delays on all pins
 - f_{CNT} to 125 MHz
- Large density range
 - 36 to 288 macrocells with 800 to 6,400 usable gates
- 5V in-system programmable
 - Endurance of 10,000 program/erase cycles
 - Program/erase over full commercial voltage and temperature range
- Enhanced pin-locking architecture
- Flexible 36V18 Function Block
 - 90 product terms drive any or all of 18 macrocells within Function Block
 - Global and product term clocks, output enables, set and reset signals
 - Extensive IEEE Std 1149.1 boundary-scan (JTAG) support
 - Programmable power reduction mode in each macrocell
 - Slew rate control on individual outputs
 - User programmable ground pin capability
 - Extended pattern security features for design protection
 - High-drive 24 mA outputs
 - 3.3V or 5V I/O capability

- Advanced CMOS 5V FastFLASH™ technology
- Supports parallel programming of multiple XC9500 devices

Family Overview

The XC9500 CPLD family provides advanced in-system programming and test capabilities for high performance, general purpose logic integration. All devices are in-system programmable for a minimum of 10,000 program/erase cycles. Extensive IEEE 1149.1 (JTAG) boundary-scan support is also included on all family members.

As shown in [Table 1](#), logic density of the XC9500 devices ranges from 800 to over 6,400 usable gates with 36 to 288 registers, respectively. Multiple package options and associated I/O capacity are shown in [Table 2](#). The XC9500 family is fully pin-compatible allowing easy design migration across multiple density options in a given package footprint.

The XC9500 architectural features address the requirements of in-system programmability. Enhanced pin-locking capability avoids costly board rework. An expanded JTAG instruction set allows version control of programming patterns and in-system debugging. In-system programming throughout the full device operating range and a minimum of 10,000 program/erase cycles provide worry-free reconfigurations and system field upgrades.

Advanced system features include output slew rate control and user-programmable ground pins to help reduce system noise. I/Os may be configured for 3.3V or 5V operation. All outputs provide 24 mA drive.

Table 1: XC9500 Device Family

	XC9536	XC9572	XC95108	XC95144	XC95216	XC95288
Macrocells	36	72	108	144	216	288
Usable Gates	800	1,600	2,400	3,200	4,800	6,400
Registers	36	72	108	144	216	288
T_{PD} (ns)	5	7.5	7.5	7.5	10	15
T_{SU} (ns)	3.5	4.5	4.5	4.5	6.0	8.0
T_{CO} (ns)	4.0	4.5	4.5	4.5	6.0	8.0
f_{CNT} (MHz) ⁽¹⁾	100	125	125	125	111.1	92.2
f_{SYSTEM} (MHz) ⁽²⁾	100	83.3	83.3	83.3	66.7	56.6

1. f_{CNT} = Operating frequency for 16-bit counters.

2. f_{SYSTEM} = Internal operating frequency for general purpose system designs spanning multiple FBs.

Table 2: Available Packages and Device I/O Pins (not including dedicated JTAG pins)

	XC9536	XC9572	XC95108	XC95144	XC95216	XC95288
44-Pin VQFP	34	-	-	-	-	-
44-Pin PLCC	34	34	-	-	-	-
48-Pin CSP	34	-	-	-	-	-
84-Pin PLCC	-	69	69	-	-	-
100-Pin TQFP	-	72	81	81	-	-
100-Pin PQFP	-	72	81	81	-	-
160-Pin PQFP	-	-	108	133	133	-
208-Pin HQFP	-	-	-	-	166	168
352-Pin BGA	-	-	-	-	166 ⁽²⁾	192

1. Most packages available in Pb-Free option. See individual data sheets for more details.

2. 352-pin BGA package is being discontinued for the XC95216. See [XCN07010](#) for details.

Architecture Description

Each XC9500 device is a subsystem consisting of multiple Function Blocks (FBs) and I/O Blocks (IOBs) fully interconnected by the Fast CONNECT™ switch matrix. The IOB provides buffering for device inputs and outputs. Each FB

provides programmable logic capability with 36 inputs and 18 outputs. The Fast CONNECT switch matrix connects all FB outputs and input signals to the FB inputs. For each FB, 12 to 18 outputs (depending on package pin-count) and

associated output enable signals drive directly to the IOBs. See Figure 1.

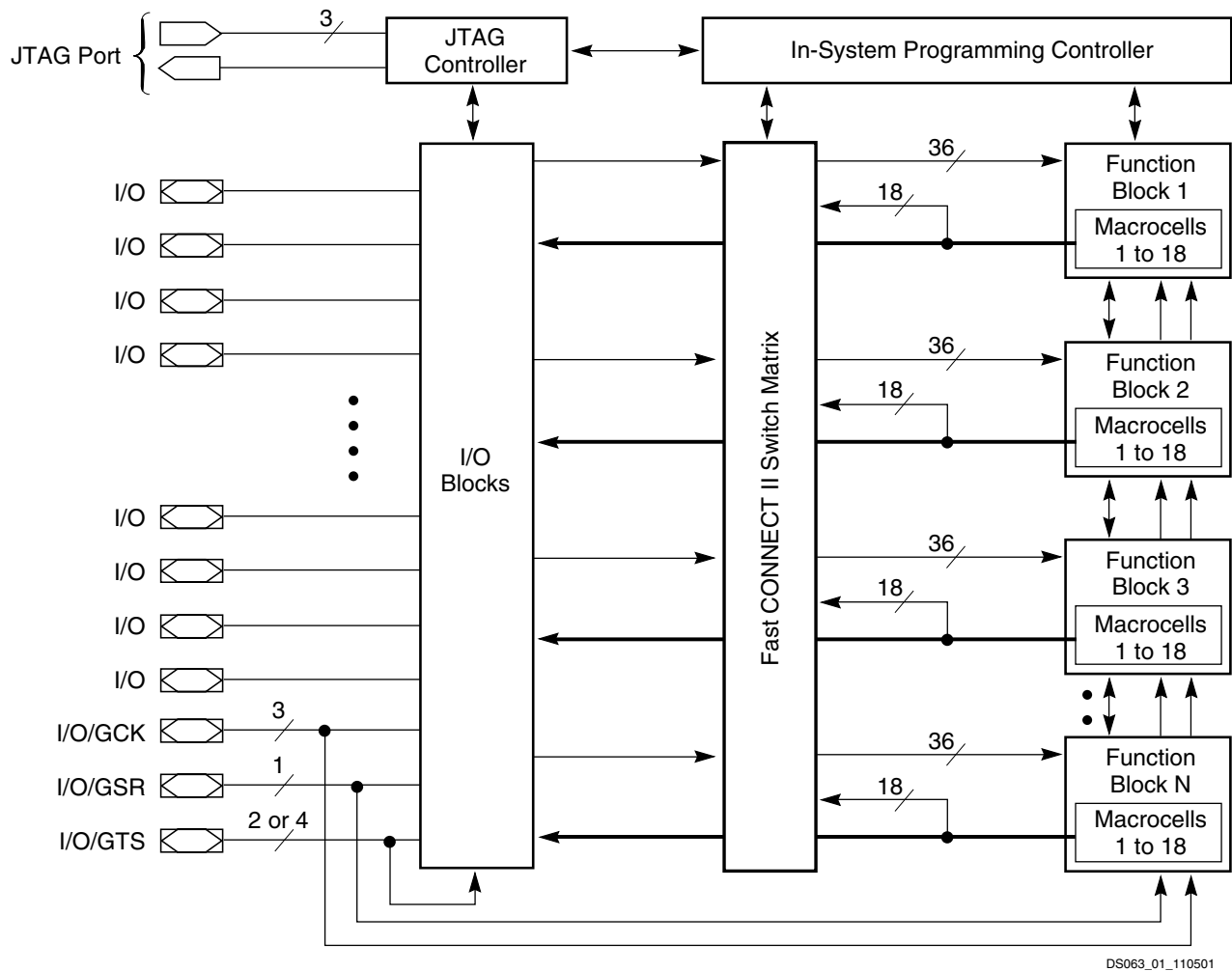


Figure 1: XC9500 Architecture

Note: Function block outputs (indicated by the bold lines) drive the I/O blocks directly.

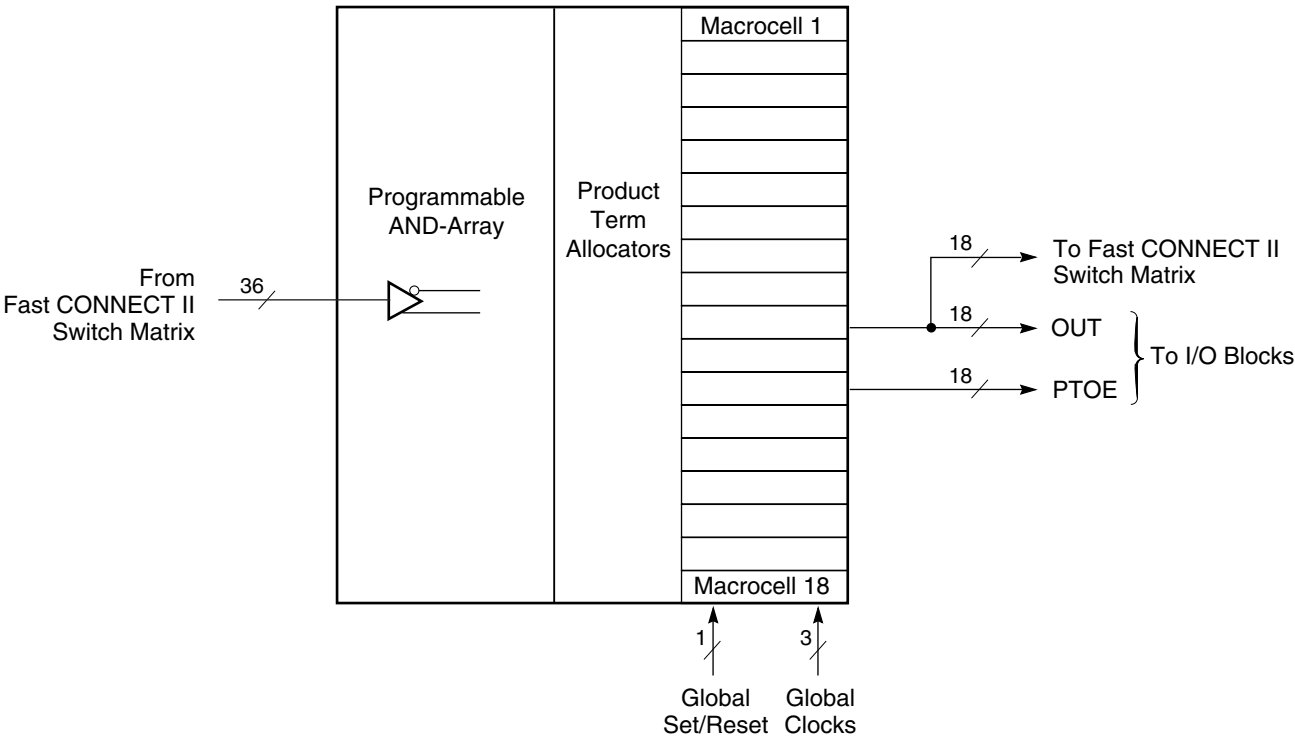
Function Block

Each Function Block, as shown in Figure 2, is comprised of 18 independent macrocells, each capable of implementing a combinatorial or registered function. The FB also receives global clock, output enable, and set/reset signals. The FB generates 18 outputs that drive the Fast CONNECT switch matrix. These 18 outputs and their corresponding output enable signals also drive the IOB.

Logic within the FB is implemented using a sum-of-products representation. Thirty-six inputs provide 72 true and complement signals into the programmable AND-array to form

90 product terms. Any number of these product terms, up to the 90 available, can be allocated to each macrocell by the product term allocator.

Each FB (except for the XC9536) supports local feedback paths that allow any number of FB outputs to drive into its own programmable AND-array without going outside the FB. These paths are used for creating very fast counters and state machines where all state registers are within the same FB.



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Figure 2: XC9500 Function Block

Five direct product terms from the AND-array are available for use as primary data inputs (to the OR and XOR gates) to implement combinatorial functions, or as control inputs including clock, set/reset, and output enable. The product

The macrocell register can be configured as a D-type or T-type flip-flop, or it may be bypassed for combinatorial operation. Each register supports both asynchronous set and reset operations. During power-up, all user registers are initialized to the user-defined preload state (default to 0 if unspecified).

