ICL3224, ICL3226, ICL3238

1µA, +3V to +5.5V, 250kbps, RS-232 Transceivers with Enhanced Automatic Powerdown

The ICL3224, ICL3226, and ICL3238 (ICL32xx) devices are 3.0V 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. Targeted applications are PDAs, Palmtops, and notebook and laptop computers where low operational power consumption and even lower standby power consumption are critical. Efficient on-chip charge pumps, coupled with manual and enhanced automatic powerdown functions, reduce the standby supply current to a 1µA trickle. Small footprint 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. This family is fully compatible with 3.3V only systems, mixed 3.3V and 5.0V systems, and 5.0V only systems.

The ICL3238 is a 5 driver, 3 receiver device that includes a noninverting always-active receiver for Ring Indicator monitoring.

The ICL32xx devices feature an enhanced automatic powerdown function that powers down the on-chip power supply and driver circuits. Powerdown occurs when all receiver and transmitter inputs detect no signal transitions for a period of 30s. These devices power back up automatically whenever they sense a transition on any transmitter or receiver input.

Table 1 summarizes the features of the devices represented by this datasheet, and AN9863 summarizes the features of each device in the ICL32xx 3V family.

Related Literature

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

ICL3224, ICL3226, and ICL3238 device pages

Features

- Pb-free (RoHS compliant)
- ±15kV ESD protected (human body model)
- Manual and enhanced automatic powerdown features
- Drop in replacements for MAX3224, MAX3226, MAX3238
- Meets EIA/TIA-232 and V.28/V.24 specifications at 3V
- Latch-up free
- RS-232 compatible with V_{CC} = 2.7V
- On-chip voltage converters require only four external 0.1µF capacitors
- Flow-through pinout (ICL3238)
- “Ready to transmit” indicator output (ICL3224/26)
- Receiver hysteresis for improved noise immunity
- Ensured minimum data rate: 250kbps
- Ensured minimum slew rate: 6V/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 phones
  - Data cradles

Table 1. Summary of Features

Part Number	Number of Tx.	Number of Rx.	Number of Monitor Rx. (R_{OUTB})	Data Rate (kbps)	Rx. Enable Function?	READY Output?	Manual Powerdown?	Enhanced Automatic Powerdown
ICL3224	2	2	0	250	No	Yes	Yes	Yes
ICL3226	1	1	0	250	No	Yes	Yes	Yes
ICL3238	5	3	1	250	No	No	Yes	Yes

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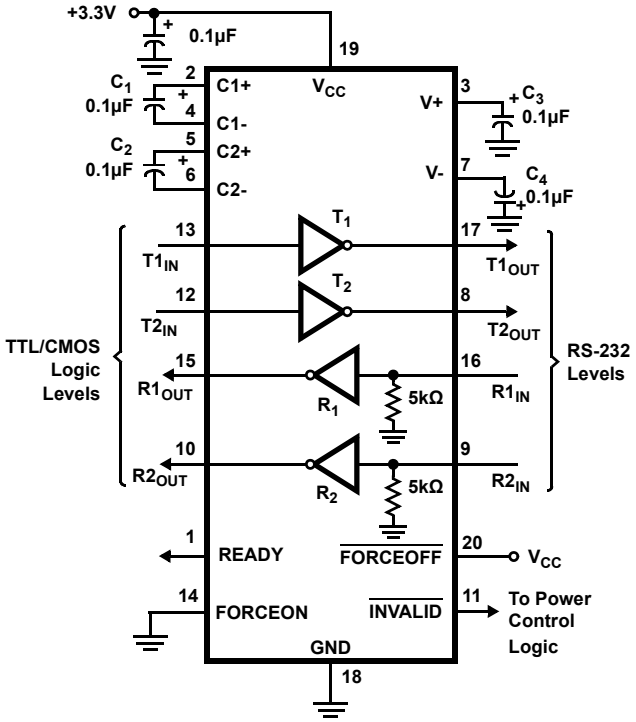
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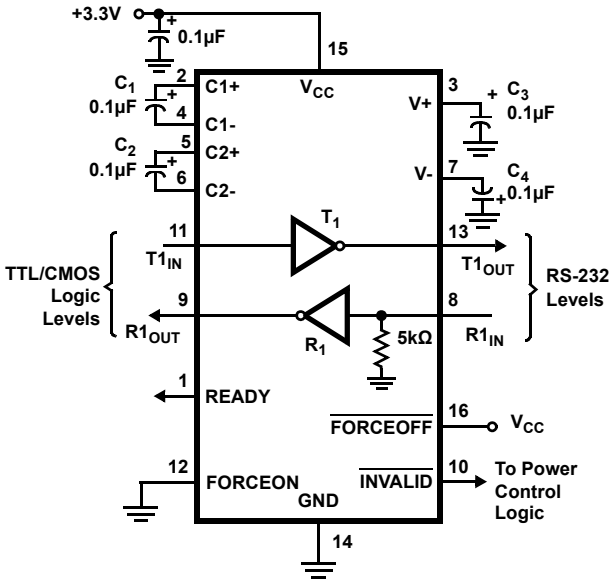
1. Overview

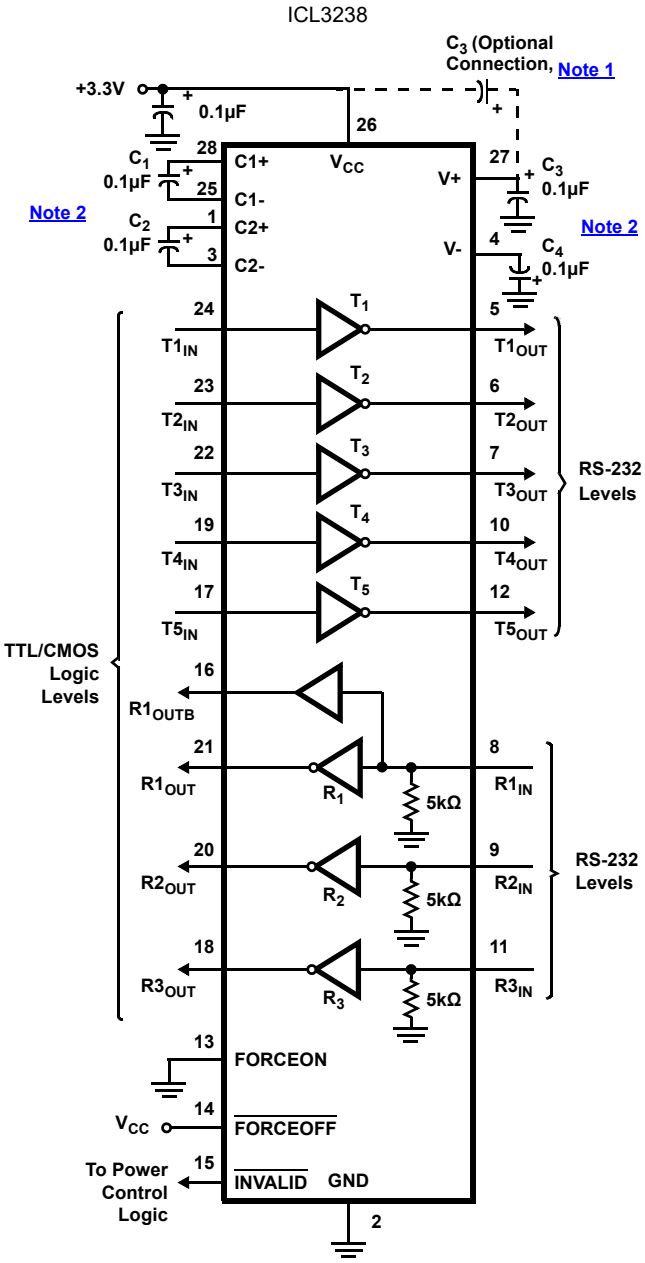
1.1 Typical Operating Circuits

ICL3224



ICL3226





Notes:

