



February 2001  
Revised August 2001

## FSTUD32211 40/48-Bit Bus Switch with -2V Undershoot Protection and Level Shifting (Preliminary)

### General Description

The Fairchild Switch FSTUD32211 provides up to 48-bits of high-speed CMOS TTL-compatible bus switching. The low On Resistance of the switch allows inputs to be connected to outputs without adding propagation delay or generating additional ground bounce noise. A diode to  $V_{CC}$  has been integrated into the circuit to allow for level shifting between 5V inputs and 3.3V outputs.

The device can be organized as four 12-bit, two 24-bit, or one 48-bit bus switch. When routed as a 40-bit bus switch, the device can be organized as four 10-bit, two 20-bit or one 40-bit bus switch. When  $\overline{OE}_1$  is LOW, the switch is ON and Port 1A is connected to Port 1B. When  $\overline{OE}_2$  is LOW, the switch is ON and Port 2A is connected to Port 2B. When  $\overline{OE}_3$  is LOW, the switch is ON and Port 3A is connected to Port 3B. When  $\overline{OE}_4$  is LOW, the switch is ON and Port 4A is connected to Port 4B. When  $\overline{OE}_1$ ,  $\overline{OE}_2$ ,  $\overline{OE}_3$ , or  $\overline{OE}_4$  are HIGH, a high impedance state exists between the A and B Ports. The A and B Ports are protected against undershoot to support an extended range to 2.0V below ground. Fairchild's integrated Undershoot Hardened Circuit (UHC™) senses undershoot at the I/O's, and responds by preventing voltage differentials from developing and turning on the switch.

### Features

- Undershoot protected to -2V (A and B Ports)
- Voltage level shifting
- 4Ω switch connection between two ports
- Minimal propagation delay through the switch
- Low  $I_{CC}$
- Zero bounce in flow-through mode
- Control inputs compatible with TTL level
- See Applications Notes AN-5008 and AN-5021 for UHC details
- Packaged in plastic Fine-Pitch Ball Grid Array (FBGA) (Preliminary)

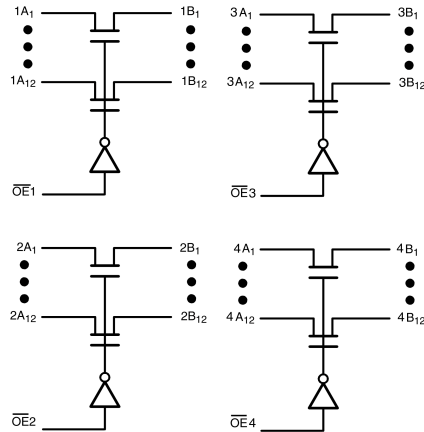
### Ordering Code:

Order Number	Package Number	Package Description
FSTUD32211GX (Note 1)	BGA114A (Preliminary)	114-Ball Fine-Pitch Ball Grid Array (FBGA), JEDEC MO-205, 5.5mm Wide [Tape and Reel]

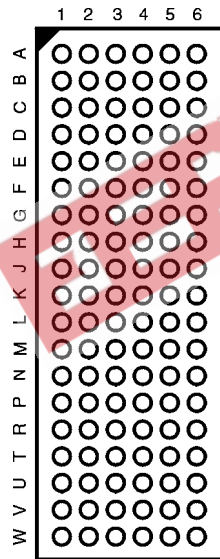
**Note 1:** BGA package available in Tape and Reel only.

