# ISL3232E, ISL4221E, ISL4223E

QFN Packaged, ±15kV ESD Protected, +2.7V to +5.5V, 150nA, 250kbps, RS-232 Transmitters/Receivers

The ISL3232E, ISL4221E, and ISL4223E devices are 2.7V to 5.5V powered RS-232 transmitters/receivers that meet EIA/TIA-232 and V.28/V.24 specifications, even at $V_{CC}$ = 3.0V. They provide ±15kV ESD protection (IEC61000-4-2 Air Gap and Human Body Model) on transmitter outputs and receiver inputs (RS-232 pins). Targeted applications are PDAs, Palmtops, and hand-held products where the low operational power consumption and even lower standby power consumption are critical. Efficient on-chip charge pumps, coupled with manual and automatic powerdown functions, reduce the standby supply current to a 150nA trickle. The 5mmx5mm Quad Flat No-Lead (QFN) packaging and the use of small, low value capacitors ensure board space savings. Data rates greater than 250kbps are ensured at worst case load conditions.

The ISL4221E is a 1 driver, 1 receiver device and the ISL3232E and ISL4223E are 2 driver, 2 receiver devices that, coupled with the 5mmx5mm QFN package, provide the industry's smallest, lowest power serial port suitable for PDAs, and hand-held applications. The 5mmx5mm QFN requires 40% less board area than a 20 Ld TSSOP, and is nearly 20% thinner.

The ISL4221E and ISL4223E versions feature an automatic powerdown function that powers down the on-chip power supply and driver circuits. Automatic powerdown occurs when an attached peripheral device is shut off or the RS-232 cable is removed, and conserves system power automatically without changes to the hardware or operating system. The ISL4221E and ISL4223E power back up automatically when a valid RS-232 voltage is applied to any receiver input.

Table 1 summarizes the features of the IC's and AN9863 summarizes the features of each device comprising the 3V RS-232 family.

## Features

- Available in near chip scale QFN (5mmx5mm) package, which is 40% smaller than a 20 Ld TSSOP
- ESD protection for RS-232 I/O pins to ±15kV (IEC61000)
- Meets EIA/TIA-232 and V.28/V.24 specifications at 3V
- RS-232 compatible with $V_{CC}$ = 2.7V
- On-chip voltage converters require only four external 0.1µF capacitors
- Manual and automatic powerdown features (except ISL3232E)
- Receiver hysteresis for improved noise immunity
- Assured minimum data rate: 250kbps
- Wide power supply range: single +2.7V to +5.5V
- Low supply current in powerdown state: 150nA
- Pb-free (RoHS compliant)

## Applications

- Any space-constrained system requiring RS-232 ports
  - Battery powered and portable equipment
  - Hand-held products (GPS receivers, bar code scanners, etc.)
  - PDAs and Palmtops, data cables
  - Cellular/mobile phones, digital cameras

## Related Literature

For a full list of related documents, visit our website:

- ISL3232E, ISL4221E, and ISL4223E device pages

**Table 1. Summary of Features**

| Part Number | Number of Tx. | Number of Rx. | QFN Pkg. Available? | Data Rate (kbps) | Rx. Enable Function? | Manual Powerdown? | Automatic Powerdown Function? |
|---|---|---|---|---|---|---|---|
| ISL4221E | 1 | 1 | Yes | 250 | Yes | Yes | Yes |
| ISL3232E | 2 | 2 | Yes | 250 | No | No | No |
| ISL4223E | 2 | 2 | Yes | 250 | Yes | Yes | Yes |

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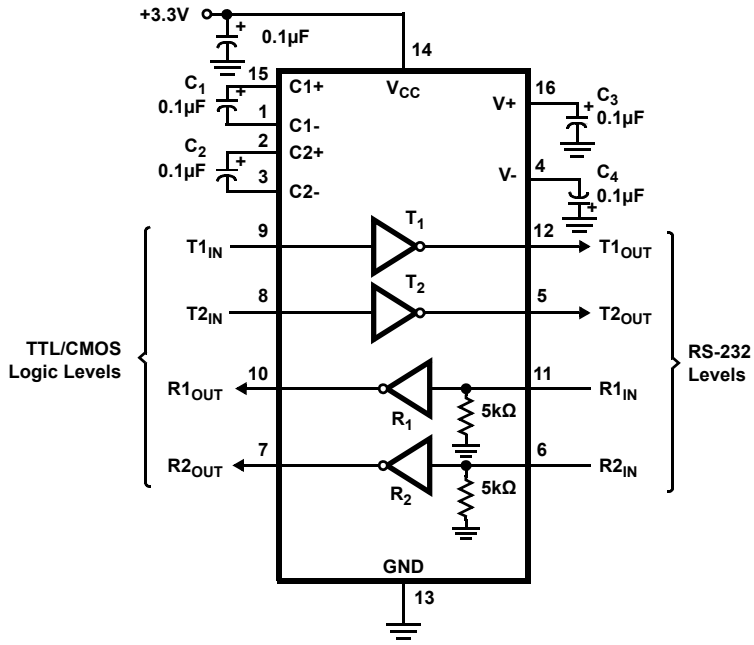
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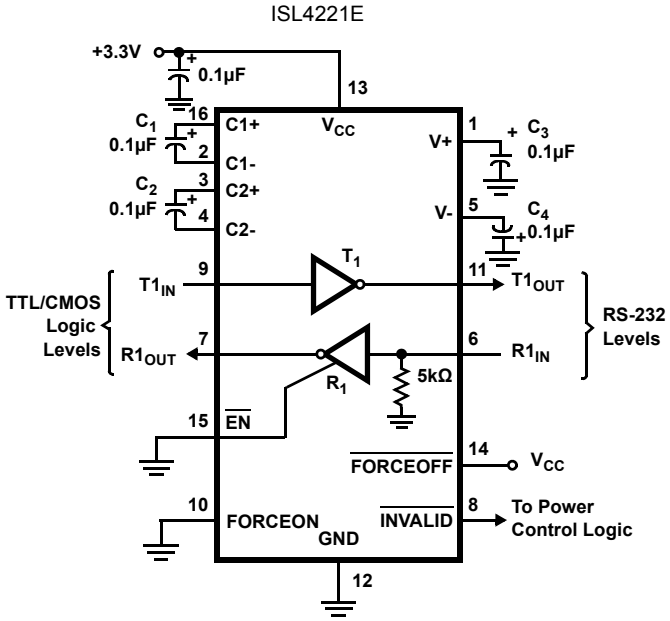
# 1. Overview