1. The negative terminal of C3 can be connected to either VCC or GND.
2. For V_{CC} = 3.15V (3.3V -5%), Use C_1 - C_4 = 0.1µF or greater. For V_{CC} = 3.0V (3.3V -10%), Use C_1 - C_4 = 0.22µF.

1.2 Ordering Information

Part Number (Notes 4, 5)	Part Marking	Temp. Range (°C)	Tape and Reel (Units) (Notes 3)	Package (RoHS Compliant)	Pkg. Dwg. #
ICL3226IAZ	ICL3226IAZ	-40 to 85	-	16 Ld SSOP	M16.209
ICL3226IAZ-T	ICL3226IAZ	-40 to 85	1k	16 Ld SSOP	M16.209
ICL3224CAZ **(No longer available, recommended replacement: ICL3224EIAZ)**	3224CAZ	0 to 70	-	20 Ld SSOP	M20.209
ICL3224CAZ-T **(No longer available, recommended replacement: ICL3224EIAZ-T)**	3224CAZ	0 to 70	1k	20 Ld SSOP	M20.209

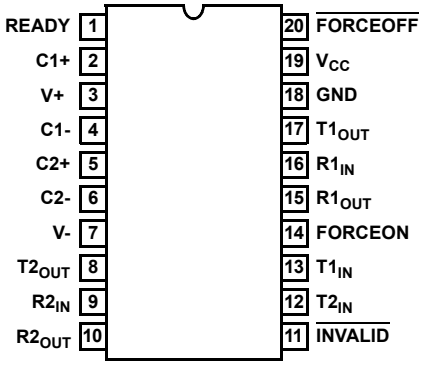
Part Number (Notes 4, 5)	Part Marking	Temp. Range (°C)	Tape and Reel (Units) (Notes 3)	Package (RoHS Compliant)	Pkg. Dwg. #
ICL3224IAZ **(No longer available, recommended replacement: ICL3224EIAZ)**	3224IAZ	-40 to 85	-	20 Ld SSOP	M20.209
ICL3224IAZ-T **(No longer available, recommended replacement: ICL3224EIAZ-T)**	3224IAZ	-40 to 85	1k	20 Ld SSOP	M20.209
ICL3226CAZ **(No longer available, recommended replacement: ICL3226EIAZ)**	ICL3226CAZ	0 to 70	-	16 Ld SSOP	M16.209
ICL3226CAZ-T **(No longer available, recommended replacement: ICL3226EIAZ-T)**	ICL3226CAZ	0 to 70	1k	16 Ld SSOP	M16.209
ICL3238CAZ **(No longer available, recommended replacement: ICL3238EIAZ)**	ICL3238CAZ	0 to 70	-	28 Ld SSOP	M28.209
ICL3238CAZ-T **(No longer available, recommended replacement: ICL3238EIAZ-T)**	ICL3238CAZ	0 to 70	1k	28 Ld SSOP	M28.209
ICL3238IAZ **(No longer available, recommended replacement: ICL3238EIAZ)**	ICL3238IAZ	-40 to 85	-	28 Ld SSOP	M28.209
ICL3238IAZ-T **(No longer available, recommended replacement: ICL3238EIAZ-T)**	ICL3238IAZ	-40 to 85	1k	28 Ld SSOP	M28.209

Notes:

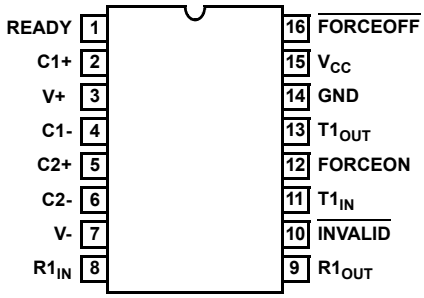
3. See TB347 for details about reel specifications.
4. Pb-free plus anneal products employ special Pb-free material sets; molding compounds/die attach materials and 100% matte tin plate termination finish, which are RoHS compliant and compatible with both SnPb and Pb-free soldering operations. Pb-free products are MSL classified at Pb-free peak reflow temperatures that meet or exceed the Pb-free requirements of IPC/JEDEC J-STD-020.
5. For Moisture Sensitivity Level (MSL), see the ICL3224, ICL3226, and ICL3238 device pages. For more information about MSL, see TB363.

1.3 Pin Configurations

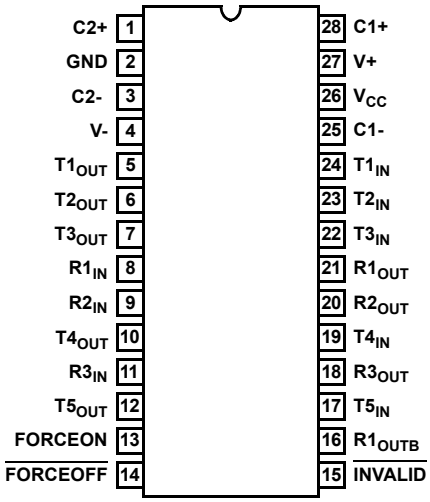
ICL3224 (SSOP)
Top View



ICL3226 (SSOP)
Top View



ICL3238 (SSOP)
Top View



1.4 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.
Tx_{IN}	TTL/CMOS compatible transmitter Inputs.
Tx_{OUT}	RS-232 level (nominally ±5.5V) transmitter outputs.
Rx_{IN}	RS-232 compatible receiver inputs.
Rx_{OUT}	TTL/CMOS level receiver outputs.
Rx_{OUTB}	TTL/CMOS level, noninverting, always enabled receiver outputs.
$\overline{INVALID}$	Active low output that indicates if no valid RS-232 levels are present on any receiver input.
READY	Active high output that indicates when the ICL32xx is ready to transmit (V- ≤ -4V)
$\overline{FORCEOFF}$	Active low to shut down transmitters and on-chip power supply, which overrides any automatic circuitry and FORCEON (see Table 5 on page 15).
FORCEON	Active high input to override automatic powerdown circuitry and keeps transmitters active. ($\overline{FORCEOFF}$ must be high).