FSTUD32211 40/48-Bit Bus Switch with -2V Undershoot Protection and Level Shifting (Preliminary)

### Logic Diagram



### Connection Diagram



(Top Thru View)

### Pin Descriptions

Pin Name	Description
$\overline{OE}_1, \overline{OE}_2, \overline{OE}_3, \overline{OE}_4$	Bus Switch Enables
1A, 2A, 3A, 4A	Bus A
1B, 2B, 3B, 4B	Bus B
NC	No Connect

### FBGA Pin Assignments

(40-Bit Routing)

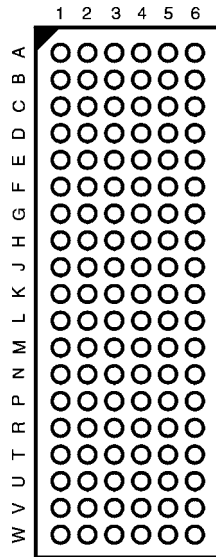
	1	2	3	4	5	6
A	1A <sub>2</sub>	1A <sub>1</sub>	NC	OE <sub>2</sub>	1B <sub>1</sub>	1B <sub>2</sub>
B	1A <sub>4</sub>	1A <sub>3</sub>	GND	OE <sub>1</sub>	1B <sub>3</sub>	1B <sub>4</sub>
C	1A <sub>6</sub>	1A <sub>5</sub>	GND	GND	1B <sub>5</sub>	1B <sub>6</sub>
D	1A <sub>8</sub>	1A <sub>7</sub>	GND	GND	1B <sub>7</sub>	1B <sub>8</sub>
E	1A <sub>10</sub>	1A <sub>9</sub>	V <sub>CC</sub>	V <sub>CC</sub>	1B <sub>9</sub>	1B <sub>10</sub>
F	2A <sub>2</sub>	2A <sub>1</sub>	V <sub>CC</sub>	V <sub>CC</sub>	2B <sub>1</sub>	2B <sub>2</sub>
G	2A <sub>4</sub>	2A <sub>3</sub>	V <sub>CC</sub>	GND	2B <sub>3</sub>	2B <sub>4</sub>
H	2A <sub>6</sub>	2A <sub>5</sub>	GND	GND	2B <sub>5</sub>	2B <sub>6</sub>
J	2A <sub>8</sub>	2A <sub>7</sub>	2A <sub>9</sub>	2B <sub>9</sub>	2B <sub>7</sub>	2B <sub>8</sub>
K	2A <sub>10</sub>	3A <sub>10</sub>	GND	GND	3B <sub>10</sub>	2B <sub>10</sub>
L	3A <sub>9</sub>	3A <sub>8</sub>	GND	GND	3B <sub>8</sub>	3B <sub>9</sub>
M	3A <sub>7</sub>	3A <sub>6</sub>	GND	V <sub>CC</sub>	3B <sub>6</sub>	3B <sub>7</sub>
N	3A <sub>5</sub>	3A <sub>4</sub>	V <sub>CC</sub>	V <sub>CC</sub>	3B <sub>4</sub>	3B <sub>5</sub>
P	3A <sub>3</sub>	3A <sub>2</sub>	V <sub>CC</sub>	V <sub>CC</sub>	3B <sub>2</sub>	3B <sub>3</sub>
R	3A <sub>1</sub>	4A <sub>10</sub>	GND	GND	4B <sub>10</sub>	3B <sub>1</sub>
T	4A <sub>9</sub>	4A <sub>8</sub>	GND	GND	4B <sub>8</sub>	4B <sub>9</sub>
U	4A <sub>7</sub>	4A <sub>6</sub>	GND	4B <sub>1</sub>	4B <sub>6</sub>	4B <sub>7</sub>
V	4A <sub>5</sub>	4A <sub>4</sub>	4A <sub>1</sub>	OE <sub>4</sub>	4B <sub>4</sub>	4B <sub>5</sub>
W	4A <sub>3</sub>	4A <sub>2</sub>	OE <sub>3</sub>	NC	4B <sub>2</sub>	4B <sub>3</sub>

### Truth Tables

Inputs		Inputs/Outputs	
$\overline{OE}_1$	$\overline{OE}_2$	1A, 1B	2A, 2B
L	L	1A = 1B	2A = 2B
L	H	1A = 1B	Z
H	L	Z	2A = 2B
H	H	Z	Z

Inputs		Inputs/Outputs	
$\overline{OE}_3$	$\overline{OE}_4$	3A, 3B	4A, 4B
L	L	3A = 3B	4A = 4B
L	H	3A = 3B	Z
H	L	Z	4A = 4B
H	H	Z	Z