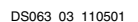
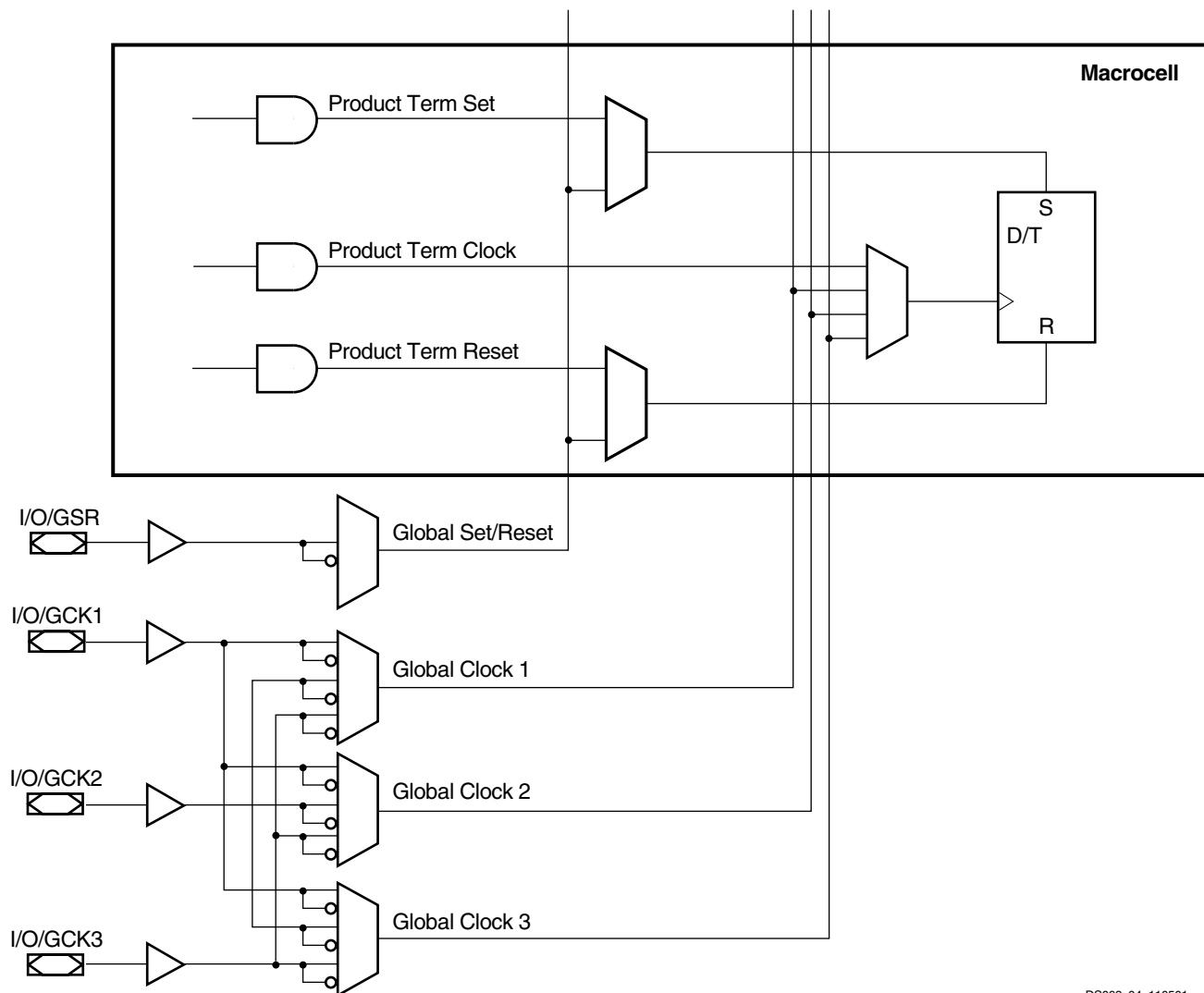


Figure 3: XC9500 Macrocell Within Function Block

All global control signals are available to each individual macrocell, including clock, set/reset, and output enable signals. As shown in **Figure 4**, the macrocell register clock originates from either of three global clocks or a product

term clock. Both true and complement polarities of a GCK pin can be used within the device. A GSR input is also provided to allow user registers to be set to a user-defined state.

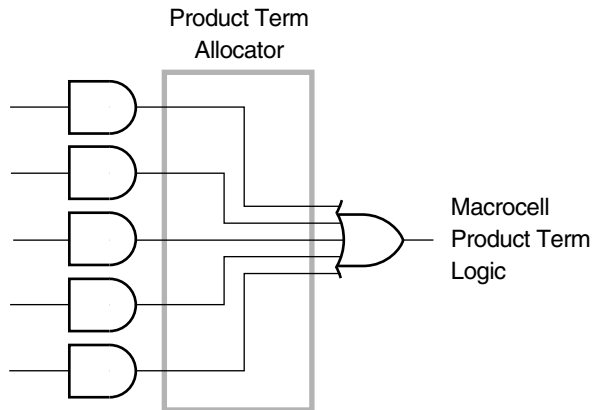


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Figure 4: Macrocell Clock and Set/Reset Capability

Product Term Allocator

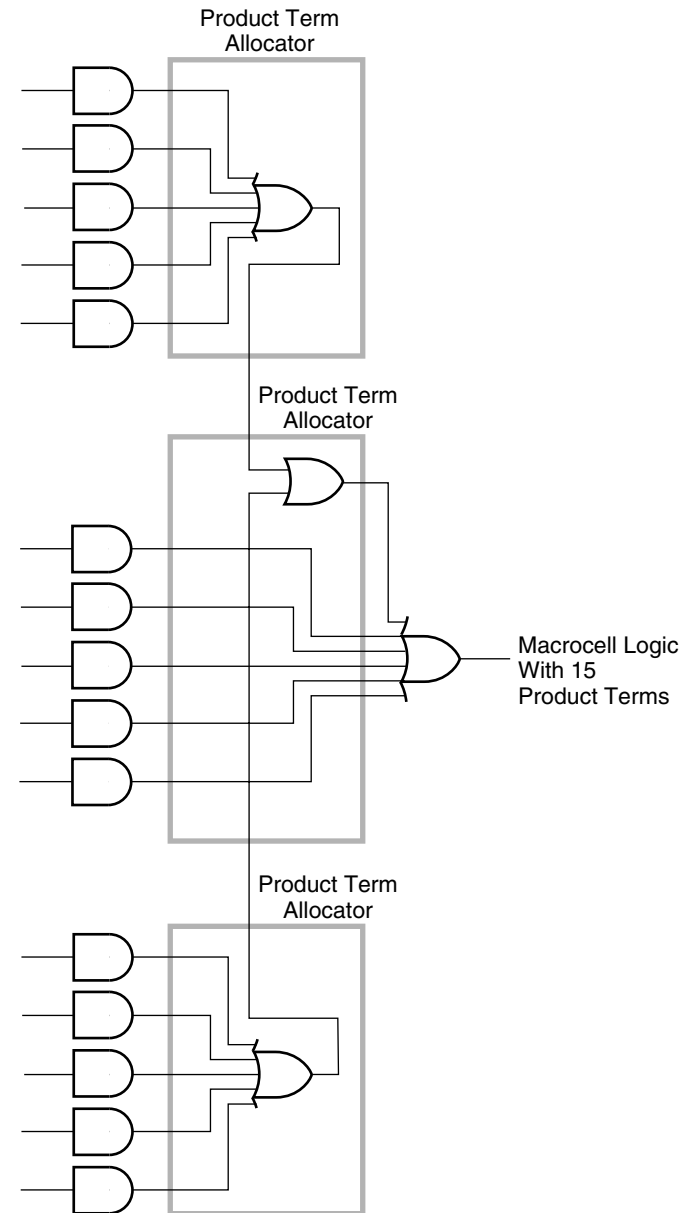
The product term allocator controls how the five direct product terms are assigned to each macrocell. For example, all five direct terms can drive the OR function as shown in Figure 5.



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Figure 5: Macrocell Logic Using Direct Product Term

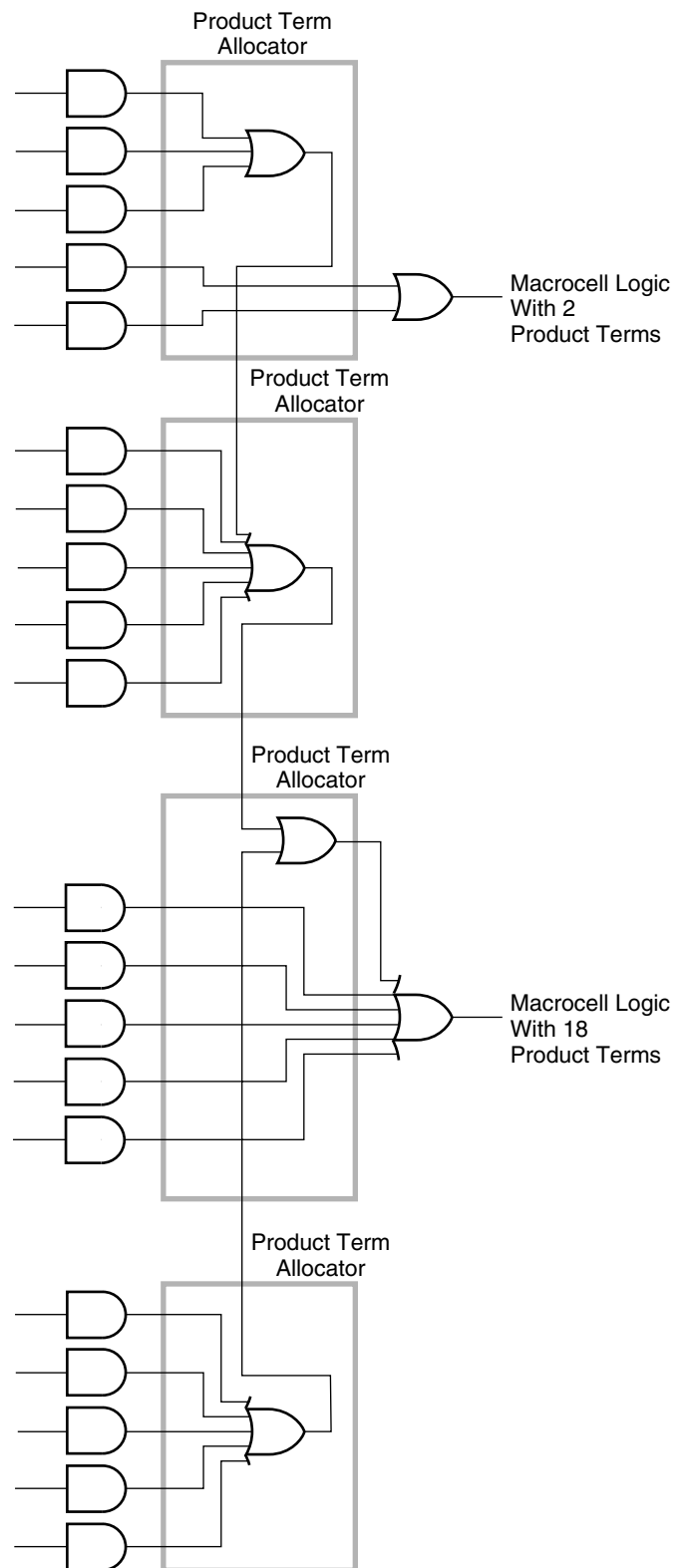
The product term allocator can re-assign other product terms within the FB to increase the logic capacity of a macrocell beyond five direct terms. Any macrocell requiring additional product terms can access uncommitted product terms in other macrocells within the FB. Up to 15 product terms can be available to a single macrocell with only a small incremental delay of T_{PTA} , as shown in Figure 6.



