ISL83387E

±15kV ESD Protected, +3V to +5.5V, 1Microamp, 250kbps, RS-232 Transceivers with Enhanced Automatic Powerdown

The ISL83387E is a 3.0V to 5.5V powered RS-232 transceiver that meets EIA/TIA-232 and V.28/V.24 specifications, even at V_{CC} = 3.0V. Additionally, it provides ±15kV ESD protection (IEC61000-4-2 Air Gap and Human Body Model) on transmitter outputs and receiver inputs (RS-232 pins). Targeted applications are industrial laptop computers, Palmtops, PDAs, and notebooks where the low operational power consumption and even lower standby power consumption is critical. Efficient on-chip charge pumps coupled with manual and enhanced automatic powerdown functions reduce the standby supply current to a 1µA trickle. The TSSOP 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 ISL83387E features a V_L pin that adjusts the logic pin output levels and input thresholds to values compatible with the V_{CC} powering the external logic (for example, a UART).

The ISL83387E includes an enhanced automatic power-down function that powers down the on-chip power-supply and driver circuits. Automatic powerdown occurs when all receiver and transmitter inputs detect no signal transitions for a period of 30 seconds. The ISL83387E powers back up automatically, when it senses a transition on any transmitter or receiver input.

Table 1 summarizes the features of the ISL83387E and Application Note AN9863 summarizes the features of each device comprising the 3V RS-232 family.

Related Literature

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

- ISL83387E device page

Features

- V_L supply pin for compatibility with mixed voltage systems
- ESD protection for RS-232 I/O pins to ±15kV (IEC61000)
- Low power, pin compatible upgrade for MAX3387E
- Manual and enhanced automatic powerdown features
- Meets EIA/TIA-232 and V.28/V.24 specifications at 3V
- On-chip charge pumps require only four external 0.1µF capacitors
- Receivers stay active in powerdown
- Very low supply current: 300µA
- Assured minimum data rate: 250kbps
- Wide power supply range: Single +3V to +5.5V
- Low supply current in powerdown state: < 1µA
- Pb-Free (RoHS compliant)

Applications

- Any system requiring RS-232 communication ports
  - Battery powered, hand-held, and portable equipment
  - Industrial laptops. Palmtops, and PDAs
  - Digital cameras

Table 1. Summary of Features

Part Number	No. of Tx.	No. of Rx.	Data Rate (kbps)	Rx. Enable Function?	V_L Logic Supply Pin?	Manual Power-Down?	Enhanced Automatic Powerdown Function?
ISL83387E	3	3	250	No	Yes	Yes	Yes

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1. Overview

1.1 Typical Operating Circuit

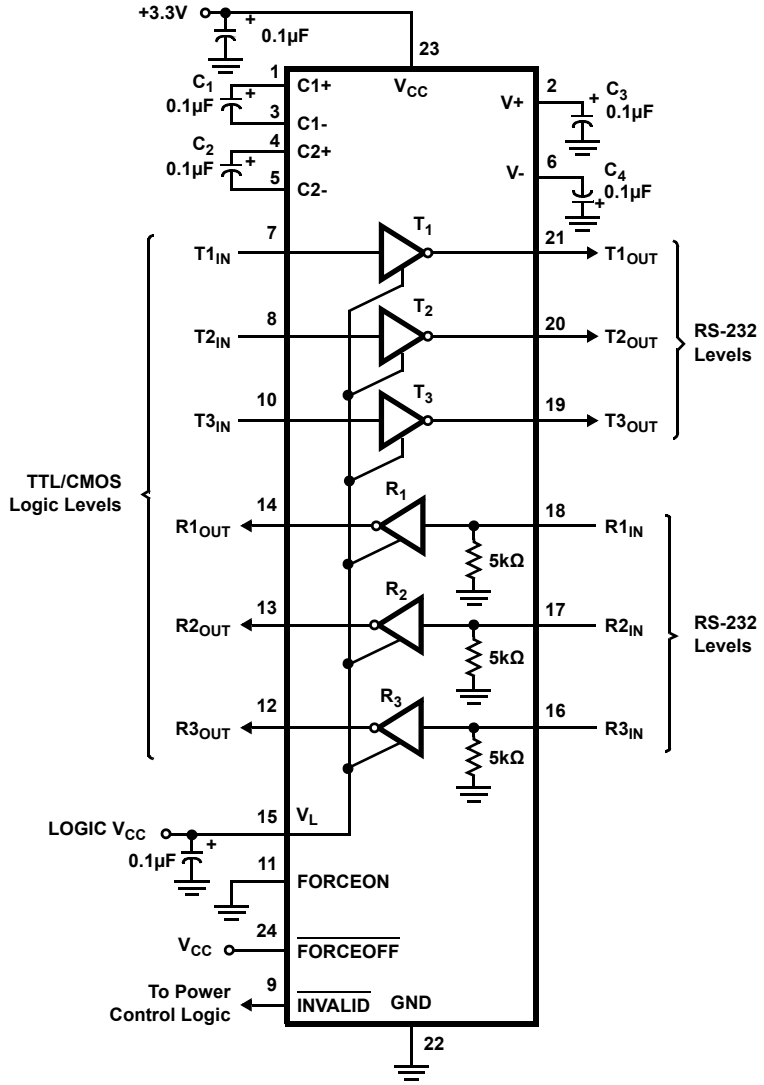


Figure 1. Typical Operating Circuit

1.2 Ordering Information

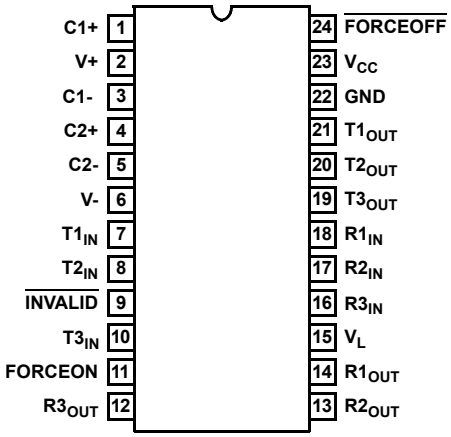
Part Number (Notes 2, 3)	Part Marking	Temp. Range (°C)	Tape and Reel (Units) (Note 1)	Package (RoHS Compliant)	Pkg. Dwg. #.
ISL83387EIVZ	83387EIVZ	-40 to 85	-	24 Ld TSSOP	M24.173
ISL83387EIVZ-T	83387EIVZ	-40 to 85	2.5k	24 Ld TSSOP	M24.173

Notes:

1. See TB347 for details about reel specifications.
2. Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are 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 ISL83387E device page. For more information about MSL, see TB363.

