Data Sheet July 2001 File Number 4876.4

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

The Intersil ICL32XX devices are 3.0V to 5.5V powered RS-232 transmitters/receivers which 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 the low operational, 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. Small footprint packaging, and the use of small, low value capacitors ensure board space savings as well. Data rates greater than 250kbps 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 ICL3244 is a 3 driver, 5 receiver device that provides a complete serial port suitable for laptop or notebook computers. The ICL3244/38 also include a noninverting always-active receiver for RING INDICATOR monitoring.

These devices feature an ***enhanced automatic powerdown*** function which powers down the on-chip power-supply and driver circuits. This occurs when all receiver and transmitter inputs detect no signal transitions for a period of 30sec. 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 data sheet, while Application Note AN9863 summarizes the features of each device comprising the ICL32XX 3V family.

Features

- Manual and Enhanced Automatic Powerdown Features
- Drop in Replacements for MAX3224, MAX3226, MAX3238, MAX3244
- Meets EIA/TIA-232 and V.28/V.24 Specifications at 3V
- Latch-Up Free
- On-Chip Voltage Converters Require Only Four External 0.1µF Capacitors
- Flow-Through Pinout (ICL3238)
- Guaranteed Mouse Driveability (ICL3244)
- “Ready to Transmit” Indicator Output (ICL3224/26)
- Receiver Hysteresis For Improved Noise Immunity
- Guaranteed Minimum Data Rate 250kbps
- Guaranteed 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

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})	DATA RATE (kbps)	Rx. ENABLE FUNCTION?	READY OUTPUT?	MANUAL POWER-DOWN?	ENHANCED AUTOMATIC POWERDOWN FUNCTION?
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
ICL3244	3	5	1	250	NO	NO	YES	YES

Ordering Information

(NOTE 1) PART NO.	TEMP. RANGE (^{o}C)	PACKAGE	PKG. NO.
ICL3224CA	0 to 70	20 Ld SSOP	M20.209
ICL3224IA	-40 to 85	20 Ld SSOP	M20.209
ICL3224CP	0 to 70	20 Ld PDIP	E20.3
ICL3226CA	0 to 70	16 Ld SSOP	M16.209
ICL3226IA	-40 to 85	16 Ld SSOP	M16.209
ICL3238CA	0 to 70	28 Ld SSOP	M28.209
ICL3238IA	-40 to 85	28 Ld SSOP	M28.209
ICL3244CA	0 to 70	28 Ld SSOP	M28.209

Ordering Information (Continued)

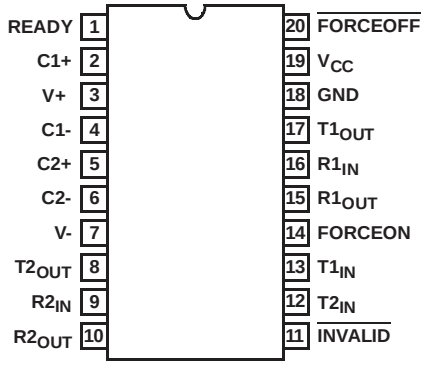
(NOTE 1) PART NO.	TEMP. RANGE (^{o}C)	PACKAGE	PKG. NO.
ICL3244IA	-40 to 85	28 Ld SSOP	M28.209
ICL3244CB	0 to 70	28 Ld SOIC	M28.3
ICL3244IB	-40 to 85	28 Ld SOIC	M28.3
ICL3244CV	0 to 70	28 Ld TSSOP	M28.173
ICL3244IV	-40 to 85	28 Ld TSSOP	M28.173

NOTE:

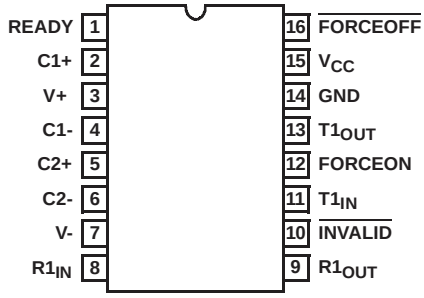
1. Most surface mount devices are available on tape and reel; add "-T" to suffix.

