

LOW POWER FIVE-CHANNEL DIGITAL ISOLATOR

Features

- High-speed operation
 - DC to 150 Mbps
- No start-up initialization required
- Wide Operating Supply Voltage
 - 2.5–5.5 V
- Up to 5000 V_{RMS} isolation
- 60-year life at rated working voltage
- High electromagnetic immunity
- Ultra low power (typical) 5 V Operation
 - 1.6 mA per channel at 1 Mbps
 - 5.5 mA per channel at 100 Mbps
- 2.5 V Operation
 - 1.5 mA per channel at 1 Mbps
 - 3.5 mA per channel at 100 Mbps
- Tri-state outputs with ENABLE
- Schmitt trigger inputs
- Selectable fail-safe mode
 - Default high or low output (ordering option)
- Precise timing (typical)
 - 10 ns propagation delay
 - 1.5 ns pulse width distortion
 - 0.5 ns channel-channel skew
 - 2 ns propagation delay skew
 - 5 ns minimum pulse width
- Transient Immunity 50 kV/μs
- AEC-Q100 qualification
- Wide temperature range
 - –40 to 125 °C
- RoHS-compliant packages
 - SOIC-16 wide body
 - SOIC-16 narrow body
 - QSOP-16

Applications

- Industrial automation systems
- Medical electronics
- Hybrid electric vehicles
- Isolated switch mode supplies
- Isolated ADC, DAC
- Motor control
- Power inverters
- Communication systems

Safety Regulatory Approvals

- UL 1577 recognized
 - Up to 5000 V_{RMS} for 1 minute
- CSA component notice 5A approval
 - IEC 60950-1, 61010-1, 60601-1 (reinforced insulation)
- VDE certification conformity
 - IEC 60747-5-2 (VDE0884 Part 2)
 - EN60950-1 (reinforced insulation)
- CQC certification approval
 - GB4943.1

Description

Silicon Lab's family of ultra-low-power digital isolators are CMOS devices offering substantial data rate, propagation delay, power, size, reliability, and external BOM advantages over legacy isolation technologies. The operating parameters of these products remain stable across wide temperature ranges and throughout device service life for ease of design and highly uniform performance. All device versions have Schmitt trigger inputs for high noise immunity and only require VDD bypass capacitors.

Data rates up to 150 Mbps are supported, and all devices achieve propagation delays of less than 10 ns. Enable inputs provide a single point control for enabling and disabling output drive. Ordering options include a choice of isolation ratings (2.5, 3.75 and 5 kV) and a selectable fail-safe operating mode to control the default output state during power loss. All products >1 kV_{RMS} are safety certified by UL, CSA, VDE, and CQC, and products in wide-body packages support reinforced insulation withstanding up to 5 kV_{RMS}.

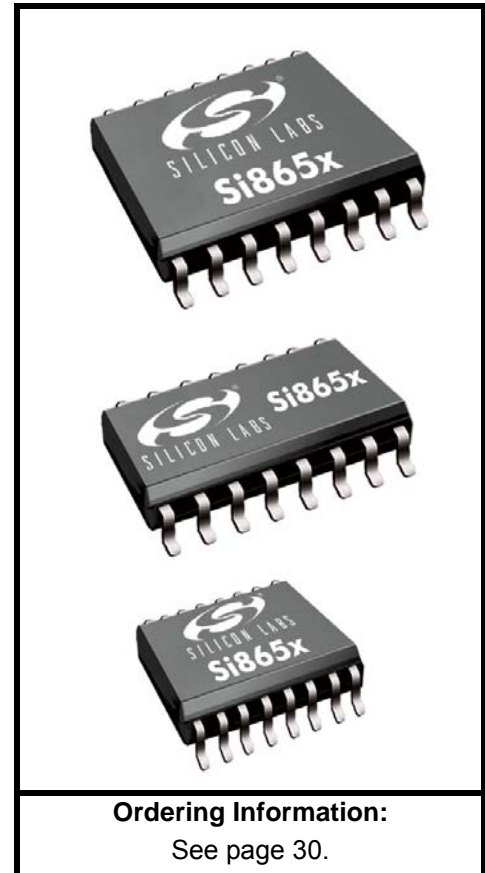


TABLE OF CONTENTS

| <u>Section</u> | <u>Page</u> |
|---|--------------------|
| 1. Electrical Specifications | 4 |
| 2. Functional Description | 20 |
| 2.1. Theory of Operation | 20 |
| 2.2. Eye Diagram | 21 |
| 3. Device Operation | 22 |
| 3.1. Device Startup | 24 |
| 3.2. Undervoltage Lockout | 24 |
| 3.3. Layout Recommendations | 25 |
| 3.4. Fail-Safe Operating Mode | 25 |
| 3.5. Typical Performance Characteristics | 26 |
| 4. Pin Descriptions (Si8650/51/52) | 28 |
| 5. Pin Descriptions (Si8655) | 29 |
| 6. Ordering Guide | 30 |
| 7. Package Outline: 16-Pin Wide Body SOIC | 31 |
| 8. Land Pattern: 16-Pin Wide-Body SOIC | 33 |
| 9. Package Outline: 16-Pin Narrow Body SOIC | 34 |
| 10. Land Pattern: 16-Pin Narrow Body SOIC | 36 |
| 11. Package Outline: 16-Pin QSOP | 37 |
| 12. Land Pattern: 16-Pin QSOP | 39 |
| 13. Top Markings | 40 |
| 13.1. Top Marking (16-Pin Wide Body SOIC) | 40 |
| 13.2. Top Marking Explanation (16-Pin Wide Body SOIC) | 40 |
| 13.3. Top Marking (16-Pin Narrow Body SOIC) | 41 |
| 13.4. Top Marking Explanation (16-Pin Narrow Body SOIC) | 41 |
| 13.5. Top Marking (16-Pin QSOP) | 42 |
| 13.6. Top Marking Explanation (16-Pin QSOP) | 42 |
| Document Change List | 43 |
| Contact Information | 44 |

Si8650/51/52/55

1. Electrical Specifications

Table 1. Recommended Operating Conditions

| Parameter | Symbol | Min | Typ | Max | Unit |
|--------------------------------|-----------|-----|-----|-----|------|
| Ambient Operating Temperature* | T_A | -40 | 25 | 125 | °C |
| Supply Voltage | V_{DD1} | 2.5 | — | 5.5 | V |
| | V_{DD2} | 2.5 | — | 5.5 | V |

*Note: The maximum ambient temperature is dependent on data frequency, output loading, number of operating channels, and supply voltage.

Table 2. Electrical Characteristics

($V_{DD1} = 5 V \pm 10\%$, $V_{DD2} = 5 V \pm 10\%$, $T_A = -40$ to 125 °C)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--------------------------------|-----------|----------------------------|--------------------------|------|----------|----------|
| VDD Undervoltage Threshold | VDDUV+ | V_{DD1}, V_{DD2} rising | 1.95 | 2.24 | 2.375 | V |
| VDD Undervoltage Threshold | VDDUV- | V_{DD1}, V_{DD2} falling | 1.88 | 2.16 | 2.325 | V |
| VDD Undervoltage Hysteresis | VDDHYS | | 50 | 70 | 95 | mV |
| Positive-Going Input Threshold | VT+ | All inputs rising | 1.4 | 1.67 | 1.9 | V |
| Negative-Going Input Threshold | VT- | All inputs falling | 1.0 | 1.23 | 1.4 | V |
| Input Hysteresis | V_{HYS} | | 0.38 | 0.44 | 0.50 | V |
| High Level Input Voltage | V_{IH} | | 2.0 | — | — | V |
| Low Level input voltage | V_{IL} | | — | — | 0.8 | V |
| High Level Output Voltage | V_{OH} | $I_{OH} = -4$ mA | $V_{DD1}, V_{DD2} - 0.4$ | 4.8 | — | V |
| Low Level Output Voltage | V_{OL} | $I_{OL} = 4$ mA | — | 0.2 | 0.4 | V |
| Input Leakage Current | I_L | | — | — | ± 10 | μA |
| Output Impedance ¹ | Z_O | | — | 50 | — | Ω |
| Enable Input High Current | I_{ENH} | $V_{ENx} = V_{IH}$ | — | 2.0 | — | μA |
| Enable Input Low Current | I_{ENL} | $V_{ENx} = V_{IL}$ | — | 2.0 | — | μA |

Notes:

1. The nominal output impedance of an isolator driver channel is approximately 50Ω , $\pm 40\%$, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces.
2. $t_{PSK(P-P)}$ is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature.
3. Start-up time is the time period from the application of power to valid data at the output.

Table 2. Electrical Characteristics (Continued) $(V_{DD1} = 5 V \pm 10\%, V_{DD2} = 5 V \pm 10\%, T_A = -40 \text{ to } 125 \text{ } ^\circ\text{C})$

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|--------|------------------------------------|-----|-----|-----|------|
| DC Supply Current (All inputs 0 V or at Supply) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | $V_I = 0(\text{Bx}), 1(\text{Ex})$ | — | 1.1 | 1.8 | mA |
| V_{DD2} | | $V_I = 0(\text{Bx}), 1(\text{Ex})$ | — | 3.1 | 4.7 | |
| V_{DD1} | | $V_I = 1(\text{Bx}), 0(\text{Ex})$ | — | 7.0 | 9.8 | |
| V_{DD2} | | $V_I = 1(\text{Bx}), 0(\text{Ex})$ | — | 3.3 | 5.0 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | $V_I = 0(\text{Bx}), 1(\text{Ex})$ | — | 1.5 | 2.4 | mA |
| V_{DD2} | | $V_I = 0(\text{Bx}), 1(\text{Ex})$ | — | 2.7 | 4.1 | |
| V_{DD1} | | $V_I = 1(\text{Bx}), 0(\text{Ex})$ | — | 6.6 | 9.2 | |
| V_{DD2} | | $V_I = 1(\text{Bx}), 0(\text{Ex})$ | — | 4.0 | 6.0 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | $V_I = 0(\text{Bx}), 1(\text{Ex})$ | — | 2.0 | 3.0 | mA |
| V_{DD2} | | $V_I = 0(\text{Bx}), 1(\text{Ex})$ | — | 2.4 | 3.6 | |
| V_{DD1} | | $V_I = 1(\text{Bx}), 0(\text{Ex})$ | — | 5.6 | 7.8 | |
| V_{DD2} | | $V_I = 1(\text{Bx}), 0(\text{Ex})$ | — | 5.0 | 7.5 | |
| 1 Mbps Supply Current (All inputs = 500 kHz square wave, $C_I = 15 \text{ pF}$ on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 3.7 | 5.2 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.2 | 5.8 | mA |
| V_{DD2} | | | — | 3.8 | 5.3 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.0 | 5.6 | mA |
| V_{DD2} | | | — | 4.0 | 5.6 | |
| 10 Mbps Supply Current (All inputs = 5 MHz square wave, $C_I = 15 \text{ pF}$ on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 5.2 | 7.2 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.4 | 6.2 | mA |
| V_{DD2} | | | — | 4.9 | 6.9 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.6 | 6.4 | mA |
| V_{DD2} | | | — | 4.9 | 6.8 | |
| Notes: | | | | | | |
| 1. The nominal output impedance of an isolator driver channel is approximately $50 \Omega, \pm 40\%$, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces. | | | | | | |
| 2. $t_{PSK(P-P)}$ is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature. | | | | | | |
| 3. Start-up time is the time period from the application of power to valid data at the output. | | | | | | |

Si8650/51/52/55

Table 2. Electrical Characteristics (Continued)

($V_{DD1} = 5 V \pm 10\%$, $V_{DD2} = 5 V \pm 10\%$, $T_A = -40$ to 125 °C)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|-----------------------|--|-----|------|------|-------------|
| 100 Mbps Supply Current (All inputs = 50 MHz square wave, CI = 15 pF on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 22.1 | 28.7 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 8.0 | 10.8 | mA |
| V_{DD2} | | | — | 18.4 | 24 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 11.7 | 15.2 | mA |
| V_{DD2} | | | — | 15 | 19.5 | |
| Timing Characteristics | | | | | | |
| Si865xBx, Ex | | | | | | |
| Maximum Data Rate | | | 0 | — | 150 | Mbps |
| Minimum Pulse Width | | | — | — | 5.0 | ns |
| Propagation Delay | t_{PHL} , t_{PLH} | See Figure 2 | 5.0 | 8.0 | 13 | ns |
| Pulse Width Distortion $ t_{PLH} - t_{PHL} $ | PWD | See Figure 2 | — | 0.2 | 4.5 | ns |
| Propagation Delay Skew ² | $t_{PSK(P-P)}$ | | — | 2.0 | 4.5 | ns |
| Channel-Channel Skew | t_{PSK} | | — | 0.4 | 2.5 | ns |
| All Models | | | | | | |
| Output Rise Time | t_r | $C_L = 15$ pF See Figure 2 | — | 2.5 | 4.0 | ns |
| Output Fall Time | t_f | $C_L = 15$ pF See Figure 2 | — | 2.5 | 4.0 | ns |
| Peak eye diagram jitter | $t_{JIT(PK)}$ | See Figure 8 | — | 350 | — | ps |
| Common Mode Transient Immunity | CMTI | $V_I = V_{DD}$ or 0 V $V_{CM} = 1500$ V (see Figure 3) | 35 | 50 | — | kV/ μ s |
| Enable to Data Valid | t_{en1} | See Figure 1 | — | 6.0 | 11 | ns |
| Enable to Data Tri-State | t_{en2} | See Figure 1 | — | 8.0 | 12 | ns |
| Start-up Time ³ | t_{SU} | | — | 15 | 40 | μ s |
| Notes: | | | | | | |
| <ol style="list-style-type: none"> 1. The nominal output impedance of an isolator driver channel is approximately 50 Ω, $\pm 40\%$, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces. 2. $t_{PSK(P-P)}$ is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature. 3. Start-up time is the time period from the application of power to valid data at the output. | | | | | | |