1.3 Pin Configuration

TSSOP
Top View



1.4 Pin Descriptions

Pin Name	Function
V_{CC}	System power supply input (3.0V to 5.5V).
V+	Internally generated positive transmitter supply (+5.5V).
V-	Internally generated negative transmitter supply (-5.5V).
GND	Ground connection.
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.
T_{IN}	TTL/CMOS compatible transmitter Inputs. The switching point is a function of the V_L voltage.
T_{OUT}	±15kV ESD Protected, RS-232 level (nominally ±5.5V) transmitter outputs.
R_{IN}	±15kV ESD Protected, RS-232 compatible receiver inputs.
R_{OUT}	TTL/CMOS level receiver outputs. Swings between GND and V_L.
V_L	Logic-Level Supply. All TTL/CMOS inputs and outputs are powered by this supply.
$\overline{\text{INVALID}}$	Active low output that indicates if no valid RS-232 levels are present on any receiver input. Swings between GND and V_L.
$\overline{\text{FORCEOFF}}$	Active low to shut down transmitters and on-chip power supply that overrides any automatic circuitry and FORCEON (see Table 5 on page 11). The switching point is a function of the V_L voltage.
FORCEON	Active high input to override automatic powerdown circuitry, which keeps transmitters active. ($\overline{\text{FORCEOFF}}$ must be high). The switching point is a function of the V_L voltage.

2. Specifications

2.1 Absolute Maximum Ratings

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

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, Note 4)	θ_{JA} (°C/W)
24 Ld TSSOP Package	140

Note:
4. θ_{JA} is measured with the component mounted on a low-effective thermal conductivity test board in free air. See TB379.

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 - C_4 = 0.1µF, V_L = V_{CC}; unless otherwise specified. Typicals are at T_A = 25°C, V_{CC} = V_L = 3.3V

Parameter	Test Conditions	Temp (°C)	Min	Typ	Max	Unit
DC Characteristics						
Supply Current, Automatic Power-Down	All R_{IN} Open, FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}	25	-	1	10	µA
Supply Current, Powerdown	$\overline{FORCEOFF}$ = GND	25	-	1	10	µA

Test conditions: V_{CC} = 3V to 5.5V, C_1 - C_4 = 0.1µF, V_L = V_{CC}; unless otherwise specified. Typicals are at T_A = 25°C, V_{CC} = V_L = 3.3V

Parameter	Test Conditions		Temp (°C)	Min	Typ	Max	Unit
Supply Current, Automatic Power-Down Disabled	All Outputs Unloaded, FORCEON = $\overline{\text{FORCEOFF}}$ = V_{CC}, V_{CC} = 3.15V		25	-	0.3	1	mA
Logic and Transmitter Inputs							
Input Logic Threshold Low	T_{IN}, FORCEON, $\overline{\text{FORCEOFF}}$	V_L = 3.3V or 5V	Full	-	-	0.8	V
		V_L = 2.5V	Full	-	-	0.6	V
Input Logic Threshold High	T_{IN}, FORCEON, $\overline{\text{FORCEOFF}}$	V_L = 5V	Full	2.4	-	-	V
		V_L = 3.3V	Full	2.0	-	-	V
		V_L = 2.5V	Full	1.4	-	-	V
		V_L = 1.8V	25	-	0.9	-	V
Transmitter Input Hysteresis			25	-	0.5	-	V
Input Leakage Current	T_{IN}, FORCEON, $\overline{\text{FORCEOFF}}$		Full	-	±0.01	±1.0	µA
Receiver Outputs							
Output Voltage Low	I_{OUT} = 1.6mA		Full	-	-	0.4	V
Output Voltage High	I_{OUT} = -1.0mA		Full	V_L - 0.6	V_L - 0.1	-	V
Receiver Inputs							
Input Voltage Range			Full	-25	-	25	V
Input Threshold Low	V_{CC} = V_L = 5.0V		25	0.8	1.5	-	V
	V_{CC} = V_L = 3.3V		25	0.6	1.2	-	V
Input Threshold High	V_{CC} = V_L = 5.0V		25	-	1.8	2.4	V
	V_{CC} = V_L = 3.3V		25	-	1.5	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	V_{OUT} = 0V		Full	-	±35	±60	mA
Output Leakage Current	V_{OUT} = ±12V, V_{CC} = 0V or 3V to 5.5V Automatic Powerdown or $\overline{\text{FORCEOFF}}$ = GND		Full	-	-	±25	µA
Enhanced Automatic Powerdown (FORCEON = GND, $\overline{\text{FORCEOFF}}$ = V_{CC})							
$\overline{\text{Receiver}}$ Input Thresholds to $\overline{\text{INVALID}}$ High	See Figure 10		Full	-2.7	-	2.7	V
$\overline{\text{Receiver}}$ Input Thresholds to $\overline{\text{INVALID}}$ Low	See Figure 10		Full	-0.3	-	0.3	V
$\overline{\text{INVALID}}$ Output Voltage Low	I_{OUT} = 1.6mA		Full	-	-	0.4	V
$\overline{\text{INVALID}}$ Output Voltage High	I_{OUT} = -1.0mA		Full	V_L - 0.6	-	-	V
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ High Delay (t_{INVH})	See Figure 13		25	-	1	-	µs
Receiver Positive or Negative Threshold to $\overline{\text{INVALID}}$ Low Delay (t_{INVL})	See Figure 13		25	-	30	-	µs
Receiver or Transmitter Edge to Transmitters Enabled Delay (t_{WU})	Note 5, see Figure 13		25	-	100	-	µs