DS063_06_110501

Figure 6: Product Term Allocation With 15 Product Terms

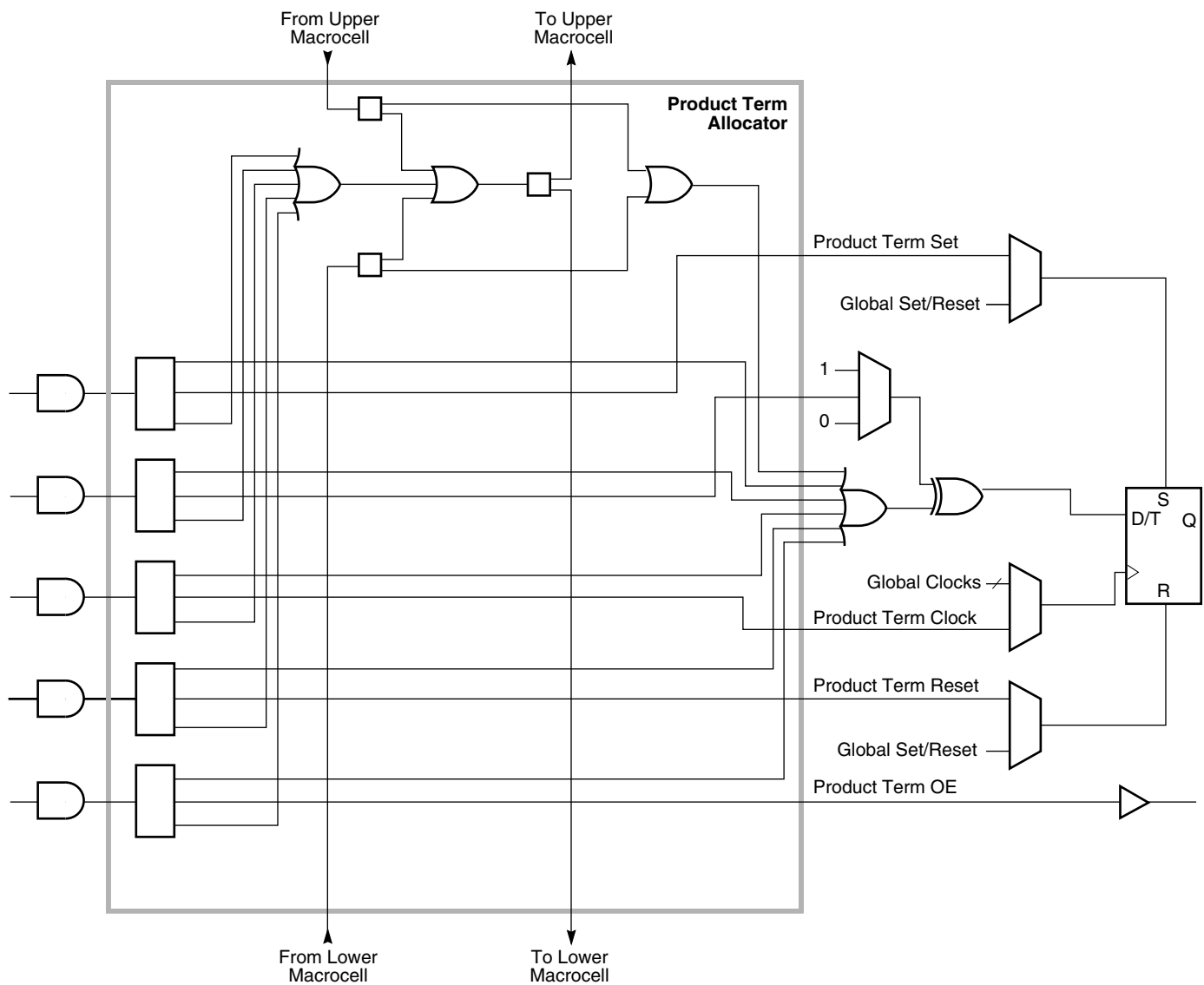
The product term allocator can re-assign product terms from any macrocell within the FB by combining partial sums of products over several macrocells, as shown in **Figure 7**. In this example, the incremental delay is only $2 \cdot T_{PTA}$. All 90 product terms are available to any macrocell, with a maximum incremental delay of $8 \cdot T_{PTA}$.



DS063_07_110501

Figure 7: Product Term Allocation Over Several Macrocells

The internal logic of the product term allocator is shown in **Figure 8**.



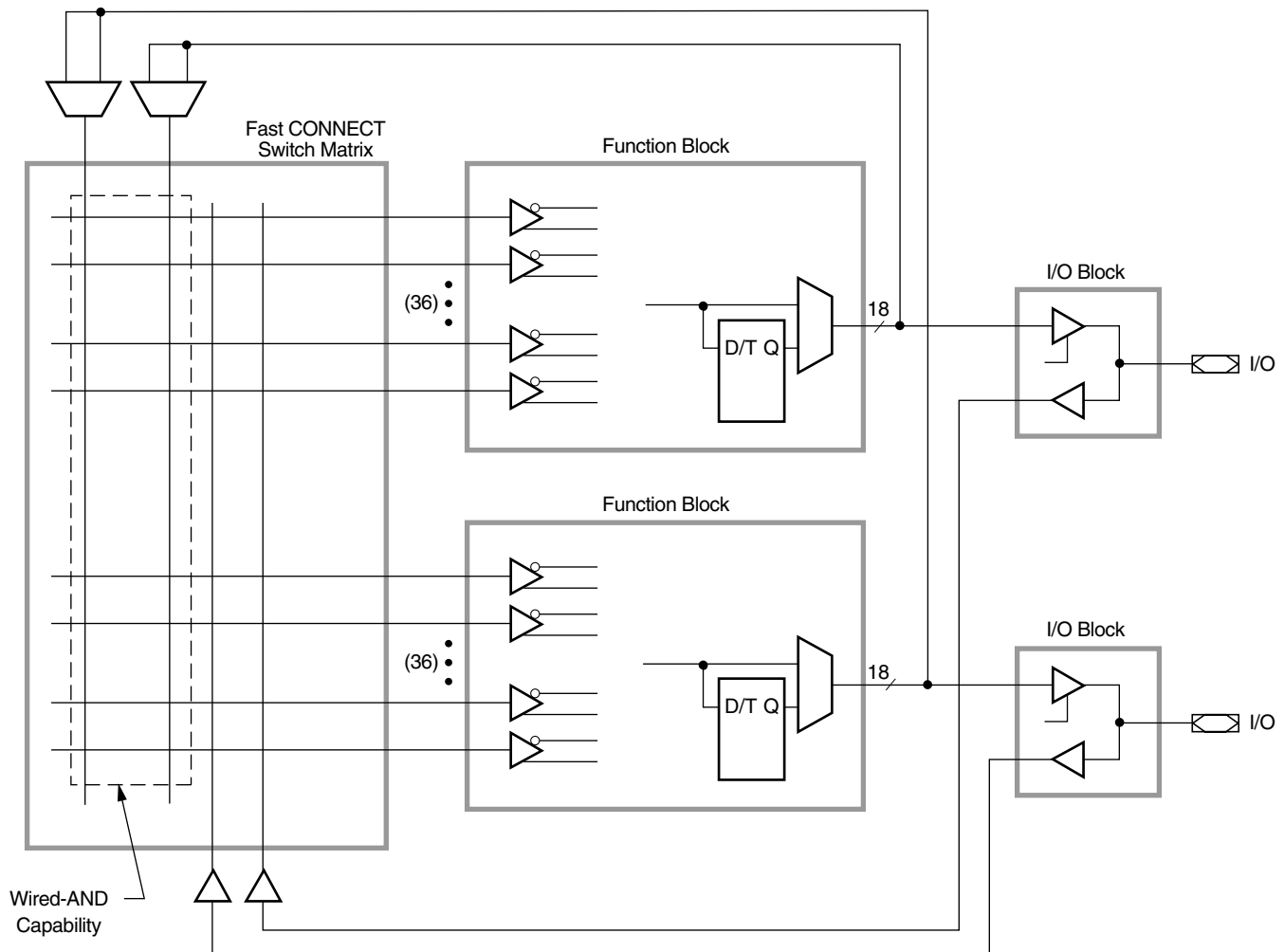
DS063_08_110501

Figure 8: Product Term Allocator Logic

Fast CONNECT Switch Matrix

The Fast CONNECT switch matrix connects signals to the FB inputs, as shown in **Figure 9**. All IOB outputs (corresponding to user pin inputs) and all FB outputs drive the Fast CONNECT matrix. Any of these (up to a FB fan-in limit of 36) may be selected, through user programming, to drive each FB with a uniform delay.

The Fast CONNECT switch matrix is capable of combining multiple internal connections into a single wired-AND output before driving the destination FB. This provides additional logic capability and increases the effective logic fan-in of the destination FB without any additional timing delay. This capability is available for internal connections originating from FB outputs only. It is automatically invoked by the development software where applicable.



DS063_09_110501

Figure 9: Fast CONNECT Switch Matrix

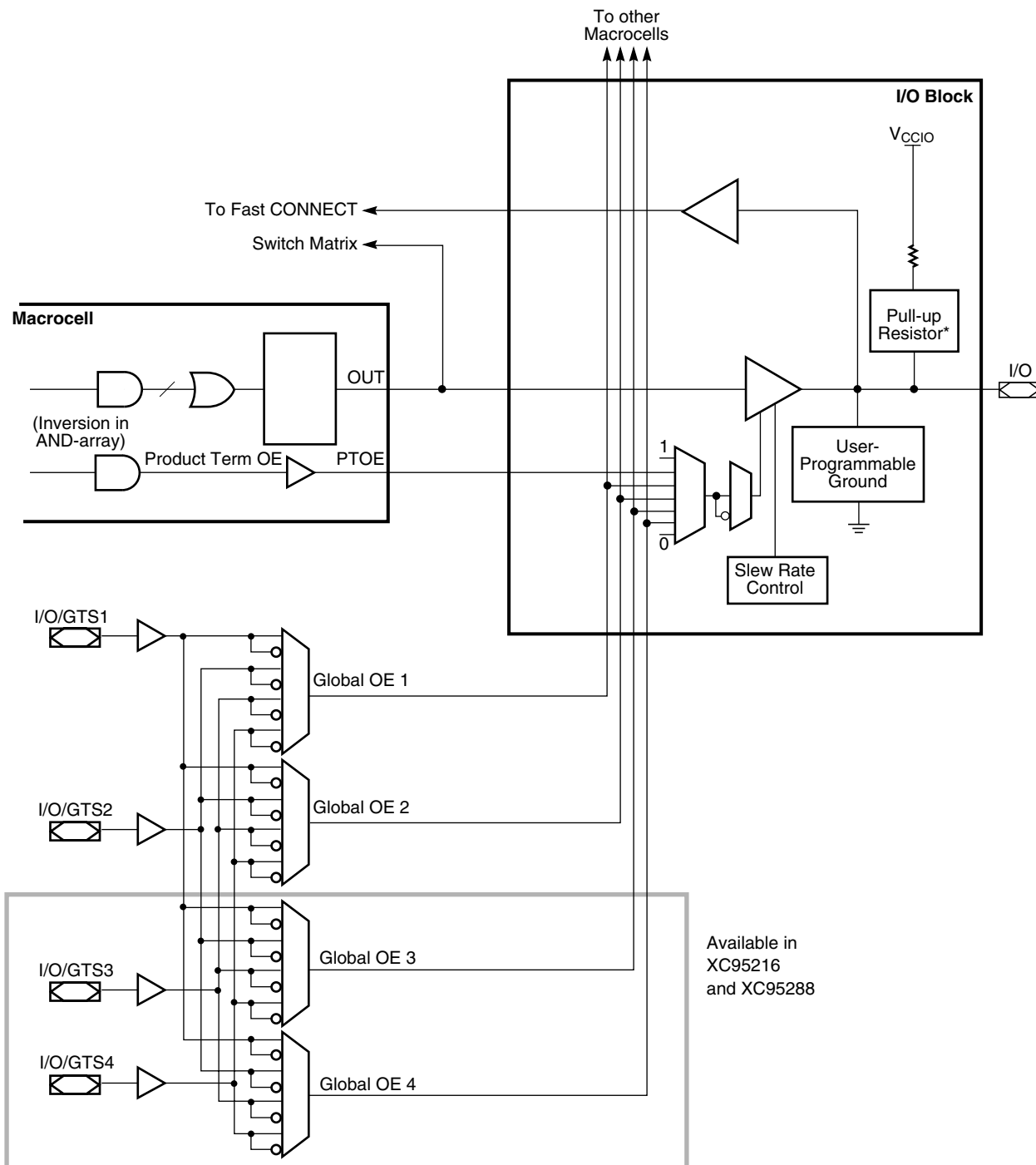
I/O Block

The I/O Block (IOB) interfaces between the internal logic and the device user I/O pins. Each IOB includes an input buffer, output driver, output enable selection multiplexer, and user programmable ground control. See Figure 10 for details.

The input buffer is compatible with standard 5V CMOS, 5V TTL, and 3.3V signal levels. The input buffer uses the internal

5V voltage supply (V_{CCINT}) to ensure that the input thresholds are constant and do not vary with the V_{CCIO} voltage.

The output enable may be generated from one of four options: a product term signal from the macrocell, any of the global OE signals, always [1], or always [0]. There are two global output enables for devices with up to 144 macrocells, and four global output enables for the rest of the devices. Both polarities of any of the global 3-state control (GTS) pins may be used within the device..



DS063_10_092203

Figure 10: I/O Block and Output Enable Capability

Each output has independent slew rate control. Output edge rates may be slowed down to reduce system noise (with an additional time delay of T_{SLEW}) through programming. See **Figure 11**.

Each IOB provides user programmable ground pin capability. This allows device I/O pins to be configured as additional ground pins. By tying strategically located programmable ground pins to the external ground connection, system noise generated from large numbers of simultaneous switching outputs may be reduced.

A control pull-up resistor (typically 10K ohms) is attached to each device I/O pin to prevent them from floating when the device is not in normal user operation. This resistor is active during device programming mode and system power-up. It is also activated for an erased device. The resistor is deactivated during normal operation.

The output driver is capable of supplying 24 mA output drive. All output drivers in the device may be configured for either 5V TTL levels or 3.3V levels by connecting the device output voltage supply (V_{CCIO}) to a 5V or 3.3V voltage supply.