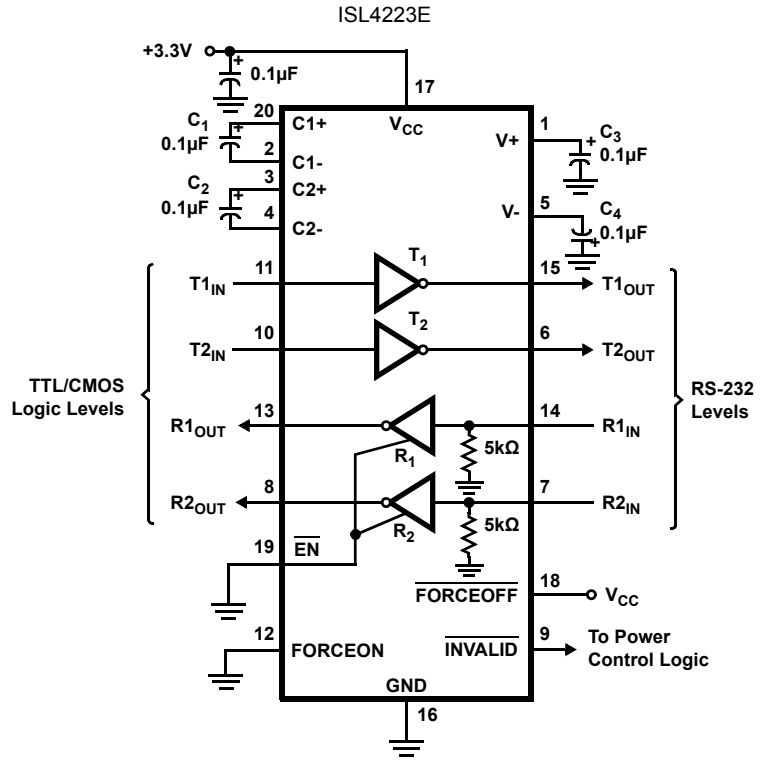
## 1.1 Typical Operating Circuits

ISL3232E




ISL4221E






## 1.2 Ordering Information

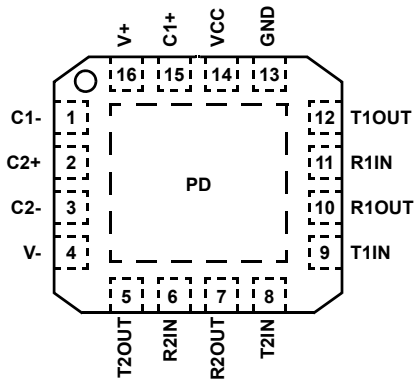
| Part Number (Notes 2, 3) | Part Marking | Temp. Range (°C) | Tape and Reel (Units) (Note 1) | Package (RoHS Compliant) | Pkg. Dwg. # |
|---|---|---|---|---|---|
| ISL3232EIRZ | ISL3232 EIRZ | -40 to +85 | - | 16 Ld QFN | L16.5x5B |
| ISL3232EIRZ-T | ISL3232 EIRZ | -40 to +85 | 6k | 16 Ld QFN | L16.5x5B |
| ISL3232EIRZ-T7A | ISL3232 EIRZ | -40 to +85 | 250 | 16 Ld QFN | L16.5x5B |
| ISL4221EIRZ | ISL4221 EIRZ | -40 to +85 | - | 16 Ld QFN | L16.5x5B |
| ISL4221EIRZ-T | ISL4221 EIRZ | -40 to +85 | 6k | 16 Ld QFN | L16.5x5B |
| ISL4223EIRZ | ISL4223 EIRZ | -40 to +85 | - | 20 Ld QFN | L20.5x5 |
| ISL4223EIRZ-T | ISL4223 EIRZ | -40 to +85 | 6k | 20 Ld QFN | L20.5x5 |
| ISL4223EIRZ-TK | ISL4223 EIRZ | -40 to +85 | 1k | 20 Ld QFN | L20.5x5 |
| ISL4223EIRZ-T7A | ISL4223 EIRZ | -40 to +85 | 250 | 20 Ld QFN | L20.5x5 |

Notes:

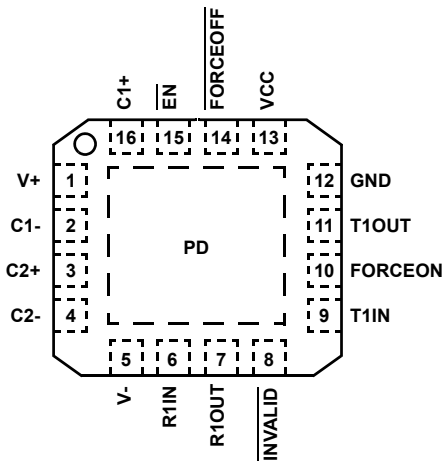
1. See TB347 for details about reel specifications.
2. These Pb-free plastic packaged products employ special Pb-free material sets, molding compounds/die attach materials, and 100% matte tin plate plus anneal (e3 termination finish, which is RoHS compliant and compatible with both SnPb and Pb-free soldering operations). Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J-STD-020.
3. For Moisture Sensitivity Level (MSL), see the ISL3232E, ISL4221E, and ISL4223E device pages. For more information about MSL, see TB363.

## 1.3 Pin Configurations

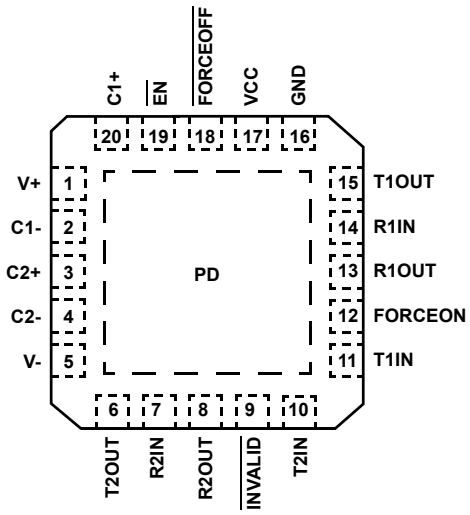
ISL3232E
(16 Ld QFN)
Top View




ISL4221E
(16 Ld QFN)
Top View




ISL4223E
(20 Ld QFN)
Top View



## 1.4 Pin Descriptions

| Pin Name | Function |
|---|---|
| VCC | System power supply input (2.7V to 5.5V). |
| V+ | Internally generated positive transmitter supply (+5.5V). |
| V- | Internally generated negative transmitter supply (-5.5V). |
| GND | Ground connection. This is also the potential of the thermal pad (PD). |
| C1+ | External capacitor (voltage doubler) is connected to this lead. |
| C1- | External capacitor (voltage doubler) is connected to this lead. |
| C2+ | External capacitor (voltage inverter) is connected to this lead. |
| C2- | External capacitor (voltage inverter) is connected to this lead. |
| TxIN | TTL/CMOS compatible transmitter Inputs. |
| TxOUT | ±15kV ESD protected, RS-232 level (nominally ±5.5V) transmitter outputs. |
| RxIN | ±15kV ESD protected, RS-232 compatible receiver inputs. |
| RxOUT | TTL/CMOS level receiver outputs. |
| $\overline{\text{INVALID}}$ | Active low output that indicates if no valid RS-232 levels are present on any receiver input. |
| $\overline{\text{FORCEOFF}}$ | Active low to shut down transmitters and on-chip power supply, which overrides any automatic circuitry and FORCEON (see Table 5 on page 14). |
| FORCEON | Active high input to override automatic powerdown circuitry, which keeps transmitters active ($\overline{\text{FORCEOFF}}$ must be high). |
| $\overline{\text{EN}}$ | Active low receiver enable control. |
| PD | Exposed thermal pad. Connect to GND. |

# 2. Specifications

## 2.1 Absolute Maximum Ratings

| Parameter | Minimum | Maximum | Unit |
|---|---|---|---|
| $V_{CC}$ to GND | -0.3 | 6 | V |
| V+ to GND | -0.3 | 7 | V |
| V- to GND | +0.3 | -7 | V |
| V+ to V- | | 14 | V |
| **Input Voltages** | | | |
| $T_{IN}$, $\overline{FORCEOFF}$, FORCEON, $\overline{EN}$ | -0.3 | 6 | V |
| $R_{IN}$ | | ±25 | V |
| **Output Voltages** | | | |
| $T_{OUT}$ | | ±13.2 | V |
| $R_{OUT}$, $\overline{INVALID}$ | -0.3 | $V_{CC}$ +0.3 | V |
| **Short-Circuit Duration** | | | |
| $T_{OUT}$ | Continuous | | |
| ESD Rating | (See "ESD Performance" on page 9) | | |

CAUTION: Do not operate at or near the maximum ratings listed for extended periods of time. Exposure to such conditions can adversely impact product reliability and result in failures not covered by warranty.

## 2.2 Thermal Information

| Thermal Resistance (Typical, Notes 4, 5) | $\theta_{JA}$ (°C/W) | $\theta_{JC}$ (°C/W) |
|---|---|---|
| 16 Ld QFN Package | 35 | 4.3 |
| 20 Ld QFN Package | 32 | 4.3 |

Notes:

4. $\theta_{JA}$ is measured in free air with the component mounted on a high-effective thermal conductivity test board with "direct attach" features. See TB379.
5. For $\theta_{JC}$, the "case temp" location is the center of the exposed metal pad on the package underside.

| Parameter | Minimum | Maximum | Unit |
|---|---|---|---|
| Maximum Junction Temperature (Plastic Package) | | +150 | °C |
| Maximum Storage Temperature Range | -65 | +150 | °C |
| Pb-Free Reflow Profile | see TB493 | | |

## 2.3 Recommended Operating Conditions

| Parameter | Minimum | Maximum | Unit |
|---|---|---|---|
| Temperature Range | -40 | +85 | °C |

## 2.4 Electrical Specifications

Test conditions: $V_{CC}$ = 3V to 5.5V, $C_1$ through $C_4$ = 0.1µF; unless otherwise specified. Typicals are at $T_A$ = +25°C

| Parameter | Test Conditions | Temp (°C) | Min (Note 7) | Typ | Max (Note 7) | Unit |
|---|---|---|---|---|---|---|
| **DC Characteristics** | | | | | | |
| Supply Current, Automatic Powerdown | All $R_{IN}$ open, FORCEON = GND, $\overline{FORCEOFF}$ = $V_{CC}$ (except ISL3232E) | 25 | - | 0.15 | 1 | µA |