Test conditions: V_{CC} = 3V to 5.5V, C_1 - C_4 = 0.1µF, V_L = V_{CC}; unless otherwise specified. Typicals are at T_A = 25°C, V_{CC} = V_L = 3.3V

Parameter	Test Conditions		Temp (°C)	Min	Typ	Max	Unit
Receiver or Transmitter Edge to Transmitters Disabled Delay ($t_{AUTOPWDN}$)	Note 5, see Figure 13		Full	15	30	60	sec
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
Time to Exit Powerdown	T_X | V_{OUT} | ≥ 3.7V		25	-	100	-	µs
Transmitter Skew	t_{PHL} - t_{PLH}		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 1000pF	25	6	18	30	V/µs
		C_L = 150pF to 2500pF	25	4	13	30	V/µs
ESD Performance							
RS-232 Pins (T_{OUT}, R_{IN})	Human Body Model		25	-	±15	-	kV
	IEC61000-4-2 Air Gap Discharge		25	-	±15	-	kV
	IEC61000-4-2 Contact Discharge		25	-	±8	-	kV

Note:

5. An “edge” is defined as a transition through the transmitter or receiver input thresholds.

3. Typical Performance Curves

V_{CC} = V_L = 3.3V, T_A = 25°C

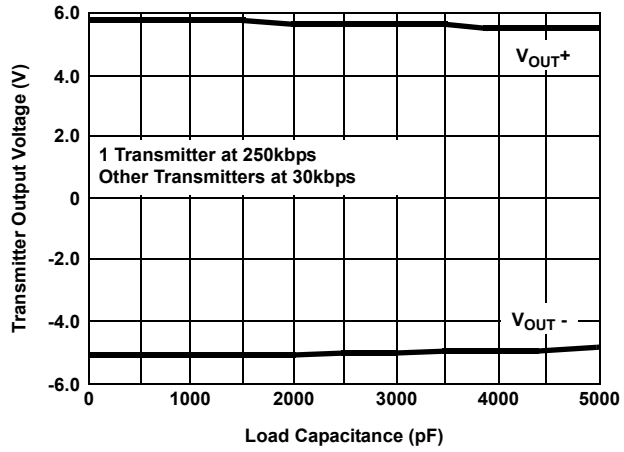


Figure 2. Transmitter Output Voltage vs Load Capacitance

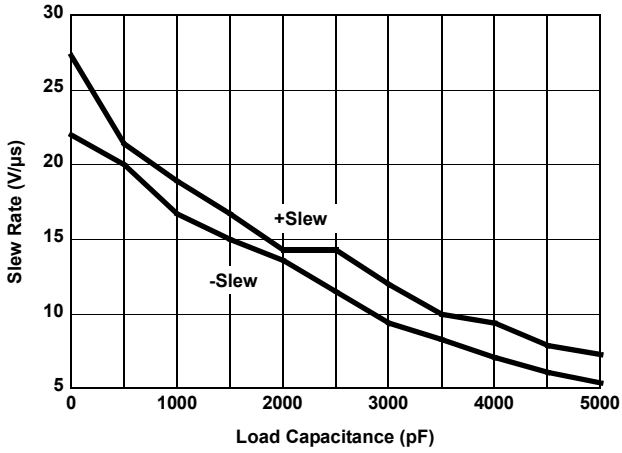


Figure 3. Slew Rate vs Load Capacitance

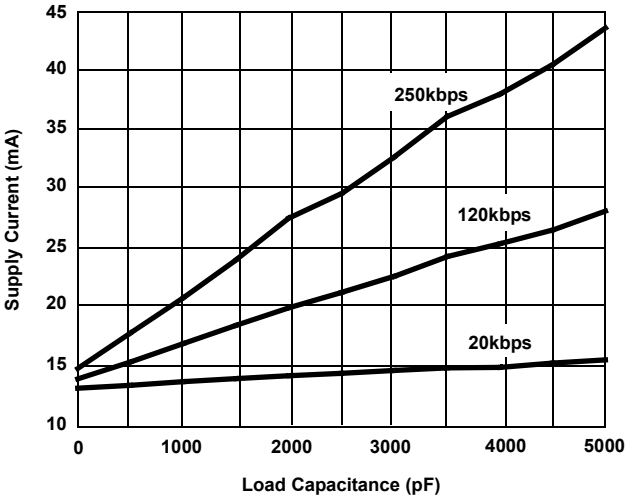


Figure 4. Supply Current vs Load Capacitance When Transmitting Data

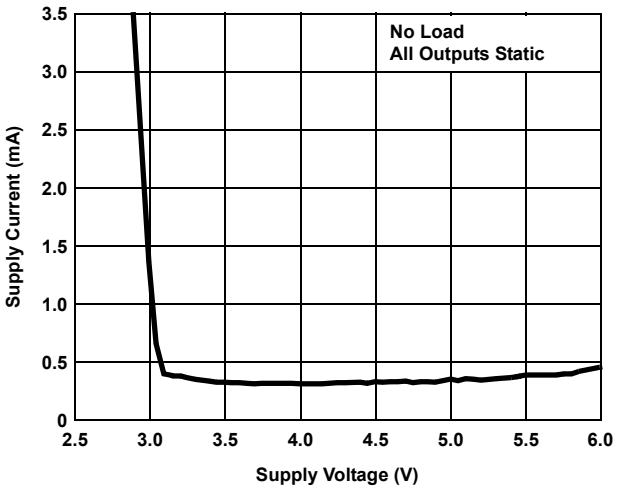


Figure 5. Supply Current vs Supply Voltage

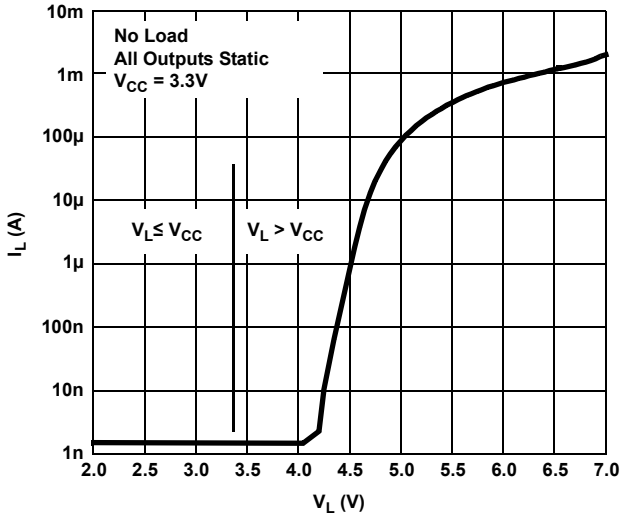


Figure 6. V_L Supply Current vs V_L Voltage

4. Application Information

The ISL83387E operates from a single +3V to +5.5V supply, ensures a 250kbps minimum data rate, requires only four small external 0.1µF capacitors, features low power consumption, and meets all EIA RS-232C and V.28 specifications.

4.1 Charge-Pump

The ISL83387E uses 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. The charge-pumps allow the device 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 over the full V_{CC} range. See "Capacitor Selection" on page 15 and Table 6 on page 15 for capacitor recommendations for other operating conditions. The charge-pumps operate discontinuously (turning off when the V+ and V- supplies are pumped up to the nominal values), providing 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 10). 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 couple with the on-chip ±5.5V supplies to deliver true RS-232 levels across a wide range of single supply system voltages.

All transmitter outputs disable and assume a high impedance state when the device enters the powerdown mode (see Table 5 on page 11). The outputs can be driven to ±12V when disabled.

The ISL83387E ensures 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 1.25Mbps.

