Using MAX 7000B Devices to Replace I/O Drivers

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Introduction

The Altera® MAX® 7000B device is the only product-term device capable of supporting the GTL+, SSTL-2, and SSTL-3 standards used in processor interfaces, backplane drivers, and SDRAM memory interfaces.

Traditionally, discrete I/O translators, buffers, drivers, and transceivers are used to convert GTL+, SSTL-2, or SSTL-3 signals to LVCMOS or to LVTTL before transferring these signals to the programmable logic. For example, in processor-based designs, a driver may be used to translate a GTL+ signal to an LVTTL before the signal is transferred to the programmable logic device (PLD). External I/O drivers require extra board space and can introduce delays in high-performance applications. You can use a single MAX 7000B device to replace multiple I/O drivers eliminating chip-to-chip delays, minimizing board space, and reducing total system cost.

This application note provides a comprehensive listing of today's discrete I/O drivers and explains how you can use Altera MAX 7000B devices to replace these I/O drivers.

Commercial I/O Drivers

You can easily implement the logic that is built into external I/O drivers using Altera's MAX+PLUS® II software, allowing a MAX 7000B device to replace almost any driver device. Generally, these I/O drivers are available from vendors such as Fairchild Semiconductor, National Semiconductor, Philips Semiconductors, and Texas Instruments. Because each vendor has different timing specifications for each device, you should consult the vendor's data sheets to compare timing parameters with the MAX 7000B device. You can find Altera's timing information in the *MAX 7000B Programmable Logic Device Family Data Sheet* at **www.altera.com**. Table 1 lists the available GTL+ drivers and Table 2 lists the SSTL-2 and SSTL-3 drivers supporting outputs in the Class I and Class II standards.

Table 1. Part Numbers for GTL+ Drivers (Part 1 of 2)

Number	Description	Part Numbers			
		Fairchild	National	Philips	TI
1	LVTTL-to-GTLP adjustable edge-rate bus transceiver				SN74GTLP1394 *(1)*
2	LVTTL-to-GTLP universal bus transceiver				SN74GTLPH1612 *(1)*, *(2)*
3	LVTTL-to-GTLP universal bus transceiver with a buffered clock				SN74GTLPH1616
4	18-bit TTL/GTLP universal bus transceiver	GTLP16612 *(2)*	GTLP16612 *(2)*	GTLP16612 *(2)*	SN74GTLPH16612 *(2)*
5	17-bit TTL/GTLP bus transceiver with buffered clock	GTL16616	GTL16616		
6	17-bit TTL/GTLP synchronous bus transceiver	GTL16617	GTL16617		
7	LVTTL-to-GTLP transceiver				SN74GTLPH1645 *(1)*
8	LVTTL-to-GTLP universal bus transceiver				SN74GTLPH16912 *(2)*
9	LVTTL to GTLP Universal bus transceiver with buffered clock				SN74GTLPH16916
10	LVTTL-to-GTLP transceiver				SN74GTLPH16945
11	16-bit LVTTL/GTLP universal bus transceiver	GTLP16T1655	GTLP16T1655		SN74GTLPH1655 *(1)*, *(2)*
12	17-bit LVTTL/GTLP bus transceiver	GTLP17T616	GTLP17T616		
13	18-bit LVTTL/GTLP universal bus transceiver	GTLP18T612	GTLP18T612		

Table 1. Part Numbers for GTL+ Drivers (Part 2 of 2)

Number	Description	Part Numbers			
		Fairchild	National	Philips	TI
14	Quad GTLP-to-TTL/LVTTL latched translator			GTL2004	
15	Quad GTLP-to-TTL/LVTTL non-latched translator			GTL2005	
16	LVTTL-to-GTLP transceiver				SN74GTLPH3245 *(1)*
17	LVTTL-to-GTLP universal bus transceiver				SN74GTLPH32912
18	LVTTL-to-GTLP universal bus transceiver with buffered clock				SN74GTLPH32916
19	LVTTL-to-GTLP transceiver				SN74GTLPH32945
20	GTLP-to-TTL 1-to-6 clock driver	GTLP6C816	GTLP6C816		
21	LVTTL-to-GTLP clock driver	GTLP6C816A			
22	GTLP-to-LVTTL 1-to-6 clock driver	GTLP6C817	GTLP6C817		SN74GTLP817
23	8-bitLVTTL-to-GTLP transceiver	GTLP8T306	GTLP8T306		SN74GTLPH306

Table 2. Part Numbers for SSTL-2 & SSTL-3 Drivers (Part 1 of 2)