Pinouts

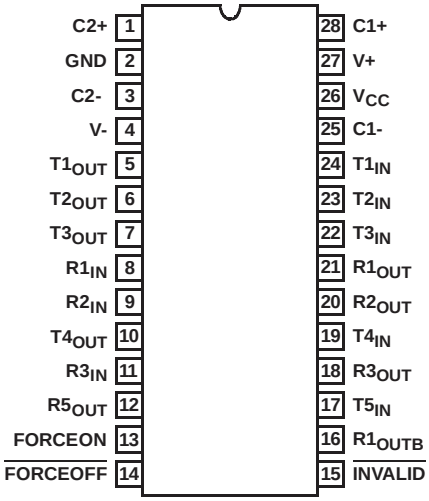
ICL3224 (PDIP, SSOP)
TOP VIEW



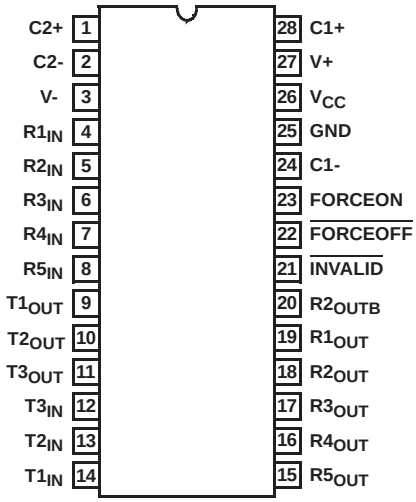
ICL3226 (SSOP)
TOP VIEW



ICL3238 (SSOP)
TOP VIEW



ICL3244 (SOIC, SSOP, TSSOP)
TOP VIEW

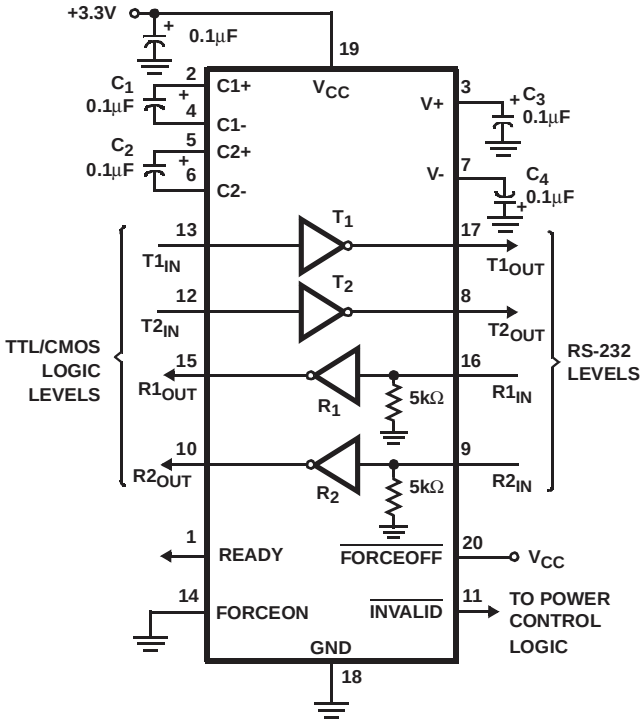


Pin Descriptions

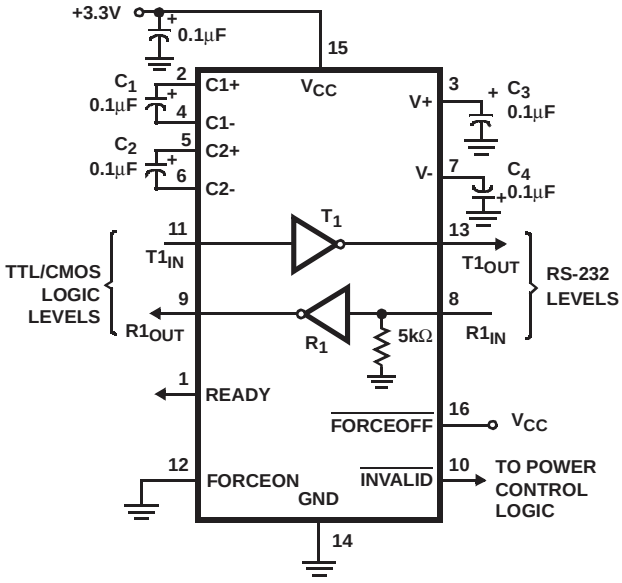
PIN	FUNCTION
V_{CC}	System power supply input (3.0V to 5.5V).
V+	Internally generated positive transmitter supply (+5.5V).
V-	Internally generated negative transmitter supply (-5.5V).
GND	Ground connection.
C1+	External capacitor (voltage doubler) is connected to this lead.
C1-	External capacitor (voltage 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 outputs.
$\overline{\text{INVALID}}$	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 (i.e., V- ≤ -4V)
$\overline{\text{FORCEOFF}}$	Active low to shut down transmitters and on-chip power supply. This overrides any automatic circuitry and FORCEON (see Table 2).
FORCEON	Active high input to override automatic powerdown circuitry thereby keeping transmitters active. ($\overline{\text{FORCEOFF}}$ must be high).