The transmitter input threshold is set by the voltage applied to the V_L supply pin. Transmitter inputs float if they remain unconnected (there are no pull-up resistors), and they can cause I_{CC} increases. Connect unused inputs to GND for best performance.

4.3 Receivers

The ISL83387E contains standard inverting receivers that 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 7) 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. Receiver outputs swing from GND to V_L and do not tristate in powerdown (see Table 5).

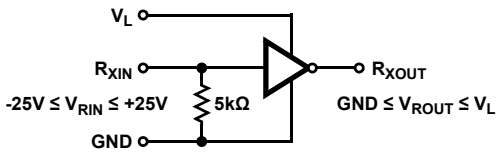


Figure 7. Receiver Connections

4.4 Low Power Operation

During normal operation (not in powerdown mode), this 3V device requires a nominal supply current of 0.3mA, even at V_{CC} = 5.5V. This current is considerably less than the 11mA current required by comparable 5V RS-232 devices, and it allows you to reduce system power simply by replacing the old style device with the ISL83387E in new designs.

4.5 Powerdown Functionality

The already low current requirement drops significantly when the device enters powerdown mode. In power-down, the supply current drops to 1µA, because the on-chip charge-pump turns off (V+ collapses to V_{CC}, V- collapses to GND) and the transmitter outputs tri-state. This micro-power mode makes the device ideal for battery powered and portable applications.

4.5.1 Software Controlled (Manual) Powerdown

The ISL83387E allows you to force the IC into the low power standby state and uses 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.

Table 5. Powerdown Logic Truth Table

RCVR or XMTR Edge Within 30 Sec?	$\overline{\text{FORCEOFF}}$ Input	FORCEON Input	Transmitter Outputs	Receiver Outputs	RS-232 Level Present at Receiver Input?	$\overline{\text{INVALID}}$ Output	Mode Of Operation
NO	H	H	Active	Active	NO	L	Normal Operation (Enhanced Auto Powerdown Disabled)
NO	H	H	Active	Active	YES	H	
YES	H	L	Active	Active	NO	L	Normal Operation (Enhanced Auto Powerdown Enabled)
YES	H	L	Active	Active	YES	H	
NO	H	L	High-Z	Active	NO	L	Powerdown Due to Enhanced Auto Powerdown Logic
NO	H	L	High-Z	Active	YES	H	
X	L	X	High-Z	Active	NO	L	Manual Powerdown
X	L	X	High-Z	Active	YES	H	
$\overline{\text{INVALID}}$ Driving FORCEON and $\overline{\text{FORCEOFF}}$ (Emulates Automatic Powerdown)							
X	NOTE 3	NOTE 3	Active	Active	YES	H	Normal Operation
X	NOTE 3	NOTE 3	High-Z	Active	NO	L	Forced Auto Powerdown

Notes:
6. Input is connected to $\overline{\text{INVALID}}$ Output.

Connecting $\overline{\text{FORCEOFF}}$ and FORCEON together disables the enhanced automatic powerdown feature, enabling them to function as a manual $\overline{\text{SHUTDOWN}}$ input (see Figure 8).