2. Specifications

2.1 Absolute Maximum Ratings

Parameter	Minimum	Maximum	Unit
V_{CC} to Ground	-0.3	6	V
V+ to Ground	-0.3	7	V
V- to Ground	+0.3	-7	V
V+ to V-		14	V
Input Voltages			
T_{IN}, $\overline{FORCEOFF}$, FORCEON	-0.3	6	V
R_{IN}		±25	V
Output Voltages			
T_{OUT}		±13.2	V
R_{OUT}, $\overline{INVALID}$, READY	-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, Note 6)	θ_{JA} (°C/W)
16 Ld SSOP Package	140
20 Ld SSOP Package	125
28 Ld SSOP Package	100

Notes:
6. 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			
ICL32xxC	0	+70	°C
ICL32xxI	-40	+85	°C

2.4 Electrical Specifications

Test conditions: V_{CC} = 3V to 5.5V, C_1 - C_4 = 0.1µF (ICL3238: C_1 - C_4 = 0.22µF at VCC = 3V); unless otherwise specified. Typical values are at TA = 25°C

Parameter	Test Conditions		Temp (°C)	Min	Typ	Max	Unit
DC Characteristics							
Supply Current, Automatic Powerdown	All R_{IN} open, FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC}		25	-	1.0	10	µA
Supply Current, Powerdown	$\overline{FORCEOFF}$ = GND		25	-	1.0	10	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, $\overline{FORCEOFF}$		Full	-	-	0.8	V
Input Logic Threshold High	T_{IN}, FORCEON, $\overline{FORCEOFF}$	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}, FORCEON, $\overline{FORCEOFF}$		Full	-	±0.01	±1.0	µA
Output Leakage Current	$\overline{FORCEOFF}$ = GND		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		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 3V to 5.5V, automatic powerdown or $\overline{FORCEOFF}$ = GND		Full	-	-	±25	µA
Enhanced Automatic Powerdown (FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC})							
Receiver Input Thresholds to $\overline{INVALID}$ High	See Figure 13		Full	-2.7	-	2.7	V
Receiver Input Thresholds to $\overline{INVALID}$ Low	See Figure 13		Full	-0.3	-	0.3	V
$\overline{INVALID}$, READY Output Voltage Low	I_{OUT} = 1.6mA		Full	-	-	0.4	V
$\overline{INVALID}$, READY Output Voltage High	I_{OUT} = -1.0mA		Full	V_{CC}-0.6	-	-	V
Receiver Positive or Negative Threshold to $\overline{INVALID}$ High Delay (t_{INVH})	ICL3238		25	-	0.1	-	µs
	All Others		25	-	1	-	µs
Receiver Positive or Negative Threshold to $\overline{INVALID}$ Low Delay (t_{INVL})	ICL3238		25	-	50	-	µs
	All Others		25	-	30	-	µs

Test conditions: V_{CC} = 3V to 5.5V, C_1 - C_4 = 0.1µF (ICL3238: C_1 - C_4 = 0.22µF at VCC = 3V); unless otherwise specified. Typical values are at TA = 25°C **(Continued)**

Parameter	Test Conditions		Temp (°C)	Min	Typ	Max	Unit
Receiver or Transmitter Edge to Transmitters Enabled Delay (t_{WU})	ICL3238, Note 7		25	-	25	-	µs
	All Others, Note 7		25	-	100	-	µs
Receiver or Transmitter Edge to Transmitters Disabled Delay ($t_{AUTOPWDN}$)	Note 7		Full	15	30	60	sec
Timing Characteristics							
Maximum Data Rate	R_L = 3kΩ, CL = 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
Receiver Output Enable Time	Normal operation (ICL3238 Only)		25	-	200	-	ns
Receiver Output Disable Time	Normal operation (ICL3238 Only)		25	-	200	-	ns
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	-	30	V/µs
		C_L = 150pF to 2500pF	25	4	8	30	V/µs
ESD Performance							
RS-232 Pins (T_{OUT}, R_{IN})	Human Body Model		25	-	±15	-	kV
	IEC61000-4-2 Contact Discharge		25	-	±8	-	kV
	IEC61000-4-2 Air Gap Discharge		25	-	±10	-	kV
All Other Pins	Human Body Model		25	-	±2.5	-	kV

Note:

