Data Sheet July 2001 File Number 6003.1

1 Microamp Supply-Current, +3V to +5.5V, 1Mbps, RS-232 Transmitters/Receivers

The Intersil ICL3237 contains 3.0V to 5.5V powered RS-232 transmitters/receivers which meet ElA/TIA-232 and V.28/V.24 specifications, even at V_{CC} = 3.0V. Targeted applications are cell phones, PDAs, Palmtops, and notebook and laptop computers where the low operational, and even lower standby, power consumption is critical. Efficient on-chip charge pumps, coupled with manual powerdown function, reduce the standby supply current to a 1µA trickle. Small footprint packaging, and the use of small, low value capacitors ensure board space savings as well. Data rates greater than 1Mbps (MBAUD = V_{CC}) are guaranteed at worst case load conditions. This family is fully compatible with 3.3V only systems, mixed 3.3V and 5.0V systems, and 5.0V only systems.

The ICL3237 is a 5 driver, 3 receiver device that also includes a noninverting always-active receiver for “wake-up” capability.

Table 1 summarizes the features of the device represented by this data sheet, while Application Note AN9863 summarizes the features of each device comprising the ICL32XX 3V family.

Ordering Information

PART NO.	TEMP. RANGE (^oC)	PACKAGE	PKG. NO.
ICL3237CA	0 to 70	28 Ld SSOP	M28.209
ICL3237CA-T	0 to 70	Tape and Reel	M28.209
ICL3237IA	-40 to 85	28 Ld SSOP	M28.209
ICL3237IA-T	-40 to 85	Tape and Reel	M28.209

Features

- Drop in Replacement for MAX3237
- Meets EIA/TIA-232 and V.28/V.24 Specifications at 3V
- Latch-Up Free
- On-Chip Voltage Converters Require Only Four External Capacitors
- Manual Powerdown Features
- Flow Through Pinout
- Receiver Hysteresis For Improved Noise Immunity
- Pin Selectable Data Rate
- Guaranteed Minimum Data Rate 250kbps/1Mbps
- Guaranteed Minimum Slew Rate . . . . . 6V/µs or 24V/µs
- Wide Power Supply Range . . . . . Single +3V to +5.5V
- Low Supply Current in Powerdown State 1µA

Applications

- Any System Requiring RS-232 Communication Ports
  - Battery Powered, Hand-Held, and Portable Equipment
  - Laptop Computers, Notebooks, Palmtops
  - Modems, Printers and other Peripherals
  - Digital Cameras
  - Cellular/Mobile Phone

Related Literature

- Technical Brief TB363 “Guidelines for Handling and Processing Moisture Sensitive Surface Mount Devices (SMDs)”
- AN9863 “3V to +5.5V, 250k-1Mbps, RS-232 Transmitters/Receivers”

TABLE 1. SUMMARY OF FEATURES

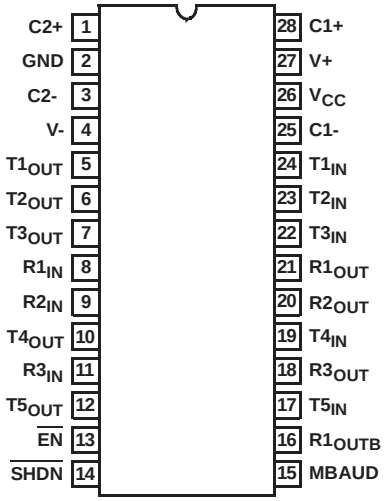
PART NUMBER	NO. OF Tx.	NO. OF Rx.	NO. OF MONITOR Rx. (R_{OUTB})	(NOTE 1) DATA RATE (kbps)	Rx. ENABLE FUNCTION?	READY OUTPUT?	MANUAL POWER-DOWN?	AUTOMATIC POWERDOWN FUNCTION?
ICL3237	5	3	1	250/1000	YES	NO	YES	NO

NOTE:

1. Data rate is selectable via the MBAUD pin.

Pinout

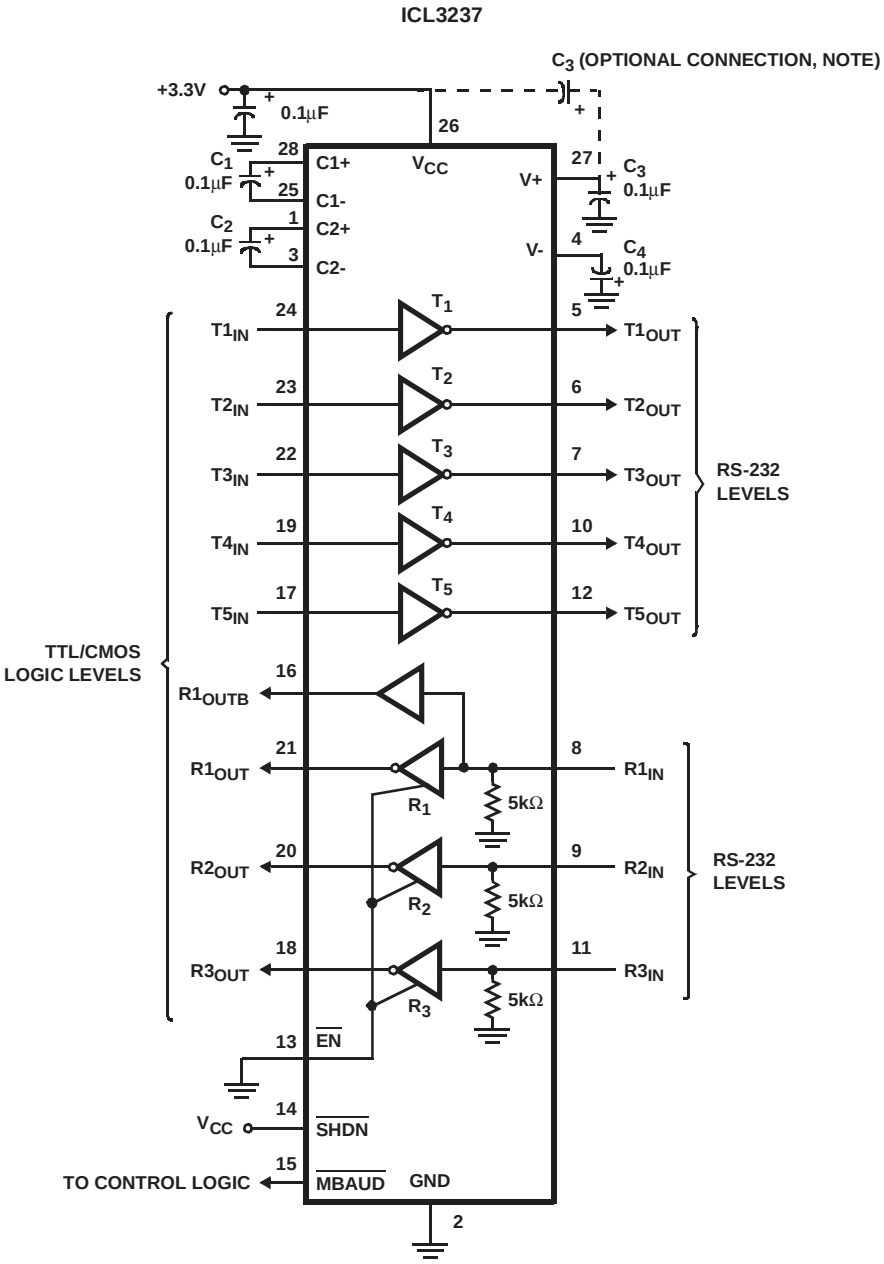
ICL3237 (SSOP)
TOP VIEW



Pin Descriptions

PIN	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.
T_{OUT}	RS-232 level (nominally ±5.5V) transmitter outputs.
R_{IN}	RS-232 Compatible Receiver Inputs.
R_{OUT}	TTL/CMOS Level Receiver Outputs.
R_{OUTB}	TTL/CMOS Level, Noninverting, Always Enabled Receiver Output.
$\overline{EN}$	Active Low Receiver Enable Control; doesn't disable R_{OUTB} output.
$\overline{SHDN}$	Active Low Input to Shutdown Transmitters and On-Board Power Supply, to place device in low power mode.
MBAUD	Input Low selects 250kbps data rate, and input high selects 1Mbps data rate.

Typical Operating Circuit



NOTE: THE NEGATIVE TERMINAL OF C_3 CAN BE CONNECTED TO EITHER V_{CC} OR GND.

Absolute Maximum Ratings

V_{CC} to Ground . . . . . -0.3V to 6V
V+ to Ground . . . . . -0.3V to 7V
V- to Ground . . . . . +0.3V to -7V
V+ to V- 14V
Input Voltages
T_{IN}, $\overline{EN}$, $\overline{SHDN}$ . . . . . -0.3V to 6V
MBAUD . . . . . -0.3V to V_{CC}+0.3V
R_{IN} . . . . . ±25V
Output Voltages
T_{OUT} . . . . . ±13.2V
R_{OUT} . . . . . -0.3V to V_{CC} +0.3V
Short Circuit Duration
T_{OUT} . . . . . Continuous
ESD Rating . . . . . See Specification Table

Thermal Information

Thermal Resistance (Typical, Note 2)	θ_{JA} (^{o}C/W)
28 Ld SSOP Package	100

Moisture Sensitivity (see Technical Brief TB363)
All Packages . . . . . Level 1
Maximum Junction Temperature (Plastic Package) . . . . . 150^{o}C
Maximum Storage Temperature Range . . . . . -65^{o}C to 150^{o}C
Maximum Lead Temperature (Soldering 10s) . . . . . 300^{o}C
(Lead Tips Only)

Operating Conditions

Temperature Range
ICL3237C . . . . . 0^{o}C to 70^{o}C
ICL3237I . . . . . -40^{o}C to 85^{o}C

CAUTION: Stresses above those listed in "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress only rating and operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied.