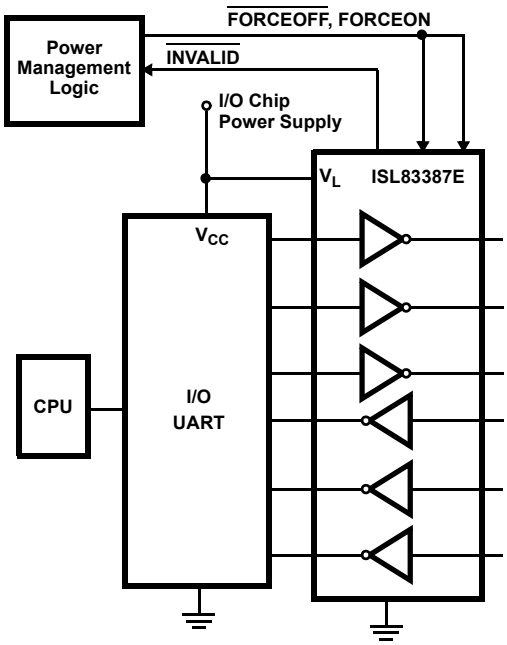


Figure 8. Connections for Manual Powerdown

With any of the control schemes, the time required to exit powerdown, and resume transmission is only 100µs.

When using both manual and enhanced automatic power-down (FORCEON = 0), the ISL83387E does not power up from manual powerdown until both $\overline{\text{FORCEOFF}}$ and FORCEON are driven high, or until a transition occurs on a receiver or transmitter input. Figure 9 shows a circuit for ensuring that the ISL83387E powers up as soon as $\overline{\text{FORCEOFF}}$ switches high. The rising edge of the master powerdown signal forces the device to power up, and the ISL83387E returns to enhanced automatic powerdown mode an RC time constant after this rising edge. The time constant isn't critical, because the ISL83387E remains powered up for 30 seconds after the FORCEON falling edge, even if there are no signal transitions. The delay gives the slow-to-wake systems (such as a mouse) plenty of time to start transmitting, and as long as it starts transmitting within 30 seconds both systems remain enabled.

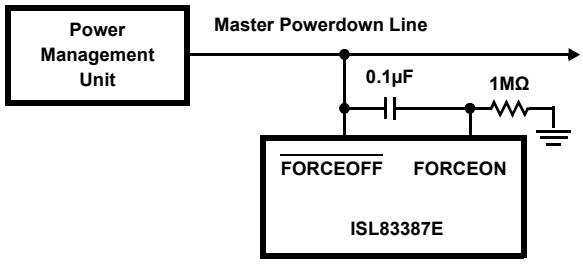


Figure 9. Circuit to Ensure Immediate Power Up When Exiting Forced Powerdown

4.5.2 $\overline{\text{INVALID}}$ Output

The $\overline{\text{INVALID}}$ output always indicates (see Table 5 on page 11) whether 30µs have elapsed with invalid RS-232 signals (see Figures 10 and 13) persisting on all of the receiver inputs, and it provides 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. If an interface cable is disconnected and 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 power down 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 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 power-down circuitry.

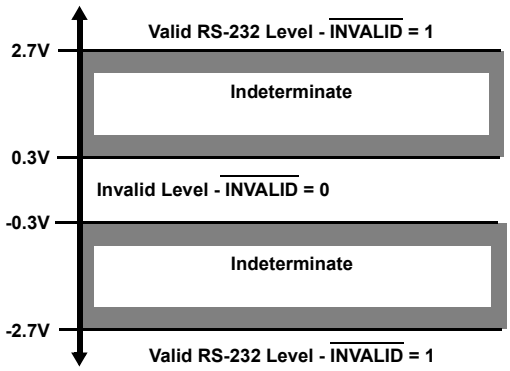


Figure 10. Definition of Valid RS-232 Receiver Levels

4.5.3 Enhanced Automatic Powerdown

Even greater power savings are available by using the enhanced automatic powerdown function. When the enhanced powerdown logic determines that no transitions have occurred on any of the transmitter nor receiver inputs for 30 seconds, the charge-pump and transmitters power-down and reduce the supply current to 1µA. The ISL83387E automatically powers back up whenever it detects a transition on one of these inputs. This automatic powerdown feature provides additional system power savings without changes to the existing operating system.

Enhanced 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 using the overriding $\overline{\text{FORCEOFF}}$ input. Table 5 summarizes the enhanced automatic powerdown functionality.

Figure 11 illustrates the enhanced powerdown control logic. Note: When the ISL83387E enters powerdown (manually or automatically), the 30 second timer remains timed out (set), keeping the ISL83387E powered down until FORCEON transitions high, or until a transition occurs on a receiver or transmitter input.

The $\overline{\text{INVALID}}$ output switches low whenever invalid levels have persisted on all of the receiver inputs for more than 30µs (see Figure 13 on page 14), but this has no direct effect on the state of the ISL83387E (see the next sections for methods of using $\overline{\text{INVALID}}$ to power down the device).

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

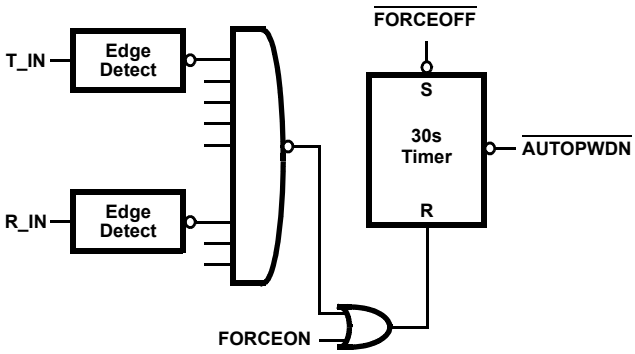


Figure 11. Enhanced Automatic Powerdown Logic

4.5.4 Emulating Standard Automatic Powerdown

If enhanced automatic powerdown is not required, you can implement the standard automatic powerdown feature (mimics the function on the ICL3221E/23E/43E) by connecting the $\overline{\text{INVALID}}$ output to the FORCEON and $\overline{\text{FORCEOFF}}$ inputs, as shown in Figure 12.