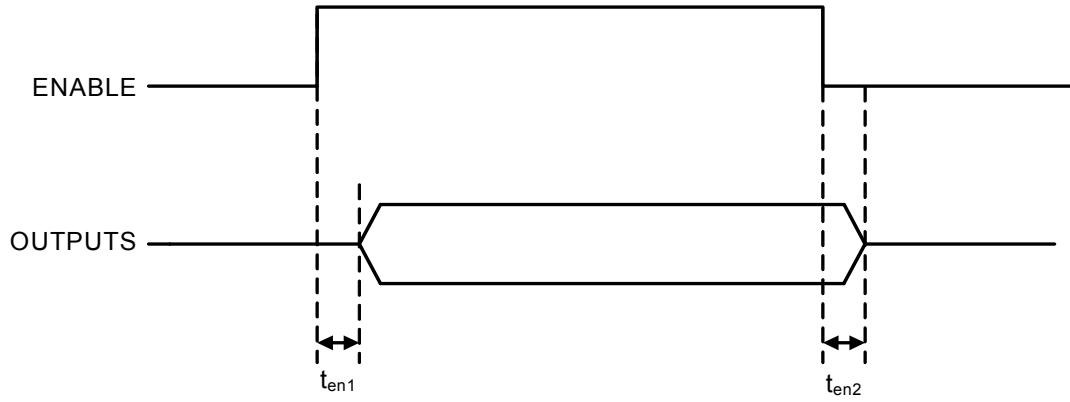


Figure 1. ENABLE Timing Diagram

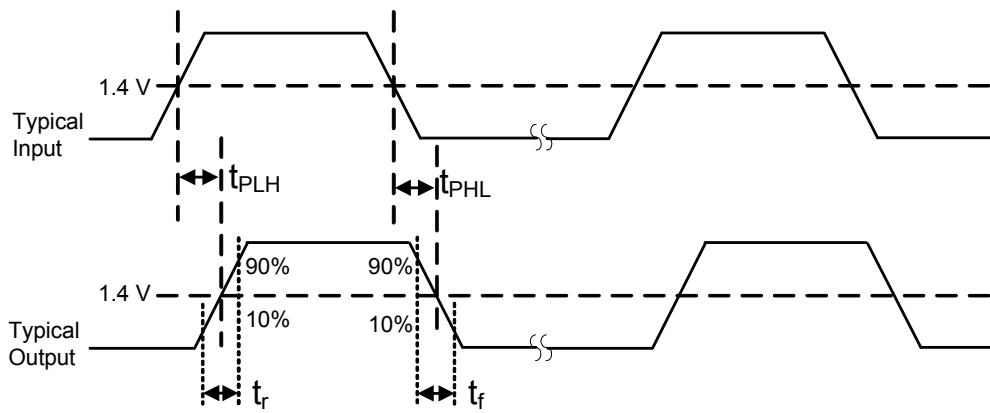


Figure 2. Propagation Delay Timing

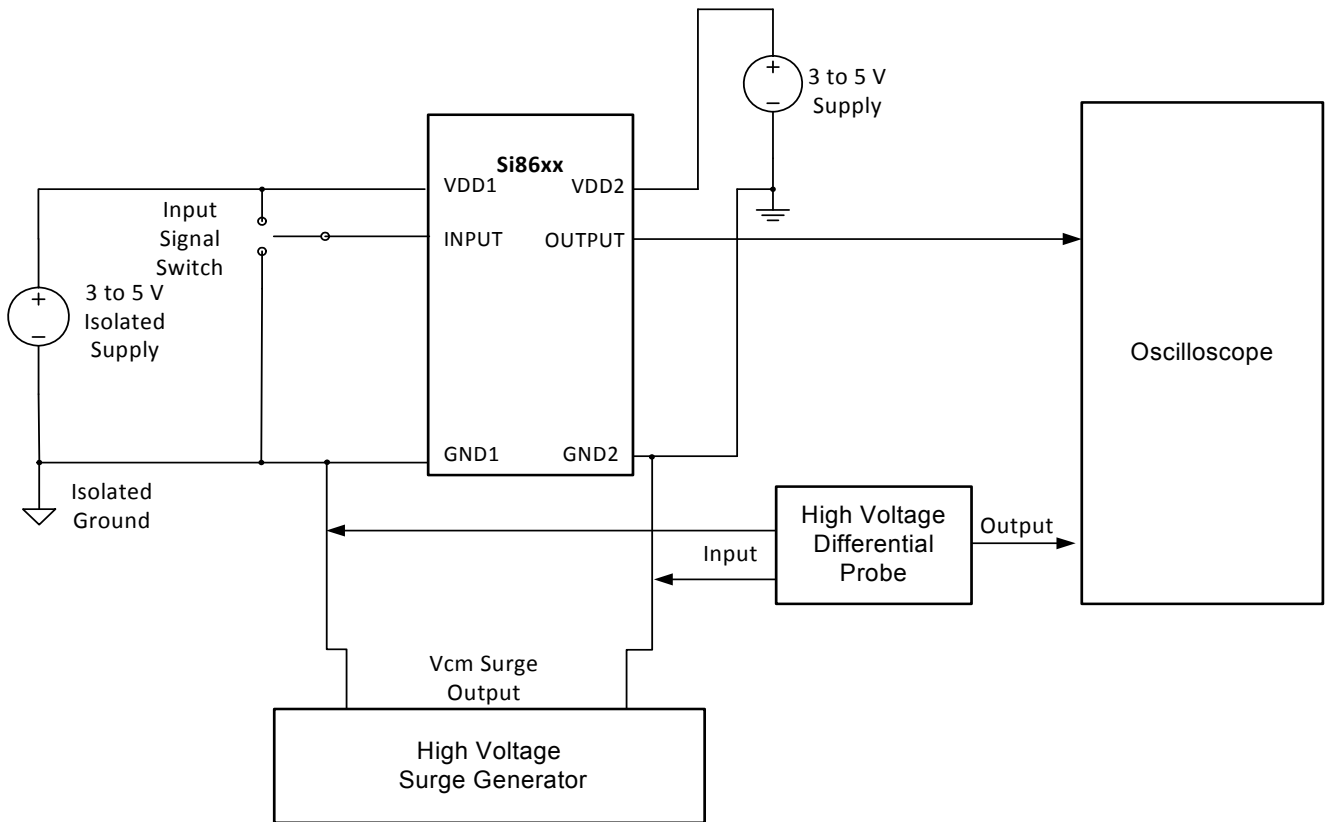


Figure 3. Common Mode Transient Immunity Test Circuit

Table 3. Electrical Characteristics $(V_{DD1} = 3.3\text{ V} \pm 10\%, V_{DD2} = 3.3\text{ V} \pm 10\%, T_A = -40\text{ to }125\text{ }^\circ\text{C})$

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|------------------|-------------------------------|--------------------------|------|-------|------|
| VDD Undervoltage Threshold | VDDUV+ | V_{DD1}, V_{DD2} rising | 1.95 | 2.24 | 2.375 | V |
| VDD Undervoltage Threshold | VDDUV- | V_{DD1}, V_{DD2} falling | 1.88 | 2.16 | 2.325 | V |
| VDD Undervoltage Hysteresis | VDDHYS | | 50 | 70 | 95 | mV |
| Positive-Going Input Threshold | VT+ | All inputs rising | 1.4 | 1.67 | 1.9 | V |
| Negative-Going Input Threshold | VT- | All inputs falling | 1.0 | 1.23 | 1.4 | V |
| Input Hysteresis | V _{HYS} | | 0.38 | 0.44 | 0.50 | V |
| High Level Input Voltage | V _{IH} | | 2.0 | — | — | V |
| Low Level Input Voltage | V _{IL} | | — | — | 0.8 | V |
| High Level Output Voltage | V _{OH} | loh = -4 mA | $V_{DD1}, V_{DD2} - 0.4$ | 3.1 | — | V |
| Low Level Output Voltage | V _{OL} | lol = 4 mA | — | 0.2 | 0.4 | V |
| Input Leakage Current | I _L | | — | — | ±10 | µA |
| Output Impedance ¹ | Z _O | | — | 50 | — | Ω |
| Enable Input High Current | I _{ENH} | $V_{ENx} = V_{IH}$ | — | 2.0 | — | µA |
| Enable Input Low Current | I _{ENL} | $V_{ENx} = V_{IL}$ | — | 2.0 | — | µA |
| DC Supply Current (All inputs 0 V or at supply) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V _{DD1} | | V _I = 0(Bx), 1(Ex) | — | 1.1 | 1.8 | mA |
| V _{DD2} | | V _I = 0(Bx), 1(Ex) | — | 3.1 | 4.7 | |
| V _{DD1} | | V _I = 1(Bx), 0(Ex) | — | 7.0 | 9.8 | |
| V _{DD2} | | V _I = 1(Bx), 0(Ex) | — | 3.3 | 5.0 | |
| Si8651Bx, Ex | | | | | | |
| V _{DD1} | | V _I = 0(Bx), 1(Ex) | — | 1.5 | 2.4 | mA |
| V _{DD2} | | V _I = 0(Bx), 1(Ex) | — | 2.7 | 4.1 | |
| V _{DD1} | | V _I = 1(Bx), 0(Ex) | — | 6.6 | 9.2 | |
| V _{DD2} | | V _I = 1(Bx), 0(Ex) | — | 4.0 | 6.0 | |
| Si8652Bx, Ex | | | | | | |
| V _{DD1} | | V _I = 0(Bx), 1(Ex) | — | 2.0 | 3.0 | mA |
| V _{DD2} | | V _I = 0(Bx), 1(Ex) | — | 2.4 | 3.6 | |
| V _{DD1} | | V _I = 1(Bx), 0(Ex) | — | 5.6 | 7.8 | |
| V _{DD2} | | V _I = 1(Bx), 0(Ex) | — | 5.0 | 7.5 | |

Notes:

1. The nominal output impedance of an isolator driver channel is approximately 50 Ω, ±40%, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces.
2. $t_{PSK(P-P)}$ is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature.
3. Start-up time is the time period from the application of power to valid data at the output.

Si8650/51/52/55

Table 3. Electrical Characteristics (Continued)

($V_{DD1} = 3.3 V \pm 10\%$, $V_{DD2} = 3.3 V \pm 10\%$, $T_A = -40$ to 125 °C)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|--------|----------------|-----|------|------|------|
| 1 Mbps Supply Current (All inputs = 500 kHz square wave, CI = 15 pF on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 3.7 | 5.2 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.2 | 5.8 | mA |
| V_{DD2} | | | — | 3.8 | 5.3 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.0 | 5.6 | mA |
| V_{DD2} | | | — | 4.0 | 5.6 | |
| 10 Mbps Supply Current (All inputs = 5 MHz square wave, CI = 15 pF on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 4.4 | 6.1 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.3 | 6.0 | mA |
| V_{DD2} | | | — | 4.3 | 6.0 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.3 | 6.0 | mA |
| V_{DD2} | | | — | 4.4 | 6.1 | |
| 100 Mbps Supply Current (All inputs = 50 MHz square wave, CI = 15 pF on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 15.5 | 20.1 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 6.6 | 8.9 | mA |
| V_{DD2} | | | — | 13.2 | 17.1 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 8.9 | 11.6 | mA |
| V_{DD2} | | | — | 11.1 | 14.4 | |
| Notes: | | | | | | |
| <ol style="list-style-type: none"> 1. The nominal output impedance of an isolator driver channel is approximately 50Ω, $\pm 40\%$, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces. 2. $t_{PSK(P-P)}$ is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature. 3. Start-up time is the time period from the application of power to valid data at the output. | | | | | | |

Table 3. Electrical Characteristics (Continued)(V_{DD1} = 3.3 V±10%, V_{DD2} = 3.3 V±10%, T_A = -40 to 125 °C)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|-------------------------------------|---|-----|-----|-----|-------|
| Timing Characteristics | | | | | | |
| Si865xBx, Ex | | | | | | |
| Maximum Data Rate | | | 0 | — | 150 | Mbps |
| Minimum Pulse Width | | | — | — | 5.0 | ns |
| Propagation Delay | t _{PHL} , t _{PLH} | See Figure 2 | 5.0 | 8.0 | 13 | ns |
| Pulse Width Distortion t _{PLH} - t _{PHL} | PWD | See Figure 2 | — | 0.2 | 4.5 | ns |
| Propagation Delay Skew ² | t _{PSK(P-P)} | | — | 2.0 | 4.5 | ns |
| Channel-Channel Skew | t _{PSK} | | — | 0.4 | 2.5 | ns |
| All Models | | | | | | |
| Output Rise Time | t _r | C _L = 15 pF See Figure 2 | — | 2.5 | 4.0 | ns |
| Output Fall Time | t _f | C _L = 15 pF (See Figure 2) | — | 2.5 | 4.0 | ns |
| Peak eye diagram jitter | t _{JIT(PK)} | (See Figure 8) | — | 350 | — | ps |
| Common Mode Transient Immunity | CMTI | V _I = V _{DD} or 0 V V _{CM} = 1500 V (See Figure 3) | 35 | 50 | — | kV/μs |
| Enable to Data Valid | t _{en1} | See Figure 1 | — | 6.0 | 11 | ns |
| Enable to Data Tri-State | t _{en2} | See Figure 1 | — | 8.0 | 12 | ns |
| Start-Up Time ³ | t _{SU} | | — | 15 | 40 | μs |
| Notes: | | | | | | |
| <ol style="list-style-type: none"> 1. The nominal output impedance of an isolator driver channel is approximately 50 Ω, ±40%, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces. 2. t_{PSK(P-P)} is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature. 3. Start-up time is the time period from the application of power to valid data at the output. | | | | | | |

