3V to +5.5V, 250k-1Mbps, RS-232 Transmitters/Receivers

Application Note | April 2003 | AN9863.9

Introduction

The newest additions to the Intersil RS-232 Interface Product portfolios are the ICL32XX, ISL42XX and ISL8XXX families. These devices all operate from a single 3.0V to 5.5V supply using four 0.1µF capacitors, and generate ±5V transmitter output levels at a minimum 250kbps data rate. Features include various driver and receiver combinations, speed grades (up to a guaranteed 1Mbps) and packaging styles (including QFN and TSSOP), as well as manual and automatic powerdown and high ESD protection options.

Devices with similar key features are categorized together below, and Table 1 summarizes the features of each IC. Note that the “E” suffix identifies the high ESD devices.

ICL3207, ICL3232 - Basic 250kbps Transceivers. Low power, high speed upgrades for existing ‘202/’232 and ‘207/’237 applications. These devices are drop-in compatible with most existing 5V applications.

ICL3207E, ICL3232E - ±15kV ESD-Protected, 250kbps Transceivers. Low power, high speed upgrades for existing ‘202E/’232E and ‘207E/’237E applications. These devices are drop-in compatible with most existing 5V applications.

ICL3221, ICL3223 - 1µA powerdown, 250kbps Transceivers with automatic powerdown feature. Receivers controlled by a separate enable pin.

ICL3221E, ICL3223E - ±15kV ESD-Protected, 1µA powerdown, 250kbps Transceivers with automatic powerdown feature. Receivers controlled by a separate enable pin.

ICL3222, ICL3241 - 1µA powerdown, 250kbps Transceivers with manual powerdown feature. Receivers controlled by a separate enable pin.

ICL3222E, ICL3241E - ±15kV ESD-Protected, 1µA powerdown, 250kbps Transceivers with manual powerdown feature. Receivers controlled by a separate enable pin.

ICL3224, ICL3226, ICL3238, ICL3244 - 1µA powerdown, 250kbps Transceivers with enhanced automatic powerdown feature, and flow through pinout (ICL3238 only).

ICL3224E, ICL3226E, ICL3238E, ICL3244E, ISL83387E - ±15kV ESD-Protected, 1µA powerdown (10nA, ICL3238E), 250kbps Transceivers with enhanced automatic powerdown feature, and flow through pinout (ICL3238E only). ISL83387E features a V_L supply pin to define logic levels of CMOS inputs and outputs.

ICL3225, ICL3227, ICL3245 - 1µA powerdown, 1Mbps Transceivers with enhanced automatic powerdown feature.

ICL3225E, ICL3227E, ICL3245E - ±15kV ESD-Protected, 1µA powerdown, 1Mbps Transceivers with enhanced automatic powerdown feature.

ICL3237 - 1µA powerdown, 250k/1000kbps Transceivers with manual powerdown, baud rate select (MBAUD pin) features, and flow through pinout. Receivers controlled by a separate enable pin.

ICL3237E - ±15kV ESD-Protected, 10nA powerdown, 250k/1000kbps Transceivers with manual powerdown, baud rate select (MBAUD pin) features, and flow through pinout. Receivers controlled by a separate enable pin.

ICL3243 - 1µA powerdown, 250kbps Transceivers with automatic powerdown feature.

ICL3243E - ±15kV ESD-Protected, 1µA powerdown, 250kbps Transceivers with automatic powerdown feature.

ICL3310 - 1µA powerdown, 250kbps Transceivers. Single SHDN pin powers down part and disables Tx and Rx outputs.

ICL3310E, ISL83239E, ISL83384E, ISL83386E - ±15kV ESD-Protected, 1µA powerdown (10nA, ISL83239E), 250kbps Transceivers. Single SHDN pin powers down part and disables Tx and Rx outputs. ISL83386E features a V_L supply pin to define logic levels of CMOS inputs and outputs.