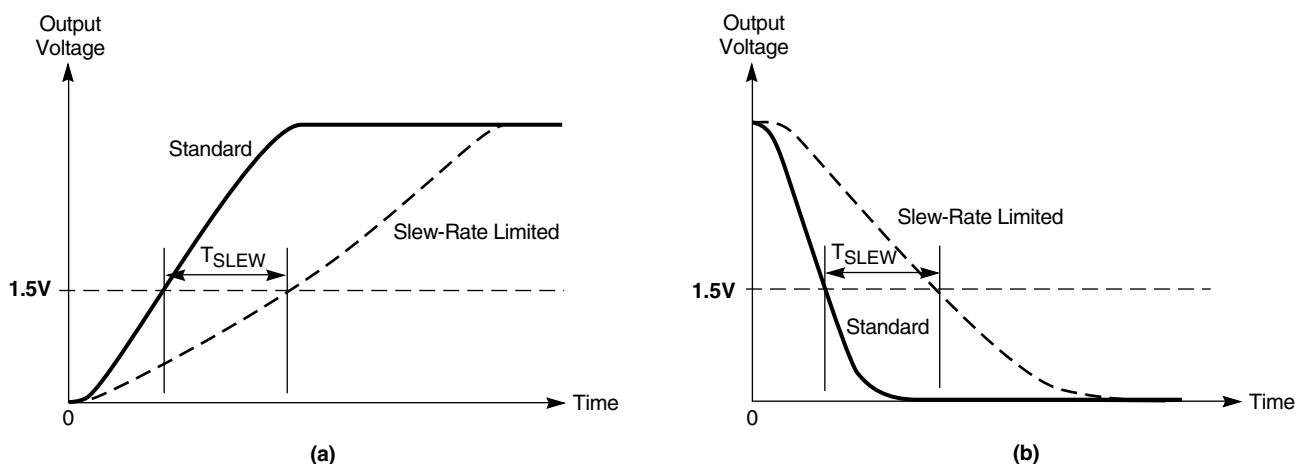
Figure 12 shows how the XC9500 device can be used in 5V only and mixed 3.3V/5V systems.

Pin-Locking Capability

The capability to lock the user defined pin assignments during design changes depends on the ability of the architecture to adapt to unexpected changes. The XC9500 devices have architectural features that enhance the ability to accept design changes while maintaining the same pinout.

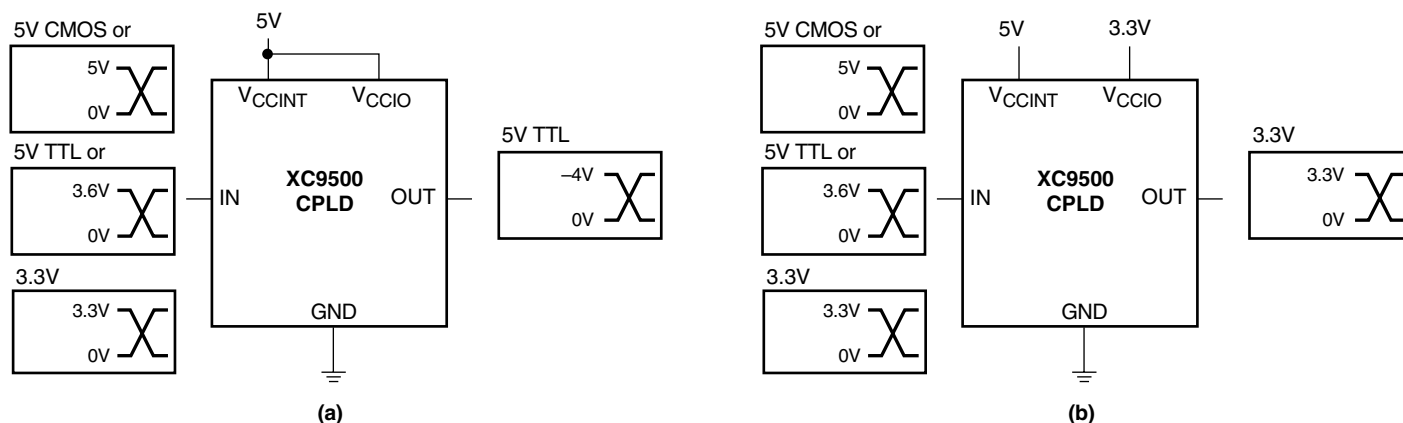
The XC9500 architecture provides maximum routing within the Fast CONNECT switch matrix, and incorporates a flexible Function Block that allows block-wide allocation of available product terms. This provides a high level of confidence of maintaining both input and output pin assignments for unexpected design changes.

For extensive design changes requiring higher logic capacity than is available in the initially chosen device, the new design may be able to fit into a larger pin-compatible device using the same pin assignments. The same board may be used with a higher density device without the expense of board rework.



DS063_11_110501

Figure 11: Output slew-Rate for (a) Rising and (b) Falling Outputs



DS063_12_110501

Figure 12: XC9500 Devices in (a) 5V Systems and (b) Mixed 5V/3.3V Systems

In-System Programming

XC9500 devices are programmed in-system via a standard 4-pin JTAG protocol, as shown in [Figure 13](#). In-system programming offers quick and efficient design iterations and eliminates package handling. The Xilinx development system provides the programming data sequence using a Xilinx download cable, a third-party JTAG development system, JTAG-compatible board tester, or a simple microprocessor interface that emulates the JTAG instruction sequence.

All I/Os are 3-stated and pulled high by the IOB resistors during in-system programming. If a particular signal must remain Low during this time, then a pulldown resistor may be added to the pin.

External Programming

XC9500 devices can also be programmed by the Xilinx HW130 device programmer as well as third-party programmers. This provides the added flexibility of using pre-programmed devices during manufacturing, with an in-system programmable option for future enhancements.

Endurance

All XC9500 CPLDs provide a minimum endurance level of 10,000 in-system program/erase cycles. Each device meets all functional, performance, and data retention specifications within this endurance limit.

IEEE 1149.1 Boundary-Scan (JTAG)

XC9500 devices fully support IEEE 1149.1 boundary-scan (JTAG). EXTEST, SAMPLE/PRELOAD, BYPASS, USERCODE, INTEST, IDCODE, and HIGHZ instructions are supported in each device. For ISP operations, five additional instructions are added; the ISPEN, FERASE, FPGM, FVIFY, and ISPEX instructions are fully compliant extensions of the 1149.1 instruction set.

The TMS and TCK pins have dedicated pull-up resistors as specified by the IEEE 1149.1 standard.

Boundary Scan Description Language (BSDL) files for the XC9500 are included in the development system and are available on the Xilinx FTP site.

Design Security

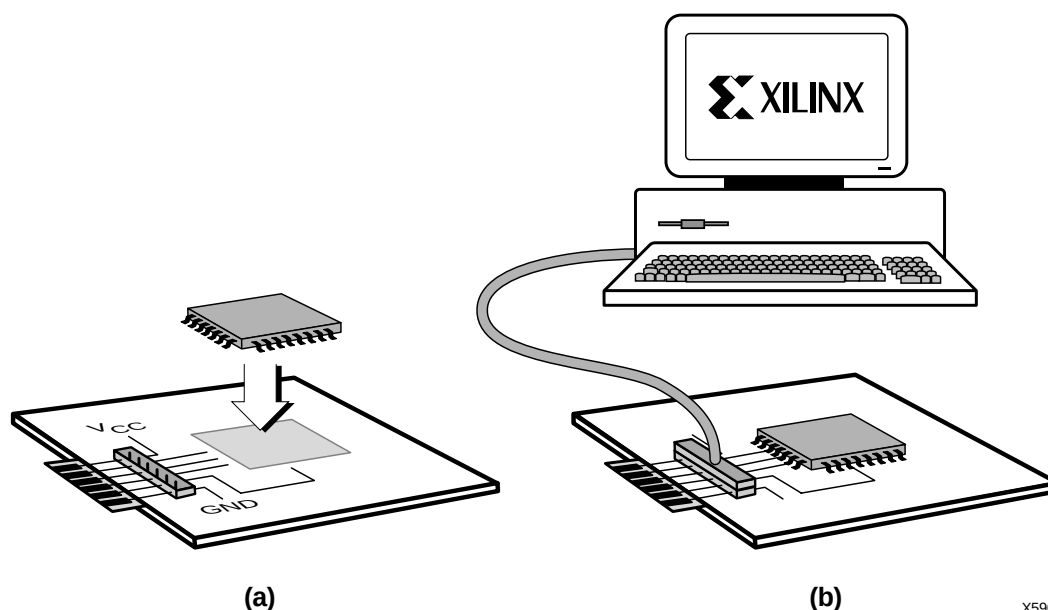
XC9500 devices incorporate advanced data security features which fully protect the programming data against unauthorized reading or inadvertent device erasure/reprogramming. [Table 3](#) shows the four different security settings available.

The read security bits can be set by the user to prevent the internal programming pattern from being read or copied. When set, they also inhibit further program operations but allow device erase. Erasing the entire device is the only way to reset the read security bit.

The write security bits provide added protection against accidental device erasure or reprogramming when the JTAG pins are subject to noise, such as during system power-up. Once set, the write-protection may be deactivated when the device needs to be reprogrammed with a valid pattern.

Table 3: Data Security Options

		Read Security	
		Default	Set
Write Security	Default	Read Allowed Program/Erase Allowed	Read Inhibited Program Inhibited Erase Allowed
	Set	Read Allowed Program/Erase Inhibited	Read Inhibited Program/Erase Inhibited



X5902

Figure 13: In-System Programming Operation (a) Solder Device to PCB and (b) Program Using Download Cable

Low Power Mode

All XC9500 devices offer a low-power mode for individual macrocells or across all macrocells. This feature allows the device power to be significantly reduced.

Each individual macrocell may be programmed in low-power mode by the user. Performance-critical parts of the application can remain in standard power mode, while other parts of the application may be programmed for low-power operation to reduce the overall power dissipation. Macrocells programmed for low-power mode incur additional delay (T_{LP}) in pin-to-pin combinatorial delay as well as register setup time. Product term clock to output and product term output enable delays are unaffected by the macrocell power-setting.

Timing Model

The uniformity of the XC9500 architecture allows a simplified timing model for the entire device. The basic timing

model, shown in Figure 14, is valid for macrocell functions that use the direct product terms only, with standard power setting, and standard slew rate setting. Table 4 shows how each of the key timing parameters is affected by the product term allocator (if needed), low-power setting, and slew-limited setting.

The product term allocation time depends on the logic span of the macrocell function, which is defined as one less than the maximum number of allocators in the product term path. If only direct product terms are used, then the logic span is 0. The example in Figure 6 shows that up to 15 product terms are available with a span of 1. In the case of Figure 7, the 18 product term function has a span of 2.

Detailed timing information may be derived from the full timing model shown in Figure 15. The values and explanations for each parameter are given in the individual device data sheets.

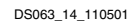


Figure 14: Basic Timing Model

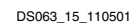


Figure 15: Detailed Timing Model

Power-Up Characteristics

The XC9500 devices are well behaved under all operating conditions. During power-up each XC9500 device employs internal circuitry which keeps the device in the quiescent state until the V_{CCINT} supply voltage is at a safe level (approximately 3.8V). During this time, all device pins and JTAG pins are disabled and all device outputs are disabled with the IOB pull-up resistors (~10K ohms) enabled, as shown in Table 5. When the supply voltage reaches a safe level, all user registers become initialized (typically within 100 μ s for 9536, 95144, 200 μ s for 95216, and 300 μ s for 95288), and the device is immediately available for operation, as shown in Figure 16.

If the device is in the erased state (before any user pattern is programmed), the device outputs remain disabled with the IOB pull-up resistors enabled. The JTAG pins are enabled to allow the device to be programmed at any time.

If the device is programmed, the device inputs and outputs take on their configured states for normal operation. The JTAG pins are enabled to allow device erasure or boundary-scan tests at any time.

Development System Support

The XC9500 CPLD family is fully supported by the development systems available from Xilinx and the Xilinx Alliance Program vendors.

The designer can create the design using ABEL, schematics, equations, VHDL, or Verilog in a variety of software front-end tools. The development system can be used to

implement the design and generate a JEDEC bitmap which can be used to program the XC9500 device. Each development system includes JTAG download software that can be used to program the devices via the standard JTAG interface and a download cable.

FastFLASH Technology

An advanced CMOS Flash process is used to fabricate all XC9500 devices. Specifically developed for Xilinx in-system programmable CPLDs, the FastFLASH process provides high performance logic capability, fast programming times, and endurance of 10,000 program/erase cycles.