Typical Operating Circuits

ICL3224

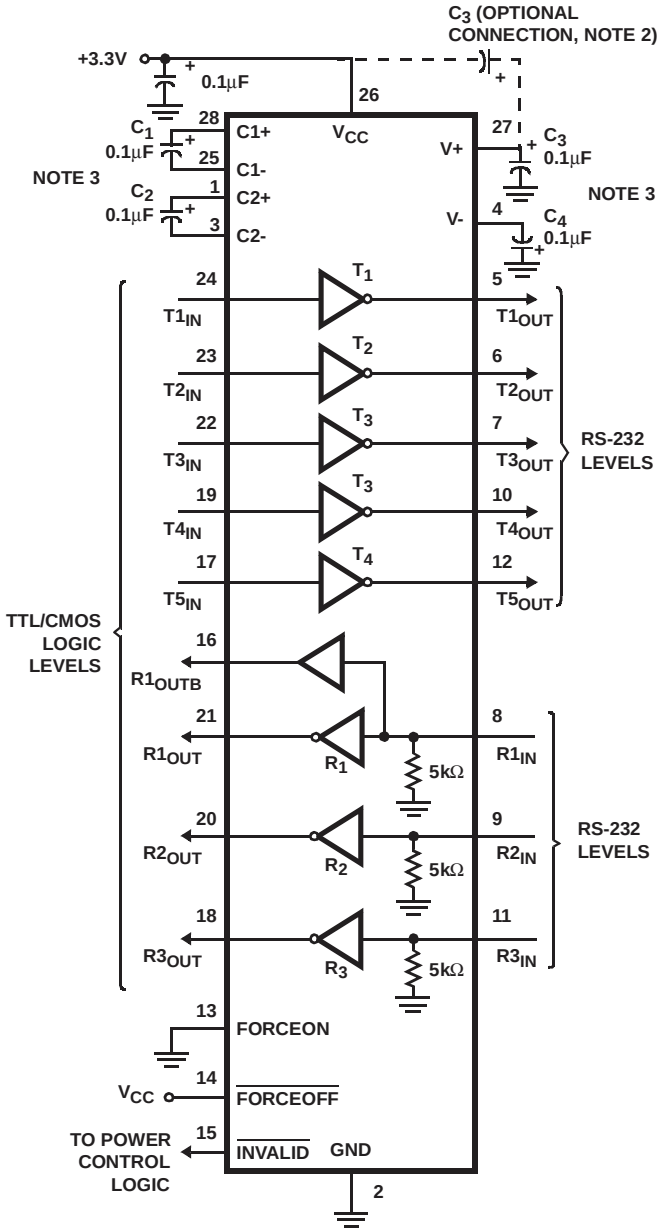


ICL3226

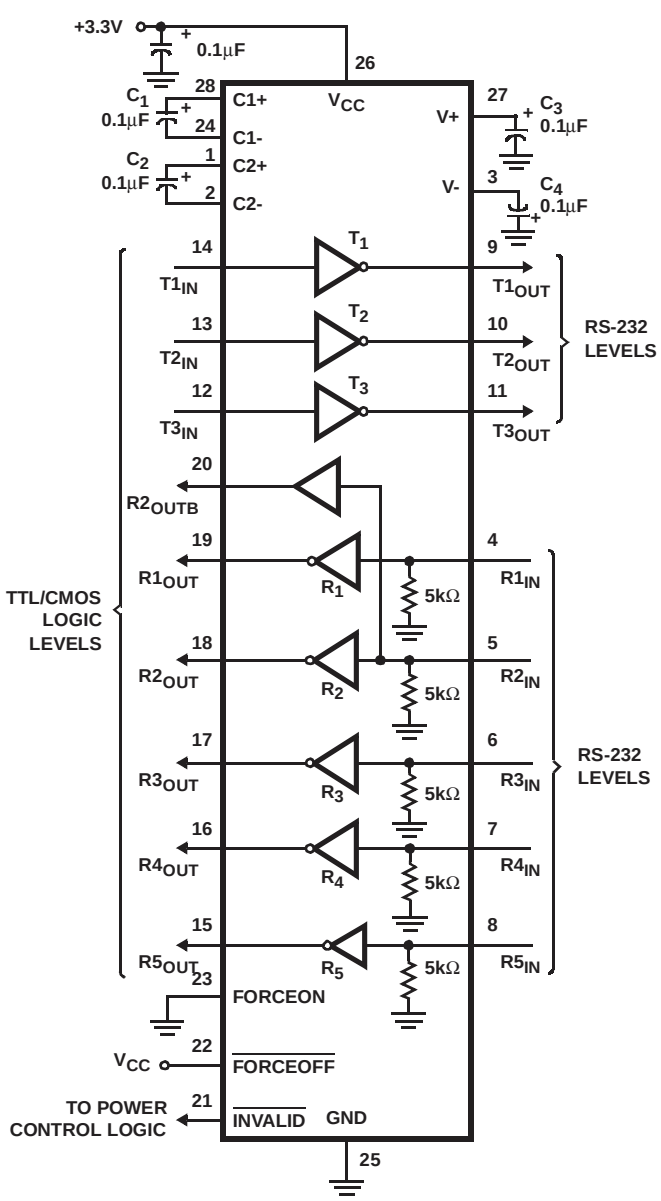


Typical Operating Circuits (Continued)

ICL3238



ICL3244



NOTES:

2. THE NEGATIVE TERMINAL OF C_3 CAN BE CONNECTED TO EITHER V_{CC} OR GND.
3. 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.

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}, $\overline{FORCEOFF}$, FORCEON. . . . . -0.3V to 6V
R_{IN} . . . . . ±25V
Output Voltages
T_{OUT} . . . . . ±13.2V
R_{OUT}, $\overline{INVALID}$, READY . . . . . -0.3V to V_{CC} +0.3V
Short Circuit Duration
T_{OUT} . . . . . Continuous
ESD Rating . . . . . See Specification Table

Thermal Information

Thermal Resistance (Typical, Note 4)	θ_{JA} (^{o}C/W)
20 Ld PDIP Package	80
28 Ld SOIC Package	75
16 Ld SSOP Package	140
20 Ld SSOP Package	125
28 Ld SSOP and TSSOP Packages	100

Moisture Sensitivity (see Technical Brief TB363)
All Packages Not Listed Below . . . . . Level 1
16 Ld SSOP Package . . . . . Level 2
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
(SOIC, SSOP, TSSOP - Lead Tips Only)

Operating Conditions

Temperature Range
ICL32XXC . . . . . 0^{o}C to 70^{o}C
ICL32XXI . . . . . -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:

4. 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 to 5.5V, C_1 - C_4 = 0.1µF (ICL3238: C_1 - C_4 = 0.22µF @ V_{CC} = 3V); 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, 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}	ICL3244, V_{CC} = 3V	25	-	0.3	1.0	mA
		All Others, 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