ISL83220E, ISL83385E - ±15kV ESD-Protected, 1µA powerdown, 250kbps Transceivers with manual powerdown and active receivers during powerdown. ISL83220E receivers can be disabled via a separate enable pin.

ISL8563 - 1µA powerdown, 250kbps Transceivers with manual powerdown. RS-562/RS-232 dual compatibility with SHDN gated pull-up devices on Tx inputs. Receivers controlled by a separate enable pin.

ISL8563E - ±15kV ESD-Protected, 1µA powerdown, 250kbps Transceivers with manual powerdown. RS-562/RS-232 dual compatibility with SHDN gated pull-up devices on Tx inputs. Receivers controlled by a separate enable pin.

ISL4238E, ISL4241E, ISL4243E, ISL4244E, ISL4245E - ±15kV ESD-Protected, 10nA powerdown, Quad Flat No-Lead (QFN) versions of the ICL3238E and ICL324XE.

ISL4221E, ISL4223E, ISL4260E, ISL4270E - ±15kV ESD-Protected, 300nA powerdown, Quad Flat No-Lead (QFN) versions of the ICL3221E, ICL3223E, ISL83386E and ISL83387E.

TABLE 1. SUMMARY OF FEATURES (See “Feature Descriptions” Section)

PART NUMBER	NO. OF Tx. / Rx.	V_L SUPPLY PIN?	QFN PKG.	NO. OF MONITOR Rx. (R_{OUTB})	DATA RATE (kbps)	POWER-DOWN I_{CC} (µA)	Rx. ENABLE FUNCTION?	READY OUTPUT?	MANUAL POWER-DOWN?	AUTOMATIC POWERDOWN FUNCTION?
ICL3207/E	5 / 3	-	-	0	250	-	NO	NO	NO	NO
ICL3217/E	5 / 3	-	-	0	250	1	NO	NO	NO	YES
ICL3221/E	1 / 1	-	-	0	250	1	YES	NO	YES	YES
ICL3222/E	2 / 2	-	-	0	250	1	YES	NO	YES	NO
ICL3223/E	2 / 2	-	-	0	250	1	YES	NO	YES	YES
ICL3224/E	2 / 2	-	-	0	250	1	NO	YES	YES	ENHANCED
ICL3225/E	2 / 2	-	-	0	1000	1	NO	YES	YES	ENHANCED
ICL3226/E	1 / 1	-	-	0	250	1	NO	YES	YES	ENHANCED
ICL3227/E	1 / 1	-	-	0	1000	1	NO	YES	YES	ENHANCED
ICL3232/E	2 / 2	-	-	0	250	-	NO	NO	NO	NO
ICL3237/E	5 / 3	-	-	1	250/1000 (Note 1)	1/ 0.01	YES	NO	YES	NO
ICL3238/E	5 / 3	-	-	1	250	1/ 0.01	NO	NO	YES	ENHANCED
ICL3241/E	3 / 5	-	-	2	250	1	YES	NO	YES	NO
ICL3243/E	3 / 5	-	-	1	250	1	NO	NO	YES	YES
ICL3244/E	3 / 5	-	-	1	250	1	NO	NO	YES	ENHANCED
ICL3245/E	3 / 5	-	-	1	1000	1	NO	NO	YES	ENHANCED
ICL3310/E	2 / 2	-	-	0	250	1	NO	NO	YES	NO
ISL4221E	1 / 1	-	5mmx5mm	0	250	0.15	YES	NO	YES	YES
ISL4223E	2 / 2	-	5mmx5mm	0	250	0.15	YES	NO	YES	YES
ISL4238E	5 / 3	-	5mmx5mm	1	250	0.01	NO	NO	YES	ENHANCED
ISL4241E	3 / 5	-	5mmx5mm	2	250	0.01	YES	NO	YES	NO
ISL4243E	3 / 5	-	5mmx5mm	1	250	0.01	NO	NO	YES	YES
ISL4244E	3 / 5	-	5mmx5mm	1	250	0.01	NO	NO	YES	ENHANCED
ISL4245E	3 / 5	-	5mmx5mm	1	1000	0.01	NO	NO	YES	ENHANCED
ISL4260E	3 / 2	YES	5mmx5mm	0	250	0.3	NO	NO	YES	NO
ISL4270E	3 / 3	YES	5mmx5mm	0	250	0.3	NO	NO	YES	ENHANCED
ISL83220E	1 / 1	-	-	0	250	1	YES	NO	YES	NO
ISL83239E	5 / 3	-	-	1	250	0.01	NO	NO	YES	NO
ISL83384E	2 / 2	-	-	0	250	1	NO	NO	YES	NO
ISL83385E	2 / 2	-	-	0	250	1	NO	NO	YES	NO
ISL83386E	3 / 2	YES	-	0	250	1	NO	NO	YES	NO
ISL83387E	3 / 3	YES	-	0	250	1	NO	NO	YES	ENHANCED
ISL8563/E	2 / 2	-	-	0	250	1	YES	NO	YES	NO