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

3. Typical Performance Curves

V_{CC} = 3.3V, T_A = 25°C

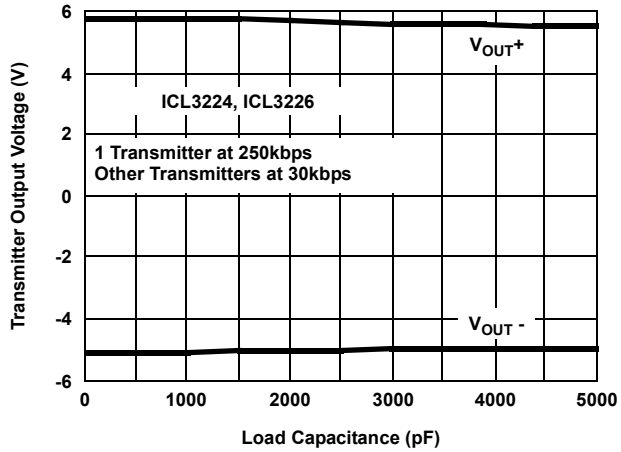


Figure 1. Transmitter Output Voltage vs Load Capacitance

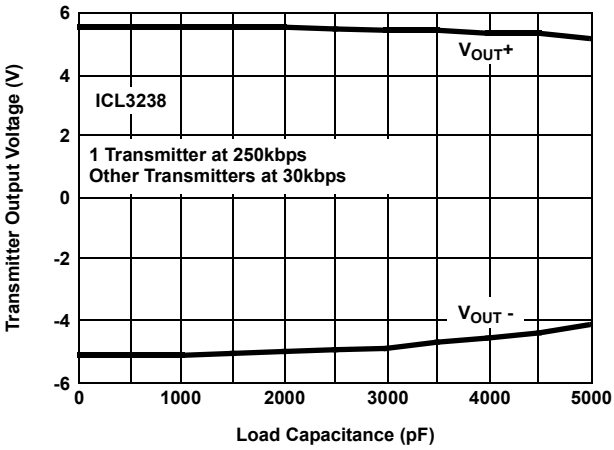


Figure 2. Transmitter Output Voltage vs Load Capacitance

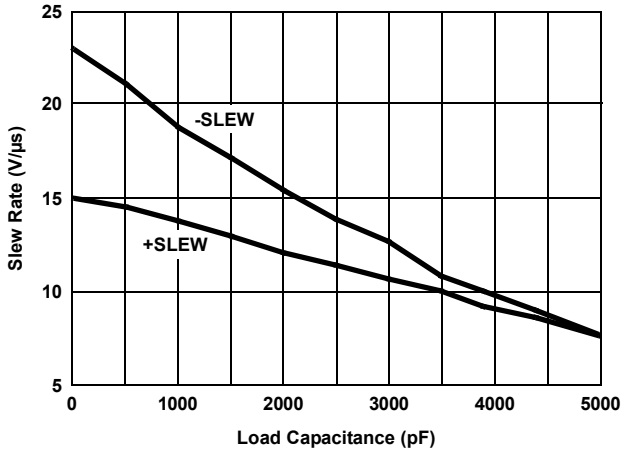


Figure 3. Slew Rate vs Load Capacitance

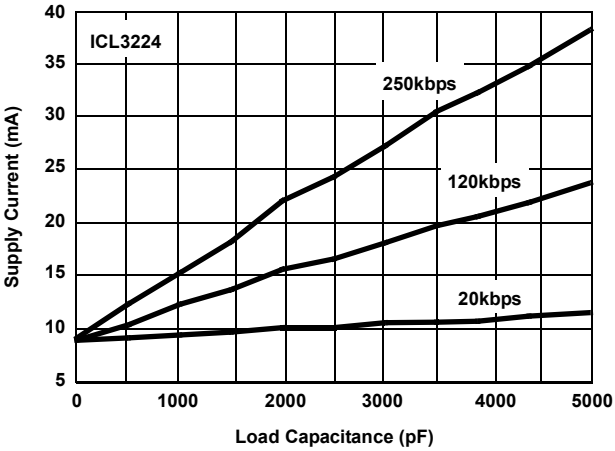


Figure 4. Supply Current vs Load Capacitance When Transmitting Data

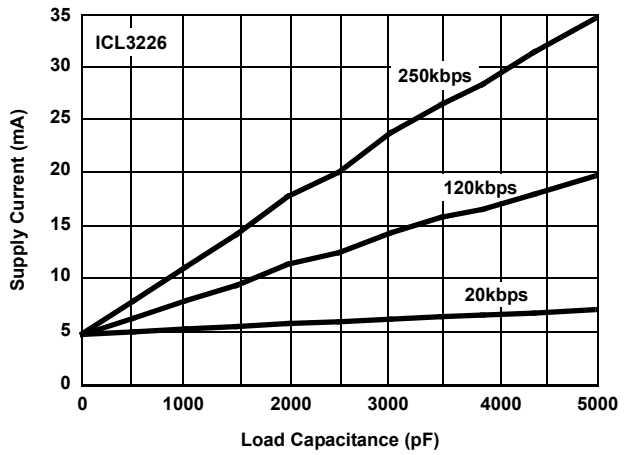


Figure 5. Supply Current vs Load Capacitance When Transmitting Data

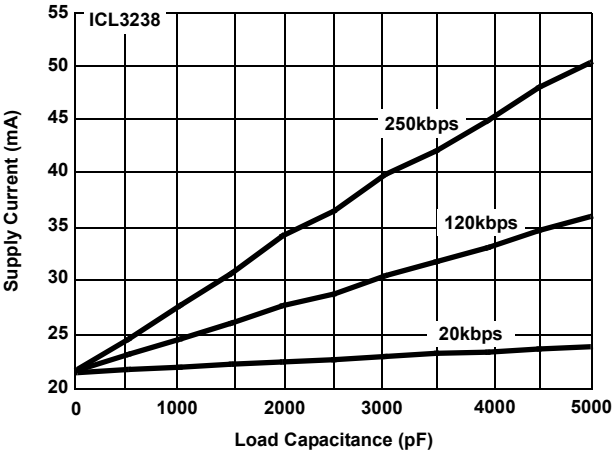


Figure 6. Supply Current vs Load Capacitance When Transmitting Data

V_{CC} = 3.3V, T_A = 25°C **(Continued)**

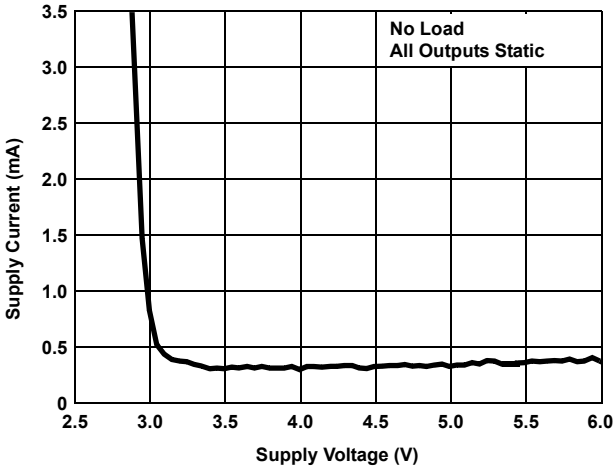


Figure 7. Supply Current vs Supply Voltage

4. Application Information

ICL3224, ICL3226, and ICL3238 (ISL32xx) devices operate from a single +3V 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.

4.1 Charge-Pump

The ICL32xx devices 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 at V_{CC} = 3.3V. See the Capacitor Selection section, and Table 6 on page 19 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), resulting in significant power savings.

4.1.1 Charge Pump Absolute Maximum Ratings

These 3V to 5V RS-232 transceivers have been fully characterized for 3.0V to 3.6V operation, and at critical points for 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 VCC values set to 3.0V and 3.6V (see Table 2). For VCC values set to 4.5V and 5.5V, the maximum values for V+ and V- can approach +9V and -7V respectively (see Table 3). 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	$T1_{IN}$ (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	5.8	6.56	-5.6	-5.88
			L	5.8	6.56	-5.6	-5.88
			2.4kbps	5.8	6.56	-5.6	-5.88
		3kΩ // 1000pF	H	5.88	6.6	-5.56	-5.92
			L	5.76	6.36	-5.56	-5.76
			2.4kbps	6	6.64	-5.64	-5.96
0.047	0.33	Open	H	5.68	6	-5.6	-5.6
			L	5.68	6	-5.6	-5.6
			2.4kbps	5.68	6	-5.6	-5.6
		3kΩ // 1000pF	H	5.76	6.08	-5.64	-5.64
			L	5.68	6.04	-5.6	-5.6
			2.4kbps	5.84	6.16	-5.64	-5.72
1	1	Open	H	5.88	6.24	-5.6	-5.6
			L	5.88	6.28	-5.6	-5.64
			2.4kbps	5.8	6.2	-5.6	-5.6
		3kΩ // 1000pF	H	5.88	6.44	-5.64	-5.72
			L	5.88	6.04	-5.64	-5.64
			2.4kbps	5.92	6.4	-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	$T1_{IN}$ (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	-6.4
			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	-5.76	-5.76
			2.4kbps	7.76	8.84	-6.4	-6.64
0.047	0.33	Open	H	6.44	6.88	-5.8	-5.88
			L	6.48	6.88	-5.84	-5.88
			2.4kbps	6.44	6.88	-5.8	-5.88
		3kΩ // 1000pF	H	6.64	7.28	-5.92	-6.04
			L	6.24	6.6	-5.52	-5.52
			2.4kbps	6.72	7.16	-5.92	-5.96
1	1	Open	H	6.84	7.6	-5.76	-5.76
			L	6.88	7.6	-5.76	-5.76
			2.4kbps	6.92	7.56	-5.72	-5.76
		3kΩ // 1000pF	H	7.28	8.16	-5.8	-5.92
			L	6.44	6.84	-5.64	-6.84
			2.4kbps	7.08	7.76	-5.8	-5.8

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 over a wide range of single supply system voltages.

Transmitter outputs disable and assume a high impedance state when the device enters the powerdown mode (see Table 5 on page 15). The outputs can be driven to ±12V when disabled.