Si8650/51/52/55

Table 4. Electrical Characteristics

($V_{DD1} = 2.5\text{ V} \pm 5\%$, $V_{DD2} = 2.5\text{ V} \pm 5\%$, $T_A = -40$ to $125\text{ }^\circ\text{C}$)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|--------------------|-------------------------------|--------------------------|------|-------|------|
| VDD Undervoltage Threshold | VDDUV+ | V_{DD1}, V_{DD2} rising | 1.95 | 2.24 | 2.375 | V |
| VDD Undervoltage Threshold | VDDUV- | V_{DD1}, V_{DD2} falling | 1.88 | 2.16 | 2.325 | V |
| VDD Undervoltage Hysteresis | VDD _{HYS} | | 50 | 70 | 95 | mV |
| Positive-Going Input Threshold | VT+ | All inputs rising | 1.4 | 1.67 | 1.9 | V |
| Negative-Going Input Threshold | VT- | All inputs falling | 1.0 | 1.23 | 1.4 | V |
| Input Hysteresis | V _{HYS} | | 0.38 | 0.44 | 0.50 | V |
| High Level Input Voltage | V _{IH} | | 2.0 | — | — | V |
| Low Level Input Voltage | V _{IL} | | — | — | 0.8 | V |
| High Level Output Voltage | V _{OH} | loh = -4 mA | $V_{DD1}, V_{DD2} - 0.4$ | 2.3 | — | V |
| Low Level Output Voltage | V _{OL} | lol = 4 mA | — | 0.2 | 0.4 | V |
| Input Leakage Current | I _L | | — | — | ±10 | µA |
| Output Impedance ¹ | Z _O | | — | 50 | — | Ω |
| Enable Input High Current | I _{ENH} | $V_{ENx} = V_{IH}$ | — | 2.0 | — | µA |
| Enable Input Low Current | I _{ENL} | $V_{ENx} = V_{IL}$ | — | 2.0 | — | µA |
| DC Supply Current (All inputs 0 V or at supply) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V _{DD1} | | V _I = 0(Bx), 1(Ex) | — | 1.1 | 1.8 | mA |
| V _{DD2} | | V _I = 0(Bx), 1(Ex) | — | 3.1 | 4.7 | |
| V _{DD1} | | V _I = 1(Bx), 0(Ex) | — | 7.0 | 9.8 | |
| V _{DD2} | | V _I = 1(Bx), 0(Ex) | — | 3.3 | 5.0 | |
| Si8651Bx, Ex | | | | | | |
| V _{DD1} | | V _I = 0(Bx), 1(Ex) | — | 1.5 | 2.4 | mA |
| V _{DD2} | | V _I = 0(Bx), 1(Ex) | — | 2.7 | 4.1 | |
| V _{DD1} | | V _I = 1(Bx), 0(Ex) | — | 6.6 | 9.2 | |
| V _{DD2} | | V _I = 1(Bx), 0(Ex) | — | 4.0 | 6.0 | |
| Si8652Bx, Ex | | | | | | |
| V _{DD1} | | V _I = 0(Bx), 1(Ex) | — | 2.0 | 3.0 | mA |
| V _{DD2} | | V _I = 0(Bx), 1(Ex) | — | 2.4 | 3.6 | |
| V _{DD1} | | V _I = 1(Bx), 0(Ex) | — | 5.6 | 7.8 | |
| V _{DD2} | | V _I = 1(Bx), 0(Ex) | — | 5.0 | 7.5 | |
| Notes: | | | | | | |
| 1. The nominal output impedance of an isolator driver channel is approximately 50 Ω, ±40%, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces. | | | | | | |
| 2. t _{PSK(P-P)} is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature. | | | | | | |
| 3. Start-up time is the time period from the application of power to valid data at the output. | | | | | | |

Table 4. Electrical Characteristics (Continued) $(V_{DD1} = 2.5\text{ V} \pm 5\%, V_{DD2} = 2.5\text{ V} \pm 5\%, T_A = -40\text{ to }125\text{ }^\circ\text{C})$

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|--|--------|----------------|-----|------|------|------|
| 1 Mbps Supply Current (All inputs = 500 kHz square wave, CI = 15 pF on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 3.7 | 5.2 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.2 | 5.8 | mA |
| V_{DD2} | | | — | 3.8 | 5.3 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.0 | 5.6 | mA |
| V_{DD2} | | | — | 4.0 | 5.6 | |
| 10 Mbps Supply Current (All inputs = 5 MHz square wave, CI = 15 pF on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 4.0 | 5.6 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.2 | 5.9 | mA |
| V_{DD2} | | | — | 4.0 | 5.6 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.8 | mA |
| V_{DD2} | | | — | 4.2 | 5.9 | |
| 100 Mbps Supply Current (All inputs = 50 MHz square wave, CI = 15 pF on all outputs) | | | | | | |
| Si8650Bx, Ex, Si8655Bx | | | | | | |
| V_{DD1} | | | — | 4.1 | 5.7 | mA |
| V_{DD2} | | | — | 12.5 | 16.2 | |
| Si8651Bx, Ex | | | | | | |
| V_{DD1} | | | — | 6.0 | 8.1 | mA |
| V_{DD2} | | | — | 10.8 | 14 | |
| Si8652Bx, Ex | | | | | | |
| V_{DD1} | | | — | 7.6 | 9.9 | mA |
| V_{DD2} | | | — | 9.3 | 12.0 | |
| Notes: | | | | | | |
| 1. The nominal output impedance of an isolator driver channel is approximately $50\ \Omega$, $\pm 40\%$, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces. | | | | | | |
| 2. $t_{PSK(P-P)}$ is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature. | | | | | | |
| 3. Start-up time is the time period from the application of power to valid data at the output. | | | | | | |

Si8650/51/52/55

Table 4. Electrical Characteristics (Continued)

($V_{DD1} = 2.5\text{ V} \pm 5\%$, $V_{DD2} = 2.5\text{ V} \pm 5\%$, $T_A = -40\text{ to }125\text{ }^\circ\text{C}$)

| Parameter | Symbol | Test Condition | Min | Typ | Max | Unit |
|---|-----------------------|--|-----|-----|-----|-------------------|
| Timing Characteristics | | | | | | |
| Si865xBx, Ex | | | | | | |
| Maximum Data Rate | | | 0 | — | 150 | Mbps |
| Minimum Pulse Width | | | — | — | 5.0 | ns |
| Propagation Delay | t_{PHL} , t_{PLH} | See Figure 2 | 5.0 | 8.0 | 14 | ns |
| Pulse Width Distortion $ t_{PLH} - t_{PHL} $ | PWD | See Figure 2 | — | 0.2 | 5.0 | ns |
| Propagation Delay Skew ² | $t_{PSK(P-P)}$ | | — | 2.0 | 5.0 | ns |
| Channel-Channel Skew | t_{PSK} | | — | 0.4 | 2.5 | ns |
| All Models | | | | | | |
| Output Rise Time | t_r | $C_L = 15\text{ pF}$ See Figure 2 | — | 2.5 | 4.0 | ns |
| Output Fall Time | t_f | $C_L = 15\text{ pF}$ See Figure 2 | — | 2.5 | 4.0 | ns |
| Peak Eye Diagram Jitter | $t_{JIT(PK)}$ | See Figure 8 | — | 350 | — | ps |
| Common Mode Transient Immunity | CMTI | $V_I = V_{DD}$ or 0 V $V_{CM} = 1500\text{ V}$ (See Figure 3) | 35 | 50 | — | kV/ μs |
| Enable to Data Valid | t_{en1} | See Figure 1 | — | 6.0 | 11 | ns |
| Enable to Data Tri-State | t_{en2} | See Figure 1 | — | 8.0 | 12 | ns |
| Startup Time ³ | t_{SU} | | — | 15 | 40 | μs |
| Notes: | | | | | | |
| <ol style="list-style-type: none"> 1. The nominal output impedance of an isolator driver channel is approximately $50\ \Omega$, $\pm 40\%$, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces. 2. $t_{PSK(P-P)}$ is the magnitude of the difference in propagation delay times measured between different units operating at the same supply voltages, load, and ambient temperature. 3. Start-up time is the time period from the application of power to valid data at the output. | | | | | | |

Table 5. Regulatory Information*

| |
|--|
| CSA |
| The Si865x is certified under CSA Component Acceptance Notice 5A. For more details, see File 232873. |
| 61010-1: Up to 600 V _{RMS} reinforced insulation working voltage; up to 600 V _{RMS} basic insulation working voltage. |
| 60950-1: Up to 600 V _{RMS} reinforced insulation working voltage; up to 1000 V _{RMS} basic insulation working voltage. |
| 60601-1: Up to 125 V _{RMS} reinforced insulation working voltage; up to 380 V _{RMS} basic insulation working voltage. |
| VDE |
| The Si865x is certified according to IEC 60747-5-2. For more details, see File 5006301-4880-0001. |
| 60747-5-2: Up to 1200 V _{peak} for basic insulation working voltage. |
| 60950-1: Up to 600 V _{RMS} reinforced insulation working voltage; up to 1000 V _{RMS} basic insulation working voltage. |
| UL |
| The Si865x is certified under UL1577 component recognition program. For more details, see File E257455. |
| Rated up to 5000 V _{RMS} isolation voltage for basic protection. |
| CQC |
| The Si865x is certified under GB4943.1-2011. For more details, see certificates CQC13001096110 and CQC13001096239. |
| Rated up to 600 V _{RMS} reinforced insulation working voltage; up to 1000 V _{RMS} basic insulation working voltage. |
| *Note: Regulatory Certifications apply to 2.5 kV _{RMS} rated devices which are production tested to 3.0 kV _{RMS} for 1 sec. Regulatory Certifications apply to 3.75 kV _{RMS} rated devices which are production tested to 4.5 kV _{RMS} for 1 sec. Regulatory Certifications apply to 5.0 kV _{RMS} rated devices which are production tested to 6.0 kV _{RMS} for 1 sec. For more information, see "6. Ordering Guide" on page 30. |

Table 6. Insulation and Safety-Related Specifications

| Parameter | Symbol | Test Condition | Value | | | Unit |
|---|-----------------|----------------|------------------|------------------|------------------|------------------|
| | | | WB SOIC-16 | NB SOIC-16 | QSOP-16 | |
| Nominal Air Gap (Clearance) ¹ | L(IO1) | | 8.0 | 4.9 | 3.6 | mm |
| Nominal External Tracking (Creepage) ¹ | L(IO2) | | 8.0 | 4.01 | 3.6 | mm |
| Minimum Internal Gap (Internal Clearance) | | | 0.014 | 0.014 | 0.014 | mm |
| Tracking Resistance (Proof Tracking Index) | PTI | IEC60112 | 600 | 600 | 600 | V _{RMS} |
| Erosion Depth | ED | | 0.019 | 0.019 | 0.031 | mm |
| Resistance (Input-Output) ² | R _{IO} | | 10 ¹² | 10 ¹² | 10 ¹² | Ω |
| Capacitance (Input-Output) ² | C _{IO} | f = 1 MHz | 2.0 | 2.0 | 2.0 | pF |
| Input Capacitance ³ | C _I | | 4.0 | 4.0 | 4.0 | pF |

Notes:

- The values in this table correspond to the nominal creepage and clearance values. VDE certifies the clearance and creepage limits as 4.7 mm minimum for the NB SOIC-16 and QSOP-16 packages and 8.5 mm minimum for the WB SOIC-16 package. UL does not impose a clearance and creepage minimum for component-level certifications. CSA certifies the clearance and creepage limits as 3.9 mm minimum for the NB SOIC-16, 3.6 mm minimum for the QSOP-16 packages and 7.6 mm minimum for the WB SOIC-16 package.
- To determine resistance and capacitance, the Si86xx is converted into a 2-terminal device. Pins 1–8 are shorted together to form the first terminal and pins 9–16 are shorted together to form the second terminal. The parameters are then measured between these two terminals.
- Measured from input pin to ground.