Connection Diagram



(Top Thru View)

Pin Descriptions

Pin Name	Description
$\overline{OE}_1, \overline{OE}_2, \overline{OE}_3, \overline{OE}_4$	Bus Switch Enables
1A, 2A, 3A, 4A	Bus A
1B, 2B, 3B, 4B	Bus B
NC	No Connect

FBGA Pin Assignments

(48-Bit Routing)

	1	2	3	4	5	6
<b>A</b>	1A <sub>2</sub>	1A <sub>1</sub>	NC	OE <sub>2</sub>	1B <sub>1</sub>	1B <sub>2</sub>
<b>B</b>	1A <sub>4</sub>	1A <sub>3</sub>	1A <sub>7</sub>	OE <sub>1</sub>	1B <sub>3</sub>	1B <sub>4</sub>
<b>C</b>	1A <sub>6</sub>	1A <sub>5</sub>	GND	1B <sub>7</sub>	1B <sub>5</sub>	1B <sub>6</sub>
<b>D</b>	1A <sub>10</sub>	1A <sub>9</sub>	1A <sub>8</sub>	1B <sub>8</sub>	1B <sub>9</sub>	1B <sub>10</sub>
<b>E</b>	1A <sub>12</sub>	1A <sub>11</sub>	2A <sub>1</sub>	2B <sub>1</sub>	1B <sub>11</sub>	1B <sub>12</sub>
<b>F</b>	2A <sub>4</sub>	2A <sub>3</sub>	2A <sub>2</sub>	2B <sub>2</sub>	2B <sub>3</sub>	2B <sub>4</sub>
<b>G</b>	2A <sub>6</sub>	2A <sub>5</sub>	V <sub>CC</sub>	GND	2B <sub>5</sub>	2B <sub>6</sub>
<b>H</b>	2A <sub>8</sub>	2A <sub>7</sub>	GND	GND	2B <sub>7</sub>	2B <sub>8</sub>
<b>J</b>	2A <sub>10</sub>	2A <sub>9</sub>	2A <sub>11</sub>	2B <sub>11</sub>	2B <sub>9</sub>	2B <sub>10</sub>
<b>K</b>	2A <sub>12</sub>	3A <sub>12</sub>	GND	GND	3B <sub>12</sub>	2B <sub>12</sub>
<b>L</b>	3A <sub>11</sub>	3A <sub>10</sub>	GND	GND	3B <sub>10</sub>	3B <sub>11</sub>
<b>M</b>	3A <sub>9</sub>	3A <sub>8</sub>	GND	V <sub>CC</sub>	3B <sub>8</sub>	3B <sub>9</sub>
<b>N</b>	3A <sub>7</sub>	3A <sub>6</sub>	3A <sub>2</sub>	3B <sub>2</sub>	3B <sub>6</sub>	3B <sub>7</sub>
<b>P</b>	3A <sub>5</sub>	3A <sub>4</sub>	3A <sub>1</sub>	3B <sub>1</sub>	3B <sub>4</sub>	3B <sub>5</sub>
<b>R</b>	3A <sub>3</sub>	4A <sub>12</sub>	4A <sub>8</sub>	4B <sub>8</sub>	4B <sub>12</sub>	3B <sub>3</sub>
<b>T</b>	4A <sub>11</sub>	4A <sub>10</sub>	4A <sub>7</sub>	4B <sub>7</sub>	4B <sub>10</sub>	4B <sub>11</sub>
<b>U</b>	4A <sub>9</sub>	4A <sub>6</sub>	GND	4B <sub>1</sub>	4B <sub>6</sub>	4B <sub>9</sub>
<b>V</b>	4A <sub>5</sub>	4A <sub>4</sub>	4A <sub>1</sub>	OE <sub>4</sub>	4B <sub>4</sub>	4B <sub>5</sub>
<b>W</b>	4A <sub>3</sub>	4A <sub>2</sub>	OE <sub>3</sub>	NC	4B <sub>2</sub>	4B <sub>3</sub>