All 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 1Mbps.

Transmitter inputs float if left unconnected, and can increase I_{CC}. Connect unused inputs to GND for best performance.

4.3 Receivers

All the ICL32xx devices contain standard inverting receivers, but only the ICL3238 receiver can tri-state, using the $\overline{\text{FORCEOFF}}$ control line. The ICL3238 includes a noninverting (monitor) receiver (denoted by the R_{OUTB} label) that is always active, regardless of the state of any control lines. This receiver converts RS-232 signals to CMOS output levels and accepts inputs up to ±25V while presenting the required 3kΩ to 7kΩ input impedance (see Figure 8) 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.

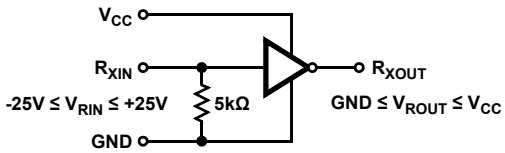


Figure 8. Inverting Receiver Connections

The ICL3238 inverting receiver disables during forced (manual) powerdown, but not during automatic powerdown (see Table 5 on page 15). Conversely, the monitor receiver remains active even during manual powerdown, which makes it 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 9 and 10). When powered down, they cannot be used for wake up functions, but the corresponding monitor receiver can be dedicated to this task as shown in Figure 10.

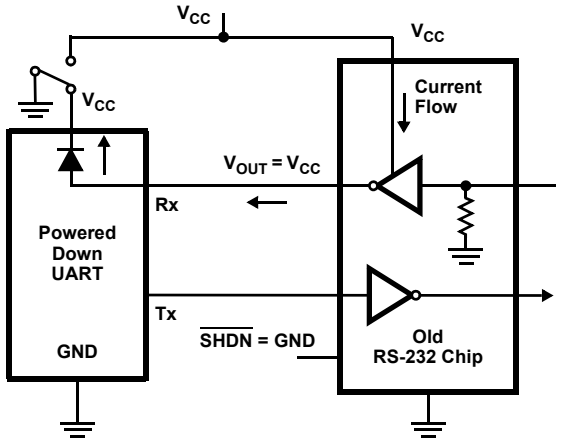


Figure 9. Power Drain Through Powered Down Peripheral

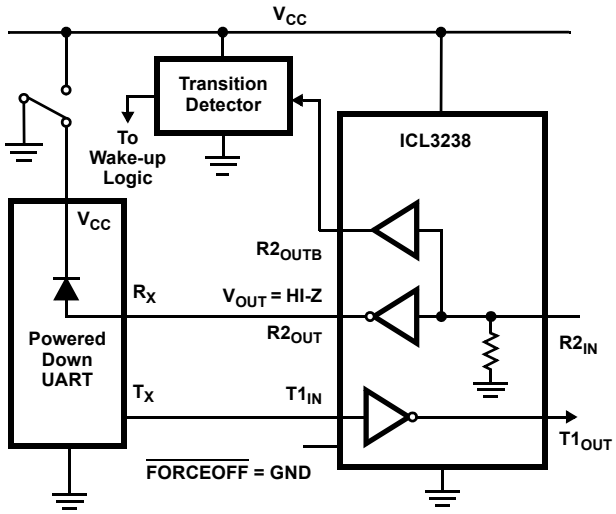


Figure 10. Disabled Receivers Prevent Power Drain

4.4 Powerdown Functionality

The 3V ICL32xx devices require a nominal supply current of 0.3mA during normal operation (not in powerdown mode). This current 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 tri-state. Inverting receiver outputs may disable in powerdown; see Table 5 for details. This micro-power mode makes these devices ideal for battery powered and portable applications.

Table 5. Powerdown Logic Truth Table

RCVR or XMTR Edge Within 30 Sec?	$\overline{\text{FORCEOFF}}$ Input	FORCEON Input	Transmitter Outputs	Receiver Outputs	(Note 8) R_{OUTB} Outputs	RS-232 Level Present at Receiver Input?	$\overline{\text{INVALID}}$ Output	Mode of Operation
ICL3224, ICL3226								
No	H	H	Active	Active	N.A.	No	L	Normal Operation (Enhanced Auto Powerdown Disabled)
No	H	H	Active	Active	N.A.	Yes	H	
Yes	H	L	Active	Active	N.A.	No	L	Normal Operation (Enhanced Auto Powerdown Enabled)
Yes	H	L	Active	Active	N.A.	Yes	H	
No	H	L	High-Z	Active	N.A.	No	L	Powerdown Due to Enhanced Auto Powerdown Logic
No	H	L	High-Z	Active	N.A.	Yes	H	
X	L	X	High-Z	Active	N.A.	No	L	Manual Powerdown
X	L	X	High-Z	Active	N.A.	Yes	H	
ICL322X - $\overline{\text{INVALID}}$ DRIVING FORCEON AND $\overline{\text{FORCEOFF}}$ (Emulates Automatic Powerdown)								
X	Note 9	Note 9	Active	Active	N.A.	Yes	H	Normal Operation
X	Note 9	Note 9	High-Z	Active	N.A.	No	L	Forced Auto Powerdown
ICL3238								
No	H	H	Active	Active	Active	No	L	Normal Operation (Enhanced Auto Powerdown Disabled)
No	H	H	Active	Active	Active	Yes	H	
Yes	H	L	Active	Active	Active	No	L	Normal Operation (Enhanced Auto Powerdown Enabled)
Yes	H	L	Active	Active	Active	Yes	H	
No	H	L	High-Z	Active	Active	No	L	Powerdown Due to Enhanced Auto Powerdown Logic
No	H	L	High-Z	Active	Active	Yes	H	
X	L	X	High-Z	High-Z	Active	No	L	Manual Powerdown
X	L	X	High-Z	High-Z	Active	Yes	H	
ICL3238 - $\overline{\text{INVALID}}$ DRIVING FORCEON AND $\overline{\text{FORCEOFF}}$ (Emulates Automatic Powerdown)								
X	Note 9	Note 9	Active	Active	Active	Yes	H	Normal Operation
X	Note 9	Note 9	High-Z	High-Z	Active	No	L	Forced Auto Powerdown

Notes:
8. Applies only to the ICL3238.
9. Input is connected to $\overline{\text{INVALID}}$ Output.

4.4.1 Software Controlled (Manual) Powerdown

The ICL32xx devices 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. The ICL3238's inverting (standard) receiver outputs also disables when the device is in powerdown and eliminates the possible current path through a shutdown peripheral's input protection diode (see Figures 9 and 10).

Connecting $\overline{\text{FORCEOFF}}$ and FORCEON together disables the enhanced automatic powerdown feature, which enables them to function as a manual $\overline{\text{SHUTDOWN}}$ input (see Figure 11).