Table 7. IEC 60664-1 (VDE 0844 Part 2) Ratings

| Parameter | Test Conditions | Specification | |
|-----------------------------|---|---------------|------------|
| | | NB SOIC-16 | WB SOIC-16 |
| Basic Isolation Group | Material Group | I | I |
| Installation Classification | Rated Mains Voltages ≤ 150 V _{RMS} | I-IV | I-IV |
| | Rated Mains Voltages ≤ 300 V _{RMS} | I-III | I-IV |
| | Rated Mains Voltages ≤ 400 V _{RMS} | I-II | I-III |
| | Rated Mains Voltages ≤ 600 V _{RMS} | I-II | I-III |

Table 8. IEC 60747-5-2 Insulation Characteristics for Si86xxxx*

| Parameter | Symbol | Test Condition | Characteristic | | Unit |
|--|------------|--|----------------|------------|----------|
| | | | WB SOIC-16 | NB SOIC-16 | |
| Maximum Working Insulation Voltage | V_{IORM} | | 1200 | 630 | Vpeak |
| Input to Output Test Voltage | V_{PR} | Method b1 ($V_{IORM} \times 1.875 = V_{PR}$, 100% Production Test, $t_m = 1$ sec, Partial Discharge < 5 pC) | 2250 | 1182 | |
| Transient Overvoltage | V_{IOTM} | $t = 60$ sec | 6000 | 6000 | Vpeak |
| Pollution Degree (DIN VDE 0110, Table 1) | | | 2 | 2 | |
| Insulation Resistance at T_S , $V_{IO} = 500$ V | R_S | | $>10^9$ | $>10^9$ | Ω |

***Note:** Maintenance of the safety data is ensured by protective circuits. The Si86xxxx provides a climate classification of 40/125/21.

Table 9. IEC Safety Limiting Values¹

| Parameter | Symbol | Test Condition | Max | | Unit |
|--|--------|--|------------|------------|------|
| | | | WB SOIC-16 | NB SOIC-16 | |
| Case Temperature | T_S | | 150 | 150 | °C |
| Safety Input, Output, or Supply Current | I_S | $\theta_{JA} = 100$ °C/W (WB SOIC-16), 105 °C/W (NB SOIC-16, QSOP-16), $V_I = 5.5$ V, $T_J = 150$ °C, $T_A = 25$ °C | 220 | 215 | mA |
| Device Power Dissipation ² | P_D | | 415 | 415 | mW |

Notes:

1. Maximum value allowed in the event of a failure; also see the thermal derating curve in Figures 4 and 5.
2. The Si86xx is tested with $VDD1 = VDD2 = 5.5$ V, $T_J = 150$ °C, $C_L = 15$ pF, input a 150 Mbps 50% duty cycle square wave.

Table 10. Thermal Characteristics

| Parameter | Symbol | WB SOIC-16 | NB SOIC-16 QSOP-16 | Unit |
|---------------------------------------|---------------|------------|-----------------------|-----------------------------|
| IC Junction-to-Air Thermal Resistance | θ_{JA} | 100 | 105 | $^{\circ}\text{C}/\text{W}$ |

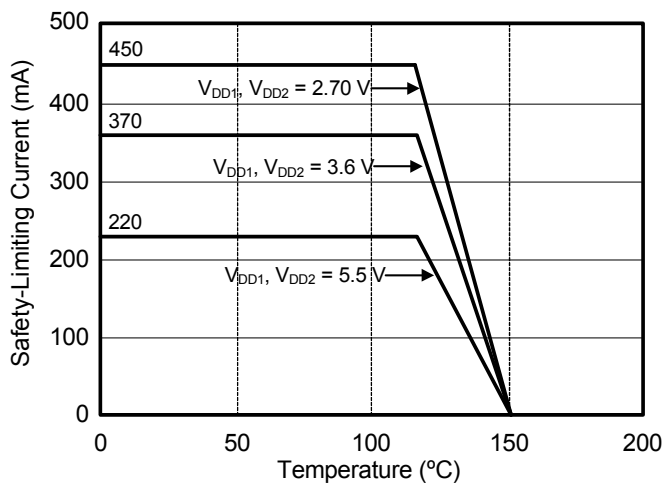


Figure 4. (WB SOIC-16) Thermal Derating Curve, Dependence of Safety Limiting Values with Case Temperature per DIN EN 60747-5-2

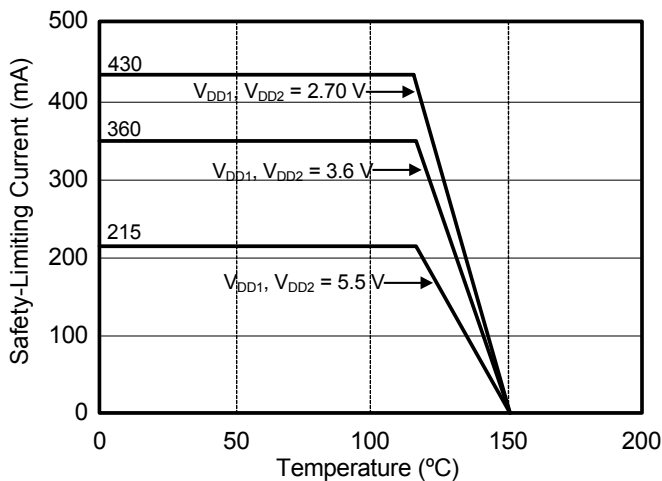


Figure 5. (NB SOIC-16) Thermal Derating Curve, Dependence of Safety Limiting Values with Case Temperature per DIN EN 60747-5-2

Table 11. Absolute Maximum Ratings¹

| Parameter | Symbol | Min | Max | Unit |
|---|--------------------|------|----------------|-----------|
| Storage Temperature ² | T_{STG} | -65 | 150 | °C |
| Ambient Temperature Under Bias | T_A | -40 | 125 | °C |
| Junction Temperature | T_J | — | 150 | °C |
| Supply Voltage | V_{DD1}, V_{DD2} | -0.5 | 7.0 | V |
| Input Voltage | V_I | -0.5 | $V_{DD} + 0.5$ | V |
| Output Voltage | V_O | -0.5 | $V_{DD} + 0.5$ | V |
| Output Current Drive Channel (All devices unless otherwise stated) | I_O | — | 10 | mA |
| Output Current Drive Channel (All Si865xxA-x-xx devices) | I_O | — | 22 | mA |
| Latchup Immunity ³ | | — | 100 | V/ns |
| Lead Solder Temperature (10 s) | | — | 260 | °C |
| Maximum Isolation (Input to Output) (1 sec) NB SOIC-16, QSOP-16 | | — | 4500 | V_{RMS} |
| Maximum Isolation (Input to Output) (1 sec) WB SOIC-16 | | — | 6500 | V_{RMS} |
| Notes: | | | | |
| 1. Permanent device damage may occur if the absolute maximum ratings are exceeded. Functional operation should be restricted to conditions as specified in the operational sections of this data sheet. | | | | |
| 2. VDE certifies storage temperature from -40 to 150 °C. | | | | |
| 3. Latchup immunity specification is for slew rate applied across GND1 and GND2. | | | | |

2. Functional Description

2.1. Theory of Operation

The operation of an Si865x channel is analogous to that of an opto coupler, except an RF carrier is modulated instead of light. This simple architecture provides a robust isolated data path and requires no special considerations or initialization at start-up. A simplified block diagram for a single Si865x channel is shown in Figure 6.

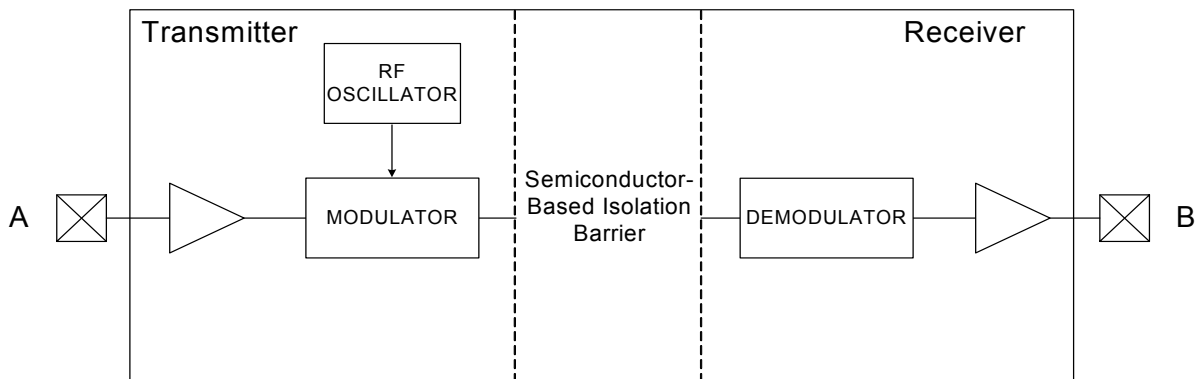


Figure 6. Simplified Channel Diagram

A channel consists of an RF Transmitter and RF Receiver separated by a semiconductor-based isolation barrier. Referring to the Transmitter, input A modulates the carrier provided by an RF oscillator using on/off keying. The Receiver contains a demodulator that decodes the input state according to its RF energy content and applies the result to output B via the output driver. This RF on/off keying scheme is superior to pulse code schemes as it provides best-in-class noise immunity, low power consumption, and better immunity to magnetic fields. See Figure 7 for more details.

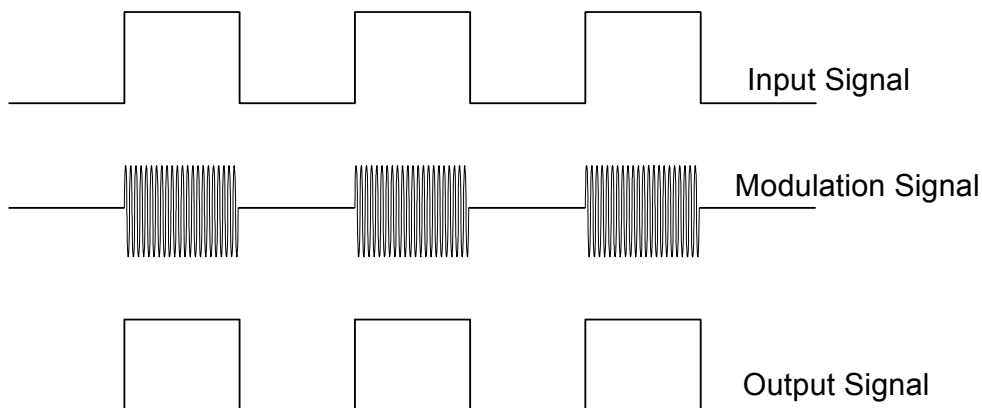


Figure 7. Modulation Scheme

2.2. Eye Diagram

Figure 8 illustrates an eye-diagram taken on an Si8650. For the data source, the test used an Anritsu (MP1763C) Pulse Pattern Generator set to 1000 ns/div. The output of the generator's clock and data from an Si8650 were captured on an oscilloscope. The results illustrate that data integrity was maintained even at the high data rate of 150 Mbps. The results also show that 2 ns pulse width distortion and 350 ps peak jitter were exhibited.

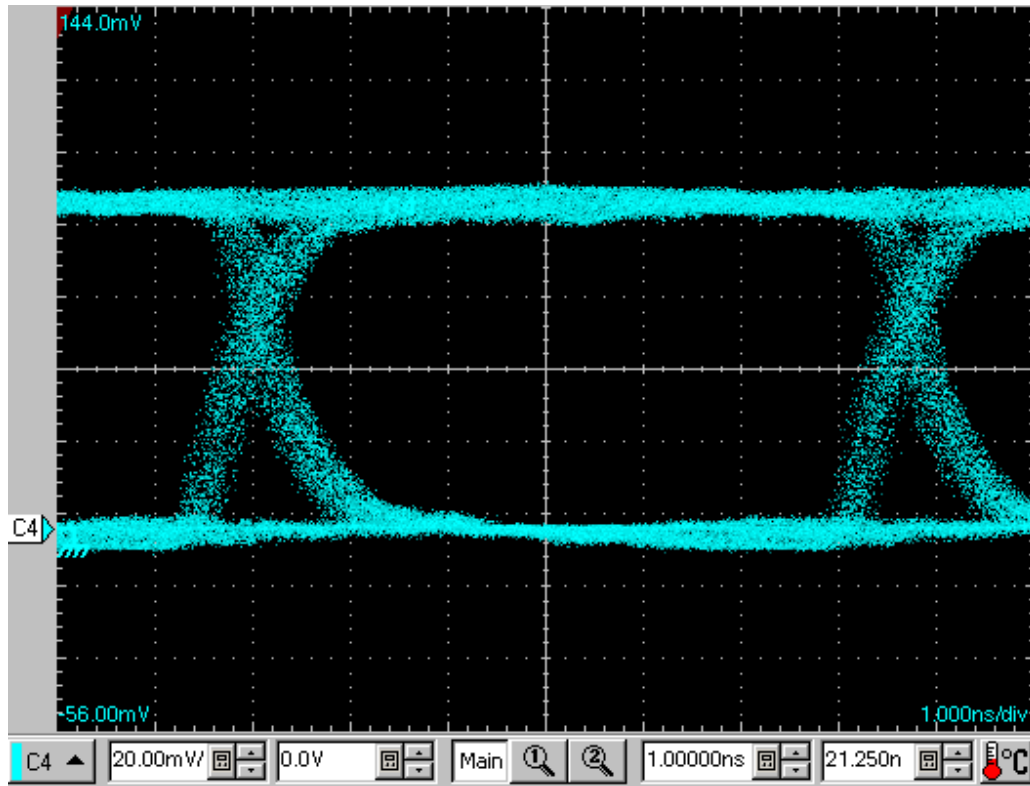


Figure 8. Eye Diagram

3. Device Operation

Device behavior during start-up, normal operation, and shutdown is shown in Figure 9, where UVLO+ and UVLO- are the positive-going and negative-going thresholds respectively. Refer to Table 12 to determine outputs when power supply (VDD) is not present. Additionally, refer to Table 13 for logic conditions when enable pins are used.