NOTE:

2. θ_{JA} is measured with the component mounted on a low effective thermal conductivity test board in free air. See Tech Brief TB379 for details.

Electrical Specifications

Test Conditions: V_{CC} = 3V, C_1 - C_4 = 0.22µF; V_{CC} = 3.15V to 5.5V, C_1 - C_4 = 0.1µF, Unless Otherwise Specified. Typicals are at T_A = 25^{o}C

PARAMETER	TEST CONDITIONS		TEMP (^{o}C)	MIN	TYP	MAX	UNITS
DC CHARACTERISTICS							
Supply Current, Powerdown Disabled	All Outputs Unloaded, V_{CC} = 3.15V, $\overline{SHDN}$ = V_{CC}		25	-	0.3	1.0	mA
Supply Current, Powerdown	$\overline{SHDN}$ = GND		25	-	1.0	10	µA
LOGIC AND TRANSMITTER INPUTS AND RECEIVER OUTPUTS							
Input Logic Threshold Low	T_{IN}, $\overline{EN}$, $\overline{SHDN}$, MBAUD		Full	-	-	0.8	V
Input Logic Threshold High	T_{IN}, $\overline{EN}$, $\overline{SHDN}$, MBAUD	V_{CC} = 3.3V	Full	2.0	-	-	V
		V_{CC} = 5.0V	Full	2.4	-	-	V
Transmitter Input Hysteresis			25	-	0.5	-	V
Input Leakage Current	T_{IN}, $\overline{EN}$, $\overline{SHDN}$, MBAUD		Full	-	±0.01	±1.0	µA
Output Leakage Current	$\overline{EN}$ = V_{CC} (Receivers Disabled)		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
RECEIVER INPUTS							
Input Voltage Range			Full	-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 to 5.0V		25	-	1.6	2.4	V
Input Hysteresis			25	-	0.3	-	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

Electrical Specifications Test Conditions: V_{CC} = 3V, C_1 - C_4 = 0.22µF; V_{CC} = 3.15V to 5.5V, C_1 - C_4 = 0.1µF, Unless Otherwise Specified. Typicals are at T_A = 25°C **(Continued)**

PARAMETER	TEST CONDITIONS			TEMP (°C)	MIN	TYP	MAX	UNITS
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 3V to 5.5V, $\overline{SHDN}$ = GND			Full	-	-	±25	µA
TIMING CHARACTERISTICS								
Maximum Data Rate	R_L = 3kΩ, One Transmitter Switching	C_L = 1000pF	MBAUD = GND	Full	250	700	-	kbps
		V_{CC} = 3V to 4.5V, C_L = 250pF	MBAUD = V_{CC}	Full	1000	1700	-	kbps
		V_{CC} = 4.5V to 5.5V, C_L = 1000pF	MBAUD = V_{CC}	Full	1000	1100	-	kbps
Receiver Propagation Delay	Receiver Input to Receiver Output, C_L = 150pF	t_{PHL}		25	-	0.15	-	µs
		t_{PLH}		25	-	0.15	-	µs
Receiver Output Enable Time	Normal Operation			25	-	200	-	ns
Receiver Output Disable Time	Normal Operation			25	-	200	-	ns
Transmitter Skew	t_{PHL} - t_{PLH}, Note 3	MBAUD = GND		25	-	100		ns
		MBAUD = V_{CC}, V_{CC} = 3.0V		25	-	25		ns
Receiver Skew	t_{PHL} - t_{PLH}, C_L = 150pF			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	MBAUD = GND	25	6	17	30	V/µs
			MBAUD = V_{CC}	25	24	40	150	V/µs
		C_L = 150pF to 2500pF	MBAUD = GND	25	4	12	30	V/µs
ESD PERFORMANCE								
RS-232 Pins (T_{OUT}, R_{IN})	Human Body Model			25	-	±15	-	kV
	IEC1000-4-2 Contact Discharge			25	-	±8	-	kV
	IEC1000-4-2 Air Gap Discharge			25	-	>±8	-	kV
All Other Pins	Human Body Model			25	-	±2.5	-	kV

NOTE:

3. Skew is measured at the input switching points (1.4V).

Detailed Description

The ICL3237 operates from a single +3V to +5.5V supply, guarantees a 1Mbps minimum data rate, requires only four small external 0.1µF capacitors, features low power consumption, and meets all EIA/TIA-232 and V.28 specifications. The circuit is divided into three sections: The charge pump, the transmitters, and the receivers.