Test conditions: $V_{CC}$ = 3V to 5.5V, $C_1$ through $C_4$ = 0.1µF; unless otherwise specified. Typicals are at $T_A$ = +25°C **(Continued)**

| Parameter | Test Conditions | | Temp (°C) | Min (Note 7) | Typ | Max (Note 7) | Unit |
|---|---|---|---|---|---|---|---|
| Supply Current, Powerdown | $\overline{FORCEOFF}$ = GND (except ISL3232E) | | 25 | - | 0.15 | 1 | µA |
| Supply Current, Automatic Powerdown Disabled | All outputs unloaded, FORCEON = $\overline{FORCEOFF}$ = $V_{CC}$ | $V_{CC}$ = 3.15V | 25 | - | 0.3 | 1.0 | mA |
| **Logic and Transmitter Inputs and Receiver Outputs** | | | | | | | |
| Input Logic Threshold Low | $T_{IN}$, FORCEON, $\overline{FORCEOFF}$, $\overline{EN}$ | | Full | - | - | 0.8 | V |
| Input Logic Threshold High | $T_{IN}$, FORCEON, $\overline{FORCEOFF}$, $\overline{EN}$ | $V_{CC}$ = 3.3V | Full | 2.0 | - | - | V |
| | | $V_{CC}$ = 5.0V | Full | 2.4 | - | - | V |
| Input Leakage Current | $T_{IN}$, FORCEON, $\overline{FORCEOFF}$, $\overline{EN}$ | | Full | - | ±0.01 | ±1.0 | µA |
| Output Leakage Current | $\overline{EN}$ = $V_{CC}$ (except ISL3232E) | | Full | - | ±0.05 | ±10 | µA |
| Output Voltage Low | $I_{OUT}$ = 1.6mA | | Full | - | - | 0.4 | V |
| Output Voltage High | $I_{OUT}$ = -1.0mA | | Full | $V_{CC}$ - 0.6 | $V_{CC}$ - 0.1 | - | V |
| **Automatic Powerdown (FORCEON = GND, $\overline{FORCEOFF}$ = $V_{CC}$, except ISL3232E)** | | | | | | | |
| Receiver Input Thresholds to Enable Transmitters | ISL4221E and ISL4223E powers up (see Figure 10) | | Full | -2.7 | - | 2.7 | V |
| Receiver Input Thresholds to Disable Transmitters | ISL4221E and ISL4223E powers down (see Figure 10) | | Full | -0.3 | - | 0.3 | V |
| $\overline{INVALID}$ Output Voltage Low | $I_{OUT}$ = 1.6mA | | Full | - | - | 0.4 | V |
| $\overline{INVALID}$ Output Voltage High | $I_{OUT}$ = -1.0mA | | Full | $V_{CC}$ - 0.6 | - | - | V |
| Receiver Threshold to Transmitters Enabled Delay ($t_{WU}$) | | | 25 | - | 100 | - | µs |
| Receiver Positive or Negative Threshold to $\overline{INVALID}$ High Delay ($t_{INVH}$) | | | 25 | - | 1 | - | µs |
| Receiver Positive or Negative Threshold to $\overline{INVALID}$ Low Delay ($t_{INVL}$) | | | 25 | - | 30 | - | µs |
| **Receiver Inputs** | | | | | | | |
| Input Voltage Range | | | 25 | -25 | - | 25 | V |
| Input Threshold Low | $V_{CC}$ = 3.3V | | 25 | 0.6 | 1.2 | - | V |
| | $V_{CC}$ = 5.0V | | 25 | 0.8 | 1.5 | - | V |
| Input Threshold High | $V_{CC}$ = 3.3V | | 25 | - | 1.5 | 2.4 | V |
| | $V_{CC}$ = 5.0V | | 25 | - | 1.8 | 2.4 | V |
| Input Hysteresis | | | 25 | - | 0.5 | - | V |
| Input Resistance | | | 25 | 3 | 5 | 7 | kΩ |
| **Transmitter Outputs** | | | | | | | |
| Output Voltage Swing | All transmitter outputs loaded with 3kΩ to ground | | Full | ±5.0 | ±5.4 | - | V |
| Output Resistance | $V_{CC}$ = V+ = V- = 0V, transmitter output = ±2V | | Full | 300 | 10M | - | Ω |
| Output Short-Circuit Current | | | Full | - | ±35 | ±60 | mA |
| Output Leakage Current | $V_{OUT}$ = ±12V, $V_{CC}$ = 0V, or $V_{CC}$ = 3V to 5.5V, with automatic powerdown or $\overline{FORCEOFF}$ = GND | | Full | - | - | ±25 | µA |
| **Timing Characteristics** | | | | | | | |
| Maximum Data Rate | $R_L$ = 3kΩ, $C_L$ = 1000pF, one transmitter switching | | Full | 250 | 500 | - | kbps |
| Receiver Propagation Delay | Receiver input to receiver output, $C_L$ = 150pF | $t_{PHL}$ | 25 | - | 0.15 | - | µs |
| | | $t_{PLH}$ | 25 | - | 0.15 | - | µs |

Test conditions: $V_{CC}$ = 3V to 5.5V, $C_1$ through $C_4$ = 0.1µF; unless otherwise specified. Typicals are at $T_A$ = +25°C **(Continued)**

| Parameter | Test Conditions | | Temp (°C) | Min (Note 7) | Typ | Max (Note 7) | Unit |
|---|---|---|---|---|---|---|---|
| Receiver Output Enable Time | Normal operation (except ISL3232E) | | 25 | - | 200 | - | ns |
| Receiver Output Disable Time | Normal operation (except ISL3232E) | | 25 | - | 200 | - | ns |
| Transmitter Skew | $t_{PHL}$ - $t_{PLH}$ (Note 6) | | 25 | - | 100 | - | ns |
| Receiver Skew | $t_{PHL}$ - $t_{PLH}$ | | 25 | - | 50 | - | ns |
| Transition Region Slew Rate | $V_{CC}$ = 3.3V, $R_L$ = 3kΩ to 7kΩ, measured from 3V to -3V or -3V to 3V | $C_L$ = 150pF to 2500pF | 25 | 4 | - | 30 | V/µs |
| | | $C_L$ = 150pF to 1000pF | 25 | 6 | - | 30 | V/µs |
| **ESD Performance** | | | | | | | |
| RS-232 Pins (TOUT, RIN) | Human Body Model | | 25 | - | ±15 | - | kV |
| | IEC61000-4-2 Contact Discharge | | 25 | - | ±8 | - | kV |
| | IEC61000-4-2 Air Gap Discharge | | 25 | - | ±15 | - | kV |
| All Other Pins | Human Body Model | | 25 | - | ±2 | - | kV |

Notes:

6. Transmitter skew is measured at the transmitter zero crossing points.
7. Parameters with Min and/or Max limits are 100% tested at +25°C, unless otherwise specified. Temperature limits established by characterization and are not production tested.