NOTE:

1. Features a MBAUD pin for high/low baud rate selection.

General Description

RS-232 Background

The Electronics Industries Association (EIA) along with AT&T and independent modem manufacturers developed the RS-232 interface standard. This standard defines a single-ended, serial connection between two computing devices. The standard is designed to meet the need for a simple, low cost interface solution. An RS-232 interface is simple to implement, well understood, and it works!

The Electronics Industry Association (EIA) is an industry group, based in Washington, D.C., which recommends and publicizes standards related to electronic components and communications. EIA recommended standard number 232, was initially called the “Interface between Data Terminal

Equipment and Data Communications Equipment Employing Serial Binary Data Interchange".

Essentially, the RS-232 link is comprised of a transmitter on one end and a receiver on the other. The RS-232 transmitter converts TTL/CMOS levels to the necessary RS-232 voltages (-5V to -25V and +5V to +25V). Similarly, the RS-232 receivers convert the RS-232 voltages back to TTL/CMOS levels.

3.0V to 5.5V Single Supply Operation

Intersil's new RS-232 family utilizes an on-chip charge pump, voltage doubler, and voltage inverter to generate ±5.5V transmitter supplies from a V_{CC} supply as low as 3.0V. A proprietary, low dropout transmitter circuit, coupled with these ±5.5V supplies, delivers true RS-232 levels over a wide range (3.0V - 5.5V) of single supply system voltages. The efficient on-chip power supplies require only four small, external 0.1µF capacitors for the voltage doubler and inverter functions. The wide supply range allows this family to be used as a lower power, enhanced performance choice for 5V systems, or as the perfect fit for 3.3V and battery powered systems.

High Speed

This family of RS-232 interface devices operates at speeds up to 1Mbps. All devices in the family are guaranteed to operate at a minimum of 250kbps. The guaranteed data rate of 250kbps is for full load conditions (3kΩ and 1000pF), $V_{CC} \geq 3.0V$, with one transmitter operating at full speed. Under more typical conditions of $V_{CC} \geq 3.3V$, $R_L = 3k\Omega$, and $C_L = 250pF$, the transmitters easily operate at 1Mbps.

The ICL3225/E, ICL3227/E, ICL3237/E and ICL3245/E are the highest baud rate devices, and are guaranteed to operate a single transmitter at a minimum of 1Mbps with $V_{CC} \geq 3.0V$, $R_L = 3k\Omega$, and $C_L = 250pF$ (or with $C_L = 1000pF$ if $V_{CC} \geq 4.5V$). In order to achieve this 1Mbps data rate, the transition-region slew rate is specified at 24V/µs - 150V/µs.