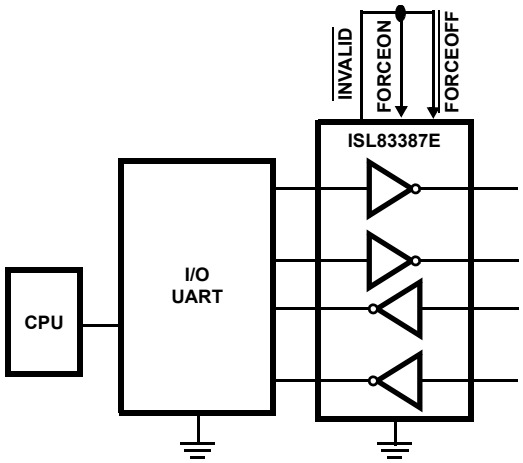


Figure 12. Connections for Automatic Powerdown when no Valid Receiver Signals Are Present

After 30µs of invalid receiver levels, $\overline{\text{INVALID}}$ switches low and drives the ISL83387E into a forced powerdown condition. $\overline{\text{INVALID}}$ switches high as soon as a receiver input senses a valid

RS-232 level, forcing the ISL83387E to power on. See the "$\overline{\text{INVALID}}$ Driving FORCEON and $\overline{\text{FORCEOFF}}$" section of Table 5 on page 11 for an operational summary. This operational mode is perfect for handheld devices that communicate with another computer using a detachable cable. Detaching the cable allows the internal receiver pull-down resistors to pull the inputs to GND (an invalid RS-232 level), causing the 30µs timer to time-out and drive the IC into powerdown. Reconnecting the cable restores valid levels, causing the IC to power back up.

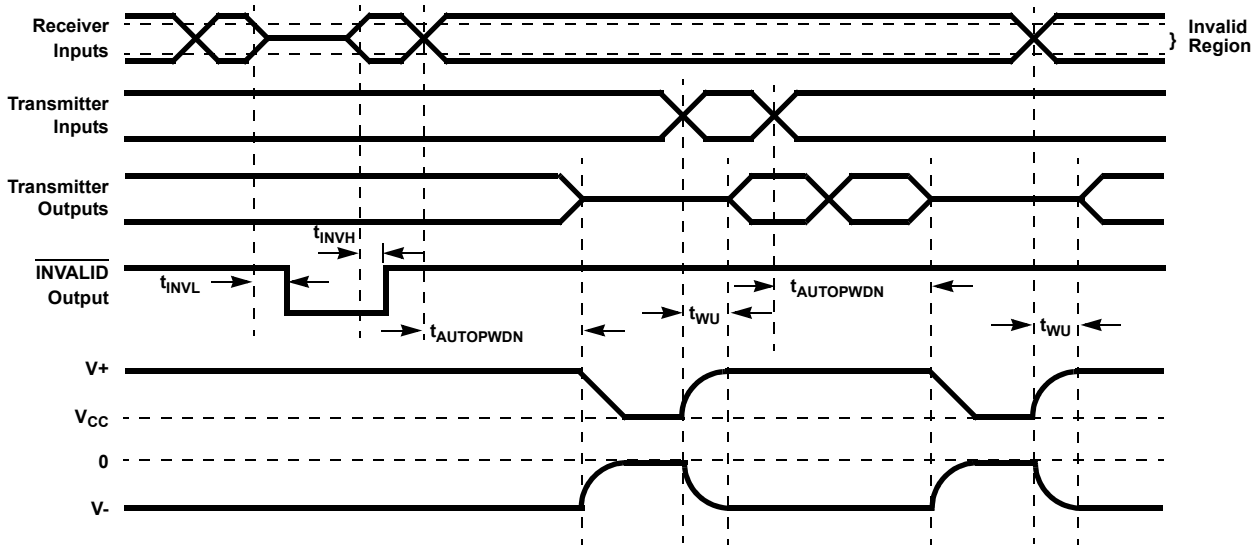


Figure 13. Enhanced Automatic Powerdown and $\overline{\text{INVALID}}$ Timing Diagrams

4.5.5 Hybrid Automatic Powerdown Options

For devices that communicate only through a detachable cable, $\overline{\text{INVALID}}$ can be connected to $\overline{\text{FORCEOFF}}$ (with FORCEON = 0). While the cable is attached, $\overline{\text{INVALID}}$ and $\overline{\text{FORCEOFF}}$ remain high, so the enhanced automatic powerdown logic powers down the ISL83387E whenever there is 30 seconds of inactivity on the receiver and transmitter inputs. Detaching the cable allows the receiver inputs to drop to an invalid level (GND), so $\overline{\text{INVALID}}$ switches low and forces the ISL83387E to power down. The ISL83387E remains powered down until the cable is reconnected ($\overline{\text{INVALID}}$ = $\overline{\text{FORCEOFF}}$ = 1), and a transition occurs on a receiver or transmitter input (see Figure 11). For immediate power up when the cable is reattached, connect FORCEON to $\overline{\text{FORCEOFF}}$ through a network similar to that shown in Figure 9 on page 12.

4.6 V_L Logic Supply Input

Unlike other RS-232 interface devices where the CMOS outputs swing between 0 and V_{CC}, the ISL83387E features a separate logic supply input (V_L; 1.8V to 5V, regardless of V_{CC}) that sets V_{OH} for the receiver and $\overline{\text{INVALID}}$ outputs. Connecting V_L to a host logic supply lower than V_{CC}, prevents the ISL83387E outputs from forward biasing the input diodes of a logic device powered by that lower supply. Connecting V_L to a logic supply greater than V_{CC} ensures that the receiver and $\overline{\text{INVALID}}$ output levels are compatible even with the CMOS input V_{IH} of AC, HC, and CD4000 devices. Note: The V_L supply current increases to 100µA with V_L = 5V and V_{CC} = 3.3V (see Figure 6). V_L also powers the transmitter and logic inputs, thereby setting their switching thresholds to levels compatible with the logic supply. This separate logic supply pin allows a great deal of flexibility in interfacing to systems with different logic supplies. If logic translation is not required, connect V_L to the ISL83387E V_{CC}.