Table 12. Si865x Logic Operation

| V _I Input ^{1,2} | EN Input ^{1,2,3,4} | VDDI State ^{1,5,6} | VDDO State ^{1,5,6} | V _O Output ^{1,2} | Comments |
|--|--------------------------------|--------------------------------|--------------------------------|--------------------------------------|--|
| H | H or NC | P | P | H | Enabled, normal operation. |
| L | H or NC | P | P | L | |
| X ⁷ | L | P | P | Hi-Z ⁸ | Disabled. |
| X ⁷ | H or NC | UP | P | L ⁹ H ⁹ | Upon transition of VDDI from unpowered to powered, V _O returns to the same state as V _I in less than 1 μs. |
| X ⁷ | L | UP | P | Hi-Z ⁸ | Disabled. |
| X ⁷ | X ⁷ | P | UP | Undetermined | Upon transition of VDDO from unpowered to powered, V _O returns to the same state as V _I within 1 μs, if EN is in either the H or NC state. Upon transition of VDDO from unpowered to powered, V _O returns to Hi-Z within 1 μs if EN is L. |

Notes:

- VDDI and VDDO are the input and output power supplies. V_I and V_O are the respective input and output terminals. EN is the enable control input located on the same output side.
- X = not applicable; H = Logic High; L = Logic Low; Hi-Z = High Impedance.
- It is recommended that the enable inputs be connected to an external logic high or low level when the Si865x is operating in noisy environments.
- No Connect (NC) replaces EN1 on Si8650. No Connects are not internally connected and can be left floating, tied to VDD, or tied to GND.
- “Powered” state (P) is defined as 2.5 V < VDD < 5.5 V.
- “Unpowered” state (UP) is defined as VDD = 0 V.
- Note that an I/O can power the die for a given side through an internal diode if its source has adequate current.
- When using the enable pin (EN) function, the output pin state is driven into a high-impedance state when the EN pin is disabled (EN = 0).
- See “6. Ordering Guide” on page 30 for details. This is the selectable fail-safe operating mode (ordering option). Some devices have default output state = H, and some have default output state = L, depending on the ordering part number (OPN). For default high devices, the data channels have pull-ups on inputs/outputs. For default low devices, the data channels have pull-downs on inputs/outputs.

Table 13. Enable Input Truth¹

| P/N | EN1 ^{1,2} | EN2 ^{1,2} | Operation |
|--------|--------------------|--------------------|--|
| Si8650 | — | H | Outputs B1, B2, B3, B4, B5 are enabled and follow input state. |
| | — | L | Outputs B1, B2, B3, B4, B5 are disabled and Logic Low or in high impedance state. ³ |
| Si8651 | H | X | Output A5 enabled and follow input state. |
| | L | X | Output A5 disabled and in high impedance state. ³ |
| | X | H | Outputs B1, B2, B3, B4 are enabled and follow input state. |
| | X | L | Outputs B1, B2, B3, B4 are disabled and in high impedance state. ³ |
| Si8652 | H | X | Outputs A4 and A5 are enabled and follow input state. |
| | L | X | Outputs A4 and A5 are disabled and in high impedance state. ³ |
| | X | H | Outputs B1, B2, B3 are enabled and follow input state. |
| | X | L | Outputs B1, B2, B3 are disabled and in high impedance state. ³ |
| Si8655 | — | — | Outputs B1, B2, B3, B4, B5 are enabled and follow input state. |

Notes:

1. Enable inputs EN1 and EN2 can be used for multiplexing, for clock sync, or other output control. These inputs are internally pulled-up to local VDD by a 2 μ A current source allowing them to be connected to an external logic level (high or low) or left floating. To minimize noise coupling, do not connect circuit traces to EN1 or EN2 if they are left floating. If EN1, EN2 are unused, it is recommended they be connected to an external logic level, especially if the Si865x is operating in a noisy environment.
2. X = not applicable; H = Logic High; L = Logic Low.
3. When using the enable pin (EN) function, the output pin state is driven into a high-impedance state when the EN pin is disabled (EN = 0).

3.1. Device Startup

Outputs are held low during powerup until VDD is above the UVLO threshold for time period t_{START} . Following this, the outputs follow the states of inputs.

3.2. Undervoltage Lockout

Undervoltage Lockout (UVLO) is provided to prevent erroneous operation during device startup and shutdown or when VDD is below its specified operating circuits range. Both Side A and Side B each have their own undervoltage lockout monitors. Each side can enter or exit UVLO independently. For example, Side A unconditionally enters UVLO when V_{DD1} falls below $V_{DD1(UVLO-)}$ and exits UVLO when V_{DD1} rises above $V_{DD1(UVLO+)}$. Side B operates the same as Side A with respect to its V_{DD2} supply.

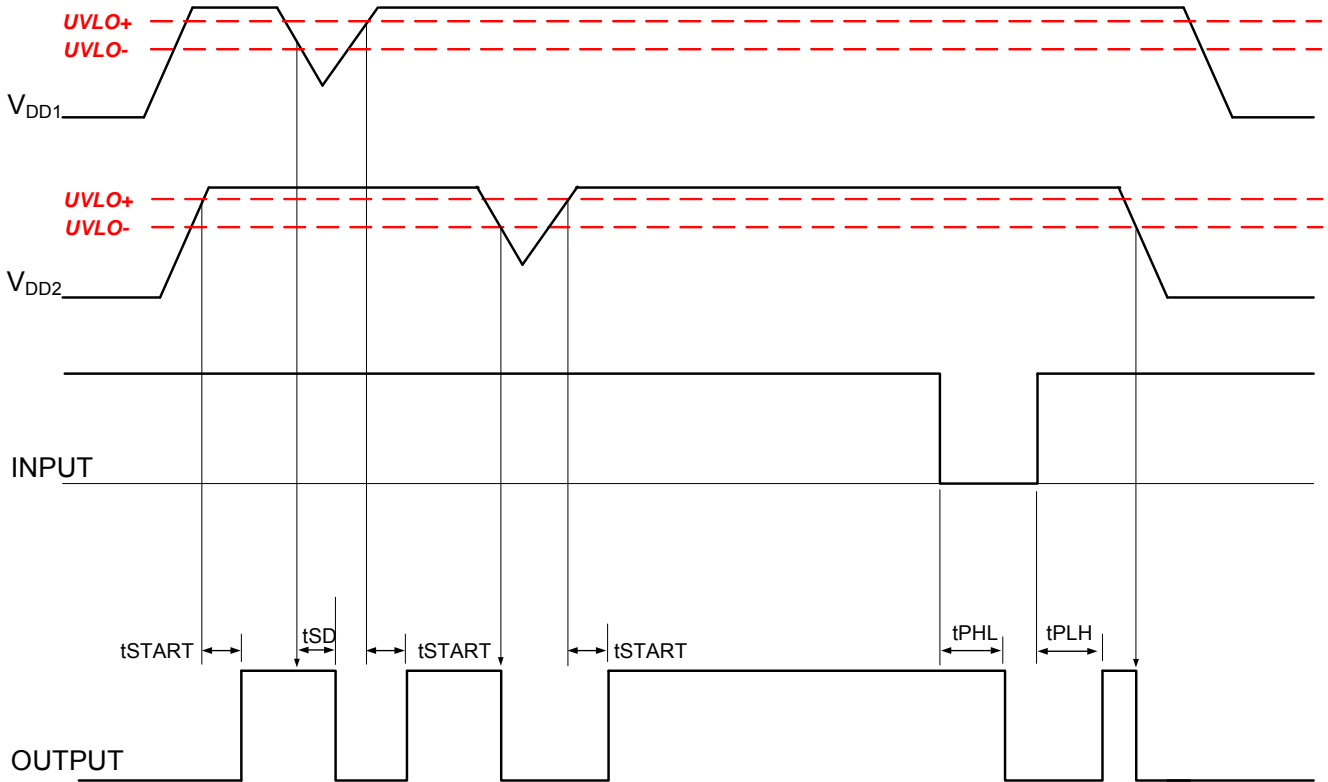


Figure 9. Device Behavior during Normal Operation

3.3. Layout Recommendations

To ensure safety in the end user application, high voltage circuits (i.e., circuits with $>30 V_{AC}$) must be physically separated from the safety extra-low voltage circuits (SELV is a circuit with $<30 V_{AC}$) by a certain distance (creepage/clearance). If a component, such as a digital isolator, straddles this isolation barrier, it must meet those creepage/clearance requirements and also provide a sufficiently large high-voltage breakdown protection rating (commonly referred to as working voltage protection). Table 5 on page 15 and Table 6 on page 16 detail the working voltage and creepage/clearance capabilities of the Si86xx. These tables also detail the component standards (UL1577, IEC60747, CSA 5A), which are readily accepted by certification bodies to provide proof for end-system specifications requirements. Refer to the end-system specification (61010-1, 60950-1, 60601-1, etc.) requirements before starting any design that uses a digital isolator.

3.3.1. Supply Bypass

The Si865x family requires a $0.1 \mu F$ bypass capacitor between V_{DD1} and GND1 and V_{DD2} and GND2. The capacitor should be placed as close as possible to the package. To enhance the robustness of a design, the user may also include resistors ($50\text{--}300 \Omega$) in series with the inputs and outputs if the system is excessively noisy.

3.3.2. Output Pin Termination

The nominal output impedance of an isolator driver channel is approximately 50Ω , $\pm 40\%$, which is a combination of the value of the on-chip series termination resistor and channel resistance of the output driver FET. When driving loads where transmission line effects will be a factor, output pins should be appropriately terminated with controlled impedance PCB traces.

3.4. Fail-Safe Operating Mode

Si86xx devices feature a selectable (by ordering option) mode whereby the default output state (when the input supply is unpowered) can either be a logic high or logic low when the output supply is powered. See Table 12 on page 22 and "6. Ordering Guide" on page 30 for more information.

Si8650/51/52/55

3.5. Typical Performance Characteristics

The typical performance characteristics depicted in the following diagrams are for information purposes only. Refer to Tables 2, 3, and 4 for actual specification limits.

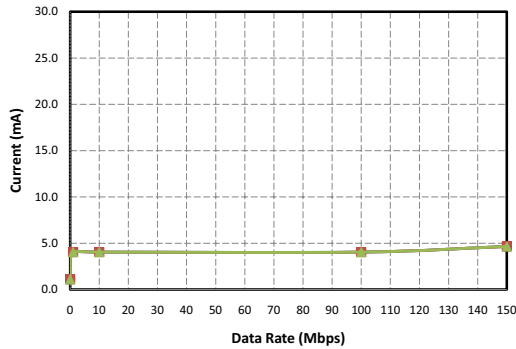


Figure 10. Si8650/55 Typical V_{DD1} Supply Current vs. Data Rate 5, 3.3, and 2.5 V Operation

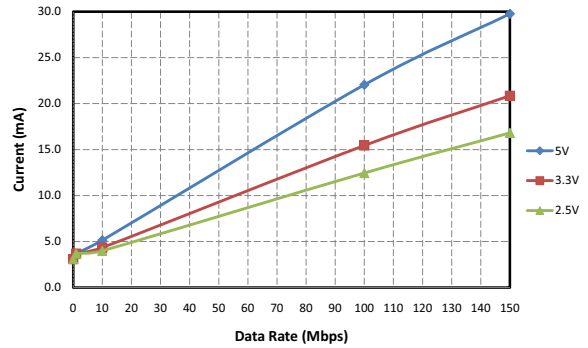


Figure 13. Si8650/55 Typical V_{DD2} Supply Current vs. Data Rate 5, 3.3, and 2.5 V Operation (15 pF Load)

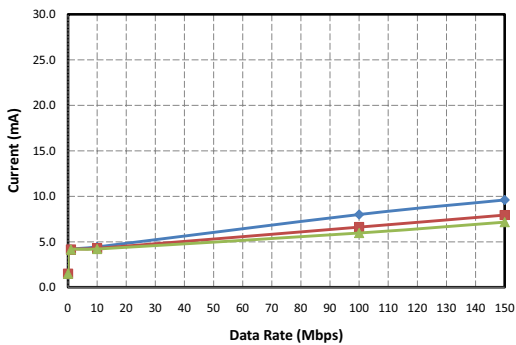


Figure 11. Si8651 Typical V_{DD1} Supply Current vs. Data Rate 5, 3.3, and 2.5 V Operation (15 pF Load)

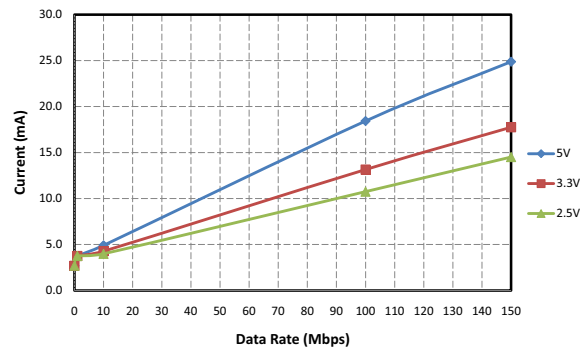


Figure 14. Si8651 Typical V_{DD2} Supply Current vs. Data Rate 5, 3.3, and 2.5 V Operation (15 pF Load)