Lower Power

This 3V family of RS-232 interface devices requires a nominal supply current of 0.3mA during normal operation (not in powerdown mode). This is considerably less than the 5mA to 11mA current required of 5V RS-232 devices. The already low current requirement drops significantly when the device enters powerdown mode. Typical supply current in powerdown is less than 1µA, but several devices (ISL42XXE, ICL3237E, ICL3238E, ISL83239E) have a typical powerdown I_{CC} of 10nA. Low power consumption is critically important in many battery powered and portable applications

This combination of low power, high data rate, and 3V operation, provides the user with the total solution for state-of-the-art, high speed, low power portable and laptop applications.

Low Power, Pin Compatible 5V Replacements

Several devices in this family offer pin compatible replacement of existing 5V devices. Table 2 cross references pin compatible devices in this family with their appropriate 5V counterparts. These parts offer drop-in replacement as long as the nominal ±5.5V output swing is acceptable, and if transmitter input pull-up resistors aren't required **(only the ISL8563 has pull-up resistors)**.

TABLE 2. 5V REPLACEMENTS

INTERSIL PART #	COMPETITORS' PART NUMBERS
ICL3207 (E)	HIN207 (E), HIN237 (E), MAX207 (E), MAX237 (E)
ICL3221 (E)	MAX221 (E)
ICL3222 (E)	MAX242, SP312A, SP312E
ICL3232 (E)	HIN202 (E), HIN232 (E), MAX202 (E), MAX232 (E)
ICL3310 (E)	MAX222, SP310A, SP310E, ADM222
ISL8563 (E)	MAX563

When replacing a device in an existing 5V application, it is acceptable to terminate C_3 to V_{CC} as shown on some 5V device data sheets. Nevertheless, terminate C_3 to GND if possible, as slightly better performance results from this configuration.

Feature Descriptions

Quad Flat No-Lead Package (QFN)

The ISL42XXE products feature ultra small (5mm x 5mm) QFN packaging, 10nA to 300nA powerdown supply current, and ±15kV IEC61000 ESD protection. The 5x5 QFN is 60% smaller than a 28 lead TSSOP, and 40% smaller than a 20 lead TSSOP.

Baud Rate Select Pin (MBAUD)

The ICL3237/E features a MBAUD pin for data rate selection. In normal operation (MBAUD = GND), a single transmitter achieves a data rate of 250kbps under worst case loads of 3kΩ and 1000pF with $V_{CC} \geq 3.0V$. In high speed mode (MBAUD = V_{CC}), a single transmitter operates at a 1Mbps data rate with worst case loads of 3kΩ and 250pF, and $V_{CC} \geq 3.0V$.

Manual Powerdown Function

Most devices in this RS-232 family provide pins that allow the user to force the IC into a low power, standby state.

On some devices the powerdown control is via a simple shutdown ($\overline{SHDN}$) pin. Driving this pin high enables normal operation, while driving it low forces the IC into its powerdown state. In powerdown, supply current drops to 1µA (10nA for select devices), because the on-chip charge pump turns off (V+ collapses to V_{CC}, V- collapses to GND), and the transmitter outputs three-state.

TABLE 3. AUTOMATIC POWERDOWN LOGIC

VALID RS-232 LEVEL AT RECEIVER INPUTS?	$\overline{\text{FORCEOFF}}$ INPUT	FORCEON INPUT	$\overline{\text{INVALID}}$ OUTPUT	TRANSCEIVER STATUS
YES	H	X	H	Normal Operation
NO	H	H	L	Normal Operation (Forced On)
NO	H	L	L	Powerdown (Automatic Powerdown)
YES	L	X	H	Powerdown (Forced Off)
NO	L	X	L	Powerdown (Forced Off)

The majority of the devices 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. To switch between active and powerdown modes, under logic control, only the $\overline{\text{FORCEOFF}}$ input need be driven. The FORCEON state isn't critical, as $\overline{\text{FORCEOFF}}$ dominates over FORCEON. Nevertheless, if strictly manual control over powerdown is desired, the user must strap FORCEON high to disable the automatic powerdown circuitry.

With either control scheme, the time required to exit powerdown, and resume transmission is only 100µs.