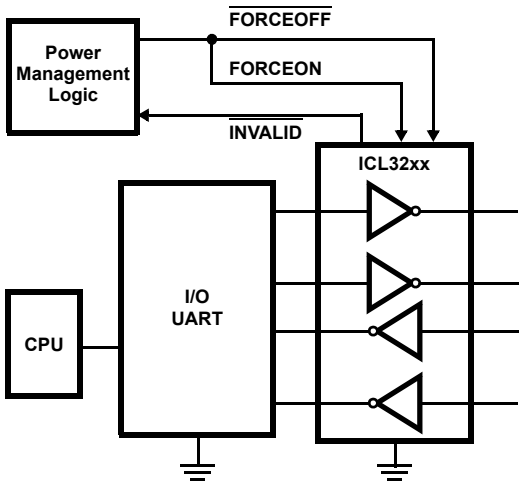


Figure 11. Connections for Manual Powerdown When No Valid Receiver Signals are Present

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

When using both manual and enhanced automatic powerdown (FORCEON = 0), the ICL32xx devices do 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 12 shows a circuit for ensuring that the ICL32xx 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 ICL32xx returns to enhanced automatic powerdown mode an RC time constant after this rising edge. The time constant is not critical, because the ICL32xx remains powered up for 30s after the FORCEON falling edge, even if there are no signal transitions. The delay gives slow-to-wake systems (such as a mouse) plenty of time to start transmitting, and as long as it starts transmitting within 30s, both systems remain enabled.

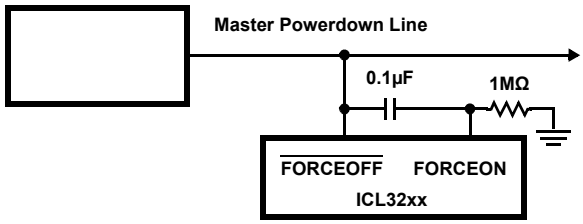


Figure 12. Circuit to Ensure Immediate Power Up When Exiting Forced Powerdown

4.4.2 $\overline{\text{INVALID}}$ Output

Table 5 on page 15 shows that the $\overline{\text{INVALID}}$ output always indicates whether or not 30µs have elapsed with invalid RS-232 signals (see Figures 13 and 15) persisting on all of the receiver inputs and provides 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. 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).

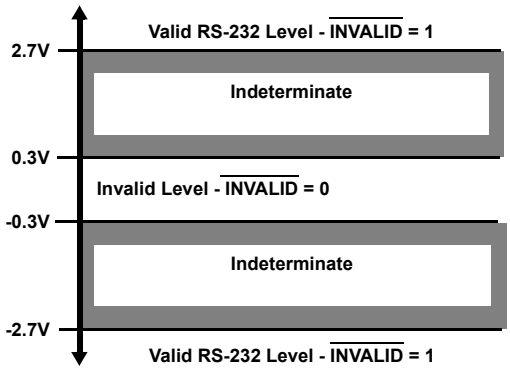


Figure 13. Definition of Valid RS-232 Receiver Levels

4.5 Enhanced Automatic Powerdown

Even greater power savings are available by using the ICL32xx's enhanced automatic powerdown function. When the enhanced powerdown logic determines that no transitions have occurred on any of the transmitter nor receiver inputs for 30s, the charge pump and transmitters powerdown, thereby reducing supply current to 1µA. The ICL32xx devices automatically power back up whenever they detect a transition on one of these inputs. The 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 14 shows the enhanced powerdown control logic. **Note:** When the ICL32xx enters powerdown (manually or automatically), the 30-second timer remains timed out (set), keeping the ICL32xx powered down until FORCEON transitions high, or until a transition occurs on a receiver or transmitter input.

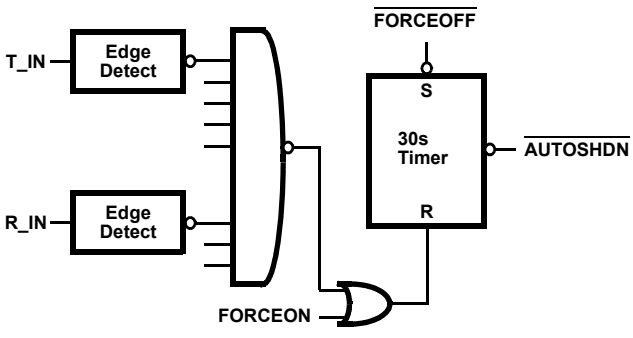


Figure 14. Enhanced Automatic Powerdown Logic

The $\overline{\text{INVALID}}$ output signal switches low to indicate that invalid levels have persisted on all of the receiver inputs for more than 30µs (see Figure 15), but this signal switch has no direct effect on the state of the ICL32xx (see the next sections for methods of using $\overline{\text{INVALID}}$ to power down the device). $\overline{\text{INVALID}}$ 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.

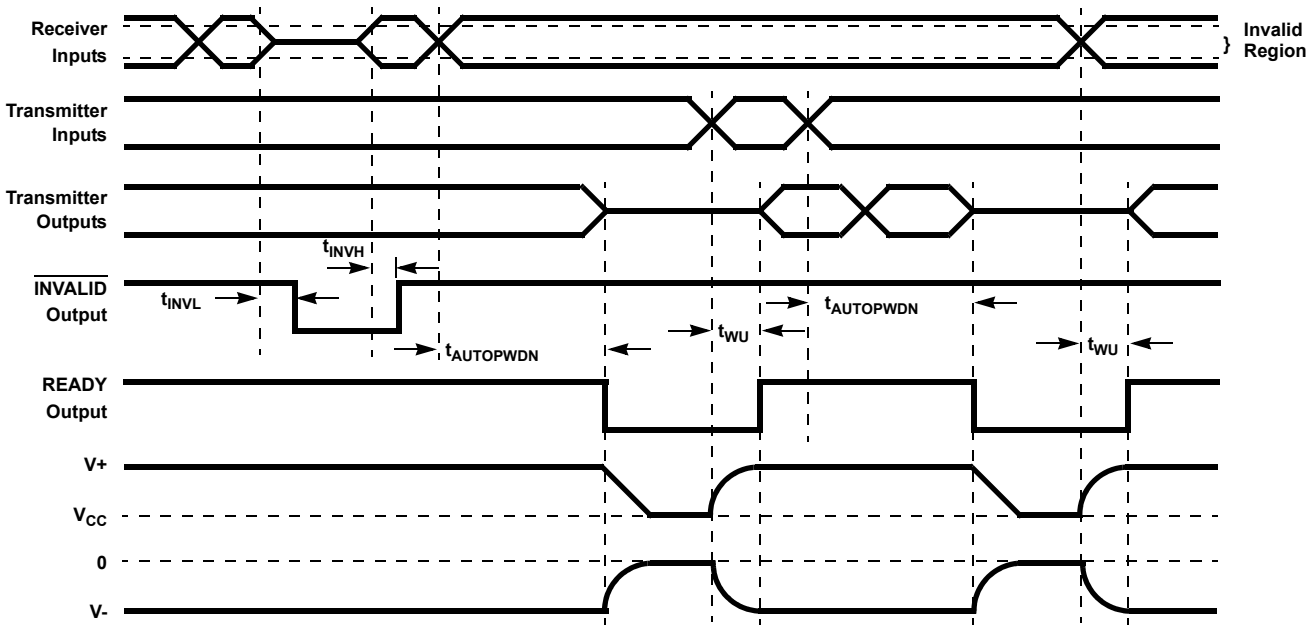


Figure 15. Enhanced Automatic Powerdown, $\overline{\text{INVALID}}$ and READY Timing Diagrams