# 3. Typical Performance Curves

$V_{CC}$ = 3.3V, $T_A$ = +25°C

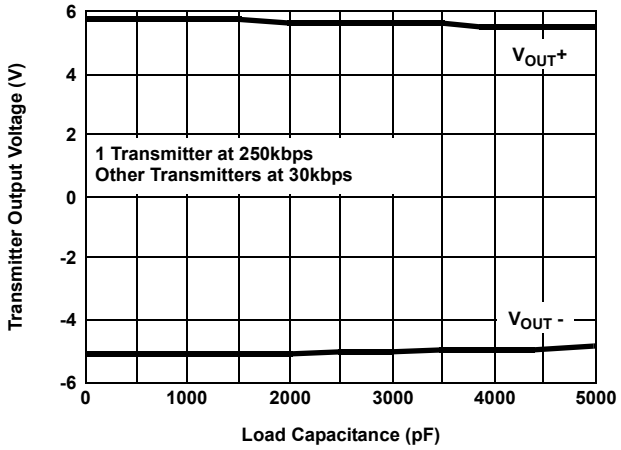



**Figure 1. Transmitter Output Voltage vs Load Capacitance**

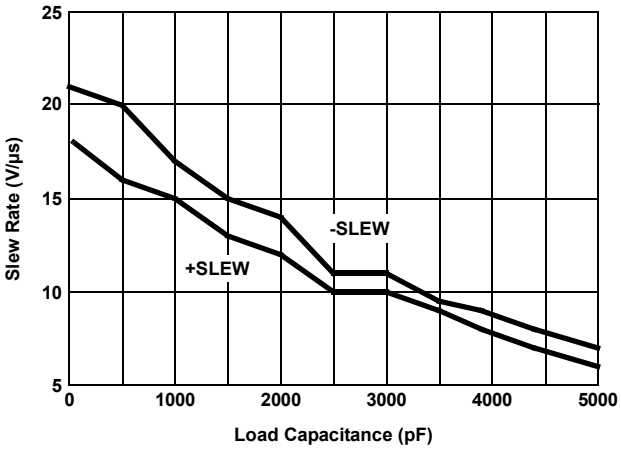



**Figure 2. Slew Rate vs Load Capacitance**

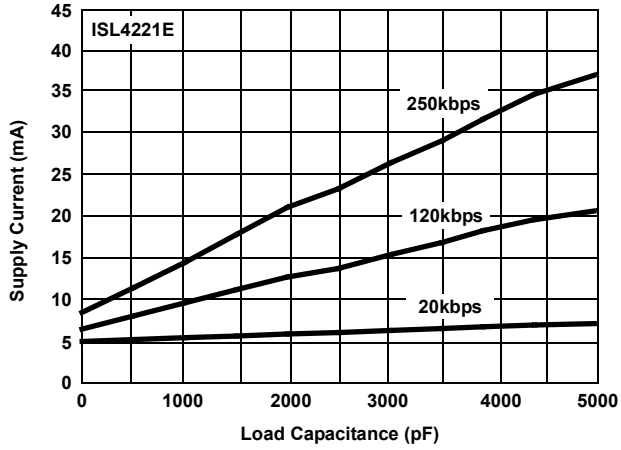



**Figure 3. Supply Current vs Load Capacitance when Transmitting Data**

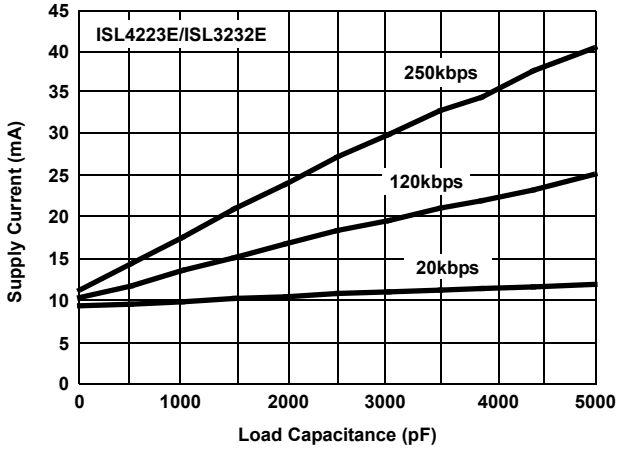



**Figure 4. Supply Current vs Load Capacitance when Transmitting Data**

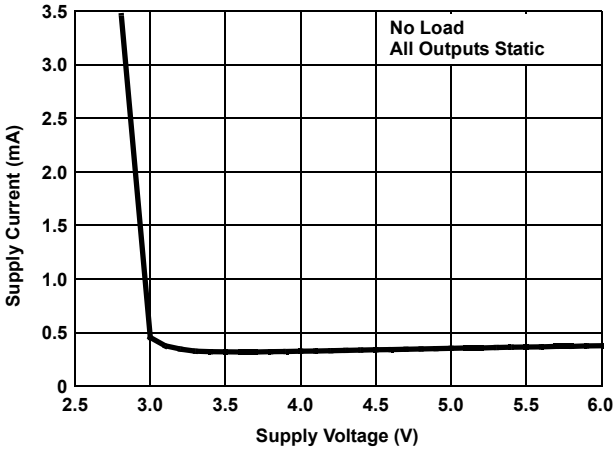



**Figure 5. Supply Current vs Supply Voltage**

# 4. Application Information

The ISL4221E, ISL4223E, and ISL3232E operate from a single +2.7V to +5.5V supply, ensure a 250kbps minimum data rate, require only four small external 0.1µF capacitors, feature low power consumption, and meet all EIA RS-232C and V.28 specifications even with $V_{CC}$ = 3.0V.

## 4.1 Charge Pump

The ISL4221E, ISL4223E, and ISL3232E use regulated on-chip dual charge pumps as voltage doublers, and voltage inverters to generate ±5.5V transmitter supplies from a $V_{CC}$ supply as low as 3.0V, which allows them to maintain RS-232 compliant output levels over the ±10% tolerance range of 3.3V powered systems. The efficient on-chip power supplies require only four small, external 0.1µF capacitors for the voltage doubler and inverter functions. The charge pumps operate discontinuously (that is, they turn off as soon as the V+ and V- supplies are pumped up to the nominal values), resulting in significant power savings.

### 4.1.1 Charge Pump Abs Max Ratings

These 3V to 5V RS-232 transceivers have been fully characterized for 3.0V to 3.6V operation and for critical points at 4.5V to 5.5V operation. Furthermore, load conditions were favorable using static logic states only.

The specified maximum values for V+ and V- are +7V and -7V, respectively. These limits apply for $V_{CC}$ values set to 3.0V and 3.6V (see Table 2). For $V_{CC}$ values set to 4.5V and 5.5V, the maximum values for V+ and V- can approach +9V and -7V, respectively (Table 3 on page 12). The breakdown characteristics for V+ and V- were measured with ±13V.

**Table 2. V+ and V- Values for $V_{CC}$ = 3.0V to 3.6V**

| $C_1$ (µF) | $C_2$, $C_3$, $C_4$ (µF) | Load | T1IN (Logic State) | V+ (V) | | V- (V) | |
|---|---|---|---|---|---|---|---|
| | | | | $V_{CC}$ = 3.0V | $V_{CC}$ = 3.6V | $V_{CC}$ = 3.0V | $V_{CC}$ = 3.6V |
| 0.1 | 0.1 | Open | H | 5.80 | 6.56 | -5.60 | -5.88 |
| | | | L | 5.80 | 6.56 | -5.60 | -5.88 |
| | | | 2.4kbps | 5.80 | 6.56 | -5.60 | -5.88 |
| | | 3kΩ // 1000pF | H | 5.88 | 6.60 | -5.56 | -5.92 |
| | | | L | 5.76 | 6.36 | -5.56 | -5.76 |
| | | | 2.4kbps | 6.00 | 6.64 | -5.64 | -5.96 |
| 0.047 | 0.33 | Open | H | 5.68 | 6.00 | -5.60 | -5.60 |
| | | | L | 5.68 | 6.00 | -5.60 | -5.60 |
| | | | 2.4kbps | 5.68 | 6.00 | -5.60 | -5.60 |
| | | 3kΩ // 1000pF | H | 5.76 | 6.08 | -5.64 | -5.64 |
| | | | L | 5.68 | 6.04 | -5.60 | -5.60 |
| | | | 2.4kbps | 5.84 | 6.16 | -5.64 | -5.72 |
| 1 | 1 | Open | H | 5.88 | 6.24 | -5.60 | -5.60 |
| | | | L | 5.88 | 6.28 | -5.60 | -5.64 |
| | | | 2.4kbps | 5.80 | 6.20 | -5.60 | -5.60 |
| | | 3kΩ // 1000pF | H | 5.88 | 6.44 | -5.64 | -5.72 |
| | | | L | 5.88 | 6.04 | -5.64 | -5.64 |
| | | | 2.4kbps | 5.92 | 6.40 | -5.64 | -5.64 |

**Table 3. V+ and V- Values for $V_{CC}$ = 4.5V to 5.5V**

| $C_1$ (µF) | $C_2$, $C_3$, $C_4$ (µF) | Load | T1IN (Logic State) | V+ (V) | | V- (V) | |
|---|---|---|---|---|---|---|---|
| | | | | $V_{CC}$ = 4.5V | $V_{CC}$ = 5.5V | $V_{CC}$ = 4.5V | $V_{CC}$ = 5.5V |
| 0.1 | 0.1 | Open | H | 7.44 | 8.48 | -6.16 | -6.40 |
| | | | L | 7.44 | 8.48 | -6.16 | -6.44 |
| | | | 2.4kbps | 7.44 | 8.48 | -6.17 | -6.44 |
| | | 3kΩ // 1000pF | H | 7.76 | 8.88 | -6.36 | -6.72 |
| | | | L | 7.08 | 8.00 | -5.76 | -5.76 |
| | | | 2.4kbps | 7.76 | 8.84 | -6.40 | -6.64 |
| 0.047 | 0.33 | Open | H | 6.44 | 6.88 | -5.80 | -5.88 |
| | | | L | 6.48 | 6.88 | -5.84 | -5.88 |
| | | | 2.4kbps | 6.44 | 6.88 | -5.80 | -5.88 |
| | | 3kΩ // 1000pF | H | 6.64 | 7.28 | -5.92 | -6.04 |
| | | | L | 6.24 | 6.60 | -5.52 | -5.52 |
| | | | 2.4kbps | 6.72 | 7.16 | -5.92 | -5.96 |
| 1 | 1 | Open | H | 6.84 | 7.60 | -5.76 | -5.76 |
| | | | L | 6.88 | 7.60 | -5.76 | -5.76 |
| | | | 2.4kbps | 6.92 | 7.56 | -5.72 | -5.76 |
| | | 3kΩ // 1000pF | H | 7.28 | 8.16 | -5.80 | -5.92 |
| | | | L | 6.44 | 6.84 | -5.64 | -6.84 |
| | | | 2.4kbps | 7.08 | 7.76 | -5.80 | -5.80 |

The resulting new maximum voltages at V+ and V- are listed in Table 4.