Number	Description	Part Numbers			
		Fairchild	National	Philips	TI
1	20-bit SSTL-3 universal bus driver class I outputs				SN74SSTL16837A *(2)*
2	20-bit SSTL-3 universal bus driver class II outputs				SN74SSTL16837A *(2)*
3	20-bit SSTL-3 interface buffer class I outputs				SN74SSTL16847

Table 2. Part Numbers for SSTL-2 & SSTL-3 Drivers (Part 2 of 2)

Number	Description	Part Numbers			
		Fairchild	National	Philips	TI
4	20-bit SSTL-3 interface buffer class II outputs				SN74SSTL16847

Notes to Tables 1 & 2:

(1) These devices have edge-rate control. MAX 7000B devices offer an adjustable output slew rate that can be configured for low-noise (slow) or high-performance (fast) operation.

(2) Certain devices have a combined register/latch functionality that is selected by an enable pin. In most cases, only one of these capabilities will be used on each design, so you can use either the register or latch primitives in the MAX+PLUS II software. When both functions are required, contact Altera Applications for a macro-function that uses the preset & clear logic on the MAX 7000B device registers.

Replacing Commercial I/O Drivers with MAX 7000B Devices

Each MAX 7000B device can only replace a certain maximum number of I/O drivers. This limitation is due to the number of I/O pins required by the driver and the current drive requirements of the I/O standards. Tables 3 through 6 list the number of I/O drivers (of a given type) that can be replaced by a MAX 7000B device. When LVTTL or LVCMOS is the output standard, the limitations are due to the number of available pins in the MAX 7000B device. When the output pins are driving GTL+ or SSTL, the current drive requirements are the limiting factor.

Most of the devices listed can be bidirectional, so Tables 3 through 6 list the most restrictive case: GTL+ or SSTL driving out. For example, line four describes device number 16612, an 18-bit TTL/GTL+ universal bus transceiver. This device requires 36 I/O pins plus several control pins. Because the device is bidirectional, the limiting factor is the current drive requirements, not the number of I/O pins when GTL+ is being driven on the output pins. Due to this drive limitation, many MAX 7000B devices (the EPM7064B device and larger) can only replace one of these drivers. However, the EPM7256B and EPM7512B devices can replace two or three of the 16612 driver devices.

The generic part numbers in Tables 3 through 6 refer to the common digits at the end of the manufacturer's part numbers. The number columns in Tables 3 through 6 can be cross-referenced with Tables 1 and 2.

Table 3. Number of I/O Drivers EPM7032B & EPM7064B Devices Can Replace (Part 1 of 2)

Number	Generic Part Number	EPM7032B			EPM7064B				
		44-Pin PLCC *(1)*	44-Pin TQFP *(1)*	49-Pin Ultra FineLine BGA	44-Pin PLCC	44-Pin TQFP	49-Pin Ultra FineLine BGA	100-Pin TQFP	100-Pin FineLine BGA
1	1394	4	4	4	4	4	4	12	12
2	1612	–	–	–	–	–	–	1	1
3	1616	–	–	–	–	–	–	1	1
4	16612	–	–	–	–	–	–	1	1
5	16616	–	–	–	–	–	–	1	1
6	16617	–	–	–	–	–	–	1	1
7	1645	–	–	–	–	–	–	1	1
8	16912	–	–	–	–	–	–	1	1
9	16916	–	–	–	–	–	–	1	1
10	16945	–	–	–	–	–	–	1	1
11	1655	–	–	–	–	–	–	1	1
12	616	–	–	–	–	–	–	1	1
13	612	–	–	–	–	–	–	1	1
14	2004	2	2	2	2	2	2	6	6
15	2005	2	2	2	2	2	2	6	6
16	3245	–	–	–	–	–	–	–	–
17	32912	–	–	–	–	–	–	–	–
18	32916	–	–	–	–	–	–	–	–
19	32645	–	–	–	–	–	–	–	–
20	816	1	1	1	1	1	1	4	4
21	816A	4	4	4	4	4	4	12	12
22	817	1	1	1	1	1	1	4	4
23	306	1	1	1	1	1	1	3	3
24	16837A-I	–	–	–	–	–	–	2	2
25	16837A-II	–	–	–	–	–	–	1	1
26	16847-I	–	–	–	–	–	–	2	2
27	16847-II	–	–	–	–	–	–	1	1
28	16857/77-I	1	1	1	1	1	1	4	4
29	16857/77-II	1	1	1	1	1	1	3	3

Table 3. Number of I/O Drivers EPM7032B & EPM7064B Devices Can Replace (Part 2 of 2)

Number	Generic Part Number	EPM7032B			EPM7064B				
		44-Pin PLCC (1)	44-Pin TQFP (1)	49-Pin Ultra FineLine BGA	44-Pin PLCC	44-Pin TQFP	49-Pin Ultra FineLine BGA	100-Pin TQFP	100-Pin FineLine BGA
30	16867	–	–	–	–	–	–	1	1

Note to Table 3:
(1) PLCC: plastic J-lead chip carrier; TQFP: thin quad flat pack.