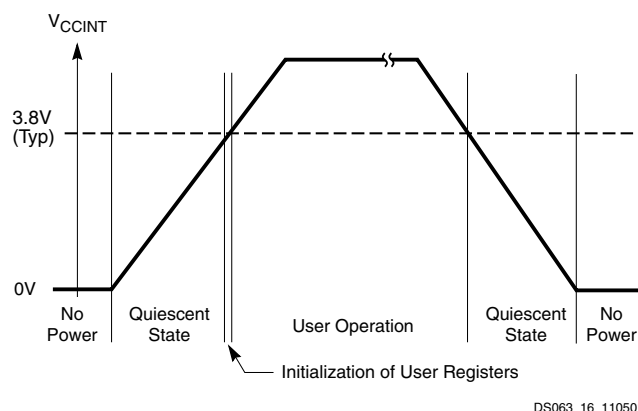


Figure 16: Device Behavior During Power-up

Table 4: Timing Model Parameters

Parameter	Description	Product Term Allocator ⁽¹⁾	Macrocell Low-Power Setting	Output Slew-Limited Setting
T_{PD}	Propagation Delay	$+ T_{PTA} * S$	$+ T_{LP}$	$+ T_{SLEW}$
T_{SU}	Global Clock Setup Time	$+ T_{PTA} * S$	$+ T_{LP}$	-
T_{CO}	Global Clock-to-output	-	-	$+ T_{SLEW}$
T_{PSU}	Product Term Clock Setup Time	$+ T_{PTA} * S$	$+ T_{LP}$	-
T_{PCO}	Product Term Clock-to-output	-	-	$+ T_{SLEW}$
T_{SYSTEM}	Internal System Cycle Period	$+ T_{PTA} * S$	$+ T_{LP}$	-

Notes:

1. S = the logic span of the function, as defined in the text.

Table 5: XC9500 Device Characteristics

Device Circuitry	Quiescent State	Erased Device Operation	Valid User Operation
IOB Pull-up Resistors	Enabled	Enabled	Disabled
Device Outputs	Disabled	Disabled	As Configured

Table 5: XC9500 Device Characteristics

Device Circuitry	Quiescent State	Erased Device Operation	Valid User Operation
Device Inputs and Clocks	Disabled	Disabled	As Configured
Function Block	Disabled	Disabled	As Configured
JTAG Controller	Disabled	Enabled	Enabled

Warranty Disclaimer

THESE PRODUCTS ARE SUBJECT TO THE TERMS OF THE XILINX LIMITED WARRANTY WHICH CAN BE VIEWED AT <http://www.xilinx.com/warranty.htm>. THIS LIMITED WARRANTY DOES NOT EXTEND TO ANY USE OF THE PRODUCTS IN AN APPLICATION OR ENVIRONMENT THAT IS NOT WITHIN THE SPECIFICATIONS STATED ON THE THEN-CURRENT XILINX DATA SHEET FOR THE PRODUCTS. PRODUCTS ARE NOT DESIGNED TO BE FAIL-SAFE AND ARE NOT WARRANTED FOR USE IN APPLICATIONS THAT POSE A RISK OF PHYSICAL HARM OR LOSS OF LIFE. USE OF PRODUCTS IN SUCH APPLICATIONS IS FULLY AT THE RISK OF CUSTOMER SUBJECT TO APPLICABLE LAWS AND REGULATIONS.

Additional Information

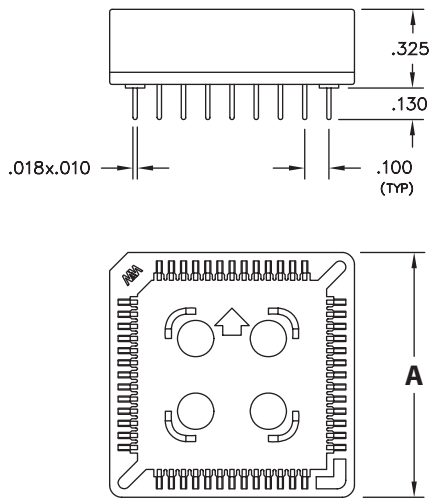
[XC9500 Data sheets and application notes.](#)

[Packages](#)

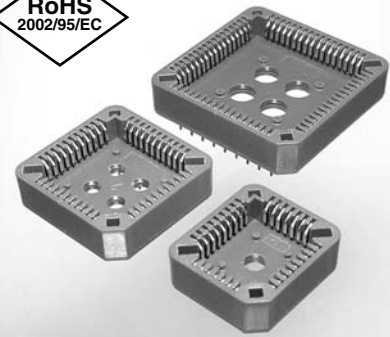
Revision History

The following table shows the revision history for this document.

Date	Version	Revision
3.0	12/14/98	Revised datasheet to reflect new AC characteristics and Internal Timing Parameters.
4.0	02/10/99	Corrected Figure 3.
5.0	09/15/99	Added -10 speed grade to XC95288.
5.1	09/22/03	Minor edits.
5.2	02/16/04	Corrected statement on GTS inputs on page 10. Added links to additional information.
5.3	04/15/05	Update to PDF attributes only. No changes to documentation.
5.4	04/03/06	Added Warranty Disclaimer. Added note on Pb-Free packages.
5.5	06/25/07	Change to Table 2, listing discontinuance of 352-pin BGA package for the XC95216. See XCN07010 for details.



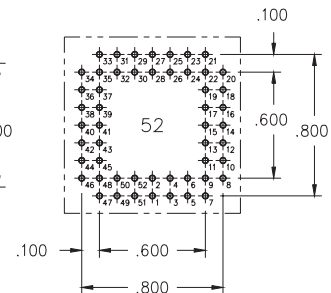
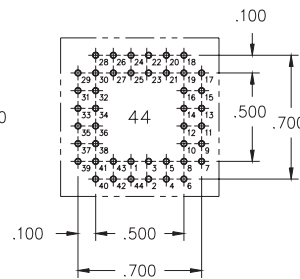
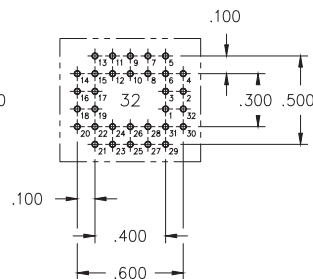
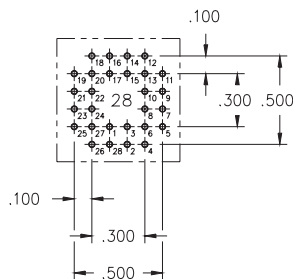
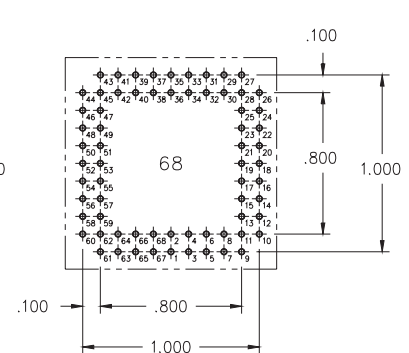
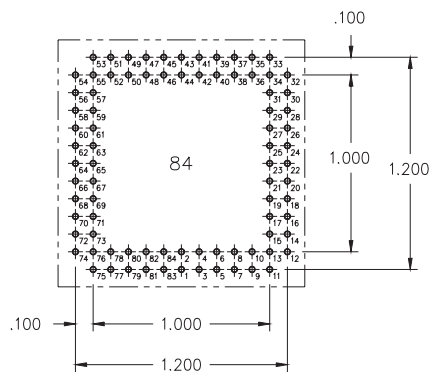
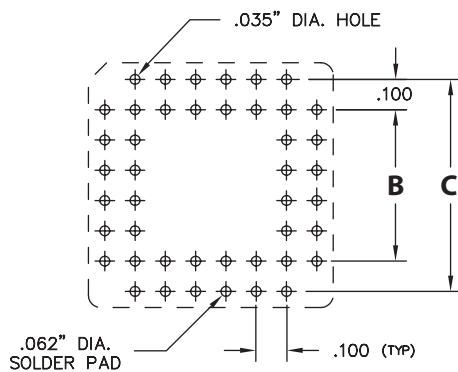
- Note: Not end stackable.
- Accepts JEDEC PLCCs MS-016 & MS-018 leaded plastic substrates.
- Internal standoffs insure proper positioning of chip carrier in socket.
- Standoffs provide clearance for heat dissipation and cleaning.
- Contacts are plated with 150 μ " tin.
- Insulator material is glass reinforced PPS.



PRINTED CIRCUIT DRILLING PATTERNS
(TOP VIEW)

.035" dia. min. mounting holes

***For Electrical,
Mechanical & Enviromental
Data, See pg. 113***



No. of Contacts	Ordering Information	- A -	- B -	- C -	Quantity per Tube
20	940-44-020-24-000000	0.613	0.200	0.400	38
28	940-44-028-24-000000	0.713	0.300	0.500	33
32*	940-44-032-24-000000*	.813 / .713	.400 / .300	.600 / .500	29
44	940-44-044-24-000000	0.913	0.500	0.700	26
52	940-44-052-24-000000	1.013	0.600	0.800	23
68	940-44-068-24-000000	1.213	0.800	1.000	19
84	940-44-084-24-000000	1.413	1.000	1.200	16
100	940-44-100-24-000000	1.603	1.200	1.400	25
Plating Code 44 ◇ = 150μ" Sn *RECTANGULAR					

REVISONS			
REV.	ECO. NO	DESCRIPTION	DATE
A	1682	INITIAL RELEASE	5/8/2008
B	1852	UPDATE DIM 'C', TABLE, NOTE 3 & TOLERANCE BLOCK	11/12/08

PART NUMBER CODING

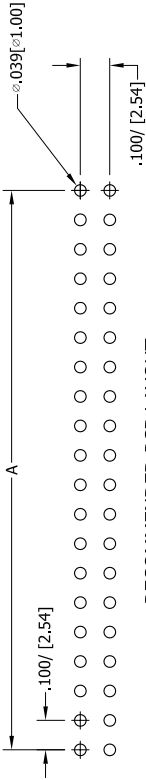
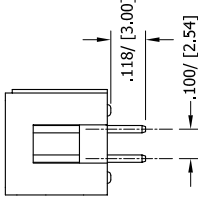
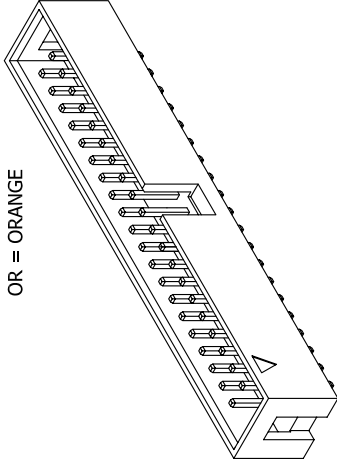
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NUMBER OF POSITIONS
(CONTACTS PER ROW)

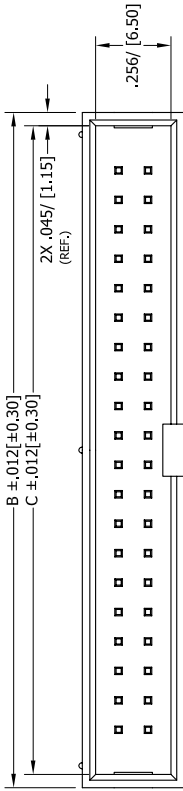
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COLOR

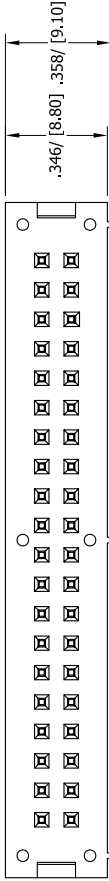
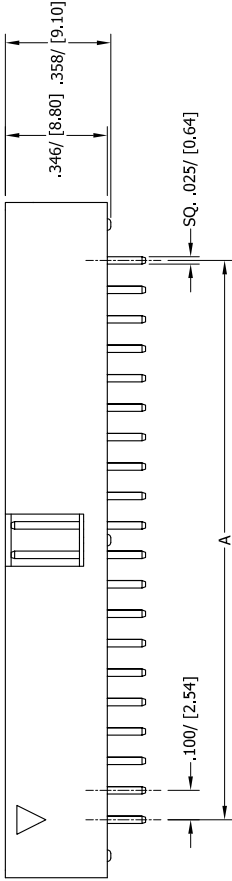
BK = BLACK
YE = YELLOW
RE = RED
BL = BLUE
GR = GREEN
GY = GREY
WH = WHITE
OR = ORANGE



RECOMMENDED PCB LAYOUT



(0.098 [2.50] FOR POSITION # 3)



PART NUMBER	POSITIONS/ CONTACTS		A		B		C	
	INCH	MM	INCH	MM	INCH	MM	INCH	MM
SBH11-PBPC-D03-ST-__	03/06	0.200	5.08	0.595	15.12	0.505	12.82	
SBH11-PBPC-D04-ST-__	04/08	0.300	7.62	0.695	17.66	0.605	15.36	
SBH11-PBPC-D05-ST-__	05/10	0.400	10.16	0.795	20.20	0.705	17.90	
SBH11-PBPC-D06-ST-__	06/12	0.500	12.70	0.895	22.74	0.805	20.44	
SBH11-PBPC-D07-ST-__	07/14	0.600	15.24	0.995	25.28	0.905	22.98	
SBH11-PBPC-D08-ST-__	08/16	0.700	17.78	1.095	27.82	1.005	25.52	
SBH11-PBPC-D10-ST-__	10/20	0.900	22.86	1.295	32.90	1.205	30.60	
SBH11-PBPC-D12-ST-__	12/24	1.100	27.94	1.495	37.98	1.405	35.68	
SBH11-PBPC-D13-ST-__	13/26	1.200	30.48	1.595	40.52	1.505	38.22	
SBH11-PBPC-D15-ST-__	15/30	1.400	35.56	1.795	45.60	1.705	43.30	
SBH11-PBPC-D17-ST-__	17/34	1.600	40.64	1.995	50.68	1.905	48.38	
SBH11-PBPC-D20-ST-__	20/40	1.900	48.26	2.295	58.30	2.205	56.00	
SBH11-PBPC-D22-ST-__	22/44	2.100	53.34	2.495	63.38	2.405	61.08	
SBH11-PBPC-D25-ST-__	25/50	2.400	60.96	2.795	71.00	2.705	68.70	
SBH11-PBPC-D30-ST-__	30/60	2.900	73.66	3.295	83.70	3.205	81.40	
SBH11-PBPC-D32-ST-__	32/64	3.100	78.74	3.495	88.78	3.405	86.48	

NOTES:

- INSULATOR MATERIAL: PBT.
- CONTACT MATERIAL: BRASS.
- PLATING: GOLD FLASH OVERALL.
- OPERATING TEMPERATURE: -40°C ~ 85°C.
- PROCESSING TEMP: 230°C FOR 60 SECONDS MAX.
(260°C, 10 SEC.)
- UL FLAMMABILITY RATING: 94V-0.
- VOLTAGE RATING: 20m OHMS MAX.
- CURRENT RATING: 3 AMP PER CONTACT.
- VOLTAGE DROP: AC 500 V.
- INSULATION RESISTANCE: 1000 MEGA OHMS.