Charge-Pump

Intersil's new ICL32XX family utilizes 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. This allows these devices 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 at V_{CC} = 3.3V. See the "Capacitor Selection" section, and Table 3 for capacitor recommendations for other operating conditions. The charge pumps operate discontinuously (i.e., they turn off as soon as the V+ and V- supplies are pumped up to the nominal values), resulting in significant power savings.

TABLE 2. POWERDOWN AND ENABLE LOGIC TRUTH TABLE

$\overline{SHDN}$ INPUT	$\overline{EN}$ INPUT	TRANSMITTER OUTPUTS	RECEIVER OUTPUTS	R_{OUTB} OUTPUT	MODE OF OPERATION
L	L	High-Z	Active	Active	Manual Powerdown
L	H	High-Z	High-Z	Active	Manual Powerdown w/Rcvr. Disabled
H	L	Active	Active	Active	Normal Operation
H	H	Active	High-Z	Active	Normal Operation w/Rcvr. Disabled

Transmitters

The transmitters are proprietary, low dropout, inverting drivers that translate TTL/CMOS inputs to EIA/TIA-232 output levels. Coupled with the on-chip ±5.5V supplies, these transmitters deliver true RS-232 levels over 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 2). These outputs may be driven to ±12V when disabled.

The ICL3237 guarantees a 1Mbps data rate (if MBAUD = 1) for full load conditions (3kΩ and 250pF), $V_{CC} \geq 3.0V$, with one transmitter operating at full speed. Under more typical conditions of $V_{CC} \geq 3.3V$, $C_{1-4} = 0.1\mu F$, $R_L = 3k\Omega$, and $C_L = 250pF$, one transmitter easily operates at 1.7Mbps.

Transmitter inputs float if left unconnected, and may cause I_{CC} increases. Connect unused inputs to GND for the best performance.

Receivers

The ICL3237 device contains standard inverting receivers that three-state only when the $\overline{EN}$ control line is driven high. Additionally, it includes a noninverting (monitor) receiver (denoted by the R_{OUTB} label) that is always active, regardless of the state of any control lines. 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 1) 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.

Monitor receivers remain active even during manual powerdown and forced receiver disable, making them extremely useful for Ring Indicator monitoring. Standard receivers driving powered down peripherals must be disabled to prevent current flow through the peripheral's protection diodes (see Figures 2 and 3). This renders them useless for wake up functions, but the corresponding monitor receiver can be dedicated to this task as shown in Figure 3.

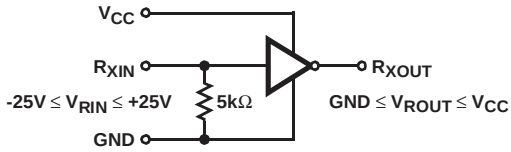


FIGURE 1. INVERTING RECEIVER CONNECTIONS

Powerdown Functionality

This 3V device 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. In powerdown, 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 three-state. This micro-power mode makes the ICL3237 ideal for battery powered and portable applications.

Software Controlled (Manual) Powerdown

On the ICL3237, 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 it's powerdown state. Connect $\overline{SHDN}$ to V_{CC} if the powerdown function isn't needed. Note that all the receiver outputs remain enabled during shutdown (see Table 2). For the lowest power consumption during powerdown, the receivers should also be disabled by driving the $\overline{EN}$ input high (see next section, and Figures 2 and 3). The time required to exit powerdown, and resume transmission is only 100µs.

Receiver ENABLE Control

This device also features an $\overline{EN}$ input to control the receiver outputs. Driving $\overline{EN}$ high disables all the inverting (standard) receiver outputs placing them in a high impedance state. This is useful to eliminate supply current, due to a receiver output forward biasing the protection diode, when driving the input of a powered down (V_{CC} = GND) peripheral (see Figure 2). The enable input has no effect on transmitter nor monitor (R_{OUTB}) outputs.