Table 4. Number of I/O Drivers a EPM7128B Device Can Replace (Part 1 of 2)

Number	Generic Part Number	49-Pin Ultra FineLine BGA	100-Pin TQFP	100-Pin FineLine BGA	144-Pin TQFP	169-Pin Ultra FineLine BGA	256-Pin FineLine BGA
1	1394	12	12	12	12	12	12
2	1612	1	1	1	1	1	1
3	1616	1	1	1	1	1	1
4	16612	1	1	1	1	1	1
5	16616	1	1	1	1	1	1
6	16617	1	1	1	1	1	1
7	1645	1	1	1	1	1	1
8	16912	1	1	1	1	1	1
9	16916	1	1	1	1	1	1
10	16945	1	1	1	1	1	1
11	1655	1	1	1	1	1	1
12	616	1	1	1	1	1	1
13	612	1	1	1	1	1	1
14	2004	6	6	6	6	6	6
15	2005	6	6	6	6	6	6
16	3245	–	–	–	–	–	–
17	32912	–	–	–	–	–	–
18	32916	–	–	–	–	–	–
19	32645	–	–	–	–	–	–
20	816	4	4	4	4	4	4
21	816A	12	12	12	12	12	12
22	817	4	4	4	4	4	4
23	306	3	3	3	3	3	3

Table 4. Number of I/O Drivers a EPM7128B Device Can Replace (Part 2 of 2)

Number	Generic Part Number	49-Pin Ultra FineLine BGA	100-Pin TQFP	100-Pin FineLine BGA	144-Pin TQFP	169-Pin Ultra FineLine BGA	256-Pin FineLine BGA
24	16837A-I	1	2	2	2	2	2
25	16837A-II	1	1	1	1	1	1
26	16847-I	1	2	2	2	2	2
27	16847-II	1	1	1	1	1	1
28	16857/77-I	2	4	4	4	4	4
29	16857/77-II	2	3	3	3	3	3
30	16867	–	1	1	1	1	1

Table 5. Number of I/O Drivers a EPM7256B Device Can Replace

Number	Generic Part Number	100-Pin TQFP	144-Pin TQFP	169-Pin FineLine BGA	208-Pin PQFP *(1)*	256-Pin FineLine BGA
1	1394	12	17	28	20	28
2	1612	1	1	3	2	3
3	1616	1	2	3	2	3
4	16612	1	1	3	2	3
5	16616	1	2	3	2	3
6	16617	1	2	3	2	3
7	1645	1	2	3	2	3
8	16912	1	1	3	2	3
9	16916	1	2	3	2	3
10	16945	1	2	3	2	3
11	1655	1	2	3	2	3
12	616	1	2	3	2	3
13	612	1	1	3	2	3
14	2004	6	8	14	10	14
15	2005	6	8	14	10	14
16	3245	–	1	1	1	1
17	32912	–	–	1	1	1
18	32916	–	1	1	1	1
19	32645	–	1	1	1	1
20	816	4	5	9	6	9
21	816A	12	17	28	20	28
22	817	4	5	9	6	9
23	306	3	4	7	5	7
24	16837A-I	2	2	3	3	3
25	16837A-II	1	1	2	2	2
26	16847-I	2	2	3	3	3
27	16847-II	1	1	2	2	2
28	16857/77-I	4	4	8	8	8
29	16857/77-II	3	3	6	6	6
30	16867	1	2	2	2	2

Note to Table 5:
(1) PQFP: plastic quad flat pack.

Table 6. Number of I/O Drivers an EPM7512B Device Can Replace

Number	Generic Part Number	100-Pin TQFP	144-Pin TQFP	169-Pin FineLine BGA	208-Pin PQFP	256-Pin FineLine BGA
1	1394	12	17	28	22	35
2	1612	1	1	3	2	3
3	1616	1	2	3	2	4
4	16612	1	1	3	2	3
5	16616	1	2	3	2	4
6	16617	1	2	3	2	4
7	1645	1	2	3	2	4
8	16912	1	1	3	2	3
9	16916	1	2	3	2	4
10	16945	1	2	3	2	4
11	1655	1	2	3	2	4
12	616	1	2	3	2	4
13	612	1	1	3	2	3
14	2004	6	8	14	11	17
15	2005	6	8	14	11	17
16	3245	–	1	1	1	2
17	32912	–	–	1	1	1
18	32916	–	1	1	1	2
19	32645	–	1	1	1	2
20	816	4	5	9	7	11
21	816A	12	17	28	22	35
22	817	3	4	7	5	8
23	306	3	4	7	5	8
24	16837A-I	2	2	4	3	5
25	16837A-II	1	1	3	2	3
26	16847-I	2	2	4	3	5
27	16847-II	1	1	3	2	3
28	16857/77-I	4	4	8	8	10
29	16857/77-II	3	3	6	6	7
30	16867	1	2	2	3	3