4.7 Capacitor Selection

The ISL83387E charge-pumps require only 0.1µF capacitors for the full operational voltage range. Table 6 lists other acceptable capacitor values for various supply voltage ranges. Do not use values smaller than those listed in Table 6. Increasing the capacitor values (by a factor of 2) reduces ripple on the transmitter outputs and slightly reduces power consumption.

Table 6. Required Capacitor Values

V_{CC} (V)	C_1 (µF)	C_2, C_3, C_4 (µF)
3.0 to 3.6	0.1	0.1
4.5 to 5.5	0.047	0.33
3.0 to 5.5	0.22	1

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-.

4.8 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.

4.9 Transmitter Outputs when Exiting Power-Down

Figure 14 shows the response of two transmitter outputs when exiting powerdown mode. As the transmitter outputs activate, they properly go to opposite RS-232 levels, with no glitching, ringing, nor undesirable transients. Each transmitter is loaded with 3kΩ in parallel with 2500pF. Note that the transmitters enable only when the magnitude of the supplies exceed approximately 3V.

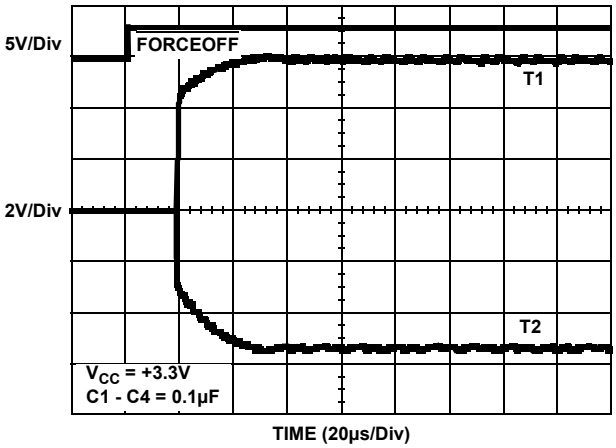


Figure 14. Transmitter Outputs when Exiting Powerdown

4.10 High Data Rates

The ISL83387E maintains the RS-232 ±5V minimum transmitter output voltages even at high data rates. Figure 15 shows a transmitter loopback test circuit, and Figure 16 on page 17 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 17 on page 17 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.

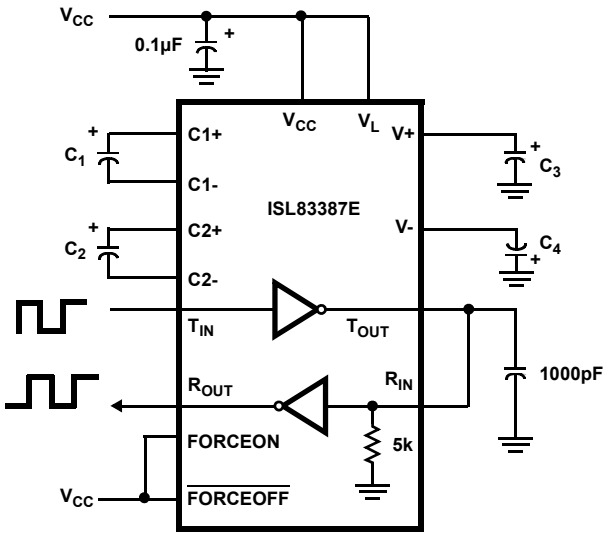


Figure 15. Transmitter Loopback Test Circuit

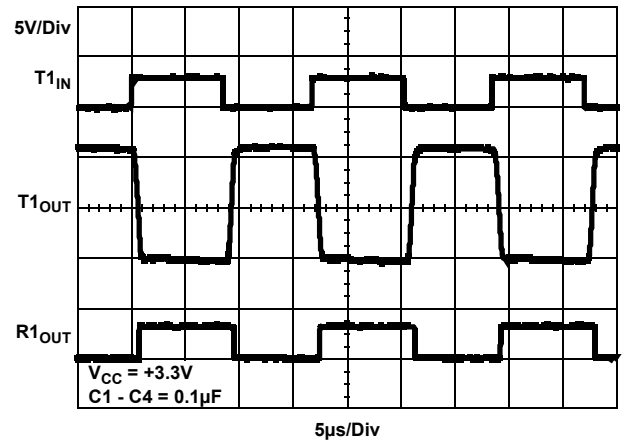


Figure 16. Loopback Test at 120kbps

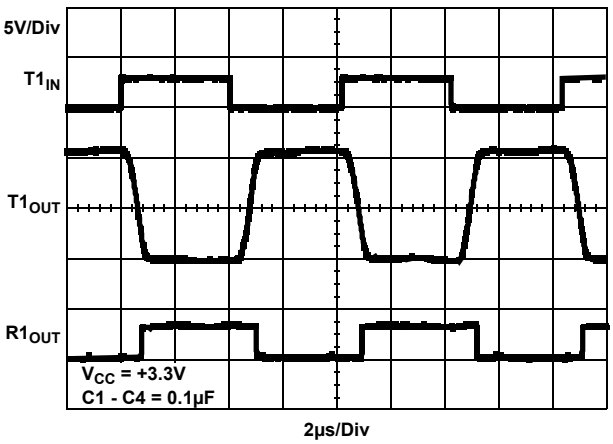


Figure 17. Loopback Test at 250kbps

4.11 Interconnection with 3V and 5V Logic

Standard 3.3V powered RS-232 devices interface well with 3V and 5V powered TTL compatible logic families (such as ACT and HCT), but the logic outputs (for example, R_{OUTS}) fail to reach the V_{IH} level of 5V powered CMOS families like HC, AC, and CD4000. The ISL83387E V_L supply pin solves this problem. By connecting V_L to the same supply (1.8V to 5V) powering the logic device, the ISL83387E logic outputs swing from GND to the logic V_{CC}.