Truth Tables

Inputs		Inputs/Outputs	
$\overline{OE}_1$	$\overline{OE}_2$	1A, 1B	2A, 2B
L	L	1A = 1B	2A = 2B
L	H	1A = 1B	Z
H	L	Z	2A = 2B
H	H	Z	Z

Inputs		Inputs/Outputs	
$\overline{OE}_3$	$\overline{OE}_4$	3A, 3B	4A, 4B
L	L	3A = 3B	4A = 4B
L	H	3A = 3B	Z
H	L	Z	4A = 4B
H	H	Z	Z

Absolute Maximum Ratings (Note 2)		Recommended Operating Conditions (Note 5)	
Supply Voltage ( $V_{CC}$ )	0.5V to +7.0V	Power Supply Operating ( $V_{CC}$ )	4.5V to 5.5V
DC Switch Voltage ( $V_S$ ) (Note 3)	-2V to +7.0V	Input Voltage ( $V_{IN}$ )	0V to 5.5V
DC Input Control Pin Voltage ( $V_{IN}$ ) (Note 4)	-0.5V to +7.0V	Output Voltage ( $V_{OUT}$ )	0V to 5.5V
DC Input Diode Current ( $I_{IK}$ ) $V_{IN} < 0V$	-50 mA	Input Rise and Fall Time ( $t_r, t_f$ )	
DC Output ( $I_{OUT}$ )	128 mA	Switch Control Input	0 ns/V to 5 ns/V
DC $V_{CC}$ /GND Current ( $I_{CC}/I_{GND}$ )	+/- 100 mA	Switch I/O	0 ns/V to DC
Storage Temperature Range ( $T_{STG}$ )	-65°C to +150 °C	Free Air Operating Temperature ( $T_A$ )	-40°C to +85°C

**Note 2:** The "Absolute Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. The device should not be operated at these limits. The parametric values defined in the Electrical Characteristics tables are not guaranteed at the absolute maximum rating. The "Recommended Operating Conditions" table will define the conditions for actual device operation.

**Note 3:**  $V_S$  is the voltage observed/applied at either A or B Ports across the switch.

**Note 4:** The input and output negative voltage ratings may be exceeded if the input and output diode current ratings are observed.

**Note 5:** Unused control inputs must be held HIGH or LOW. They may not float.

**DC Electrical Characteristics**

Symbol	Parameter	$V_{CC}$ (V)	$T_A = -40^\circ\text{C to } +85^\circ\text{C}$			Units	Conditions
			Min	Typ (Note 6)	Max		
$V_{IK}$	Clamp Diode Voltage	4.5			-1.2	V	$I_{IN} = -18\text{ mA}$
$V_{IH}$	HIGH Level Input Voltage	4.5 - 5.5	2.0			V	
$V_{IL}$	LOW Level Input Voltage	4.5 - 5.5			0.8	V	
$V_{OH}$	HIGH Level	4.5 - 5.5	See Figure 4			V	
$I_I$	Input Leakage Current	5.5			$\pm 1.0$	$\mu\text{A}$	$0 \leq V_{IN} \leq 5.5V$
		0			10	$\mu\text{A}$	$V_{IN} = 5.5V$
$I_{OZ}$	OFF-STATE Leakage Current	5.5			$\pm 1.0$	$\mu\text{A}$	$0 \leq A, B \leq V_{CC}$
$R_{ON}$	Switch On Resistance (Note 7)	4.5		4	7	$\Omega$	$V_{IN} = 0V, I_{IN} = 64\text{ mA}$
		4.5		4	7	$\Omega$	$V_{IN} = 0V, I_{IN} = 30\text{ mA}$
		4.5		35	50	$\Omega$	$V_{IN} = 2.4V, I_{IN} = 15\text{ mA}$
$I_{CC}$	Quiescent Supply Current	5.5			1.5	mA	$OE_1 = OE_2 = GND$ $V_{IN} = V_{CC}$ or $GND, I_{OUT} = 0$
					10	$\mu\text{A}$	$OE_1 = OE_2 = V_{CC}$ $V_{IN} = V_{CC}$ or $GND, I_{OUT} = 0$
$\Delta I_{CC}$	Increase in $I_{CC}$ per Input	5.5			2.5	mA	One Input at 3.4V Other Inputs at $V_{CC}$ or $GND$
$V_{IKU}$	Voltage Undershoot	5.5			-2.0	V	$0.0\text{ mA} \geq I_{IN} \geq -50\text{ mA}$ $OE_{1,2} = 5.5V$