Electrical Specifications Test Conditions: V_{CC} = 3V to 5.5V, C_1 - C_4 = 0.1µF (ICL3238: C_1 - C_4 = 0.22µF @ V_{CC} = 3V); 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, Automatic Powerdown or $\overline{FORCEOFF}$ = GND		Full	-	-	±25	µA
MOUSE DRIVEABILITY (ICL3244 Only)							
Transmitter Output Voltage (See Figure 11)	$T1_{IN}$ = $T2_{IN}$ = GND, $T3_{IN}$ = V_{CC}, $T3_{OUT}$ Loaded with 3kΩ to GND, $T1_{OUT}$ and $T2_{OUT}$ Loaded with 2.5mA Each		Full	±5	-	-	V
ENHANCED AUTOMATIC POWERDOWN (FORCEON = GND, $\overline{FORCEOFF}$ = V_{CC})							
Receiver Input Thresholds to $\overline{INVALID}$ High	ICL32XX Powers Up (See Figure 6)		Full	-2.7	-	2.7	V
Receiver Input Thresholds to $\overline{INVALID}$ Low	ICL32XX Powers Down (See Figure 6)		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
Receiver or Transmitter Edge to Transmitters Enabled Delay (t_{WU})	ICL3238, Note 5		25	-	25	-	µs
	All Others, Note 5		25	-	100	-	µs
Receiver or Transmitter Edge to Transmitters Disabled Delay ($t_{AUTOPWDN}$)	Note 5		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
Receiver Output Enable Time	Normal Operation (ICL3238/44 Only)		25	-	200	-	ns
Receiver Output Disable Time	Normal Operation (ICL3238/44 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
	IEC1000-4-2 Contact Discharge		25	-	±8	-	kV
	IEC1000-4-2 Air Gap Discharge		25	-	±10	-	kV
All Other Pins	Human Body Model		25	-	±2.5	-	kV

NOTE:

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

Detailed Description

These ICL32XX interface ICs operate from a single +3V to +5.5V supply, guarantee 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. 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.

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.

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.

All devices guarantee 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 may cause I_{CC} increases. Connect unused inputs to GND for the best performance.

Receivers

All the ICL32XX devices contain standard inverting receivers, but only the ICL3238 and ICL3244 receivers can tristate, via the $\overline{\text{FORCEOFF}}$ control line. Additionally, the ICL3238 and ICL3244 include a noninverting (monitor) receiver (denoted by the R_{OUTB} label) that is always active, regardless of the state of any control lines. Both receiver types 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.

The ICL3238 and ICL3244 inverting receivers disable during forced (manual) powerdown, but not during automatic powerdown (see Table 2). Conversely, the monitor receiver remains active even during manual powerdown making 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 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.

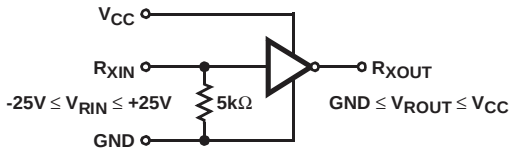


FIGURE 1. INVERTING RECEIVER CONNECTIONS

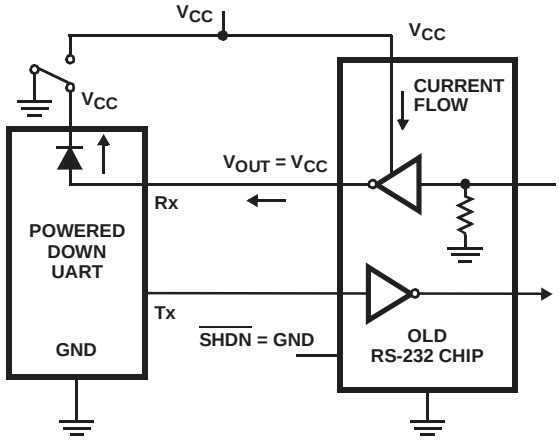


FIGURE 2. POWER DRAIN THROUGH POWERED DOWN PERIPHERAL

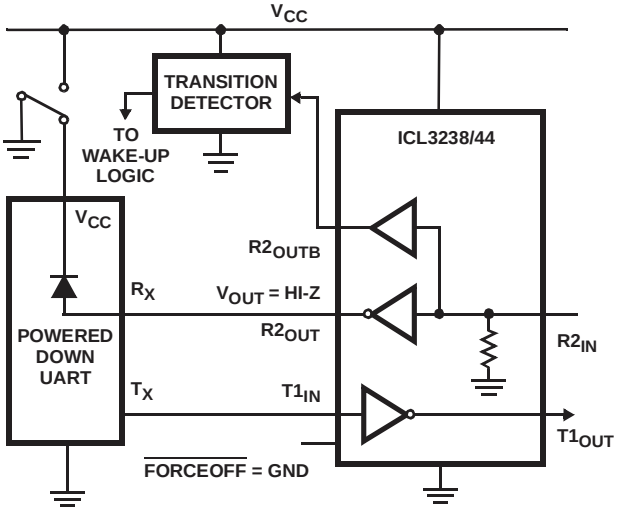


FIGURE 3. DISABLED RECEIVERS PREVENT POWER DRAIN

Powerdown Functionality

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

TABLE 2. POWERDOWN LOGIC TRUTH TABLE

RCVR OR XMTR EDGE WITHIN 30 SEC?	$\overline{\text{FORCEOFF}}$ INPUT	FORCEON INPUT	TRANSMITTER OUTPUTS	RECEIVER OUTPUTS	(NOTE 6) 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 7	NOTE 7	Active	Active	N.A.	YES	H	Normal Operation
X	NOTE 7	NOTE 7	High-Z	Active	N.A.	NO	L	Forced Auto Powerdown
ICL3238, ICL3244								
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, ICL3244 - $\overline{\text{INVALID}}$ DRIVING FORCEON AND $\overline{\text{FORCEOFF}}$ (EMULATES AUTOMATIC POWERDOWN)								
X	NOTE 7	NOTE 7	Active	Active	Active	YES	H	Normal Operation
X	NOTE 7	NOTE 7	High-Z	High-Z	Active	NO	L	Forced Auto Powerdown

NOTES:

6. Applies only to the ICL3238 and ICL3244.
7. Input is connected to $\overline{\text{INVALID}}$ Output.

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 tristate. Inverting receiver outputs may or may not disable in powerdown; refer to Table 2 for details. This micro-power mode makes these devices ideal for battery powered and portable applications.