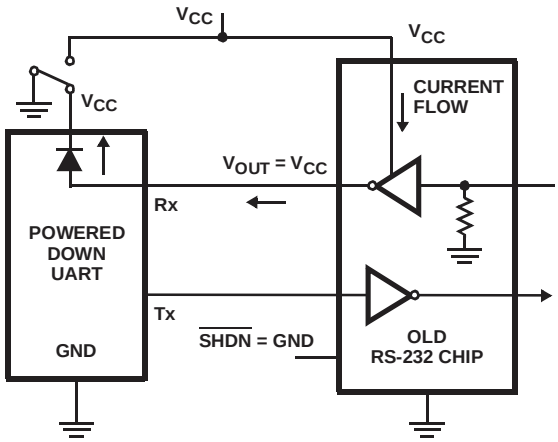


FIGURE 2. POWER DRAIN THROUGH POWERED DOWN PERIPHERAL

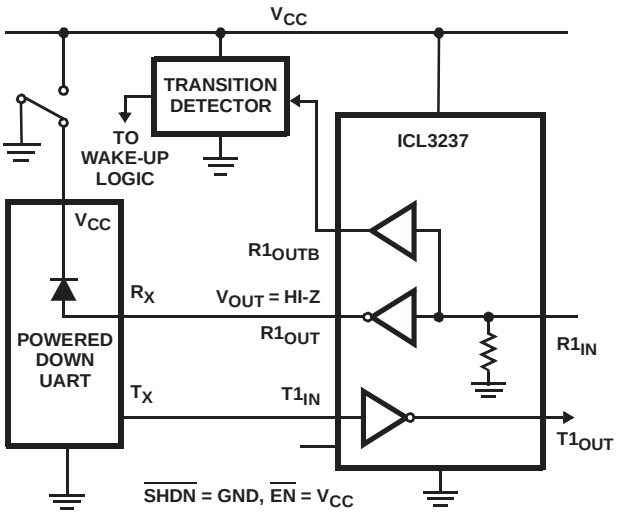


FIGURE 3. DISABLED RECEIVERS PREVENT POWER DRAIN

MegaBaud Selection

In normal operating mode (MBAUD = GND), the ICL3237 transmitters guarantee a 250kbps data rate with worst-case loads of 3kΩ in parallel with 1000pF. This provides compatibility with PC-to-PC communication software, such as Laplink™.

For higher speed serial communications, the ICL3237 features MegaBaud operation. In MegaBaud operating mode (MBAUD = V_{CC}), the ICL3237 transmitters guarantee a 1Mbps data rate with worst-case loads of 3kΩ in parallel with 250pF for 3.0V < V_{CC} < 4.5V. For 5V ±10% operation, the ICL3237 transmitters guarantee a 1Mbps data rate into worst-case loads of 3kΩ in parallel with 1000pF.

Capacitor Selection

The charge pumps require 0.1µF capacitors for 3.3V operation. For other supply voltages refer to Table 3 for capacitor values. Do not use values smaller than those listed in Table 3. Increasing the capacitor values (by a factor of 2) reduces ripple on the transmitter outputs and slightly reduces power consumption. C_2, C_3, and C_4 can be increased without increasing C_1's value, however, do not increase C_1 without also increasing C_2, C_3, and C_4 to maintain the proper ratios (C_1 to the other capacitors).

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-.

TABLE 3. REQUIRED CAPACITOR VALUES

V_{CC} (V)	C_1 (µF)	C_2, C_3, C_4 (µF)
3.0 to 3.6	0.22	0.22
3.15 to 3.6	0.1	0.1
4.5 to 5.5	0.047	0.33
3.0 to 5.5	0.22	1.0

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.

Transmitter Outputs when Exiting Powerdown

Figure 4 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. Note that the transmitters enable only when the magnitude of the supplies exceed approximately 3V.

High Data Rates

The ICL3237 maintains the RS-232 ±5V minimum transmitter output voltages even at high data rates. Figure 5 details a transmitter loopback test circuit, and Figure 6 illustrates the standard speed loopback test result for a single transmitter driving 1000pF and an RS-232 load at 250kbps. Figure 7 shows the megabaud loopback results for a single transmitter driving 250pF and an RS-232 load at 1Mbps. The static transmitters were also loaded with an RS-232 receiver.

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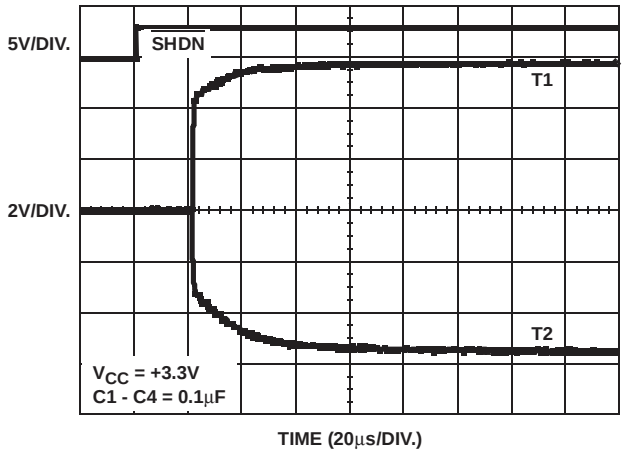