RoHS COMPLIANT

UNLESS OTHERWISE SPECIFIED:
DIMENSIONS ARE IN INCHES (MM)

TOLERANCES:
ANGULAR: ± 1°
XX = ±.012 [0.30]
XXX = ±.008 [0.20]
XXXX = ±.004 [0.10]
PARENT DIMENSIONAL INFORMATION IS FOR
REFERENCE ONLY

INTERPRET DIMENSIONS AND GEOMETRIC
TOLERANCING
PER: ANSI Y14.5-1994

DRAWN: V. JARA
DATE: 5/8/2008

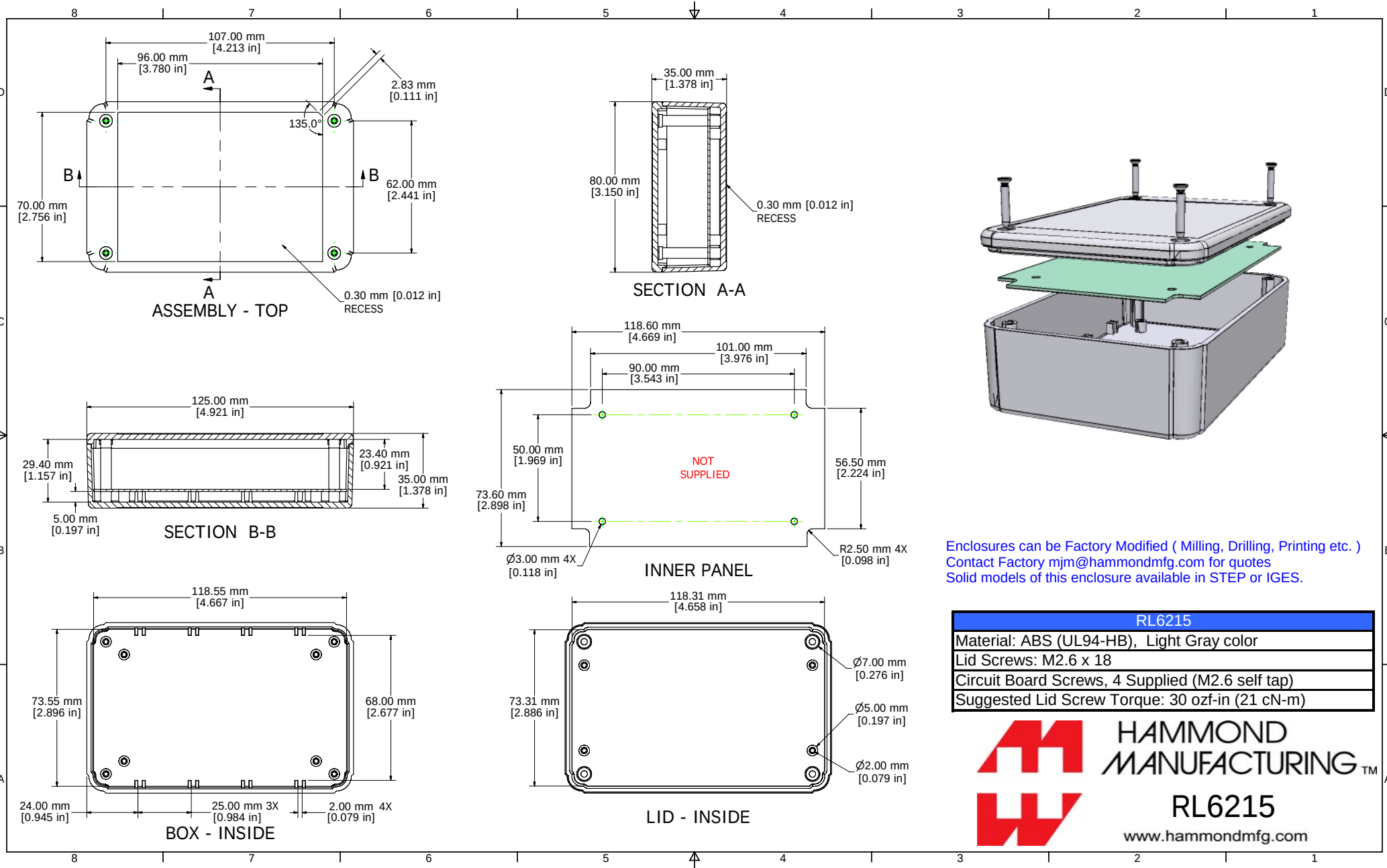
THESE DIMENSIONS ARE FOR INFORMATION ONLY
SULLINS ELECTRONICS AND ITS NET
WORKS DO NOT ASSUME ANY
DISCLOSED TO OTHERS FOR ANY
PURPOSE WITHOUT THE WRITTEN
AUTHORIZATION OF SULLINS ELECTRONICS.

DESIGNATION: BOX-HEADER, .100 [2.54] CC/RS
PART NUMBER: SBH11-PBPC-D-__-ST-__
SIZE (DWG. NO.): C 11091
REV: B

SCALE: NONE

SHEET 1 OF 1

SULLINS
CONNECTOR SOLUTIONS



Enclosures can be Factory Modified (Milling, Drilling, Printing etc.)
Contact Factory mjm@hammondmg.com for quotes
Solid models of this enclosure available in STEP or IGES.

RL6215
Material: ABS (UL94-HB), Light Gray color
Lid Screws: M2.6 x 18
Circuit Board Screws, 4 Supplied (M2.6 self tap)
Suggested Lid Screw Torque: 30 ozf-in (21 cN-m)