Software Controlled (Manual) Powerdown

These devices allow the user to force the IC into the low power, standby state, and utilize 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 or software 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 enhanced automatic powerdown circuitry. ICL3238 and ICL3244 inverting (standard) receiver outputs also disable when the device is in powerdown, thereby eliminating the possible current path through a shutdown peripheral's input protection diode (see Figures 2 and 3).

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 4).

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 won't power up from manual

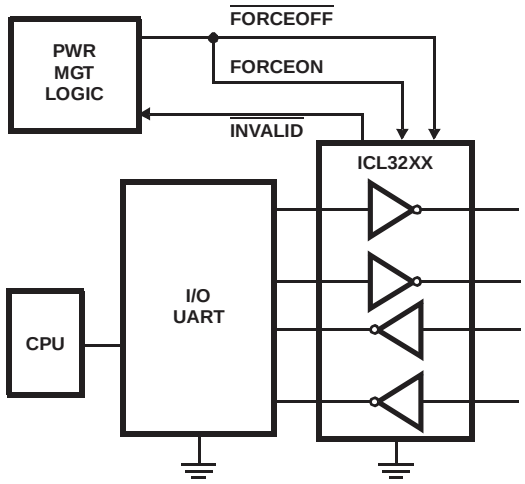


FIGURE 4. CONNECTIONS FOR MANUAL POWERDOWN WHEN NO VALID RECEIVER SIGNALS ARE PRESENT

powerdown until both $\overline{\text{FORCEOFF}}$ and FORCEON are driven high, or until a transition occurs on a receiver or transmitter input. Figure 5 illustrates 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 isn't critical, because the ICL32XX remains powered up for 30 seconds after the FORCEON falling edge, even if there are no signal transitions. This gives slow-to-wake systems (e.g., a mouse) plenty of time to start transmitting, and as long as it starts transmitting within 30 seconds both systems remain enabled.

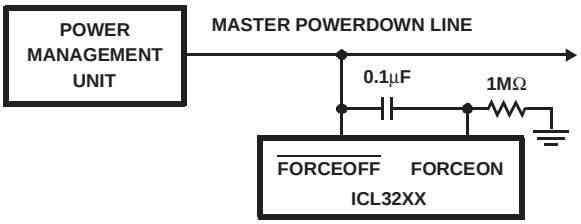


FIGURE 5. CIRCUIT TO ENSURE IMMEDIATE POWER UP WHEN EXITING FORCED POWERDOWN

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

The $\overline{\text{INVALID}}$ output always indicates (see Table 2) whether or not 30µs have elapsed with invalid RS-232 signals (see Figures 6 and 8) persisting on all of the receiver inputs, giving the user an easy way to determine when the interface block should power down. Invalid receiver levels occur whenever the driving peripheral's outputs are shut off (powered down) or when the RS-232 interface cable is disconnected. In the case of a disconnected interface cable where all the receiver inputs are floating (but pulled to GND by the internal receiver pull down resistors), the $\overline{\text{INVALID}}$ logic detects the invalid levels and drives the output low. The power management logic then uses this indicator to 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).

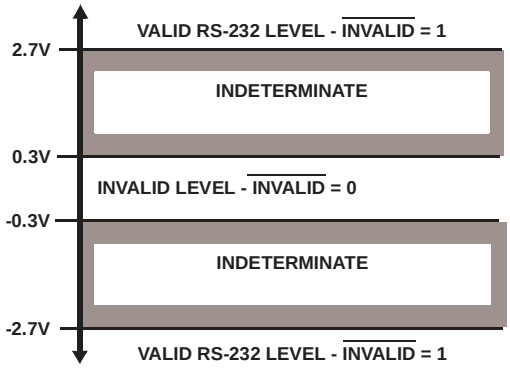


FIGURE 6. DEFINITION OF VALID RS-232 RECEIVER LEVELS

Enhanced Automatic Powerdown

Even greater power savings is available by using these devices which feature an *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 powerdown, thereby reducing supply current to 1µA. The ICL32XX 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 via the overriding $\overline{\text{FORCEOFF}}$ input. Table 2 summarizes the enhanced automatic powerdown functionality.

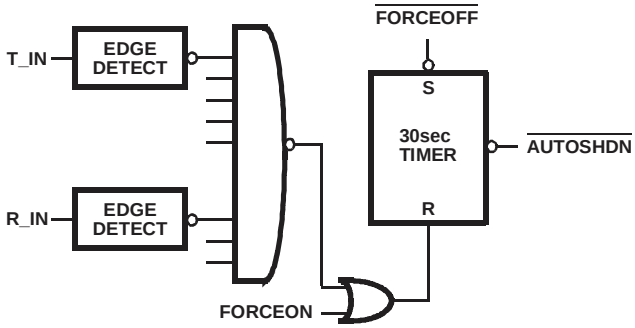


FIGURE 7. ENHANCED AUTOMATIC POWERDOWN LOGIC

Figure 7 illustrates the enhanced powerdown control logic. Note that once 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.

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 8), but this has no direct effect on the state of the ICL32XX (see the next sections for methods of utilizing $\overline{\text{INVALID}}$ 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.

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

Emulating Standard Automatic Powerdown

If enhanced automatic powerdown isn't desired, the user 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 9. 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 $\overline{\text{FORCEOFF}}$" section of Table 2 for an operational summary. This operational mode is perfect for handheld devices that communicate with another computer via 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.