5. ±15kV ESD Protection

All pins on the 3V interface devices include ESD protection structures, but the ISL83387E incorporates advanced structures that allow the RS-232 pins (transmitter outputs and receiver inputs) 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 latch-up 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 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 meets Level 4 criteria without the need for additional board level protection on the RS-232 port.

5.2.1 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.

5.2.2 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 Potential (Powered Up)	GND
Transistor Count	1063
Process	Si Gate CMOS

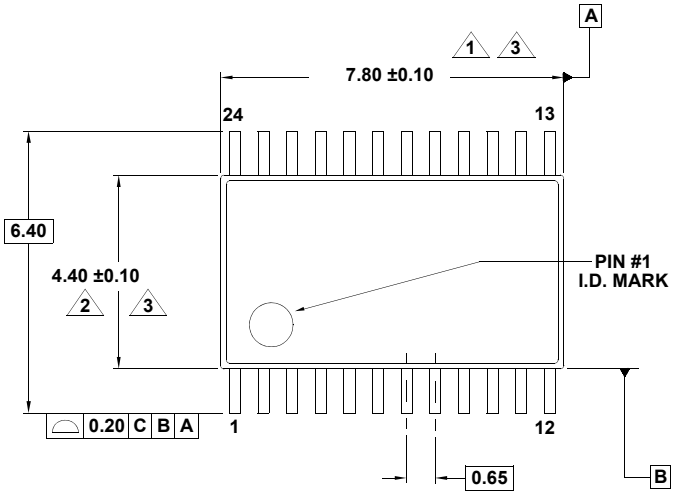
7. Revision History

Rev.	Date	Description
2.00	Apr.19.19	Applied new format. Updated Links throughout document. Updated Ordering Information table by removing retired parts and updating notes. Added “Charge-Pump Abs Max Ratings” on page 9. Added Revision History Updated package outline drawing M28.173 from revision 0 to revision 1. Convert to new POD format by moving dimensions from table onto drawing and adding land pattern. No dimension changes. Updated Disclaimer.

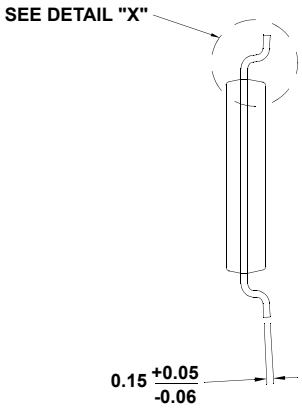
8. Package Outline Drawing

For the most recent package outline drawing, see M24.173.

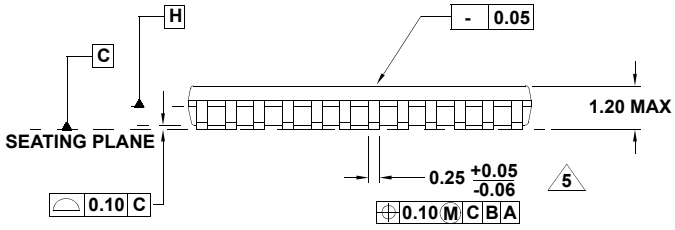
M24.173
24 LEAD THIN SHRINK SMALL OUTLINE PACKAGE (TSSOP)
Rev 1, 5/10



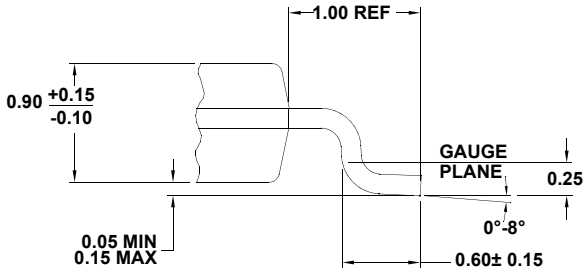
TOP VIEW



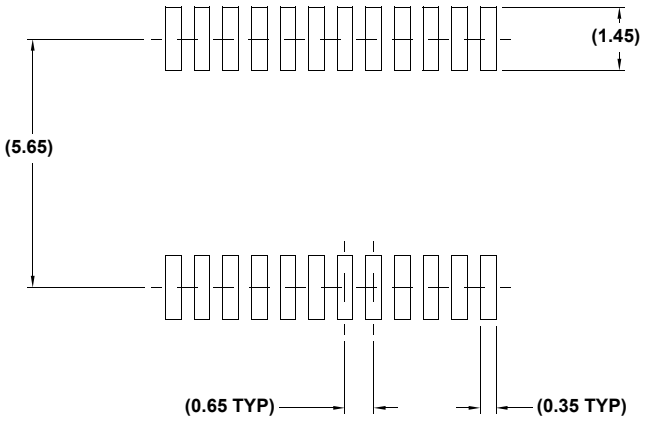
END VIEW



SIDE VIEW



DETAIL "X"



TYPICAL RECOMMENDED LAND PATTERN

NOTES:

1. Dimension does not include mold flash, protrusions or gate burrs. Mold flash, protrusions or gate burrs shall not exceed 0.15 per side.
2. Dimension does not include interlead flash or protrusion. Interlead flash or protrusion shall not exceed 0.25 per side.
3. Dimensions are measured at datum plane H.
4. Dimensioning and tolerancing per ASME Y14.5M-1994.
5. Dimension does not include dambar protrusion. Allowable protrusion shall be 0.08mm total in excess of dimension at maximum material condition. Minimum space between protrusion and adjacent lead is 0.07mm.
6. Dimension in ( ) are for reference only.
7. Conforms to JEDEC MO-153.

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