**Table 4. New Measured Withstanding Voltages**

| | |
|---|---|
| V+, V- to Ground | ±13V |
| V+ to V- | 20V |

## 4.2 Transmitters

The transmitters are proprietary, low dropout, inverting drivers that translate TTL/CMOS inputs to EIA/TIA-232 output levels. The transmitters are coupled with the on-chip ±5.5V supplies to deliver true RS-232 levels across a wide range of single supply system voltages.

All ISL4221E and ISL4223E transmitter outputs disable and assume a high impedance state when the device enters the powerdown mode (see Table 5 on page 14). The outputs can be driven to ±12V when disabled.

The devices ensure a 250kbps data rate for full load conditions (3kΩ and 1000pF), $V_{CC} \geq 3.0V$, with one transmitter operating at full speed. Under more typical conditions of $V_{CC} \geq 3.3V$, $R_L$ = 3kΩ, and $C_L$ = 250pF, one transmitter easily operates at 900kbps.

Transmitter inputs float if they remain unconnected and can cause $I_{CC}$ increases. Connect unused inputs to GND for best performance.

## 4.3 Receivers

The ISL4221E, ISL4223E, and ISL3232E contain standard inverting receivers, and the ISL4221E and ISL4223E receivers tri-state using the $\overline{EN}$ control line. All the receivers convert RS-232 signals to CMOS output levels and accept inputs up to ±25V while presenting the required 3kΩ to 7kΩ input impedance (see Figure 6) even if the power is off ($V_{CC}$ = 0V). The receivers' Schmitt trigger input stage uses hysteresis to increase noise immunity and decrease errors due to slow input signal transitions.

Receivers driving a powered down UART must be disabled to prevent current flow through and possible damage to the UART's protection diodes (see Figures 7 and 8), which can be accomplished on the ISL4221E and ISL4223E by driving the $\overline{EN}$ input high whenever the UART powers down. Figure 8 also shows that the $\overline{INVALID}$ output can be used to determine when the UART should be powered down. When the RS-232 cable is disconnected, $\overline{INVALID}$ switches low indicating that the UART is no longer needed. Reconnecting the cable drives $\overline{INVALID}$ back high, indicating that the UART should be powered up.

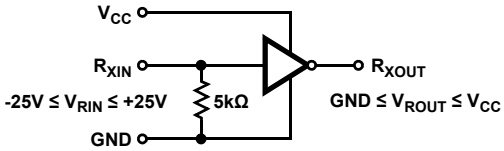



Figure 6. Inverting Receiver Connections

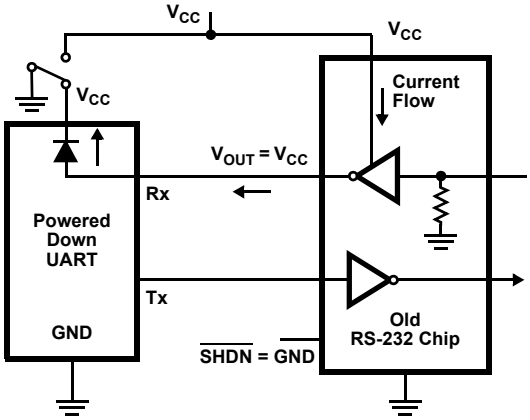



Figure 7. Power Drain Through Powered Down Peripheral

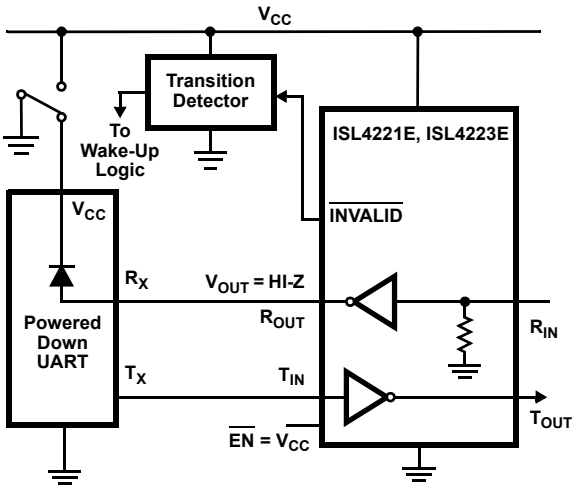



Figure 8. Disabled Receivers Prevent Power Drain

## 4.4 Low Power Operation

The 3V ISL4221E, ISL4223E, and ISL3232E require a nominal supply current of 0.3mA, even at $V_{CC}$ = 5.5V during normal operation (not in powerdown mode). This supply current is considerably less than the 5mA to 11mA current required by comparable 5V RS-232 devices, which allows you to reduce system power simply by switching to this new family.

## 4.5 Powerdown Functionality (Excluding ISL3232E)

The already low current requirement drops significantly when the device enters powerdown mode. In powerdown, supply current drops to 150nA because the on-chip charge pump turns off (V+ collapses to $V_{CC}$, V- collapses to GND) and the transmitter outputs tri-state. Receiver outputs are unaffected by powerdown; see Table 5 for details. This micro-power mode makes the ISL4221E and ISL4223E ideal for battery-powered and portable applications.

**Table 5. Powerdown and Enable Logic Truth Table (Excluding ISL3232E)**

| RS-232 Signal Present at Receiver Input? | $\overline{\text{FORCEOFF}}$ Input | FORCEON Input | $\overline{\text{EN}}$ Input | Transmitter Outputs | Receiver Outputs | $\overline{\text{INVALID}}$ Output | Mode of Operation |
|---|---|---|---|---|---|---|---|
| No | H | H | L | Active | Active | L | Normal Operation (Auto Powerdown Disabled) |
| No | H | H | H | Active | High-Z | L | |
| Yes | H | L | L | Active | Active | H | Normal Operation (Auto Powerdown Enabled) |
| Yes | H | L | H | Active | High-Z | H | |
| No | H | L | L | High-Z | Active | L | Powerdown Due to Auto Powerdown Logic |
| No | H | L | H | High-Z | High-Z | L | |
| Yes | L | X | L | High-Z | Active | H | Manual Powerdown |
| Yes | L | X | H | High-Z | High-Z | H | Manual Powerdown w/Rcvr. Disabled |
| No | L | X | L | High-Z | Active | L | Manual Powerdown |
| No | L | X | H | High-Z | High-Z | L | Manual Powerdown w/Rcvr. Disabled |

### 4.5.1 Software Controlled (Manual) Powerdown

The ISL4221E and ISL4223E family provide pins that allow you to force the IC into the low power, standby state, and use a two pin approach where the FORCEON and $\overline{\text{FORCEOFF}}$ inputs determine the IC's mode. For always enabled operation, FORCEON and $\overline{\text{FORCEOFF}}$ are both strapped high. Under logic or software control, only the $\overline{\text{FORCEOFF}}$ input needs to be driven to switch between active and powerdown modes. The FORCEON state is not critical because $\overline{\text{FORCEOFF}}$ overrides FORCEON. However, if strictly manual control over powerdown is needed, you must strap FORCEON high to disable the automatic powerdown circuitry.

Connecting $\overline{\text{FORCEOFF}}$ and FORCEON together disables the automatic powerdown feature, enabling them to function as a manual $\overline{\text{SHUTDOWN}}$ input (see Figure 9).

The time to recover from automatic powerdown mode is typically 100µs.