Hybrid Automatic Powerdown Options

For devices which communicate only through a detachable cable, connecting $\overline{\text{INVALID}}$ to $\overline{\text{FORCEOFF}}$ (with FORCEON = 0) may be a desirable configuration. 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 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 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 7). For immediate power up when the cable is reattached, connect FORCEON to $\overline{\text{FORCEOFF}}$ through a network similar to that shown in Figure 5.

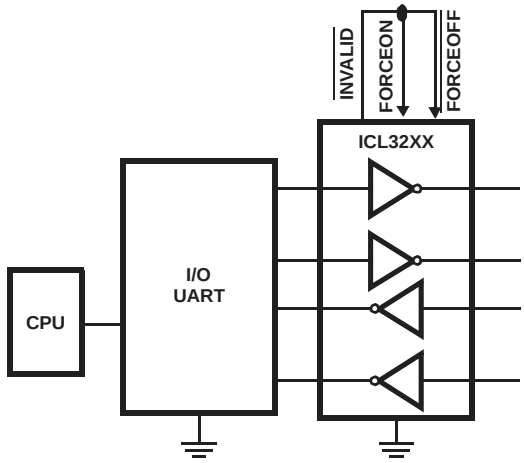


FIGURE 9. CONNECTIONS FOR AUTOMATIC POWERDOWN WHEN NO VALID RECEIVER SIGNALS ARE PRESENT

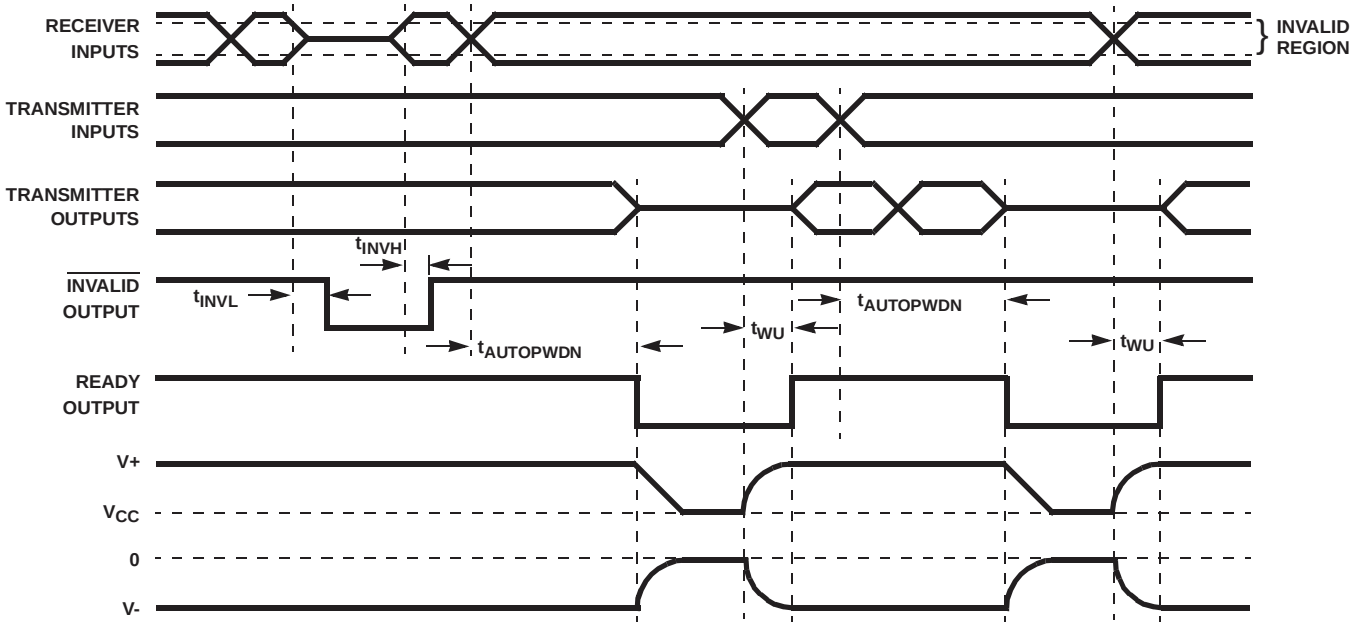


FIGURE 8. ENHANCED AUTOMATIC POWERDOWN, $\overline{\text{INVALID}}$ AND READY TIMING DIAGRAMS

Ready Output (ICL3224 and ICL3226 only)

The Ready output indicates that the ICL322X is ready to transmit. Ready switches low whenever the device enters powerdown, and switches back high during power-up when V- reaches -4V or lower.

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 (Note 8)

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:

8. Parenthesized values apply only to the ICL3238

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 10 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.

Mouse Driveability

The ICL3244 is specifically designed to power a serial mouse while operating from low voltage supplies. Figure 11 shows the transmitter output voltages under increasing load current. The on-chip switching regulator ensures the transmitters will supply at least ±5V during worst case conditions (15mA for paralleled V+ transmitters, 7.3mA for single V- transmitter).