FIGURE 4. TRANSMITTER OUTPUTS WHEN EXITING POWERDOWN

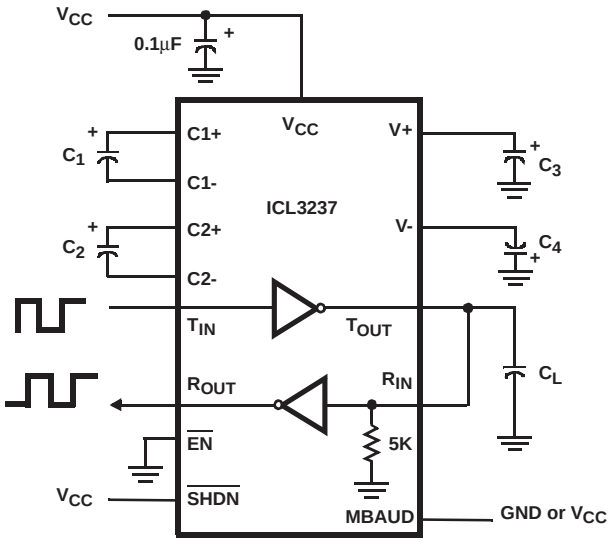


FIGURE 5. TRANSMITTER LOOPBACK TEST CIRCUIT

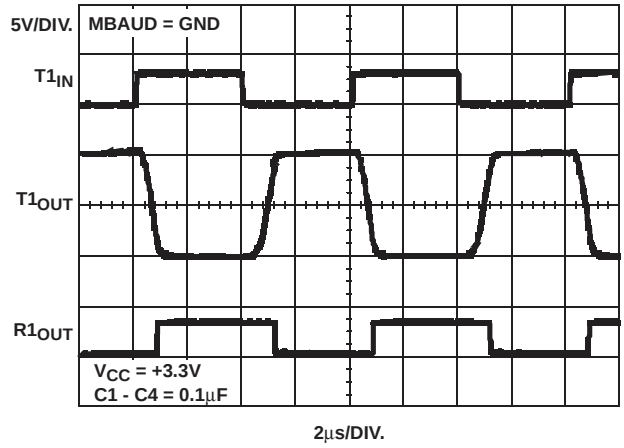


FIGURE 6. LOOPBACK TEST AT 250kbps (C_L = 1000pF)

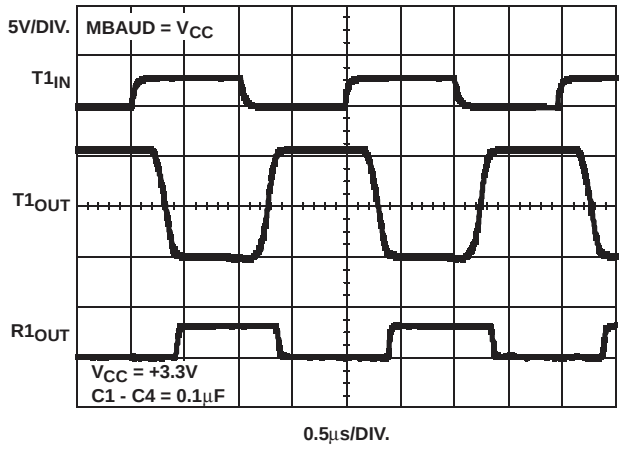


FIGURE 7. LOOPBACK TEST AT 1Mbps (C_L = 250pF)

Interconnection with 3V and 5V Logic

The ICL3237 directly interfaces with most 5V logic families, including ACT and HCT CMOS. See Table 4 for more information on possible combinations of interconnections.

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 families.
5	5	Compatible with all TTL and CMOS logic families.
5	3.3	Compatible with ACT and HCT CMOS, and with TTL. Incompatible with AC, HC, or CD4000 CMOS.