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

4.5.1 Emulating Standard Automatic Powerdown

If enhanced automatic powerdown is not desired, you can implement the standard automatic powerdown feature (mimics the function on the ICL3221/23/43) by connecting the $\overline{\text{INVALID}}$ output to the FORCEON and $\overline{\text{FORCEOFF}}$ inputs, as shown in Figure 16. After 30µs of invalid receiver levels, $\overline{\text{INVALID}}$ switches low and drives the ICL32xx into a forced powerdown condition. $\overline{\text{INVALID}}$ switches high as soon as a receiver input senses a valid RS-232 level, forcing the ICL32xx to power on. See the "$\overline{\text{INVALID}}$ Driving FORCEON and $\overline{\text{FORCEOFF}}$" sections of Table 5 on page 15 for an operational summary. This operational mode is perfect for hand-held 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.

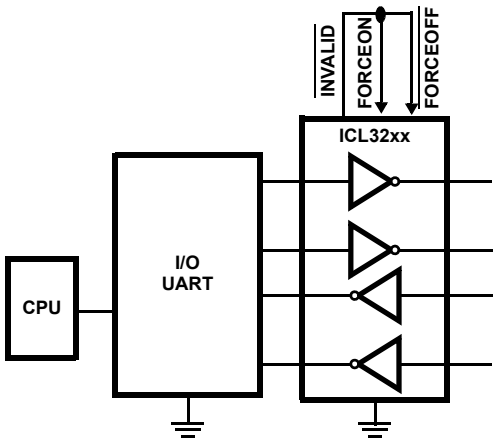


Figure 16. Connections for Automatic Powerdown When No Valid Receiver Signals are Present

4.5.2 Hybrid Automatic Powerdown Options

For devices that communicate only through a detachable cable, you can connect $\overline{\text{INVALID}}$ 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 RS-232 device whenever there is 30s 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 RS-232 device to power down. The ICL32xx 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 14 on page 17). For immediate power up when the cable is reattached, connect FORCEON to $\overline{\text{FORCEOFF}}$ through a network similar to that shown in Figure 12 on page 16.

4.6 READY Output (ICL3224 and ICL3226 only)

The READY output indicates that the ICL322x devices are ready to transmit. READY switches low whenever the device enters powerdown, and switches back high during power-up when V- reaches -4V or lower.

4.7 Capacitor Selection

The charge pumps require 0.1µF capacitors for 3.3V operation. For other supply voltages see Table 6 for capacitor values. 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. 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 influences the amount of ripple on V+ and V-.

Table 6. Required Capacitor Values

V_{CC} (V)	C_1 (µF)	C_2, C_3, C_4 (µF)
3.0 to 3.6 (3.3V ±10%)	0.1 (0.22)	0.1 (0.22)
3.15 to 3.6 (3.3V ±5%)	(0.1)	(0.1)
4.5 to 5.5	0.047	0.33
3.0 to 5.5	0.1 (0.22)	0.47 (1.0)

Note:
10. Parenthesized values apply only to the ICL3238

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 Powerdown

Figure 17 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**: The transmitters enable only when the magnitude of the supplies exceed approximately 3V.

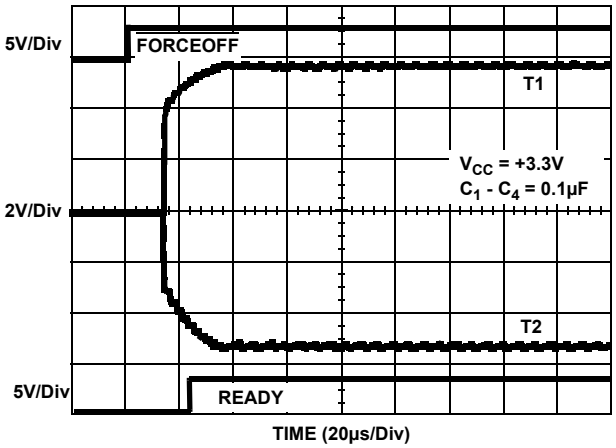


Figure 17. Transmitter Outputs When Exiting Powerdown

4.10 Operation Down to 2.7V

The ICL32xx 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.

4.11 High Data Rates

The ICL32xx maintain the RS-232 ±5V minimum transmitter output voltages even at high data rates. Figure 18 shows a transmitter loopback test circuit, and Figure 19 on page 21 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 20 on page 21 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.

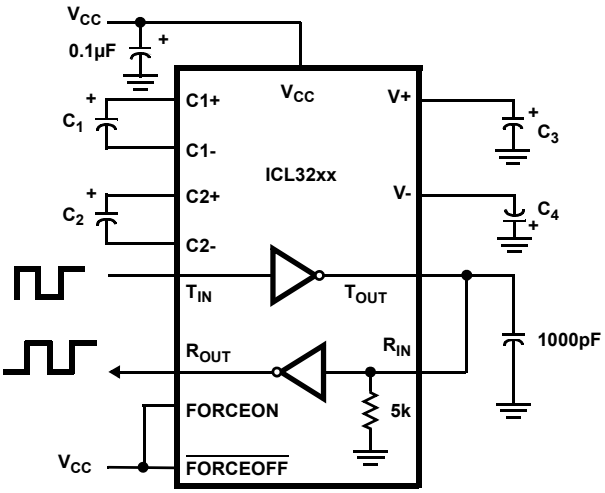


Figure 18. Transmitter Loopback Test Circuit

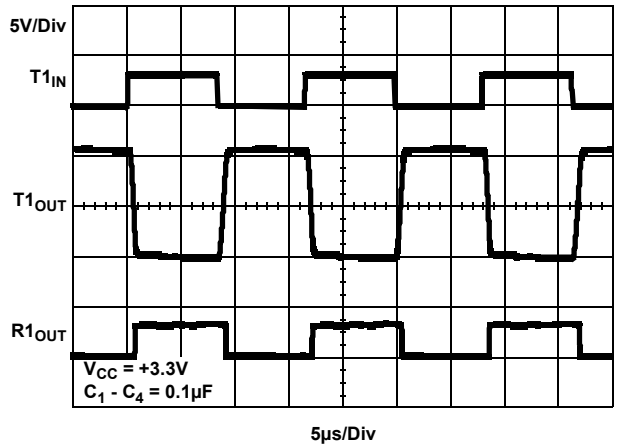


Figure 19. Loopback Test at 120kbps

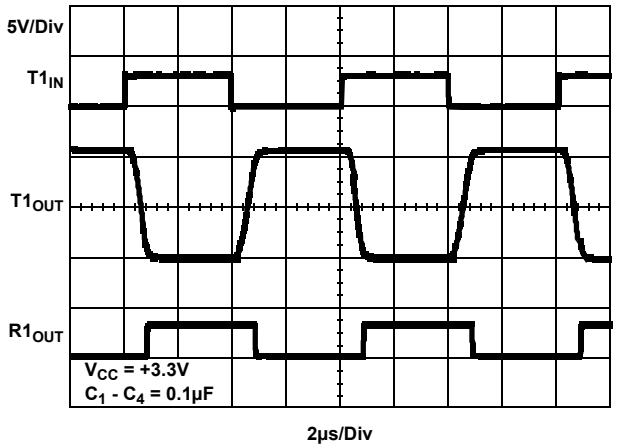


Figure 20. Loopback Test at 250kbps

4.12 Interconnection with 3V and 5V Logic

The ICL32xx directly interface with 5V CMOS and TTL logic families. The AC, HC, and CD4000 outputs can drive ICL32xx inputs with the ICL32xx at 3.3V and the logic supply at 5V, but ICL32xx outputs do not reach the minimum V_{IH} for these logic families. See Table 7 for more information.