**Note 6:** Typical values are at  $V_{CC} = 5.0V$  and  $T_A = +25^\circ\text{C}$

**Note 7:** Measured by the voltage drop between A and B pins at the indicated current through the switch. On Resistance is determined by the lower of the voltages on the two (A or B) pins.

### AC Electrical Characteristics

Symbol	Parameter	T <sub>A</sub> = -40 °C to +85 °C, C <sub>L</sub> = 50pF, R <sub>U</sub> = R <sub>D</sub> = 500Ω V <sub>CC</sub> = 4.5 – 5.5V		Units	Conditions	Figure Number
		Min	Max			
		t <sub>PHL</sub> , t <sub>PLH</sub>	Propagation Delay Bus to Bus (Note 8)			
t <sub>PZH</sub> , t <sub>PZL</sub>	Output Enable Time	1.5	10.0	ns	V <sub>I</sub> = 7V for t <sub>PZL</sub> V <sub>I</sub> = OPEN for t <sub>PZH</sub>	Figures 2, 3
t <sub>PHZ</sub> , t <sub>PLZ</sub>	Output Disable Time	1.5	9.0	ns	V <sub>I</sub> = 7V for t <sub>PLZ</sub> V <sub>I</sub> = OPEN for t <sub>PHZ</sub>	Figures 2, 3

**Note 8:** This parameter is guaranteed by design but is not tested. The bus switch contributes no propagation delay other than the RC delay of the typical On Resistance of the switch and the 50pF load capacitance, when driven by an ideal voltage source (zero output impedance).

### Capacitance (Note 9)

Symbol	Parameter	Typ	Max	Units	Conditions
C <sub>IN</sub>	Control Pin Input Capacitance	3		pF	V <sub>CC</sub> = 5.0V
C <sub>I/O</sub>	Input/Output Capacitance	6		pF	V <sub>CC</sub> , $\overline{OE}$ = 5.0V

**Note 9:** T<sub>A</sub> = +25°C, f = 1 MHz, Capacitance is characterized but not tested.

### Undershoot Characteristic (Note 10)

Symbol	Parameter	Min	Typ	Max	Units	Conditions
V <sub>OUTU</sub>	Output Voltage During Undershoot	2.5	V <sub>OH</sub> - 0.3		V	Figure 1

**Note 10:** This test is intended to characterize the device's protective capabilities by maintaining output signal integrity during an input transient voltage undershoot event.

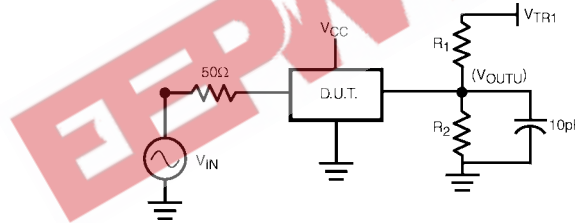
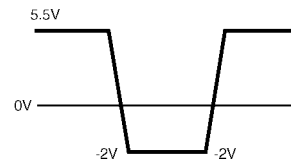


FIGURE 1.