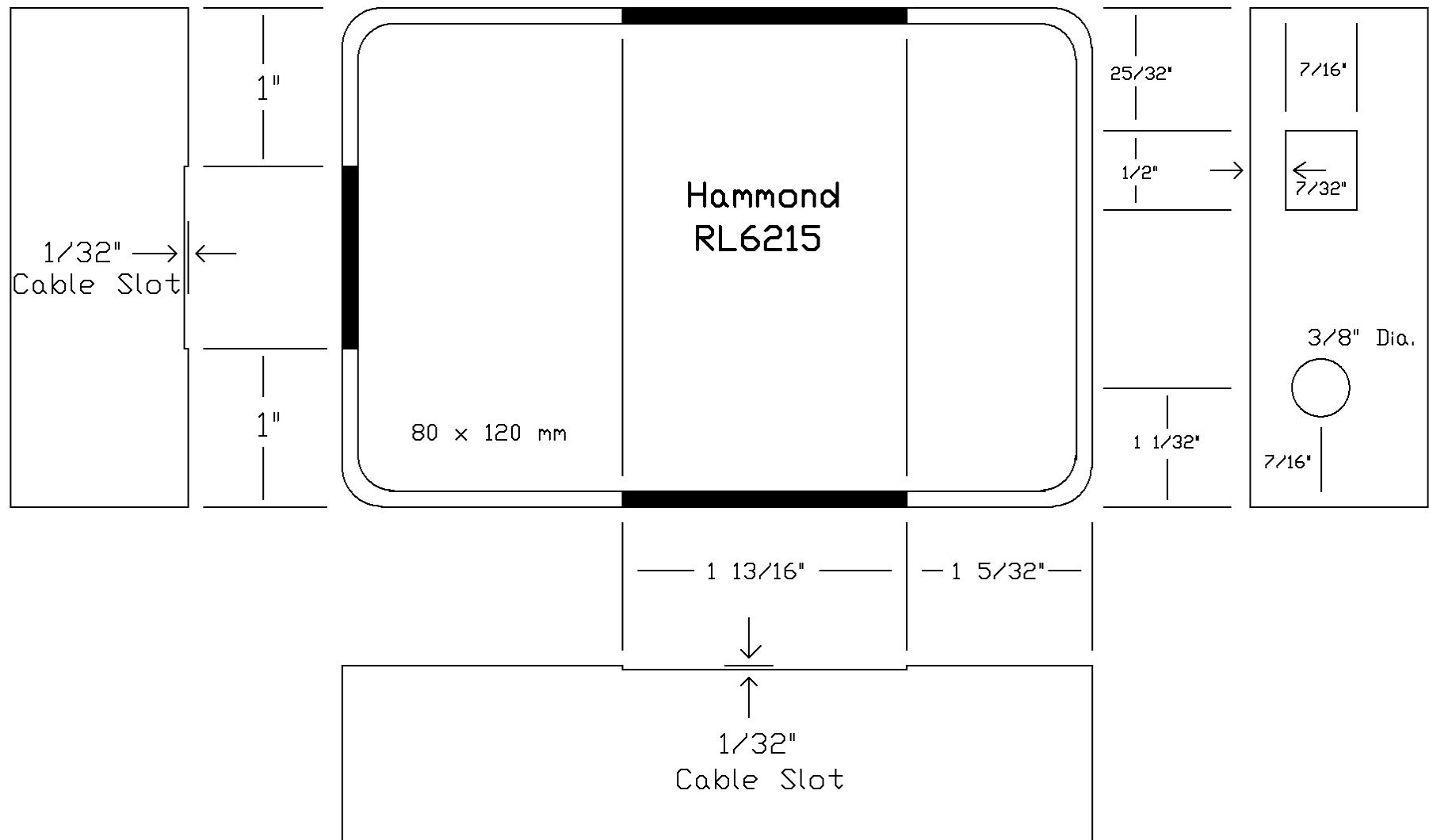


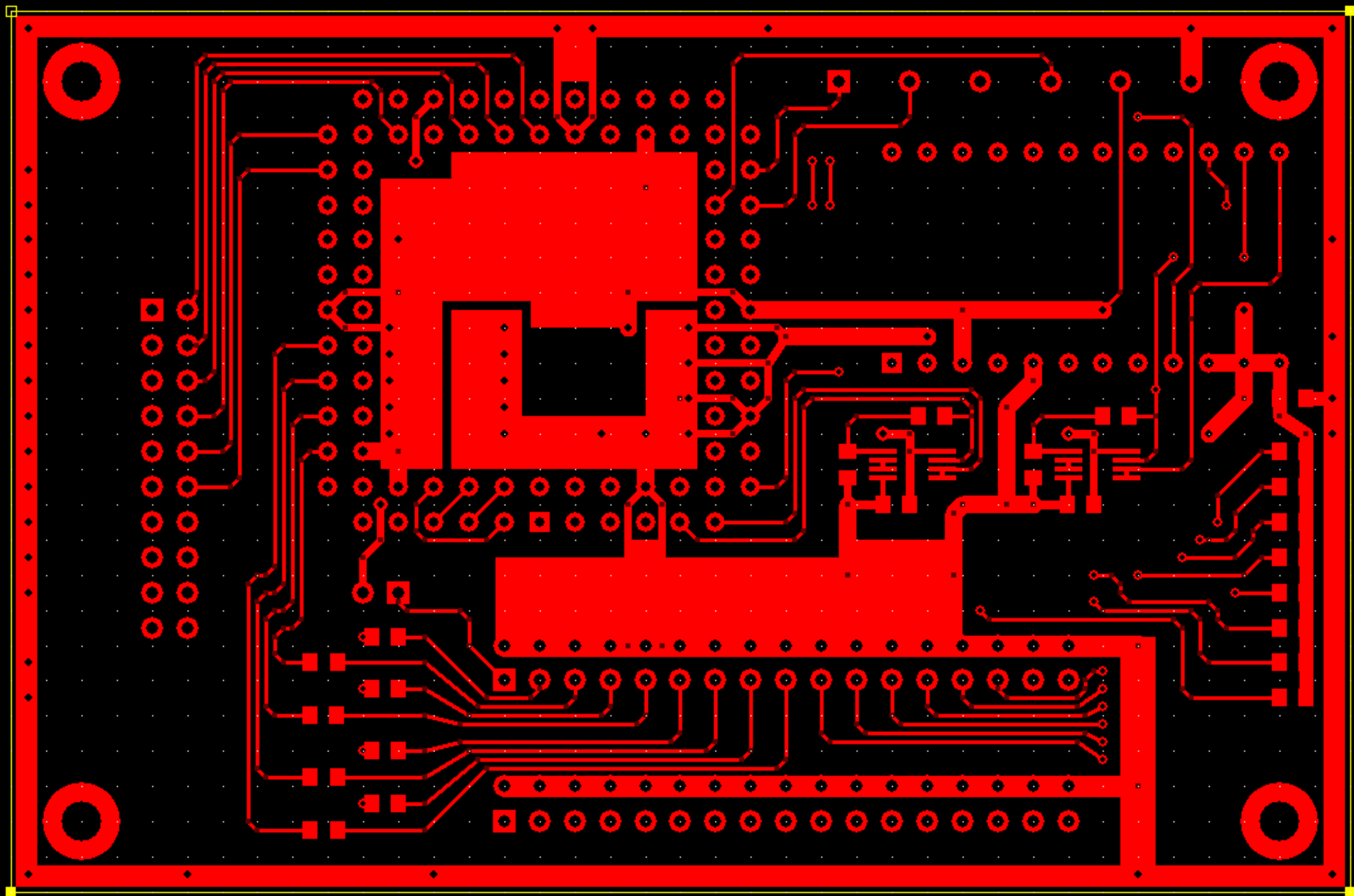
**HAMMOND
MANUFACTURING™**

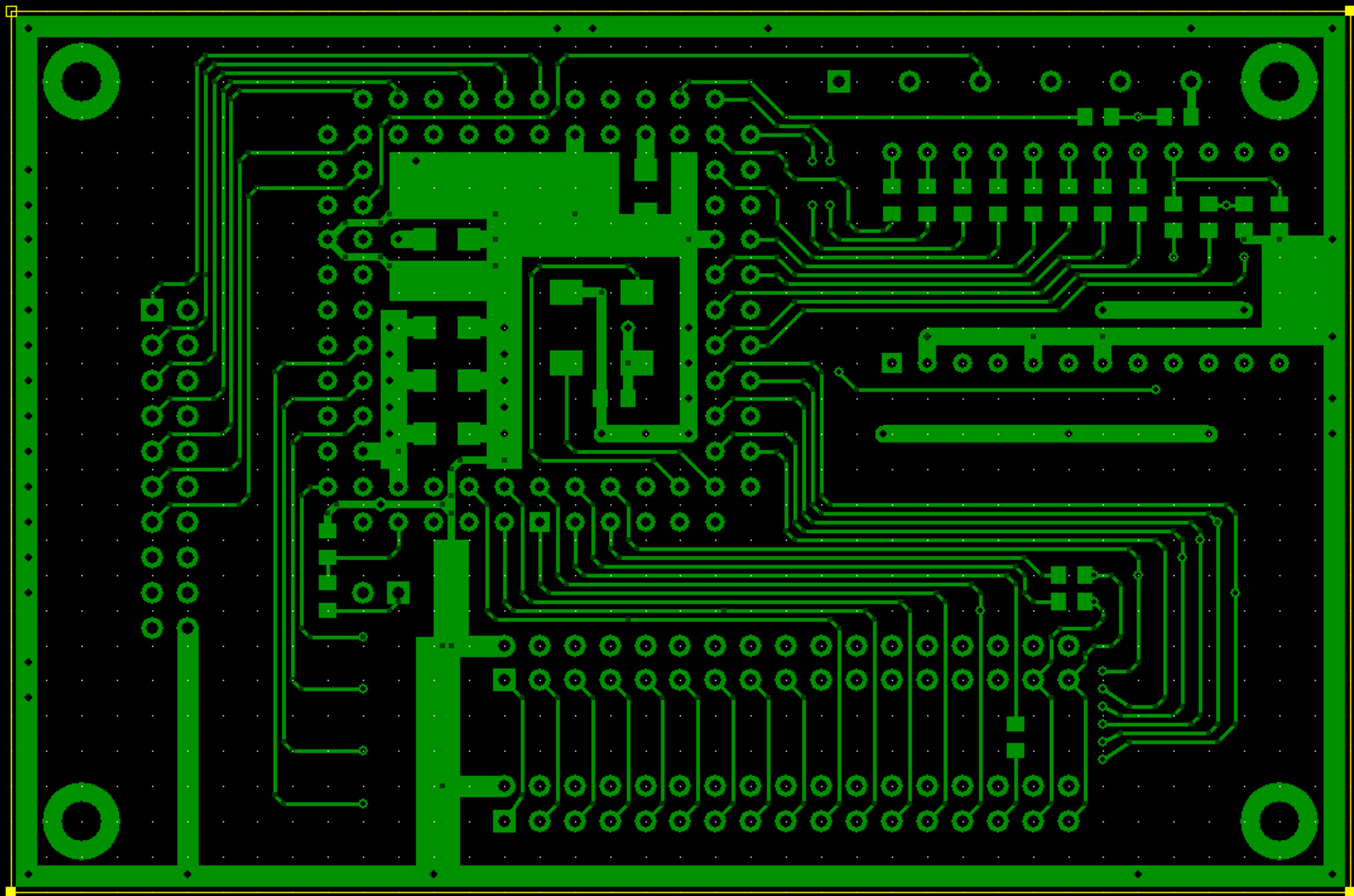
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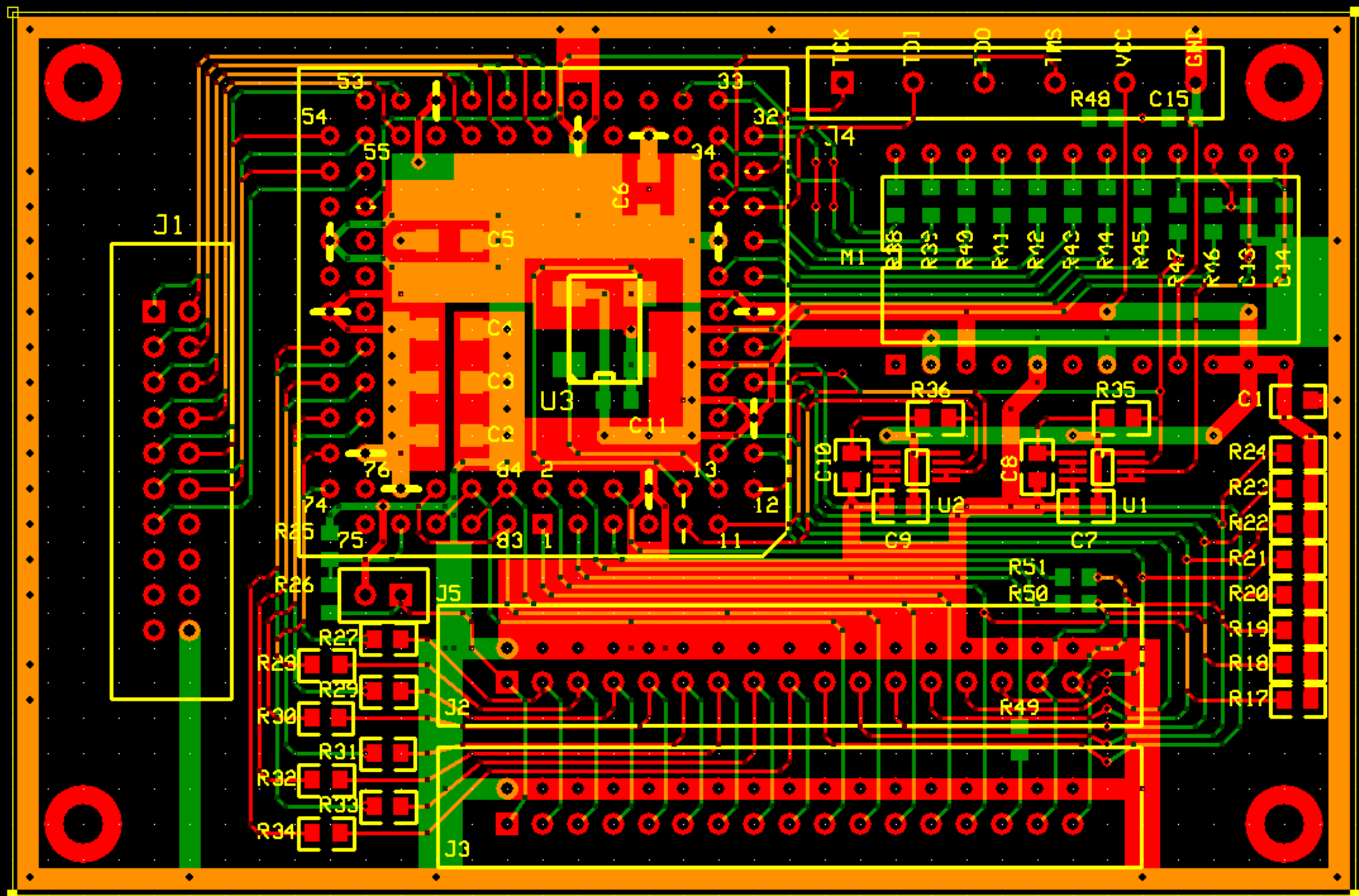
www.hammondmg.com