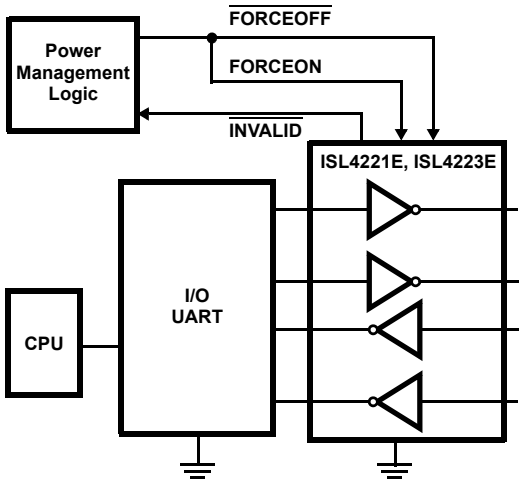



**Figure 9. Connections for Manual Powerdown when No Valid Receiver Signals are Present**

### 4.5.2 Automatic Powerdown (Excluding ISL3232E)

Even greater power savings are available by using the automatic powerdown function. When no valid RS-232 voltages (see Figure 10) are sensed on any receiver input for 30µs, the charge pump and transmitters power down, and reduce supply current to 150nA. Invalid receiver levels occur whenever the driving peripheral's outputs are shut off (powered down) or when the RS-232 interface cable is disconnected. The ISL4221E and ISL4223E power back up whenever they detect a valid RS-232 voltage level on any receiver input. This automatic powerdown feature provides additional system power savings without changes to the existing operating system.

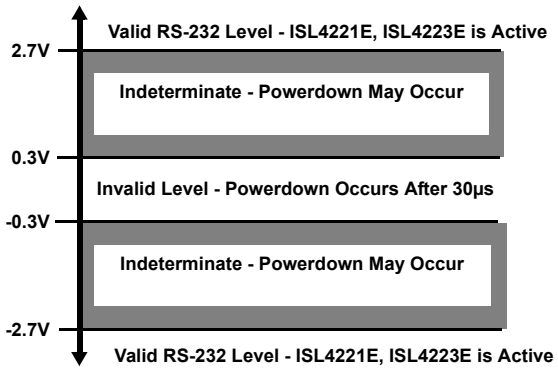



**Figure 10. Definition of Valid RS-232 Receiver Levels**

Automatic powerdown operates when the FORCEON input is low, and the $\overline{\text{FORCEOFF}}$ input is high. Tying FORCEON high disables automatic powerdown, but manual powerdown is always available with the overriding $\overline{\text{FORCEOFF}}$ input. Table 5 on page 14 summarizes the automatic powerdown functionality.

Some applications may need more time to wake up from shutdown. If automatic powerdown is used, the RS-232 device re-enters powerdown if valid receiver levels are not reestablished within 30µs of the ISL4221E and ISL4223E powering up. Figure 11 illustrates a circuit that keeps the ISL4221E and ISL4223E from initiating automatic powerdown for 100ms after powering up. The delay gives the slow-to-wake peripheral circuit time to re-establish valid RS-232 output levels.

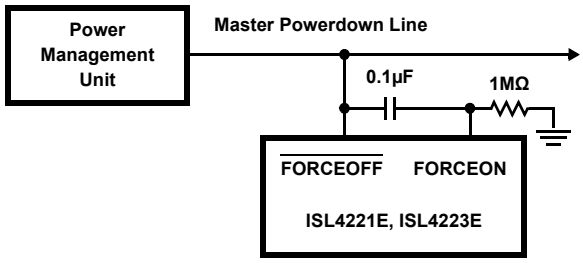



**Figure 11. Circuit to Prevent Auto Powerdown for 100ms After Forced Power-Up**

The time to recover from automatic powerdown mode is typically 100µs.

### 4.5.3 $\overline{\text{INVALID}}$ Output (Excluding ISL3232E)

The $\overline{\text{INVALID}}$ output always indicates whether or not a valid RS-232 signal (see Figure 10) is present at any of the receiver inputs (see Table 5 on page 14), giving you a way to determine when the interface block should power down. Invalid receiver levels occur whenever the driving peripheral's outputs are shut off (powered down) or when the RS-232 interface cable is disconnected. In the case of a disconnected interface cable where all the receiver inputs are floating (but pulled to GND by the internal receiver pull down resistors), the $\overline{\text{INVALID}}$ logic detects the invalid levels and drives the output low. The power management logic then uses this indicator to powerdown the interface block. Reconnecting the cable restores valid levels at the receiver inputs, $\overline{\text{INVALID}}$ switches high, and the power management logic wakes up the interface block. $\overline{\text{INVALID}}$ can also be used to indicate the DTR or RING INDICATOR signal, as long as the other receiver inputs are floating, or driven to GND (as in the case of a powered down driver).

$\overline{\text{INVALID}}$ switches low after invalid levels have persisted on all of the receiver inputs for more than 30µs (see Figure 12). $\overline{\text{INVALID}}$ switches back high 1µs after detecting a valid RS-232 level on a receiver input. $\overline{\text{INVALID}}$ operates in all modes (forced or automatic powerdown, or forced on), so it is also useful for systems employing manual powerdown circuitry. When automatic powerdown is used, $\overline{\text{INVALID}}$ = 0 indicates that the ISL4221E and ISL4223E are in powerdown mode.

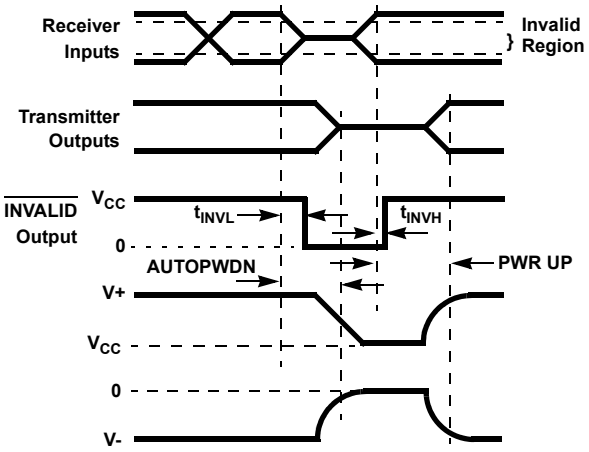



**Figure 12. Automatic Powerdown and $\overline{\text{INVALID}}$ Timing Diagrams**

## 4.6 Capacitor Selection

The charge pumps require 0.1µF, or greater, capacitors for proper operation. Increasing the capacitor values (by a factor of 2) reduces ripple on the transmitter outputs and slightly reduces power consumption.

When using minimum required capacitor values, make sure that capacitor values do not degrade excessively with temperature. If in doubt, use capacitors with a larger nominal value. The capacitor's Equivalent Series Resistance (ESR) usually rises at low temperatures and it influences the amount of ripple on V+ and V-.

## 4.7 Power Supply Decoupling

In most circumstances a 0.1µF bypass capacitor is adequate. In applications that are particularly sensitive to power supply noise, decouple $V_{CC}$ to ground with a capacitor of the same value as the charge-pump capacitor $C_1$. Connect the bypass capacitor as close as possible to the IC.

## 4.8 Transmitter Outputs when Exiting Powerdown

Figure 13 shows the response of two transmitter outputs when exiting powerdown mode. As they activate, the two transmitter outputs properly go to opposite RS-232 levels, with no glitching, ringing, nor undesirable transients. Each transmitter is loaded with 3kΩ in parallel with 2500pF.

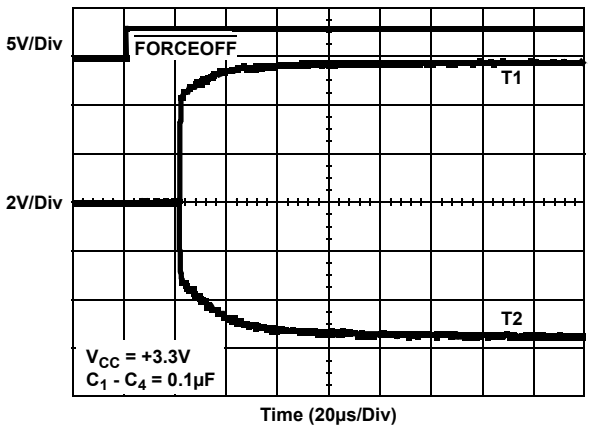



**Figure 13. Transmitter Outputs When Exiting Powerdown**

**Note:** The transmitters enable only when the magnitude of the supplies exceed approximately 3V.

## 4.9 Operation Down to 2.7V

ISL4221E, ISL4223E, and ISL3232E transmitter outputs meet RS-562 levels (±3.7V), at the full data rate, with $V_{CC}$ as low as 2.7V. RS-562 levels typically ensure interoperability with RS-232 devices.