### Device Test Conditions

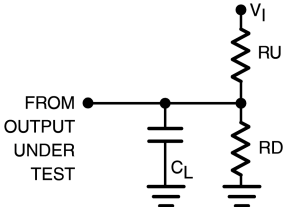
Parameter	Value	Units
V <sub>IN</sub>	see Waveforms	V
R <sub>1</sub> = R <sub>2</sub>	100K	Ω
V <sub>TRI</sub>	11.0	V
V <sub>CC</sub>	5.5	V

### Transient Input Voltage (V<sub>IN</sub>) Waveform



FSTUD32211

### AC Loading and Waveforms



**Note:** Input driven by 50Ω source terminated in 50Ω  
**Note:**  $C_L$  includes load and stray capacitance  
**Note:** Input PRR = 1.0 MHz,  $t_W = 500$  ns

FIGURE 2. AC Test Circuit

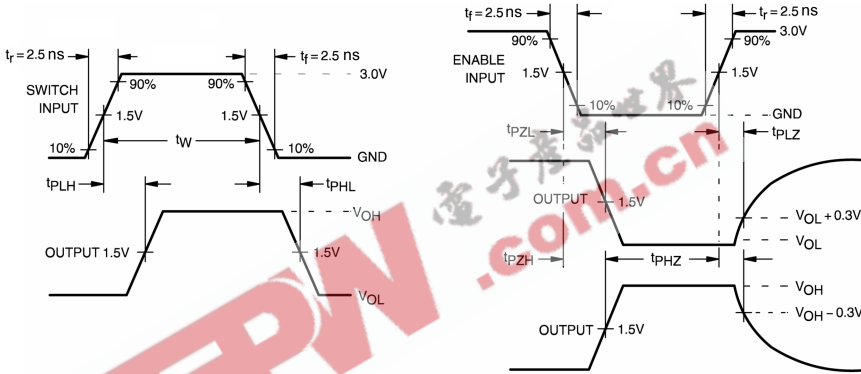


FIGURE 3. AC Waveforms

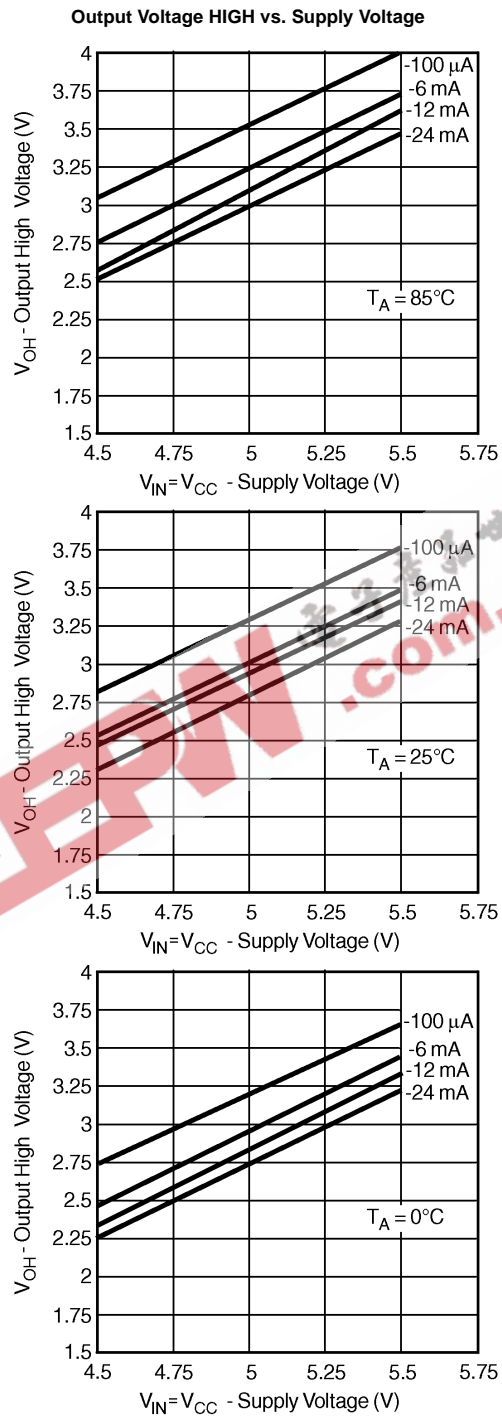


FIGURE 4.

