

Combining Test and System I/O Functions on a single pin

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Many ASIC products include a large number of signal inputs and outputs. However few ASIC designers are willing to dedicate I/O lines for testing. This article helps designers share system I/O functions with test I/O functions, saving pin cost and maximizing I/O utilization.

System I/O generally fall into the following three categories:

- Input
- Output
- Bi-directional

Test I/O however fall into the following two categories:

- Test Input
- Test Output

In most ASICs designed today, any Test I/O (input or output) can be combined with any system I/O function (input, output or bi-directional). The table below lists the possible combinations:

System Input	Scan Input
	Scan Output
System Output	Scan Input
	Scan Output
System Bi-directional	Scan Input
	Scan Output

1. System Input with Scan Input

Figure 1 illustrates how the data input to a scan register can be shared with system input. The input pad is attached to the PAD input of a buffer cell. The output of this buffer cell simply fans out serving both as system input SysIn and as a scan input ScanIn.

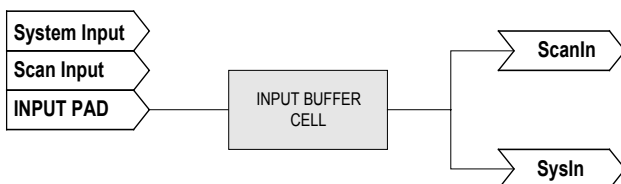


Fig. 1

2. System Input with Scan Output

Figure 2 illustrates how a test bi-directional buffer can be used as a system input and as a scan output. When ScanEnable is high the bi-directional buffer is placed in the "output" mode enabling the path from the internal scan register denoted as ScanOut. When ScanEnable is low the driver is placed in high impedance and the circuit behaves as a system input.

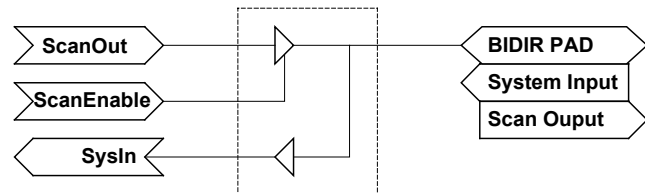


Fig. 2

3. System Output with Scan Input

Figure 3 illustrates how a test bi-directional buffer can be used as a system output and as a scan input. When ScanEnable is low the bi-directional buffer is placed in the "output" mode and SysOut is propagated to the pad. When ScanEnable is high the driver is placed in high impedance and the circuit behaves as a scan input.

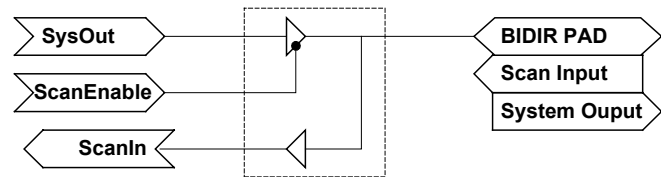


Fig. 3

4. System Output with Scan Output

Figure 4 illustrates how a system output can be used as a scan output. When ScanEnable is high the mux selects ScanOut as the output from the internal scan register on to the pad. When ScanEnable is low the system output SysOut gets propagated on to the pad.

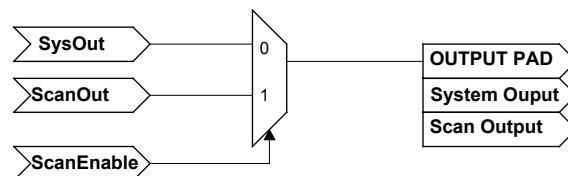


Fig. 4

5. System 3-State Output with Scan Output

Figure 5 illustrates how a system 3-state output can be used as a scan output. When ScanEnable is high the path from the internal scan register ScanOut is enabled on to the pad. When SysOE is high the system output SysOut gets propagated on to the pad.

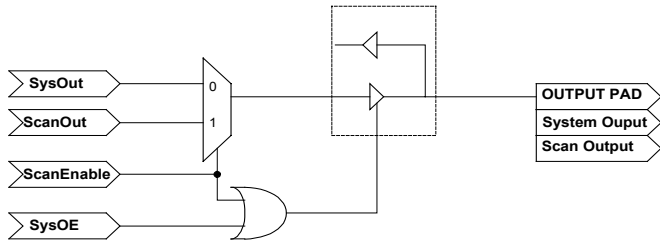


Fig. 5

6. System Bi-directional with Scan Input

Figure 6 illustrates how a system bi-directional I/O can be used as scan input. When the ScanEnable is low the circuit acts as a conventional 3-state bi-directional I/O. When SysOE is high SysBidiOut is driven to the pad. When SysOE is low an external source may drive the pad. If ScanEnable is high the driver is placed in high impedance and the circuit behaves as a scan input.

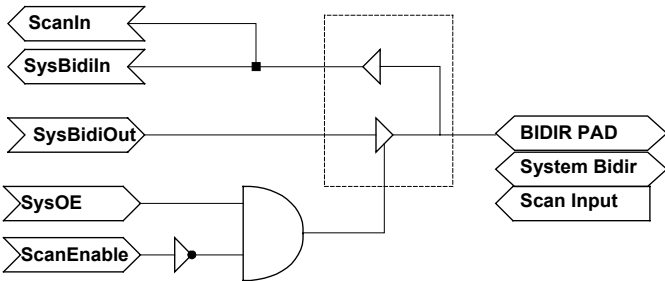


Fig. 6

7. System Bi-directional with Scan Output

Figure 7 illustrates how a system bi-directional I/O can be used as a scan output. When ScanEnable is high, a path from the scan register to the pad is enabled. When ScanEnable is low the circuit operates as a 3-state output; when SysOE is high SysBidiOut is driven on to the pad. When the SysOE is low an external source may drive the pad.

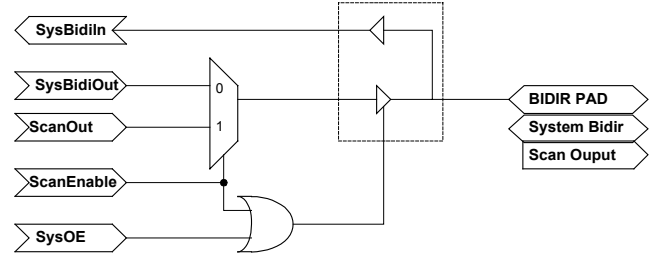


Fig. 7

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