Typical Performance Curves V_{CC} = 3.3V, T_A = 25°C

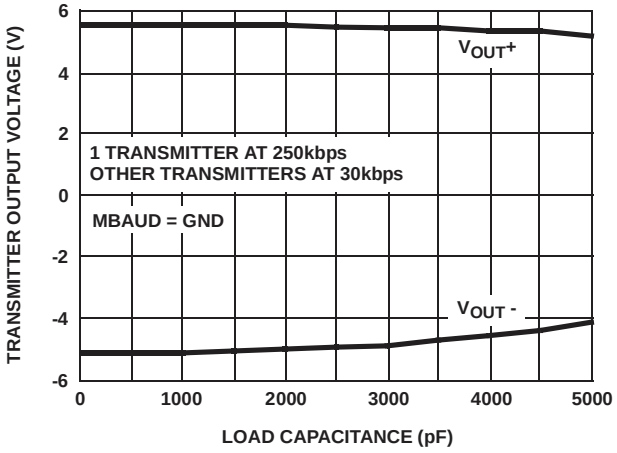


FIGURE 8. LOW SPEED TRANSMITTER OUTPUT VOLTAGE vs LOAD CAPACITANCE

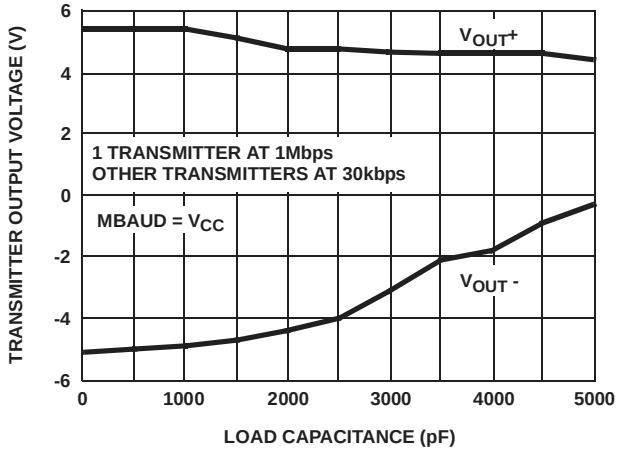


FIGURE 9. HIGH SPEED TRANSMITTER OUTPUT VOLTAGE vs LOAD CAPACITANCE

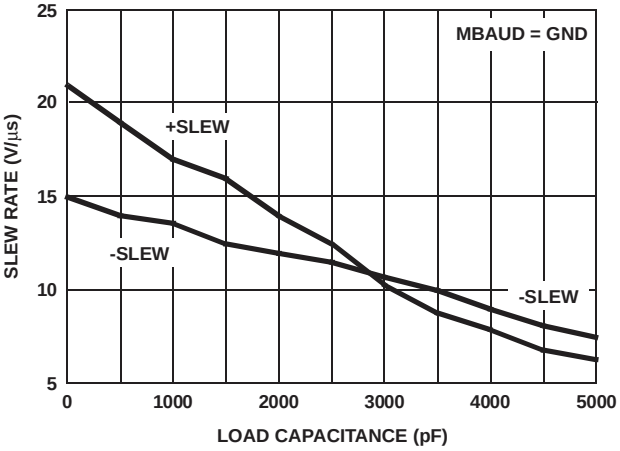


FIGURE 10. LOW SPEED SLEW RATE vs LOAD CAPACITANCE

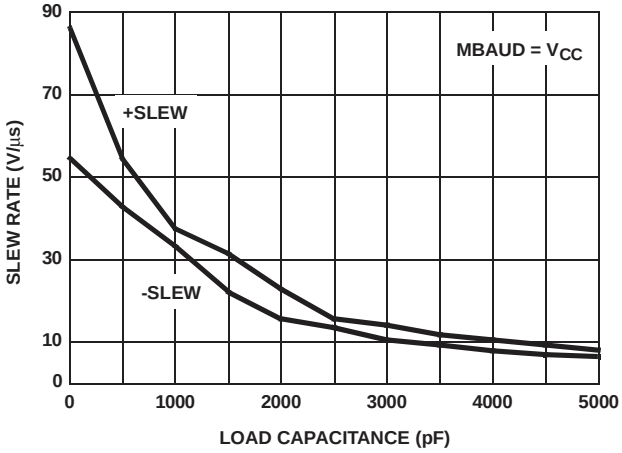


FIGURE 11. HIGH SPEED SLEW RATE vs LOAD CAPACITANCE

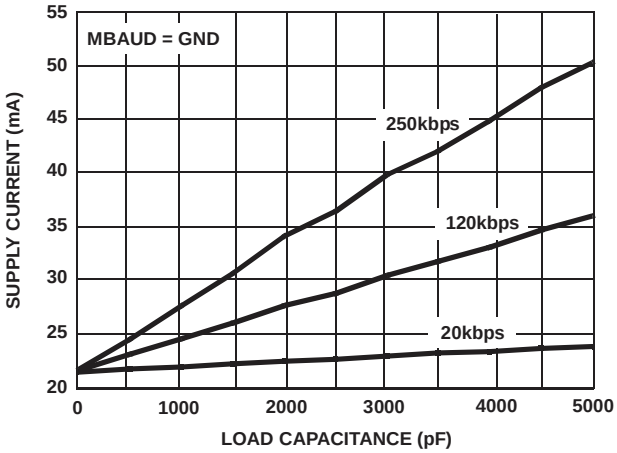


FIGURE 12. LOW SPEED SUPPLY CURRENT vs LOAD CAPACITANCE WHEN TRANSMITTING DATA

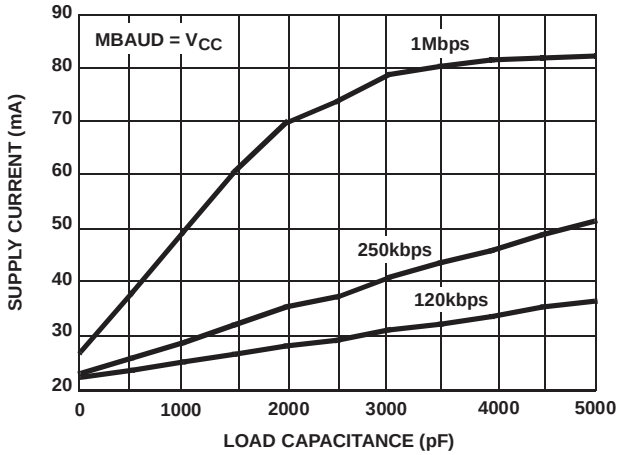


FIGURE 13. HIGH SPEED SUPPLY CURRENT vs LOAD CAPACITANCE WHEN TRANSMITTING DATA

Typical Performance Curves V_{CC} = 3.3V, T_A = 25°C (Continued)