Table 7. 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. ICL32xx outputs are incompatible with AC, HC, and CD4000 CMOS inputs.

5. Die Characteristics

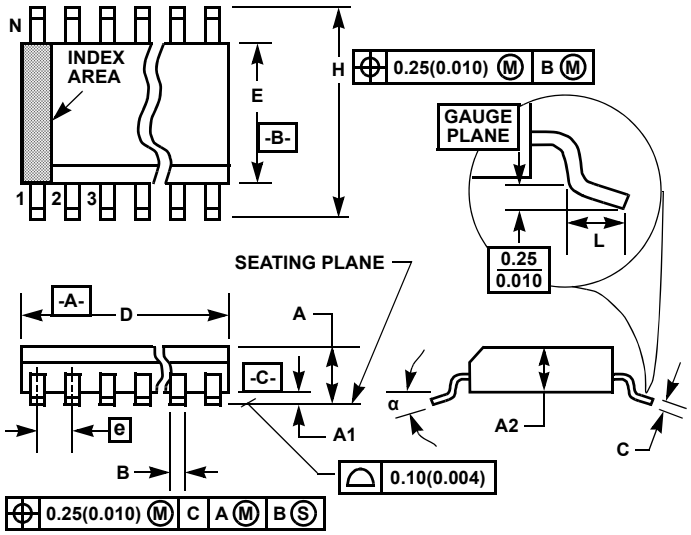
Substrate Potential (Powered Up)	GND
Transistor Count	ICL3224: 937 ICL3226: 825 ICL3238: 1235
Process	Si Gate CMOS

6. Revision History

Rev.	Date	Description
11	May.29.19	Updated to latest formatting. Updated Related Literature section. Removed ICL3244 and MAX3244 information from document. Updated Ordering information table by adding tape and reel information, updated notes, removed retired parts, and stamped EOL parts. Added “Charge Pump Absolute Maximum Ratings” on page 12. Added Revision History Updated disclaimer.

7. Package Outline Drawings

For the most recent package outline drawing, see M16.209.



M16.209 (JEDEC MO-150-AC ISSUE B)
16 Lead Shrink Small Outline Plastic Package (SSOP

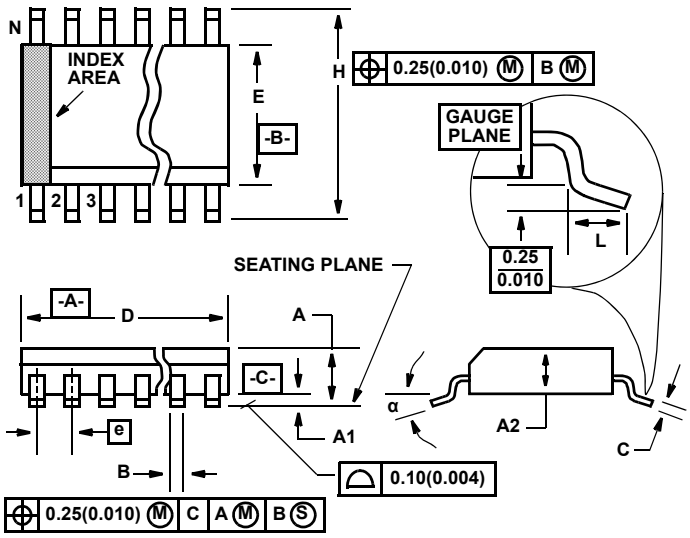
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.078	-	2.00	-
A1	0.002	-	0.05	-	-
A2	0.065	0.072	1.65	1.85	-
B	0.009	0.014	0.22	0.38	9
C	0.004	0.009	0.09	0.25	-
D	0.233	0.255	5.90	6.50	3
E	0.197	0.220	5.00	5.60	4
e	0.026 BSC		0.65 BSC		-
H	0.292	0.322	7.40	8.20	-
L	0.022	0.037	0.55	0.95	6
N	16		16		7
α	0°	8°	0°	8°	-

Rev. 3 6/05

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.

For the most recent package outline drawing, see M20.209.



M20.209 (JEDEC MO-150-AE ISSUE B)
20 Lead Shrink Small Outline Plastic Package (SSOP)

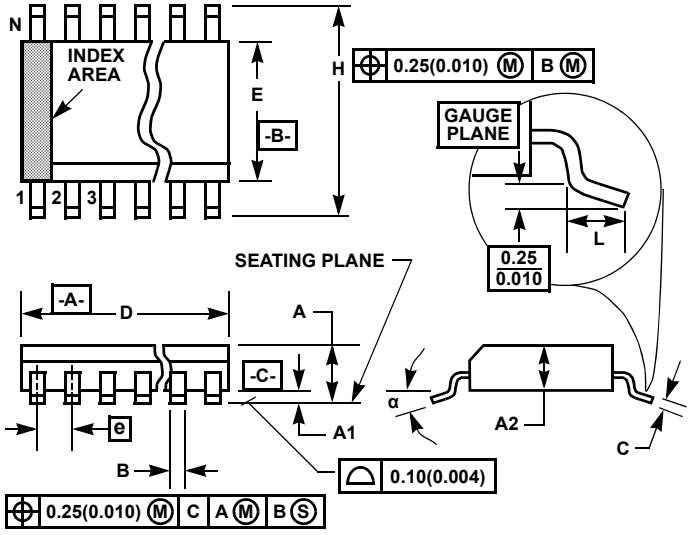
SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.068	0.078	1.73	1.99	
A1	0.002	0.008’	0.05	0.21	
A2	0.066	0.070’	1.68	1.78	
B	0.010’	0.015	0.25	0.38	9
C	0.004	0.008	0.09	0.20’	
D	0.278	0.289	7.07	7.33	3
E	0.205	0.212	5.20’	5.38	4
e	0.026 BSC		0.65 BSC		
H	0.301	0.311	7.65	7.90’	
L	0.025	0.037	0.63	0.95	6
N	20		20		7
α	0 deg.	8 deg.	0 deg.	8 deg.	

Rev. 3 11/02

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.
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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.

For the most recent package outline drawing, see M28.209.



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.

M28.209 (JEDEC MO-150-AH ISSUE B)
28 Lead Shrink Small Outline Plastic Package (SSOP)

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°	8°	0°	8°	-

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