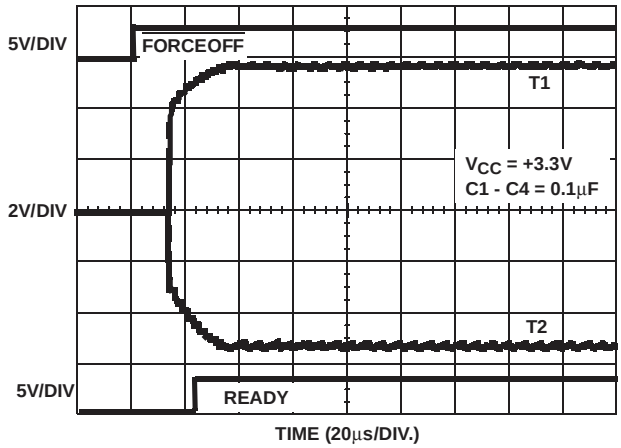


FIGURE 10. TRANSMITTER OUTPUTS WHEN EXITING POWERDOWN

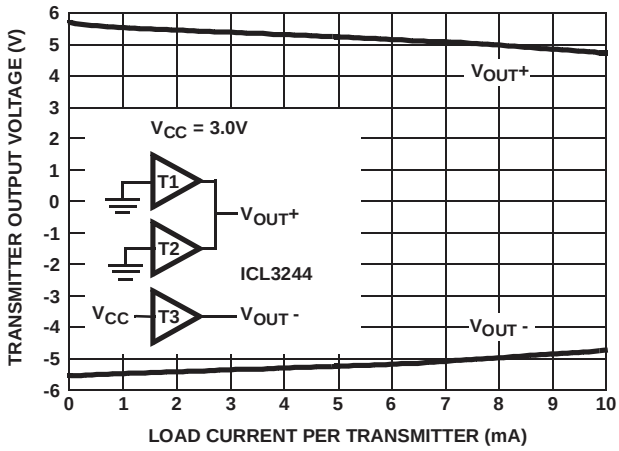


FIGURE 11. TRANSMITTER OUTPUT VOLTAGE vs LOAD CURRENT (PER TRANSMITTER, i.e., DOUBLE CURRENT AXIS FOR TOTAL V_{OUT+} CURRENT)

High Data Rates

The ICL32XX maintain the RS-232 ±5V minimum transmitter output voltages even at high data rates. Figure 12 details a transmitter loopback test circuit, and Figure 13 illustrates the loopback test result at 120kbps. For this test, all transmitters were simultaneously driving RS-232 loads in parallel with 1000pF, at 120kbps. Figure 14 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.

Interconnection with 3V and 5V Logic

The ICL32XX directly interface with 5V CMOS and TTL logic families. Nevertheless, with the ICL32XX at 3.3V, and the logic supply at 5V, AC, HC, and CD4000 outputs can drive ICL32XX inputs, but ICL32XX outputs do not reach the

minimum V_{IH} for these logic families. See Table 4 for more information.

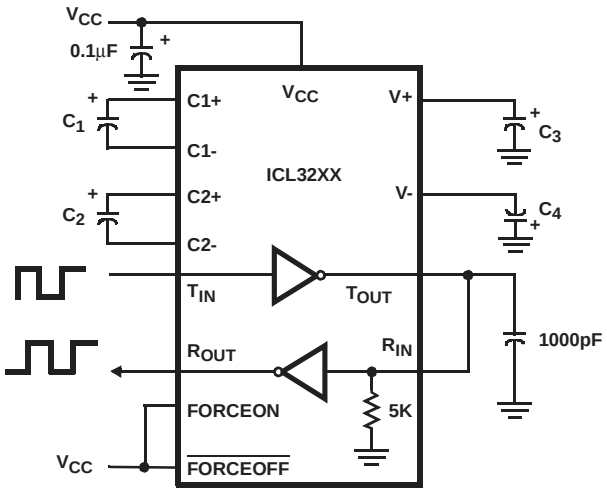


FIGURE 12. TRANSMITTER LOOPBACK TEST CIRCUIT

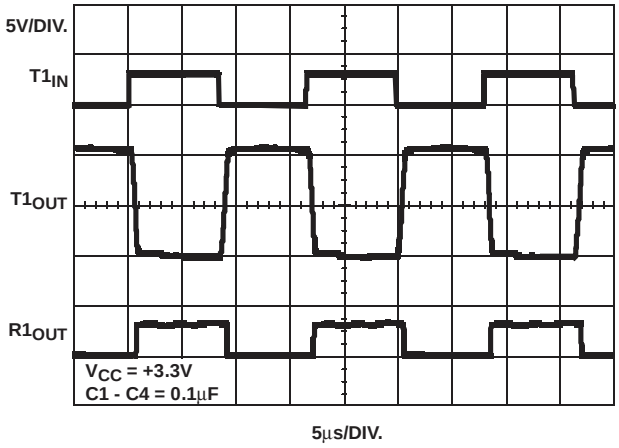


FIGURE 13. LOOPBACK TEST AT 120kbps

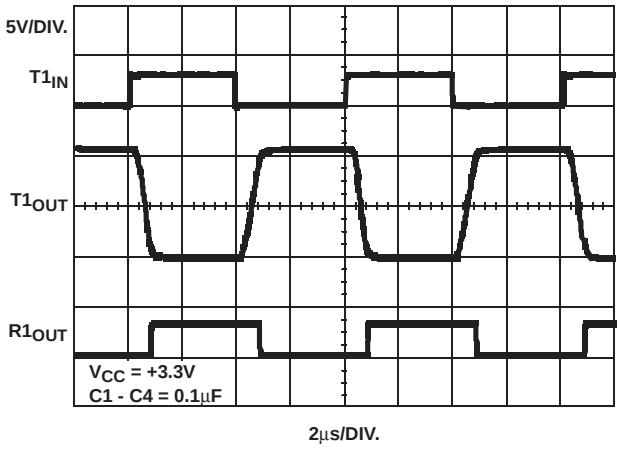


FIGURE 14. LOOPBACK TEST AT 250kbps

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. ICL32XX outputs are incompatible with AC, HC, and CD4000 CMOS inputs.