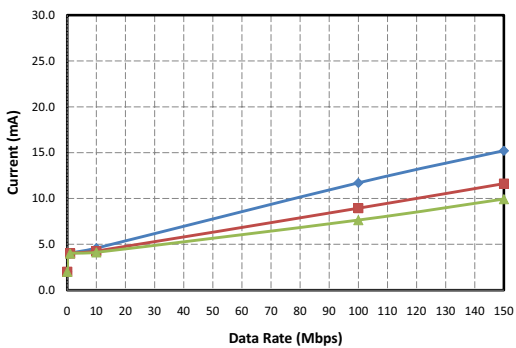


Figure 12. Si8652 Typical V_{DD1} Supply Current vs. Data Rate 5, 3.3, and 2.5 V Operation (15 pF Load)

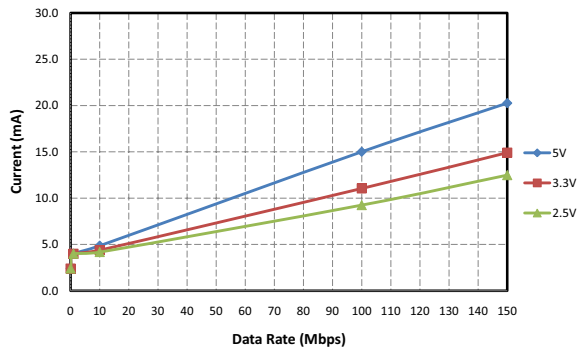


Figure 15. Si8652 Typical V_{DD2} Supply Current vs. Data Rate 5, 3.3, and 2.5 V Operation (15 pF Load)

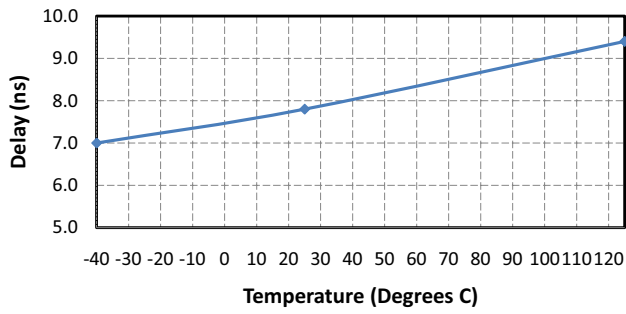
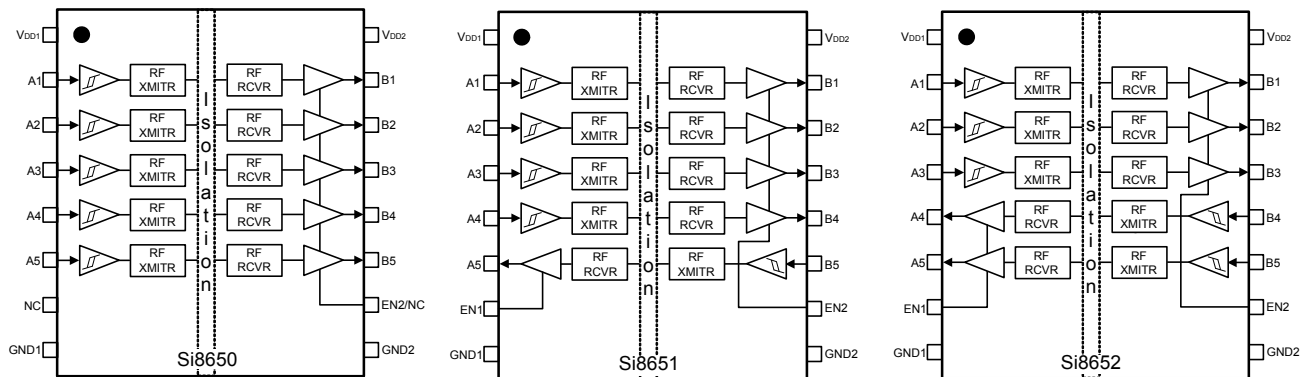


Figure 16. Propagation Delay vs. Temperature

Si8650/51/52/55

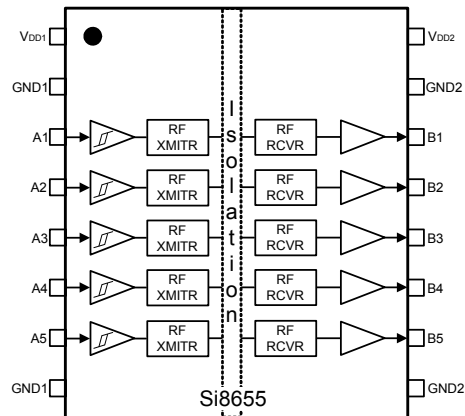
4. Pin Descriptions (Si8650/51/52)



| Name | SOIC-16 Pin# | Type | Description |
|------------------|--------------|----------------|--|
| V _{DD1} | 1 | Supply | Side 1 power supply. |
| A1 | 2 | Digital Input | Side 1 digital input. |
| A2 | 3 | Digital Input | Side 1 digital input. |
| A3 | 4 | Digital Input | Side 1 digital input. |
| A4 | 5 | Digital I/O | Side 1 digital input or output. |
| A5 | 6 | Digital I/O | Side 1 digital input or output. |
| EN1/NC* | 7 | Digital Input | Side 1 active high enable. NC on Si8650. |
| GND1 | 8 | Ground | Side 1 ground. |
| GND2 | 9 | Ground | Side 2 ground. |
| EN2 | 10 | Digital Input | Side 2 active high enable. |
| B5 | 11 | Digital I/O | Side 2 digital input or output. |
| B4 | 12 | Digital I/O | Side 2 digital input or output. |
| B3 | 13 | Digital Output | Side 2 digital output. |
| B2 | 14 | Digital Output | Side 2 digital output. |
| B1 | 15 | Digital Output | Side 2 digital output. |
| V _{DD2} | 16 | Supply | Side 2 power supply. |

***Note:** No Connect. These pins are not internally connected. They can be left floating, tied to V_{DD} or tied to GND.

5. Pin Descriptions (Si8655)



| Name | SOIC-16 Pin# | Type | Description |
|------------------|--------------|----------------|------------------------|
| V _{DD1} | 1 | Supply | Side 1 power supply. |
| GND1 | 2* | Ground | Side 1 ground. |
| A1 | 3 | Digital Input | Side 1 digital input. |
| A2 | 4 | Digital Input | Side 1 digital input. |
| A3 | 5 | Digital Input | Side 1 digital input. |
| A4 | 6 | Digital Input | Side 1 digital input. |
| A5 | 7 | Digital Input | Side 1 digital input. |
| GND1 | 8* | Ground | Side 1 ground. |
| GND2 | 9* | Ground | Side 2 ground. |
| B5 | 10 | Digital Output | Side 2 digital output. |
| B4 | 11 | Digital Output | Side 2 digital output. |
| B3 | 12 | Digital Output | Side 2 digital output. |
| B2 | 13 | Digital Output | Side 2 digital output. |
| B1 | 14 | Digital Output | Side 2 digital output. |
| GND2 | 15* | Ground | Side 2 ground. |
| V _{DD2} | 16 | Supply | Side 2 power supply. |

***Note:** For narrow-body devices, Pin 2 and Pin 8 GND must be externally connected to respective ground. Pin 9 and Pin 15 must also be connected to external ground.

6. Ordering Guide

Table 14. Ordering Guide for Valid OPNs^{1,2}

| Ordering Part Number (OPN) | Number of Inputs VDD1 Side | Number of Inputs VDD2 Side | Max Data Rate (Mbps) | Default Output State | Isolation rating (kV) | Temp (°C) | Package |
|----------------------------|----------------------------|----------------------------|----------------------|----------------------|-----------------------|---------------|------------|
| Si8650BB-B-IS1 | 5 | 0 | 150 | Low | 2.5 | -40 to 125 °C | NB SOIC-16 |
| Si8650EC-B-IS1 | 5 | 0 | 150 | High | 3.75 | -40 to 125 °C | NB SOIC-16 |
| Si8650BD-B-IS | 5 | 0 | 150 | Low | 5.0 | -40 to 125 °C | WB SOIC-16 |
| Si8650ED-B-IS | 5 | 0 | 150 | High | 5.0 | -40 to 125 °C | WB SOIC-16 |
| Si8651BB-B-IS1 | 4 | 1 | 150 | Low | 2.5 | -40 to 125 °C | NB SOIC-16 |
| Si8651BC-B-IS1 | 4 | 1 | 150 | Low | 3.75 | -40 to 125 °C | NB SOIC-16 |
| Si8651EC-B-IS1 | 4 | 1 | 150 | High | 3.75 | -40 to 125 °C | NB SOIC-16 |
| Si8651BD-B-IS | 4 | 1 | 150 | Low | 5.0 | -40 to 125 °C | WB SOIC-16 |
| Si8651ED-B-IS | 4 | 1 | 150 | High | 5.0 | -40 to 125 °C | WB SOIC-16 |
| Si8652BB-B-IS1 | 3 | 2 | 150 | Low | 2.5 | -40 to 125 °C | NB SOIC-16 |
| Si8652BC-B-IS1 | 3 | 2 | 150 | Low | 3.75 | -40 to 125 °C | NB SOIC-16 |
| Si8652EC-B-IS1 | 3 | 2 | 150 | High | 3.75 | -40 to 125 °C | NB SOIC-16 |
| Si8652BD-B-IS | 3 | 2 | 150 | Low | 5.0 | -40 to 125 °C | WB SOIC-16 |
| Si8652ED-B-IS | 3 | 2 | 150 | High | 5.0 | -40 to 125 °C | WB SOIC-16 |
| Si8655BA-B-IU | 5 | 0 | 150 | Low | 1.0 | -40 to 125 °C | QSOP-16 |
| Si8655BA-C-IU | 5 | 0 | 150 | Low | 1.0 | -40 to 125 °C | QSOP-16 |
| Si8655BA-B-IS | 5 | 0 | 150 | Low | 1.0 | -40 to 125 °C | WB SOIC-16 |
| Si8655BB-B-IS1 | 5 | 0 | 150 | Low | 2.5 | -40 to 125 °C | NB SOIC-16 |
| Si8655BD-B-IS | 5 | 0 | 150 | Low | 5.0 | -40 to 125 °C | WB SOIC-16 |

Notes:

1. All packages are RoHS-compliant with peak reflow temperatures of 260 °C according to the JEDEC industry standard classifications and peak solder temperatures.
2. "Si" and "SI" are used interchangeably.

7. Package Outline: 16-Pin Wide Body SOIC

Figure 17 illustrates the package details for the Si865x Digital Isolator. Table 15 lists the values for the dimensions shown in the illustration.

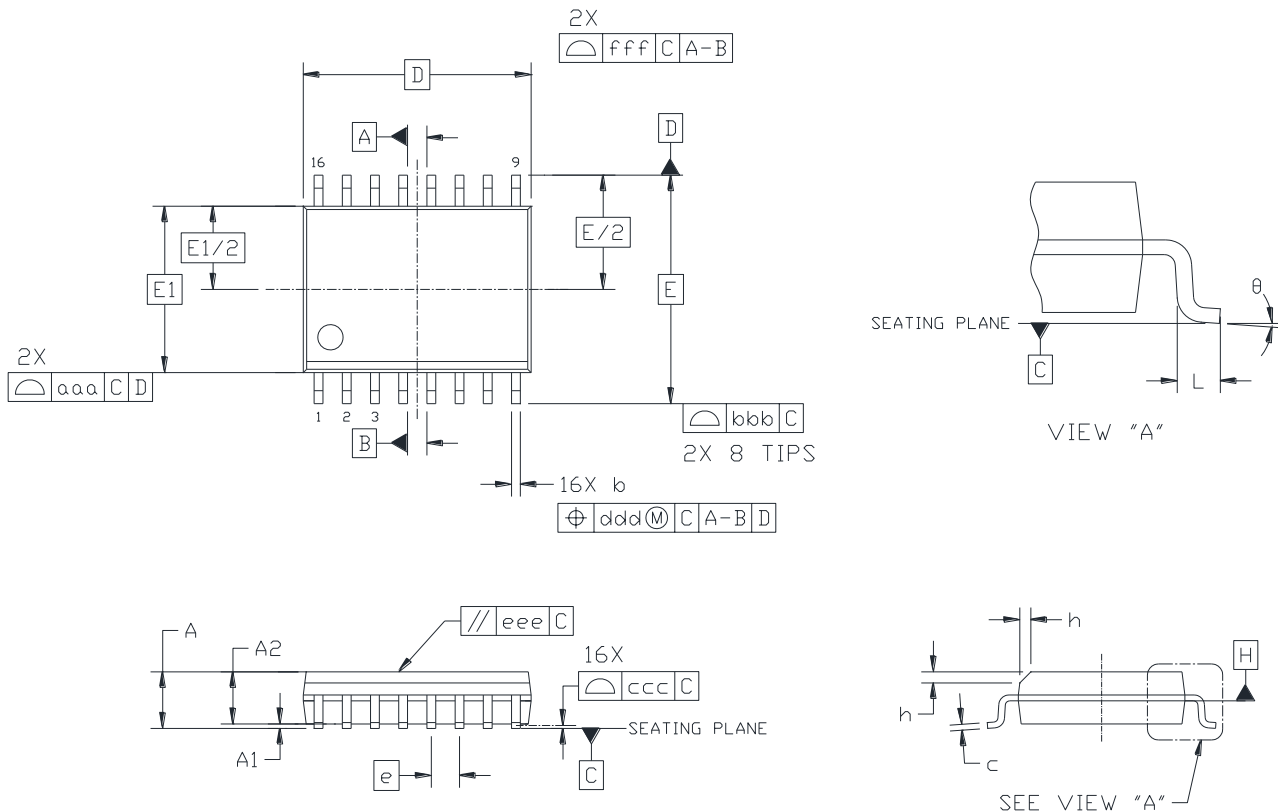


Figure 17. 16-Pin Wide Body SOIC

Table 15. Package Diagram Dimensions

| Dimension | Min | Max |
|---|-----------|------|
| A | — | 2.65 |
| A1 | 0.10 | 0.30 |
| A2 | 2.05 | — |
| b | 0.31 | 0.51 |
| c | 0.20 | 0.33 |
| D | 10.30 BSC | |
| E | 10.30 BSC | |
| E1 | 7.50 BSC | |
| e | 1.27 BSC | |
| L | 0.40 | 1.27 |
| h | 0.25 | 0.75 |
| θ | 0° | 8° |
| aaa | — | 0.10 |
| bbb | — | 0.33 |
| ccc | — | 0.10 |
| ddd | — | 0.25 |
| eee | — | 0.10 |
| fff | — | 0.20 |
| Notes: | | |
| <ol style="list-style-type: none"> 1. All dimensions shown are in millimeters (mm) unless otherwise noted. 2. Dimensioning and Tolerancing per ANSI Y14.5M-1994. 3. This drawing conforms to JEDEC Outline MS-013, Variation AA. 4. Recommended reflow profile per JEDEC J-STD-020C specification for small body, lead-free components. | | |

8. Land Pattern: 16-Pin Wide-Body SOIC

Figure 18 illustrates the recommended land pattern details for the Si865x in a 16-pin wide-body SOIC. Table 16 lists the values for the dimensions shown in the illustration.