Automatic Powerdown Function

Even greater power savings is available by using the devices which feature the *automatic* powerdown function. When no valid RS-232 voltages are sensed on any receiver input for 30µs, the charge pump and transmitters are shut off, thereby reducing supply current to 1µA (10nA for select devices). 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 IC powers back up whenever it detects 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.

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 via the overriding $\overline{\text{FORCEOFF}}$ input. Table 3 summarizes the automatic powerdown control logic.

Devices with the automatic powerdown feature include an $\overline{\text{INVALID}}$ output signal, which switches low to indicate that invalid levels have persisted on all of the receiver inputs for more than 30µs. $\overline{\text{INVALID}}$ 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 powerdown circuitry.

Enhanced Automatic Powerdown Function

Half of the family features an *enhanced* automatic powerdown function. This enhanced function differs from automatic powerdown (which monitors only receiver inputs for valid *levels*) in that both receiver *and* transmitter inputs are monitored for signal *transitions*.

When no signal transitions are detected on any of the receiver and transmitter inputs for 30 seconds (see Figure 1), the on-chip charge pump and transmitters turn off, reducing supply current to less than 1µA (10nA for select devices). The IC exits powerdown mode whenever a transition occurs on a transmitter or receiver input. The control signals FORCEON and $\overline{\text{FORCEOFF}}$, and the $\overline{\text{INVALID}}$ output, serve the same function as with automatic powerdown (reference Table 3). Therefore, tying FORCEON high disables enhanced automatic powerdown, while it is enabled if the FORCEON input is low, and the $\overline{\text{FORCEOFF}}$ input is high.

Both the automatic powerdown and enhanced automatic powerdown features provide the user with an additional power reduction capability without the need for an operating system change or hardware modification.

Receiver Enable Function

Some devices in this family feature an $\overline{\text{EN}}$ input to control the receiver outputs. Driving $\overline{\text{EN}}$ high disables all the inverting (standard) receiver outputs placing them in a high impedance state. The enable input has no effect on transmitter nor monitor (R_{OUTB}) outputs.

Monitor Receiver Function

Several devices (e.g., ICL3237) feature noninverting receivers that remain active during powerdown and forced receiver disable ($\overline{\text{EN}}$ = 1). The suffix "B" on the receiver number identifies these always active receivers, and each monitor receiver shares an input with one of the standard receivers. Monitor receivers are ideal for applications such as Ring Indicator signal monitoring in systems that powerdown peripherals to preserve battery life. The receiver driving the peripheral must be disabled to eliminate current flow through the peripheral's input protection diode, but the corresponding monitor receiver remains active and drives wake up circuitry which recognizes the Ring signal.

READY Output

The READY output indicates that the on-chip power supplies have pumped up, and the drivers are ready to transmit data. READY is set high when V- is more negative than -4V. A monitoring system uses this signal to indicate