## 4.10 High Data Rates

The ISL4221E, ISL4223E, and ISL3232E maintain the RS-232 ±5V minimum transmitter output voltages even at high data rates. Figure 14 shows a transmitter loopback test circuit, and Figure 15 shows the loopback test result at 120kbps. For this test, all transmitters were simultaneously driving RS-232 loads in parallel with 1000pF, at 120kbps. Figure 16 shows the loopback results for a single transmitter driving 1000pF and an RS-232 load at 250kbps. The static transmitters were also loaded with an RS-232 receiver.

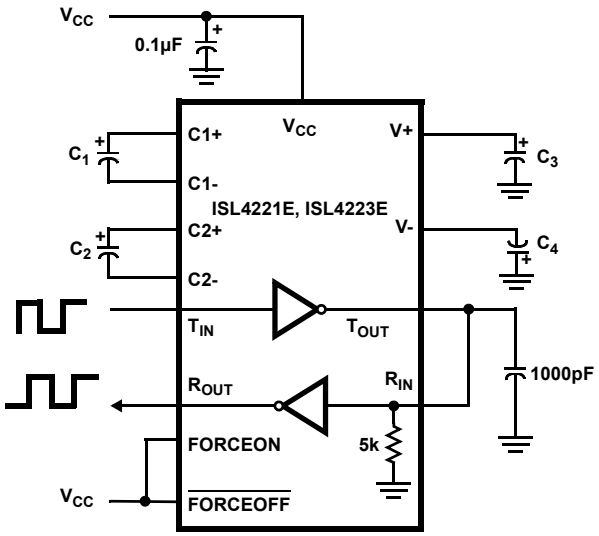



**Figure 14. Transmitter Loopback Test Circuit**

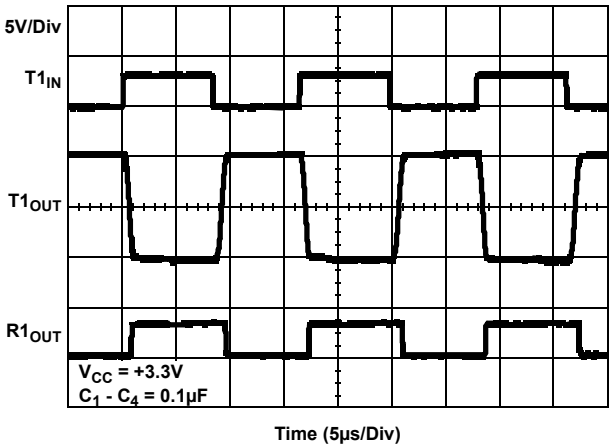



**Figure 15. Loopback Test at 120kbps**

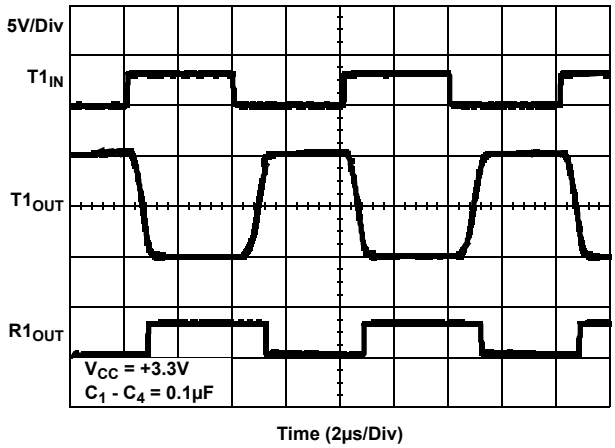



**Figure 16. Loopback Test at 250kbps**

## 4.11 Interconnection with 3V and 5V Logic

The ISL4221E, ISL4223E, and ISL3232E directly interface with 5V CMOS and TTL logic families. Nevertheless, with the ISL4221E, ISL4223E, and ISL3232E at 3.3V, and the logic supply at 5V, AC, HC, and CD4000 outputs can properly drive ISL4221E, ISL4223E, and ISL3232E inputs, but ISL4221E, ISL4223E, and ISL3232E outputs do not reach the minimum $V_{IH}$ for these logic families. See Table 6 for more information.

**Table 6. Logic Family Compatibility with Various Supply Voltages**

| System Power-Supply Voltage (V) | $V_{CC}$ Supply Voltage (V) | Compatibility |
|---|---|---|
| 3.3 | 3.3 | Compatible with all CMOS families. |
| 5 | 5 | Compatible with all TTL and CMOS logic families. |
| 5 | 3.3 | Compatible with ACT and HCT CMOS, and with TTL. ISL4221E, ISL4223E, and ISL3232E outputs are incompatible with AC, HC, and CD4000 CMOS inputs. |

# 5. ±15kV ESD Protection

All pins on ISL4221E, ISL4223E, and ISL3232E devices include ESD protection structures, but the RS-232 pins (transmitter outputs and receiver inputs) incorporate advanced structures that allow them to survive ESD events up to ±15kV. The RS-232 pins are particularly vulnerable to ESD damage because they typically connect to an exposed port on the exterior of the finished product. Touching the port pins, or connecting a cable, can cause an ESD event that might destroy unprotected ICs. The ESD structures protect the device whether or not it is powered-up, protect without allowing any latchup mechanism to activate, and do not interfere with RS-232 signals as large as ±25V.

## 5.1 Human Body Model (HBM) Testing

The Human Body Model (HBM) test method emulates the ESD event delivered to an IC during human handling. The tester delivers the charge through a 1.5kΩ current limiting resistor, so the test is less severe than the IEC61000 test, which uses a 330Ω limiting resistor. The HBM method determines an IC's ability to withstand the ESD transients typically present during handling and manufacturing. Due to the random nature of these events, each pin is tested with respect to all other pins. The RS-232 pins on "E" family devices can withstand HBM ESD events to ±15kV.

## 5.2 IEC61000-4-2 Testing

The IEC61000-4-2 test method applies to finished equipment, rather than to an individual IC. Therefore, the pins most likely to suffer an ESD event are those that are exposed to the outside world (the RS-232 pins in this case), and the IC is tested in its typical application configuration (power applied) rather than testing each pin-to-pin combination. The lower current limiting resistor coupled with the larger charge storage capacitor yields a test that is much more severe than the HBM test. The extra ESD protection built into this device's RS-232 pins allows the design of equipment that meet Level 4 criteria without the need for additional board level protection on the RS-232 port.

## 5.3 Air-Gap Discharge Test Method

For the air-gap discharge test method, a charged probe tip moves toward the IC pin until the voltage arcs to it. The current waveform delivered to the IC pin depends on factors such as approach speed, humidity, and temperature so it is difficult to obtain repeatable results. The "E" device RS-232 pins withstand ±15kV air-gap discharges.

## 5.4 Contact Discharge Test Method

During the contact discharge test, the probe contacts the tested pin before the probe tip is energized and eliminates the variables associated with the air-gap discharge. The result is a more repeatable and predictable test, but equipment limits prevent testing devices at voltages higher than ±8kV. All "E" family devices survive ±8kV contact discharges on the RS-232 pins.

# 6. Die Characteristics

| | |
|---|---|
| Substrate and QFN Thermal Pad Potential (Powered Up) | GND |
| Transistor Count | ISL3232E: 296<br>ISL4221E: 286<br>ISL4223E: 357 |
| Process | Si Gate CMOS |

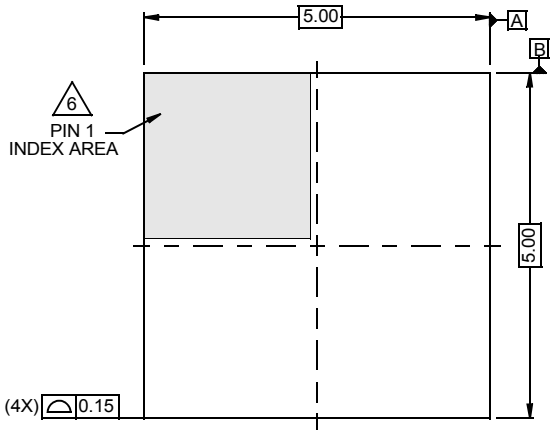
# 7. Revision History

| Rev. | Date | Description |
|---|---|---|
| 7 | May.2.19 | Updated to latest formatting.<br>Updated Related Literature section.<br>Updated Ordering information table by adding active tape and reel information, updated notes, adding note 3, and removed retired parts<br>Added “Charge Pump Absolute Maximum Ratings” on page 11.<br>Removed About Intersil section.<br>Added Revision History section.<br>Updated disclaimer. |