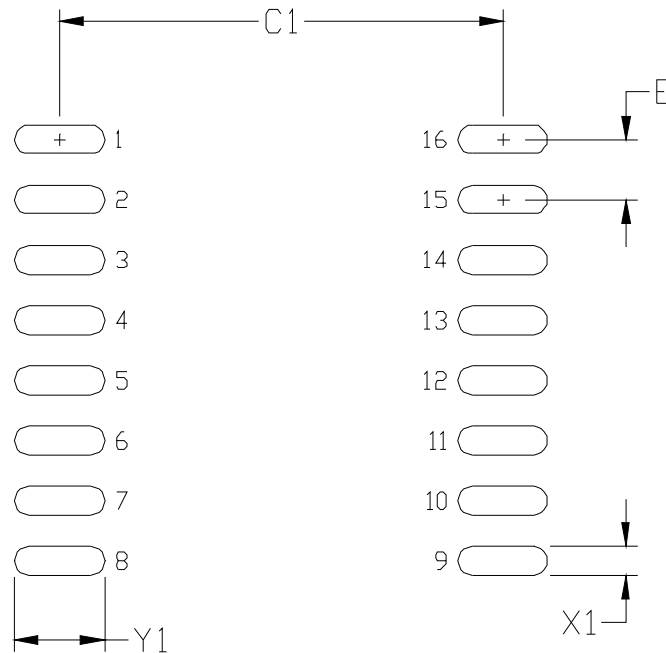


Figure 18. 16-Pin SOIC Land Pattern

Table 16. 16-Pin Wide Body SOIC Land Pattern Dimensions

| Dimension | Feature | (mm) |
|-----------|--------------------|------|
| C1 | Pad Column Spacing | 9.40 |
| E | Pad Row Pitch | 1.27 |
| X1 | Pad Width | 0.60 |
| Y1 | Pad Length | 1.90 |

Notes:

1. This Land Pattern Design is based on IPC-7351 pattern SOIC127P1032X265-16AN for Density Level B (Median Land Protrusion).
2. All feature sizes shown are at Maximum Material Condition (MMC) and a card fabrication tolerance of 0.05 mm is assumed.

9. Package Outline: 16-Pin Narrow Body SOIC

Figure 19 illustrates the package details for the Si865x in a 16-pin narrow-body SOIC (SO-16). Table 17 lists the values for the dimensions shown in the illustration.

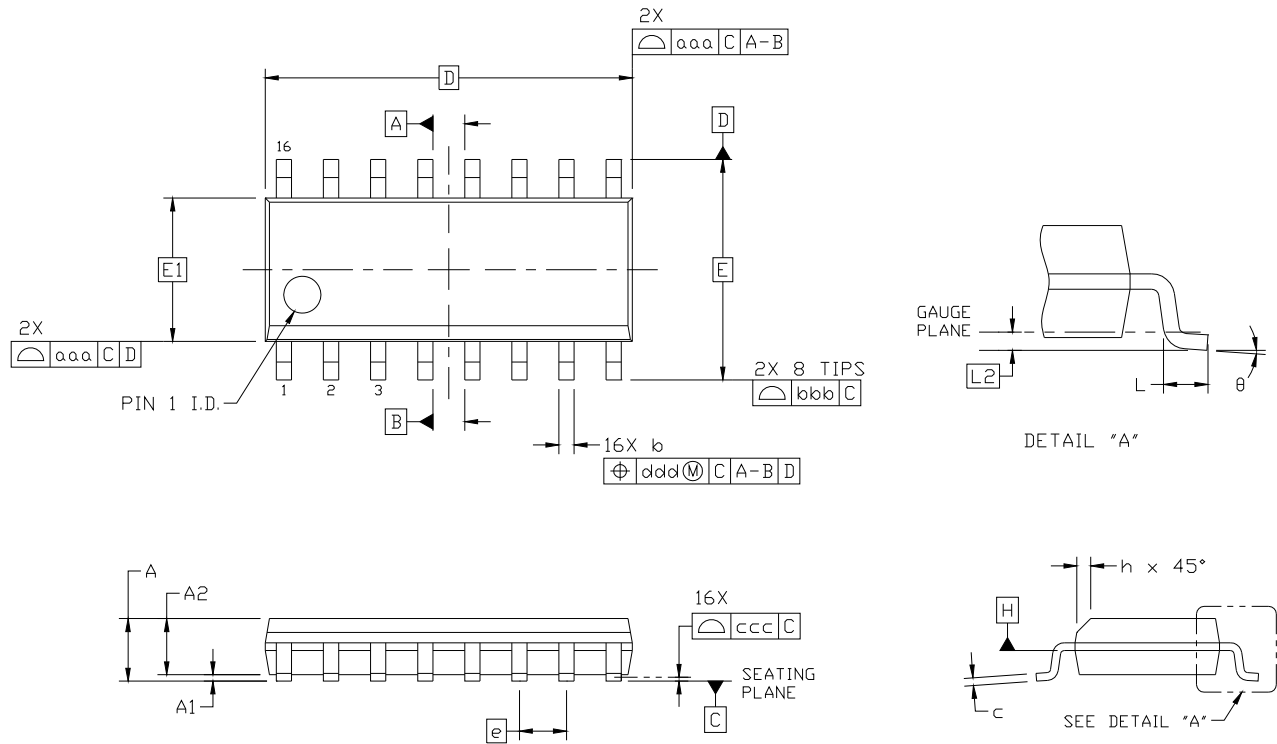


Figure 19. 16-pin Small Outline Integrated Circuit (SOIC) Package

Table 17. Package Diagram Dimensions

| Dimension | Min | Max |
|---|----------|------|
| A | — | 1.75 |
| A1 | 0.10 | 0.25 |
| A2 | 1.25 | — |
| b | 0.31 | 0.51 |
| c | 0.17 | 0.25 |
| D | 9.90 BSC | |
| E | 6.00 BSC | |
| E1 | 3.90 BSC | |
| e | 1.27 BSC | |
| L | 0.40 | 1.27 |
| L2 | 0.25 BSC | |
| h | 0.25 | 0.50 |
| θ | 0° | 8° |
| aaa | 0.10 | |
| bbb | 0.20 | |
| ccc | 0.10 | |
| ddd | 0.25 | |
| Notes: | | |
| <ol style="list-style-type: none"> 1. All dimensions shown are in millimeters (mm) unless otherwise noted. 2. Dimensioning and Tolerancing per ANSI Y14.5M-1994. 3. This drawing conforms to the JEDEC Solid State Outline MS-012, Variation AC. 4. Recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components. | | |

10. Land Pattern: 16-Pin Narrow Body SOIC

Figure 20 illustrates the recommended land pattern details for the Si865x in a 16-pin narrow-body SOIC. Table 18 lists the values for the dimensions shown in the illustration.

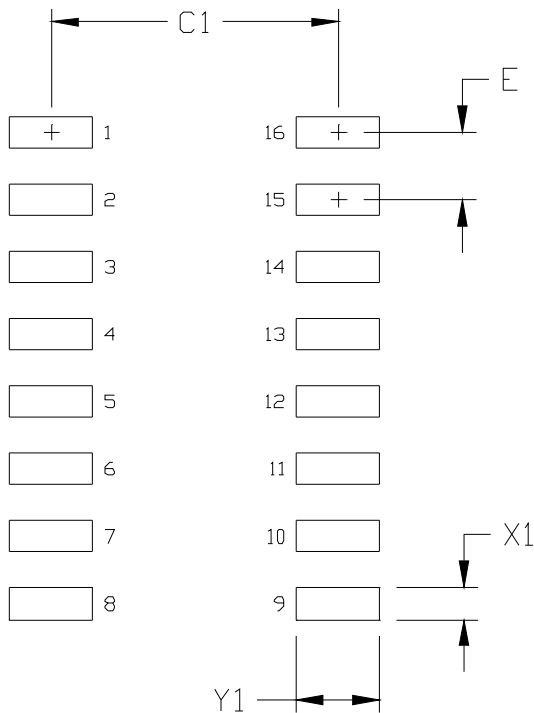


Figure 20. 16-Pin Narrow Body SOIC PCB Land Pattern

Table 18. 16-Pin Narrow Body SOIC Land Pattern Dimensions

| Dimension | Feature | (mm) |
|-----------|--------------------|------|
| C1 | Pad Column Spacing | 5.40 |
| E | Pad Row Pitch | 1.27 |
| X1 | Pad Width | 0.60 |
| Y1 | Pad Length | 1.55 |

Notes:

1. This Land Pattern Design is based on IPC-7351 pattern SOIC127P600X165-16N for Density Level B (Median Land Protrusion).
2. All feature sizes shown are at Maximum Material Condition (MMC) and a card fabrication tolerance of 0.05 mm is assumed.

11. Package Outline: 16-Pin QSOP

Figure 21 illustrates the package details for the Si865x in a 16-pin QSOP package. Table 19 lists the values for the dimensions shown in the illustration.

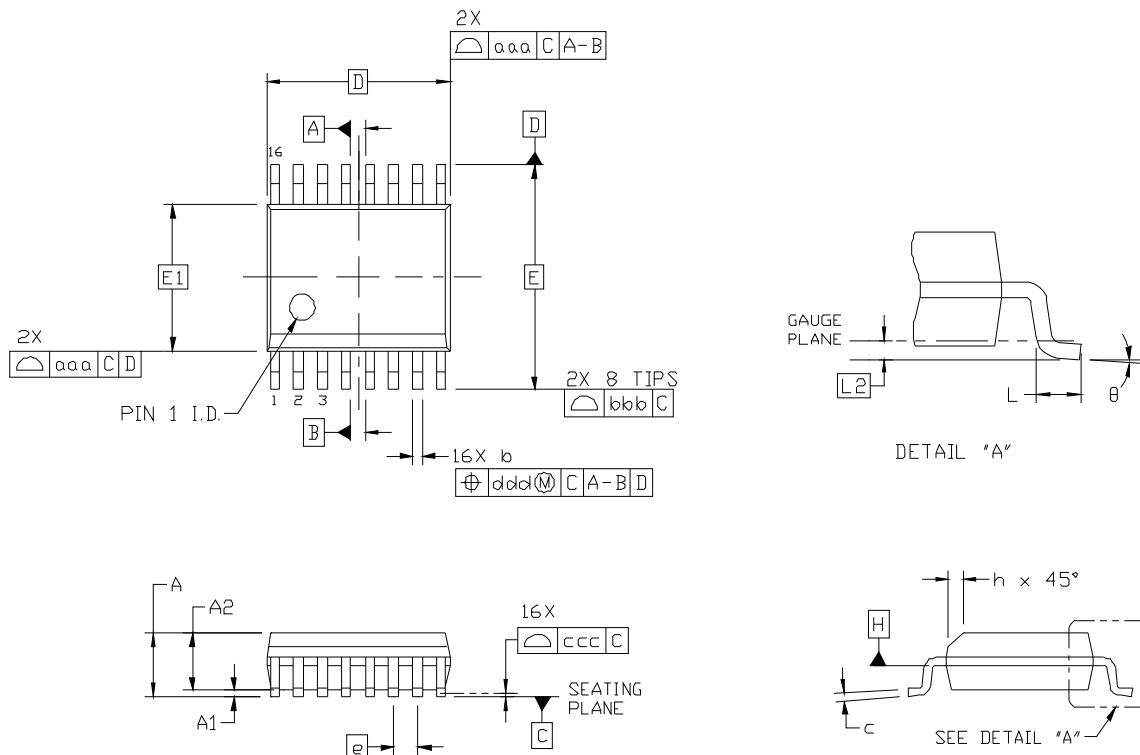


Figure 21. 16-pin QSOP Package

Table 19. Package Diagram Dimensions

| Dimension | Min | Max |
|---|-----------|------|
| A | — | 1.75 |
| A1 | 0.10 | 0.25 |
| A2 | 1.25 | — |
| b | 0.20 | 0.30 |
| c | 0.17 | 0.25 |
| D | 4.89 BSC | |
| E | 6.00 BSC | |
| E1 | 3.90 BSC | |
| e | 0.635 BSC | |
| L | 0.40 | 1.27 |
| L2 | 0.25 BSC | |
| h | 0.25 | 0.50 |
| θ | 0° | 8° |
| aaa | 0.10 | |
| bbb | 0.20 | |
| ccc | 0.10 | |
| ddd | 0.25 | |
| Notes: | | |
| <ol style="list-style-type: none"> 1. All dimensions shown are in millimeters (mm) unless otherwise noted. 2. Dimensioning and Tolerancing per ANSI Y14.5M-1994. 3. This drawing conforms to the JEDEC Solid State Outline MO-137, Variation AB. 4. Recommended card reflow profile is per the JEDEC/IPC J-STD-020 specification for Small Body Components. | | |

12. Land Pattern: 16-Pin QSOP

Figure 22 illustrates the recommended land pattern details for the Si865x in a 16-pin narrow-body SOIC. Table 20 lists the values for the dimensions shown in the illustration.