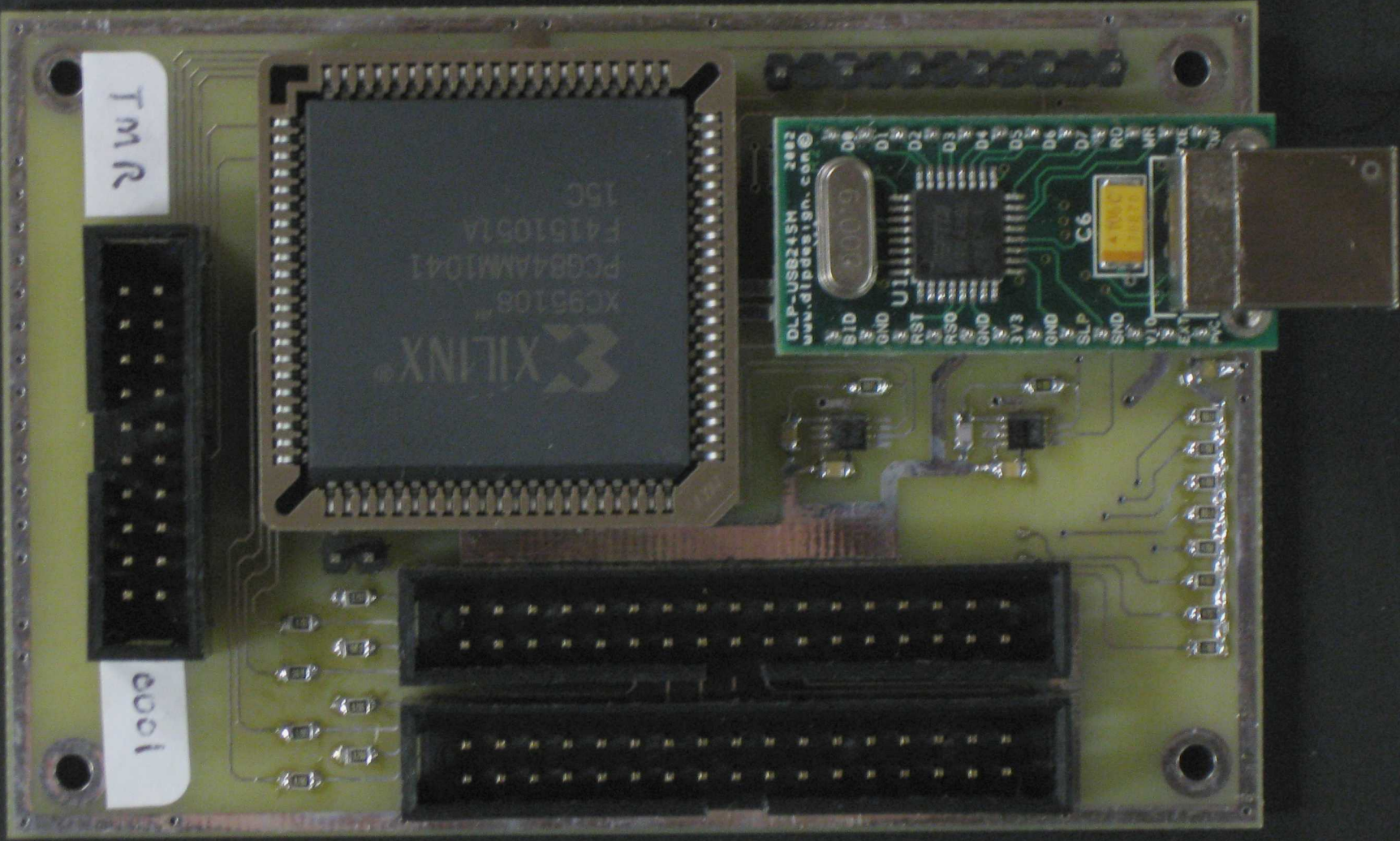
Multiparameter IO Module - ADC









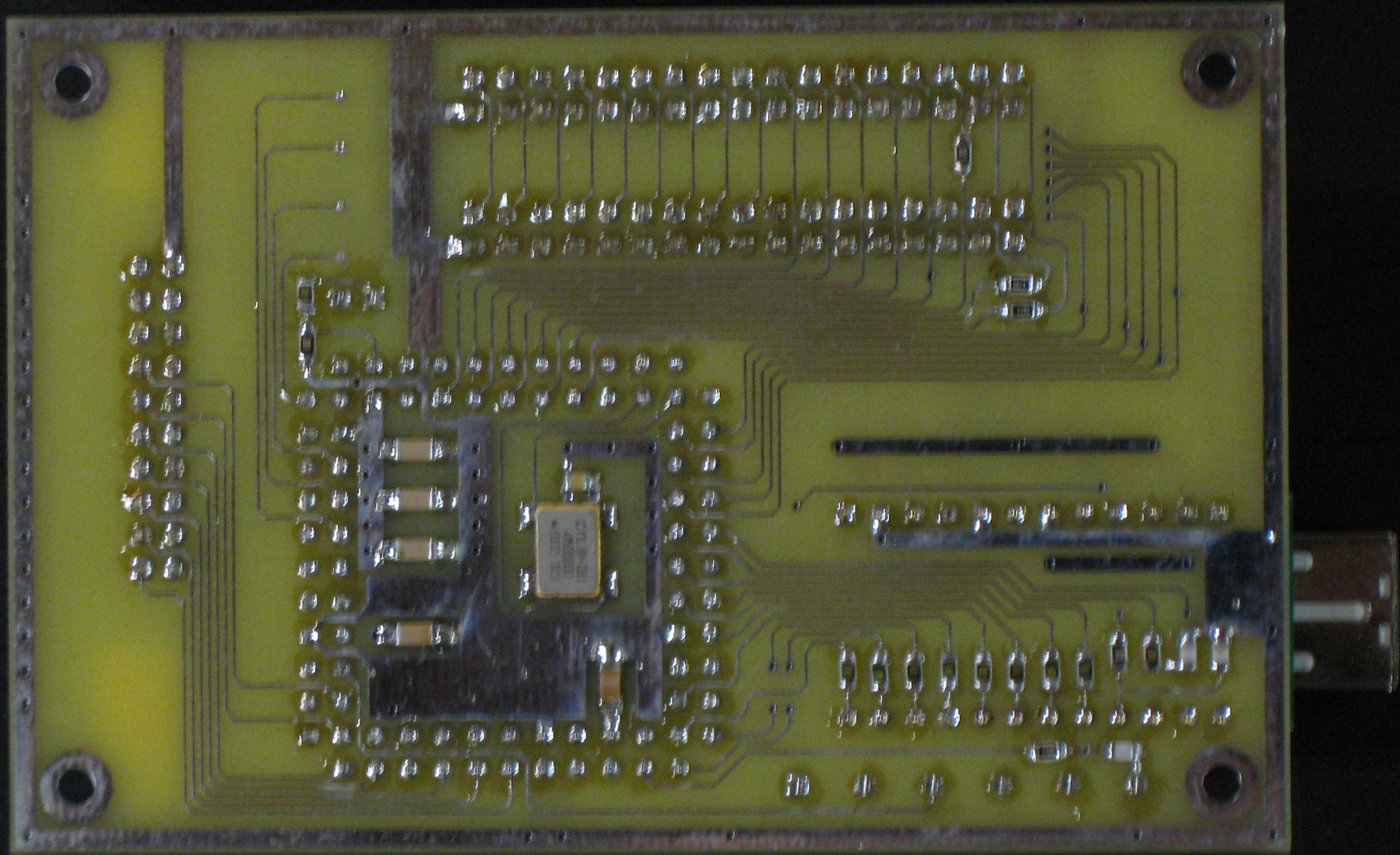


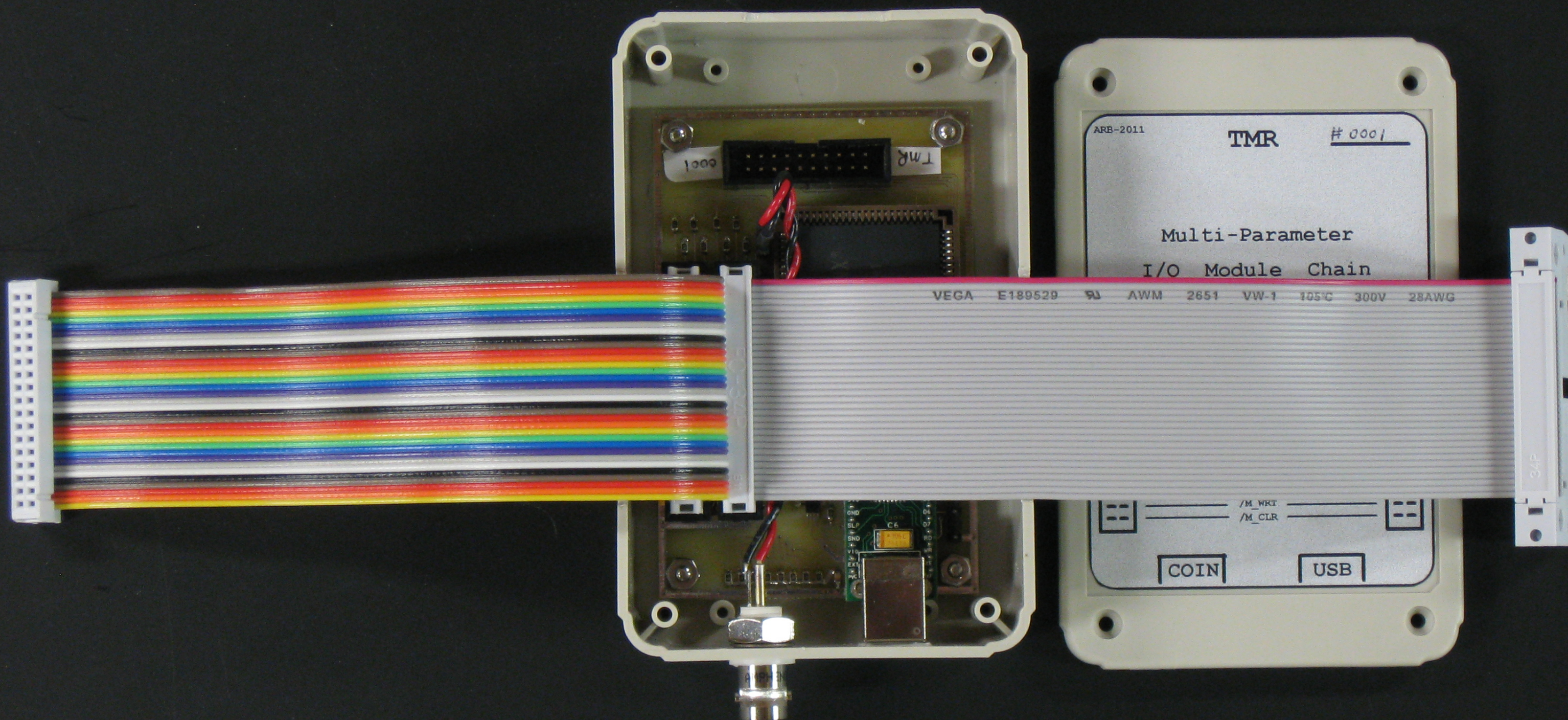
TMR

0001

XILINX
XC95108
PCG844MM1041
F4151051A
15C

DLP-USB245M
www.dipdesign.com
2482
600-9
C6
SLP
SND
V0
EAT
AVC
3V3
GND
RST
GND
RST
GND
D0
D1
D2
D3
D4
D5
D6
D7
RD
WR
OE
WE



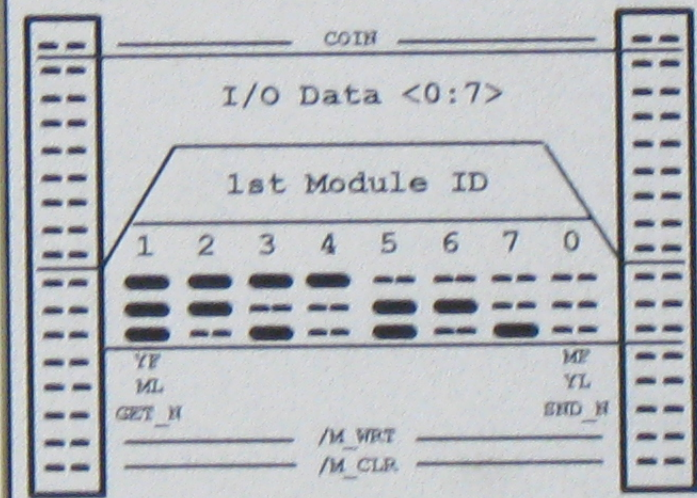


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TMR

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Multi-Parameter
I/O Module Chain



COIN

USB

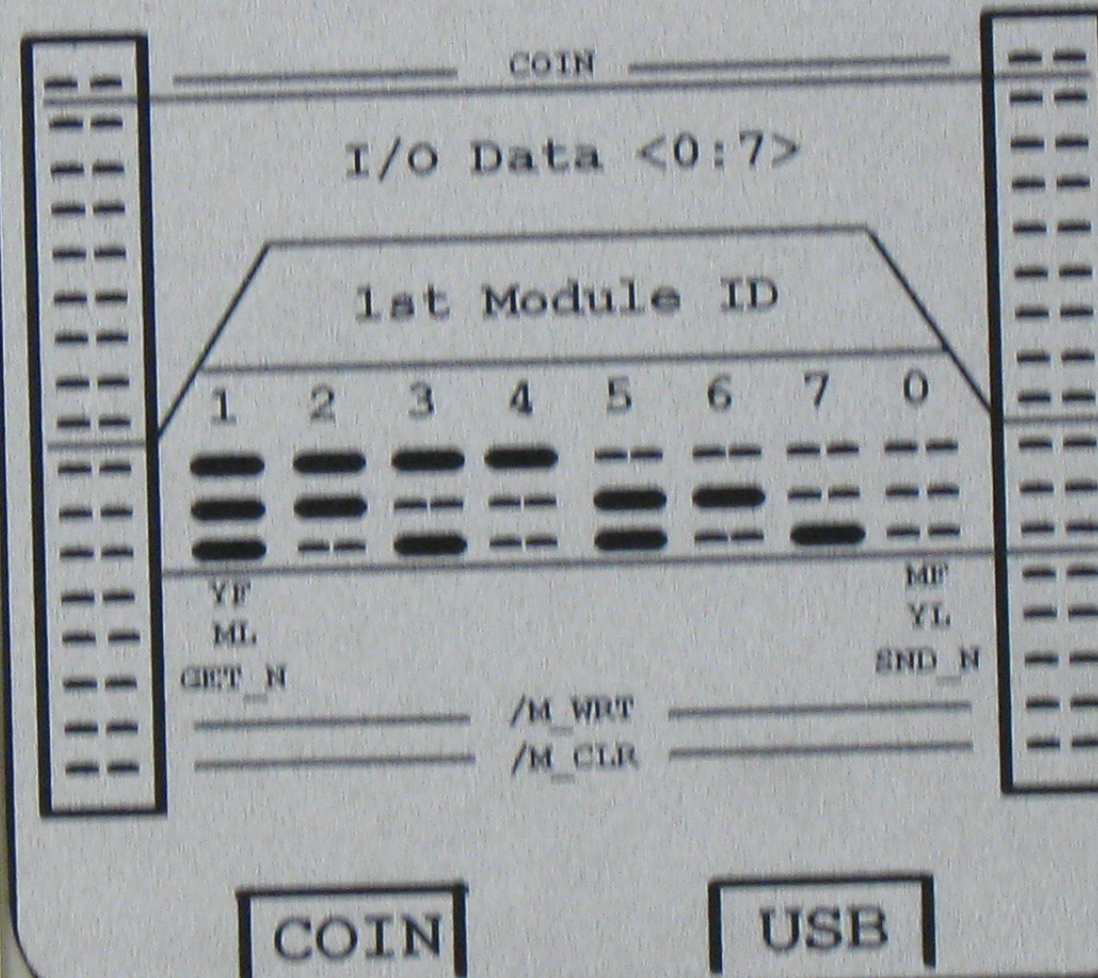
520 91 AWM 2651 VW-1 105°C 300V 28AWG

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TMR

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Multi-Parameter I/O Module Chain



520 W AWM 2651 VW-1 105°C