Technical Details

The number of output pins that can be assigned to advanced I/O standards is limited because I/O standards require a high current drive. Table 7 lists the different drive requirements. The GTL+ and SSTL standards require more current than LVTTL or LVCMOS.

Table 7. Current Drive Requirements for I/O Standards

I/O Standard	I_{CC} to GNDIO	I_{CC} to VCCIO
LVTTL	4 mA	4 mA
LVCMOS	2 mA	2 mA
STTL-2 Class I	16 mA	16 mA
SSTL-2 Class II	22 mA	22 mA
SSTL-3 Class I	23 mA	23 mA
SSTL-3 Class II	33 mA	33 mA
GTL+	50 mA	0 mA

I/O pins on a MAX 7000B device are divided into `GNDIO` and `VCCIO` groups with sizes that vary depending on the device's density and package. The *MAX 7000B Programmable Logic Device Family Data Sheet* lists the maximum current allowed per group. The I/O standard used on each pin determines the current requirements for that pin and the sum of these currents in any one group may not exceed the maximum. The Quartus® II software will not perform automatic I/O pin placement to meet current requirements, but it will report errors. The report file generated by the Quartus II software will also list the V_{CCIO} and GNDIO levels for each bank along with the maximum values.

Tables 8 through 11 list the maximum number of GTL+ or SSTL outputs that you can use on each MAX 7000B device (assuming all output pins are the same standard). This information can be used along with the drive requirements to help determine which MAX 7000B device is required for various applications.

Table 8. Maximum Number of GTL+ or SSTL Outputs in EPM7032B & EPM7064B Devices

I/O Standard	EPM7032B			EPM7064B				
	44-Pin PLCC	44-Pin TQFP	49-Pin Ultra FineLine BGA	44-Pin PLCC	44-Pin TQFP	49-Pin FineLine BGA	100-Pin TQFP	100-Pin FineLine BGA
GTL+	8	8	8	8	8	8	24	24
SSTL-2 C I	24	24	24	24	24	24	60	60
SSTL-2 C II	16	16	16	16	16	16	50	50
SSTL-3 C I	16	16	16	16	16	16	46	46
SSTL-3 C II	12	12	12	12	12	12	36	36

Table 9. Maximum Number of GTL+ or SSTL Outputs in a EPM7128B Device

I/O Standard	49-Pin Ultra FineLine BGA	100-Pin TQFP	100-Pin FineLine BGA	144-Pin TQFP	169-Pin Ultra FineLine BGA	256-Pin FineLine BGA
GTL+	24	24	24	24	24	24
SSTL-2 C I	37	66	66	68	68	68
SSTL-2 C II	36	50	50	52	52	52
SSTL-3 C I	36	46	46	48	48	48
SSTL-3 C II	33	36	36	36	36	36

Table 10. Maximum Number of GTL+ or SSTL Outputs in a EPM7256B Device

I/O Standard	100-Pin TQFP	144-Pin TQFP	169-Pin Ultra FineLine BGA	208-Pin PQFP	256-Pin FineLine BGA
GTL+	24	35	56	40	56
SSTL-2 C I	66	69	115	115	115
SSTL-2 C II	49	50	86	86	86
SSTL-3 C I	45	46	78	78	78
SSTL-3 C II	34	34	58	58	58

Table 11. Maximum Number of GTL+ or SSTL Outputs in a EPM7512B Device

I/O Standard	100-Pin TQFP	144-Pin TQFP	169-Pin Ultra FineLine BGA	208-Pin PQFP	256-Pin FineLine BGA
GTL+	24	35	56	44	70
SSTL-2 C I	66	69	123	115	141
SSTL-2 C II	49	50	94	86	109
SSTL-3 C I	45	46	85	78	100
SSTL-3 C II	34	34	64	58	76

Conclusion

The GTL+, SSTL-2, and SSTL-3 standards are becoming increasingly popular in today's high-performance designs. You can use MAX 7000B devices to replace multiple I/O drivers and incorporate logic on the board eliminating chip-to-chip delays, minimizing board space, and reducing total system cost.

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