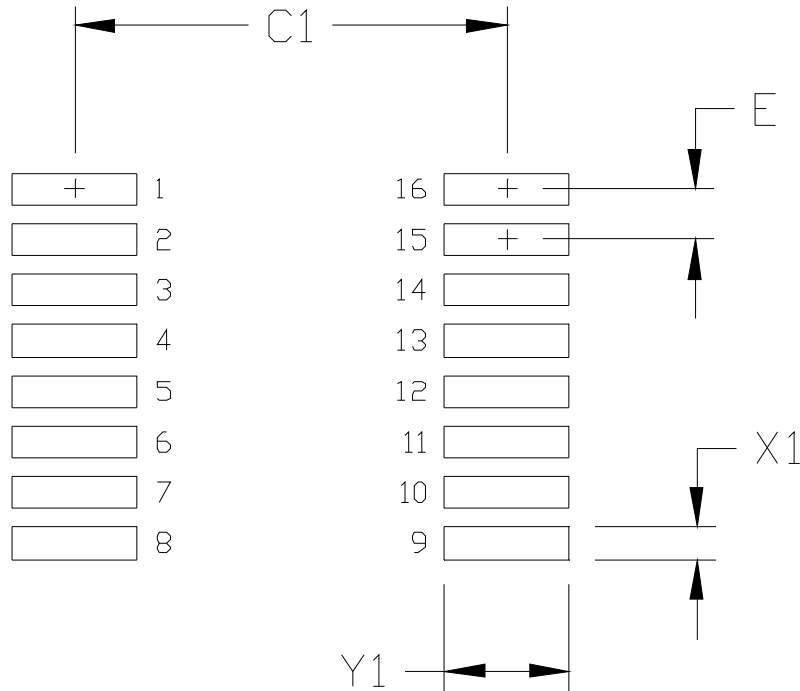


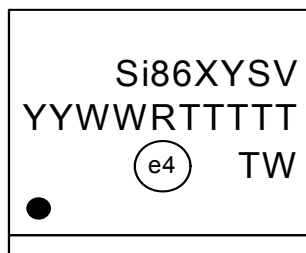
Figure 22. 16-Pin QSOP PCB Land Pattern

Table 20. 16-Pin QSOP Land Pattern Dimensions

| Dimension | Feature | (mm) |
|--|--------------------|-------|
| C1 | Pad Column Spacing | 5.40 |
| E | Pad Row Pitch | 0.635 |
| X1 | Pad Width | 0.40 |
| Y1 | Pad Length | 1.55 |
| Notes: | | |
| <ol style="list-style-type: none"> 1. This Land Pattern Design is based on IPC-7351 pattern SOP63P602X173-16N for Density Level B (Median Land Protrusion). 2. All feature sizes shown are at Maximum Material Condition (MMC) and a card fabrication tolerance of 0.05 mm is assumed. | | |

13. Top Markings

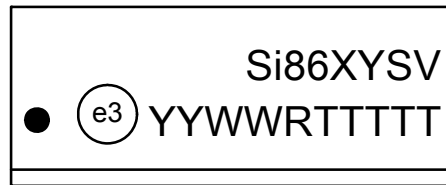
13.1. Top Marking (16-Pin Wide Body SOIC)



13.2. Top Marking Explanation (16-Pin Wide Body SOIC)

| | | |
|--|--|---|
| Line 1 Marking: | Base Part Number Ordering Options (See Ordering Guide for more information). | Si86 = Isolator product series XY = Channel Configuration X = # of data channels (5, 4, 3, 2, 1) Y = # of reverse channels (2, 1, 0)* S = Speed Grade (max data rate) and operating mode: A = 1 Mbps (default output = low) B = 150 Mbps (default output = low) D = 1 Mbps (default output = high) E = 150 Mbps (default output = high) V = Insulation rating A = 1 kV; B = 2.5 kV; C = 3.75 kV; D = 5.0 kV |
| | Line 2 Marking: YY = Year WW = Workweek RTTTTT = Mfg Code | Assigned by assembly subcontractor. Corresponds to the year and work week of the mold date. Manufacturing code from assembly house "R" indicates revision |
| Line 3 Marking: | Circle = 1.7 mm Diameter (Center-Justified) | "e4" Pb-free symbol |
| | Country of Origin ISO Code Abbreviation | TW = Taiwan |
| *Note: Si8655 has 0 reverse channels. | | |

13.3. Top Marking (16-Pin Narrow Body SOIC)

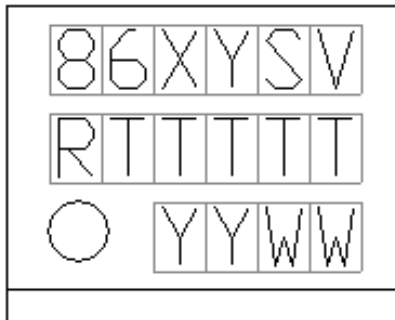


13.4. Top Marking Explanation (16-Pin Narrow Body SOIC)

| | | |
|---------------------------------------|--|---|
| Line 1 Marking: | Base Part Number Ordering Options (See Ordering Guide for more information). | Si86 = Isolator product series XY = Channel Configuration X = # of data channels (5, 4, 3, 2, 1) Y = # of reverse channels (2, 1, 0)* S = Speed Grade (max data rate) and operating mode: A = 1 Mbps (default output = low) B = 150 Mbps (default output = low) D = 1 Mbps (default output = high) E = 150 Mbps (default output = high) V = Insulation rating A = 1 kV; B = 2.5 kV; C = 3.75 kV |
| | Line 2 Marking: | Circle = 1.2 mm Diameter YY = Year WW = Work Week RTTTTT = Mfg Code |
| | | "e3" Pb-Free Symbol Assigned by the assembly subcontractor. Corresponds to the year and work week of the mold date. Manufacturing code from assembly house "R" indicates revision |
| *Note: Si8655 has 0 reverse channels. | | |

Si8650/51/52/55

13.5. Top Marking (16-Pin QSOP)



13.6. Top Marking Explanation (16-Pin QSOP)

| | | |
|--|--|---|
| Line 1 Marking: | Base Part Number Ordering Options (See Ordering Guide for more information). | 86 = Isolator product series XY = Channel Configuration X = # of data channels (5, 4, 3, 2, 1) Y = # of reverse channels (2, 1, 0)* S = Speed Grade (max data rate) and operating mode: A = 1 Mbps (default output = low) B = 150 Mbps (default output = low) D = 1 Mbps (default output = high) E = 150 Mbps (default output = high) V = Insulation rating A = 1 kV; B = 2.5 kV; C = 3.75 kV |
| Line 2 Marking: | RTTTTT = Mfg Code | Manufacturing code from assembly house "R" indicates revision |
| Line 3 Marking: | YY = Year WW = Work Week | Assigned by the Assembly House. Corresponds to the year and work week of the mold date. |
| *Note: Si8655 has 0 reverse channels. | | |

DOCUMENT CHANGE LIST

Revision 0.1 to Revision 0.2

- Deleted sections 4.3.4 and 4.3.5.
- Updated "6. Ordering Guide" on page 30.
 - Updated Table 14, "Ordering Guide for Valid OPNs^{1,2}," on page 30.
- Added "3.4. Fail-Safe Operating Mode" on page 25.

Revision 0.2 to Revision 1.0

- Added chip graphics on page 1.
- Moved Tables 1 and 11 to page 19.
- Updated Table 6, "Insulation and Safety-Related Specifications," on page 16.
- Updated Table 8, "IEC 60747-5-2 Insulation Characteristics for Si86xxxx*," on page 17.
- Moved Table 12 to page 22.
- Moved Table 13 to page 23.
- Moved "Typical Performance Characteristics" to page 26.
- Updated "4. Pin Descriptions (Si8650/51/52)" on page 28.
- Updated "5. Pin Descriptions (Si8655)" on page 29.
- Updated "6. Ordering Guide" on page 30.

Revision 1.0 to Revision 1.1

- Reordered spec tables to conform to new convention.
- Removed "pending" throughout document.

Revision 1.1 to Revision 1.2

- Updated High Level Output Voltage V_{OH} to 3.1 V in Table 3, "Electrical Characteristics," on page 9.
- Updated High Level Output Voltage V_{OH} to 2.3 V in Table 4, "Electrical Characteristics," on page 12.

Revision 1.2 to Revision 1.3

- Added Output Current Drive Channel specification for Si865xxA-x-xx devices.
- Added Latchup Immunity specification.

Revision 1.3 to Revision 1.4

- Updated Table 14, "Ordering Guide for Valid OPNs^{1,2}," on page 30.
 - Updated Note 1 with MSL2A.

Revision 1.4 to Revision 1.5

- Updated "6. Ordering Guide" on page 30 to include MSL2A.
- Updated Table 14, "Ordering Guide for Valid OPNs^{1,2}," on page 30.

Revision 1.5 to Revision 1.6

- Updated Table 11 on page 19.
 - Added junction temperature spec.
- Updated "3.3.1. Supply Bypass" on page 25.
- Removed "3.3.2. Pin Connections" on page 23.
- Updated "4. Pin Descriptions (Si8650/51/52)" on page 28.
 - Updated table notes.
- Updated "6. Ordering Guide" on page 30.
 - Removed Rev A devices.
- Updated "7. Package Outline: 16-Pin Wide Body SOIC" on page 31.
- Updated Top Marks.
 - Added revision description.

Revision 1.6 to Revision 1.7

- Added Figure 3, "Common Mode Transient Immunity Test Circuit," on page 8.
- Added references to CQC throughout.
- Added references to 2.5 kV_{RMS} devices throughout.
- Updated "6. Ordering Guide" on page 30.
- Updated "13.1. Top Marking (16-Pin Wide Body SOIC)" on page 40.
- Updated "13.5. Top Marking (16-Pin QSOP)" on page 42.

Revision 1.7 to Revision 1.8

- Updated Table 5 on page 15.
 - Added CQC certificate numbers.
- Updated "6. Ordering Guide" on page 30.
 - Removed references to moisture sensitivity levels.
 - Removed note 2.

CONTACT INFORMATION

Silicon Laboratories Inc.

400 West Cesar Chavez
Austin, TX 78701
Tel: 1+(512) 416-8500
Fax: 1+(512) 416-9669
Toll Free: 1+(877) 444-3032

Please visit the Silicon Labs Technical Support web page:
<https://www.silabs.com/support/pages/contacttechnicalsupport.aspx>
and register to submit a technical support request.

Patent Notice

Silicon Labs invests in research and development to help our customers differentiate in the market with innovative low-power, small size, analog-intensive mixed-signal solutions. Silicon Labs' extensive patent portfolio is a testament to our unique approach and world-class engineering team.

The information in this document is believed to be accurate in all respects at the time of publication but is subject to change without notice. Silicon Laboratories assumes no responsibility for errors and omissions, and disclaims responsibility for any consequences resulting from the use of information included herein. Additionally, Silicon Laboratories assumes no responsibility for the functioning of undescribed features or parameters. Silicon Laboratories reserves the right to make changes without further notice. Silicon Laboratories makes no warranty, representation or guarantee regarding the suitability of its products for any particular purpose, nor does Silicon Laboratories assume any liability arising out of the application or use of any product or circuit, and specifically disclaims any and all liability, including without limitation consequential or incidental damages. Silicon Laboratories products are not designed, intended, or authorized for use in applications intended to support or sustain life, or for any other application in which the failure of the Silicon Laboratories product could create a situation where personal injury or death may occur. Should Buyer purchase or use Silicon Laboratories products for any such unintended or unauthorized application, Buyer shall indemnify and hold Silicon Laboratories harmless against all claims and damages.

Silicon Laboratories and Silicon Labs are trademarks of Silicon Laboratories Inc.
Other products or brandnames mentioned herein are trademarks or registered trademarks of their respective holders.