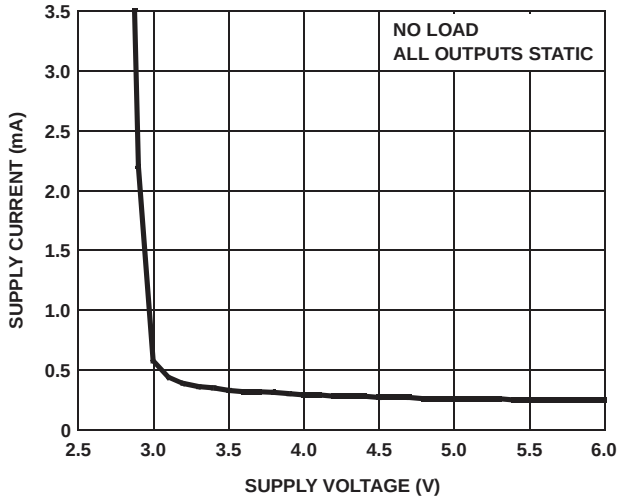


FIGURE 14. SUPPLY CURRENT vs SUPPLY VOLTAGE

Die Characteristics

DIE DIMENSIONS

106 mils x 128 mils (2700µm x 3250µm)

METALLIZATION

Type: Metal 1: AlSi (1%)
Thickness: Metal 1: 8kÅ
Type: Metal 2: AlSi (1%)
Thickness: Metal 2: 10kÅ

SUBSTRATE POTENTIAL (POWERED UP)

GND

PASSIVATION

Type: Silox
Thickness: 13kÅ

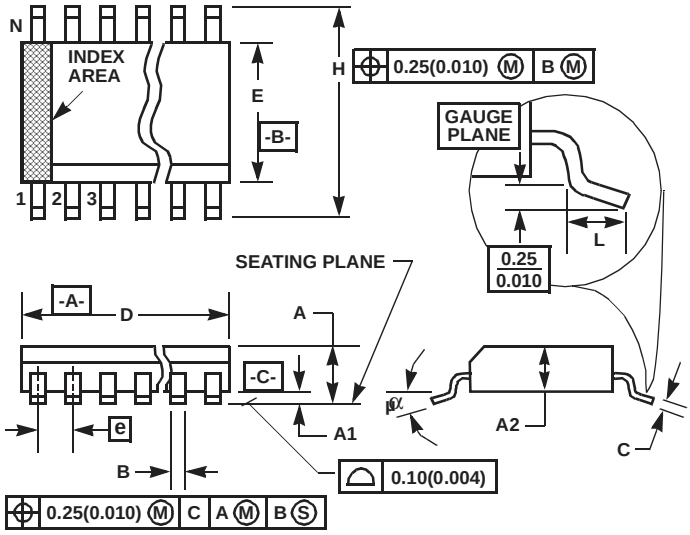
TRANSISTOR COUNT

619

PROCESS

Si Gate CMOS

Shrink Small Outline Plastic Packages (SSOP)



M28.209 **(JEDEC MO-150-AH ISSUE B)**
28 LEAD SHRINK SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.078	-	2.00	-
A1	0.002	-	0.05	-	-
A2	0.065	0.072	1.65	1.85	-
B	0.009	0.014	0.22	0.38	9
C	0.004	0.009	0.09	0.25	-
D	0.390	0.413	9.90	10.50	3
E	0.197	0.220	5.00	5.60	4
e	0.026 BSC		0.65 BSC		-
H	0.292	0.322	7.40	8.20	-
L	0.022	0.037	0.55	0.95	6
N	28		28		7
α	0^o	8^o	0^o	8^o	-

Rev. 1 3/95

NOTES:

1. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.20mm (0.0078 inch) per side.
4. Dimension “E” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.20mm (0.0078 inch) per side.
5. The chamfer on the body is optional. If it is not present, a visual index feature must be located within the crosshatched area.
6. “L” is the length of terminal for soldering to a substrate.
7. “N” is the number of terminal positions.
8. Terminal numbers are shown for reference only.
9. Dimension “B” does not include dambar protrusion. Allowable dambar protrusion shall be 0.13mm (0.005 inch) total in excess of “B” dimension at maximum material condition.
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

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