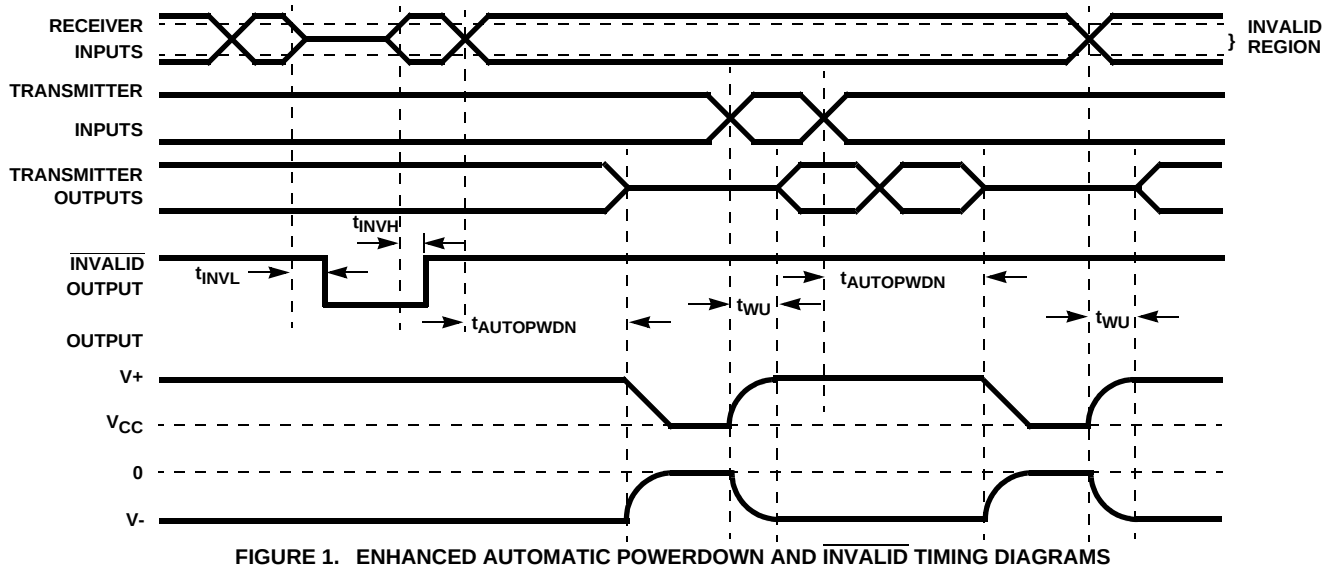

FIGURE 1. ENHANCED AUTOMATIC POWERDOWN AND $\overline{\text{INVALID}}$ TIMING DIAGRAMS

that the RS-232 device is not in powerdown mode and is ready for data.

V_L Logic Supply Input

Unlike other RS-232 interface devices where the CMOS outputs swing between GND and V_{CC}, the ISL83386E/87E and ISL4260E/70E feature a separate logic supply input (V_L) that sets V_{OH} for the receiver and logic outputs. Connecting V_L to the host logic supply (1.8V to 5V), prevents the ISL83386E/87E from forward biasing the input diodes of a logic device operated from a lower supply voltage. V_L also powers the transmitter and logic inputs, thereby setting their switching thresholds to levels compatible with the logic supply. This feature allows a great deal of flexibility in interfacing to systems with different logic supplies.

Compatibility with 5V and 3V Systems

These products directly interface with 5V CMOS and TTL logic families. Nevertheless, with the RS-232 IC supply at 3.3V, and the logic supply at 5V, AC, HC, and CD4000 outputs can properly drive this family's inputs, but this family's outputs (except for the ISL83386E/87E and ISL4260E/70E) do not reach the minimum V_{IH} for these logic families. See Table 4 for more information.

Operation Down to 2.7V

All transmitter outputs typically meet RS-562 levels (±3.7V), at the full data rate, with V_{CC} as low as 2.7V. RS-562 levels typically ensure inter operability with RS-232 devices.

TABLE 4. 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 and TTL families.
5	5	Compatible with all TTL and CMOS logic families.
5	3.3	ISL83386E/87E and ISL4260E/70E are compatible with all TTL and CMOS logic families when the V_L supply pin is connected to the system power supply voltage.
5	3.3	Compatible with ACT and HCT CMOS, and with TTL. ICL32XX outputs are incompatible with AC, HC, and CD4000 CMOS inputs.

15kV ESD-Protection

In addition to the various features listed above, the E-Series of 3V RS-232 devices provide the user with superior ESD protection to 15kV. Advanced internal ESD protection structures are provided on all RS-232 input and output pins. The ESD protection limits are measured by three different standards as follows:

1. ±15kV using Human Body Model
2. ±8kV using Contact Discharge Model specified in IEC61000-4-2 (formerly IEC1000-4-2)
3. ±15kV using Air-Gap Discharge method specified in IEC61000-4-2 (formerly IEC1000-4-2)