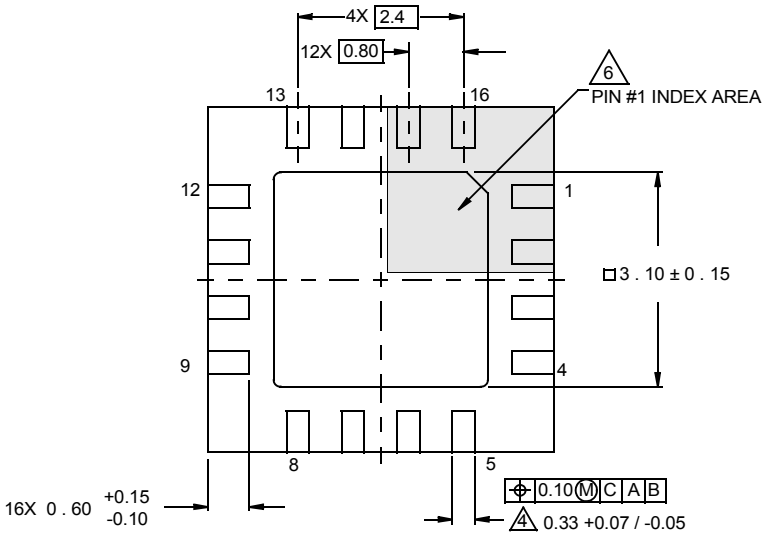
# 8. Package Outline Drawings

For the most recent package outline drawing, see L16.5x5B.

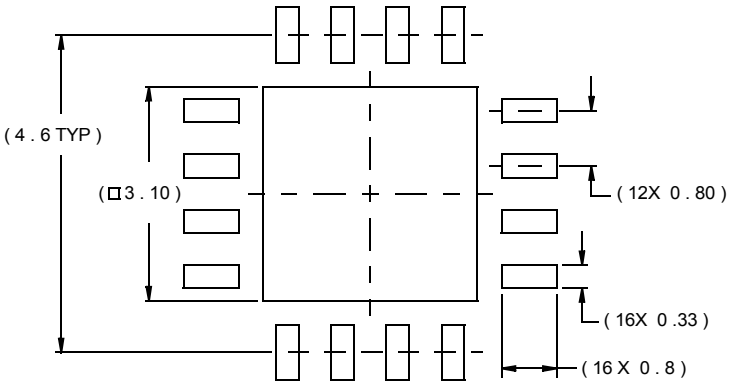
L16.5x5B
16 LEAD QUAD FLAT NO-LEAD PLASTIC PACKAGE
Rev 2, 02/08



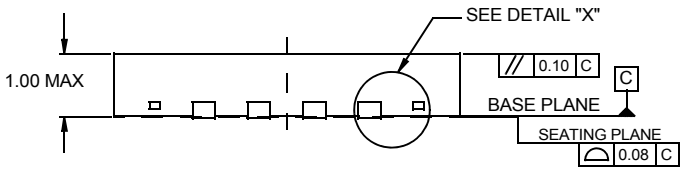

TOP VIEW



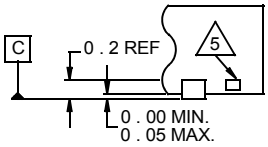

BOTTOM VIEW




TYPICAL RECOMMENDED LAND PATTERN




SIDE VIEW

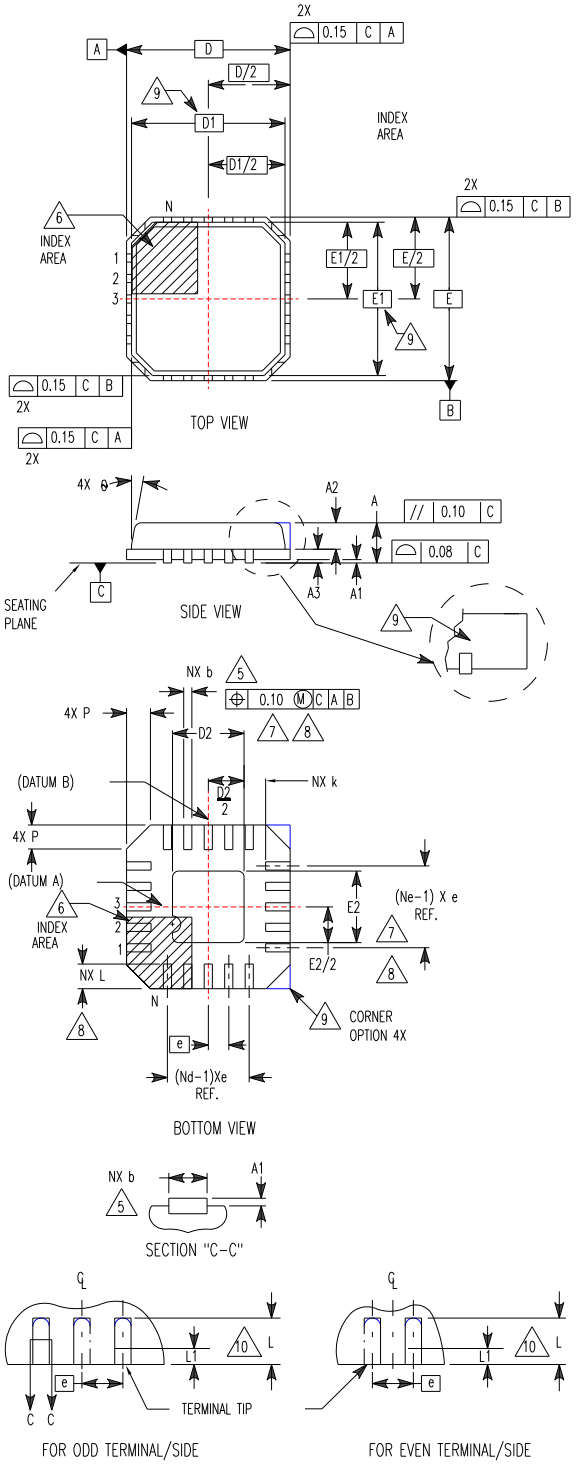



DETAIL "X"

NOTES:

1. Dimensions are in millimeters.
   Dimensions in ( ) for Reference Only.
2. Dimensioning and tolerancing conform to AMSE Y14.5m-1994.
3. Unless otherwise specified, tolerance : Decimal ± 0.05
4. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
5. Tiebar shown (if present) is a non-functional feature.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.

For the most recent package outline drawing, see L20.5x5.




L20.5x5
20 Lead Quad Flat No-Lead Plastic Package (QFN)
Micro Lead Frame Plastic Package (MLFP)

| SYMBOL | MILLIMETERS | | | NOTES |
|---|---|---|---|---|
| | MIN | NOMINAL | MAX | |
| A | 0.80 | 0.90 | 1.00 | - |
| A1 | - | 0.02 | 0.05 | - |
| A2 | - | 0.65 | 1.00 | 9 |
| A3 | | 0.20 REF | | 9 |
| b | 0.23 | 0.30 | 0.38 | 5, 8 |
| D | | 5.00 BSC | | - |
| D1 | | 4.75 BSC | | 9 |
| D2 | 2.95 | 3.10 | 3.25 | 7, 8 |
| E | | 5.00 BSC | | - |
| E1 | | 4.75 BSC | | 9 |
| E2 | 2.95 | 3.10 | 3.25 | 7, 8 |
| e | | 0.65 BSC | | - |
| k | 0.20 | - | - | - |
| L | 0.35 | 0.60 | 0.75 | 8 |
| N | | 20 | | 2 |
| Nd | | 5 | | 3 |
| Ne | | 5 | | 3 |
| P | - | - | 0.60 | 9 |
| θ | - | - | 12 | 9 |

Rev. 4 11/04

Notes:

1. Dimensioning and tolerancing conform to ASME Y14.5-1994.
2. N is the number of terminals.
3. Nd and Ne refer to the number of terminals on each D and E.
4. All dimensions are in millimeters. Angles are in degrees.
5. Dimension b applies to the metallized terminal and is measured between 0.15mm and 0.30mm from the terminal tip.
6. The configuration of the pin #1 identifier is optional, but must be located within the zone indicated. The pin #1 identifier may be either a mold or mark feature.
7. Dimensions D2 and E2 are for the exposed pads which provide improved electrical and thermal performance.
8. Nominal dimensions are provided to assist with PCB Land Pattern Design efforts, see TB389.
9. Features and dimensions A2, A3, D1, E1, P & θ are present when Anvil singulation method is used and not present for saw singulation.
10. Compliant to JEDEC MO-220VHHC Issue I except for the "b" dimension.

## Notice

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