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

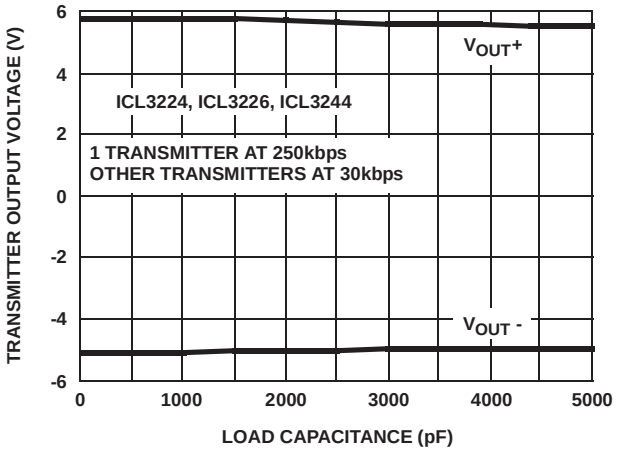


FIGURE 15. TRANSMITTER OUTPUT VOLTAGE vs LOAD CAPACITANCE

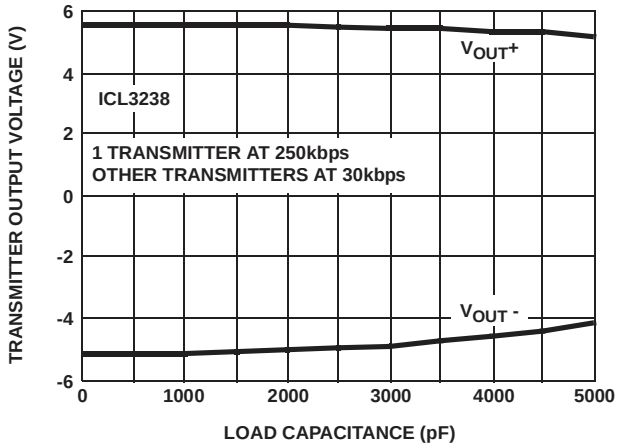


FIGURE 16. TRANSMITTER OUTPUT VOLTAGE vs LOAD CAPACITANCE

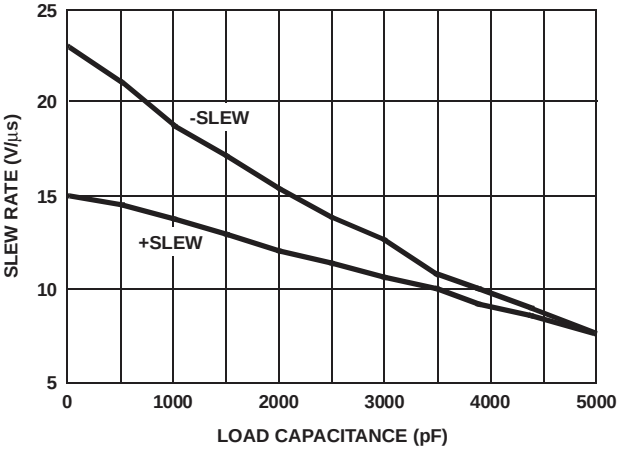


FIGURE 17. SLEW RATE vs LOAD CAPACITANCE

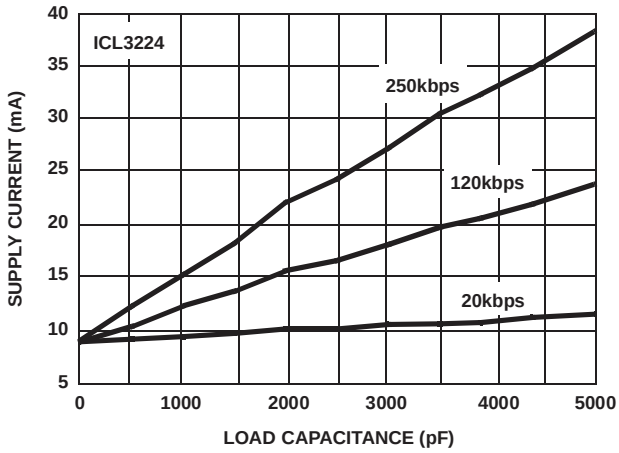


FIGURE 18. SUPPLY CURRENT vs LOAD CAPACITANCE WHEN TRANSMITTING DATA

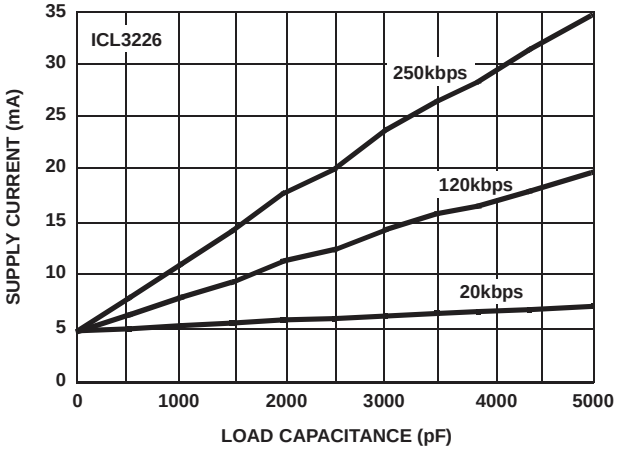


FIGURE 19. SUPPLY CURRENT vs LOAD CAPACITANCE WHEN TRANSMITTING DATA

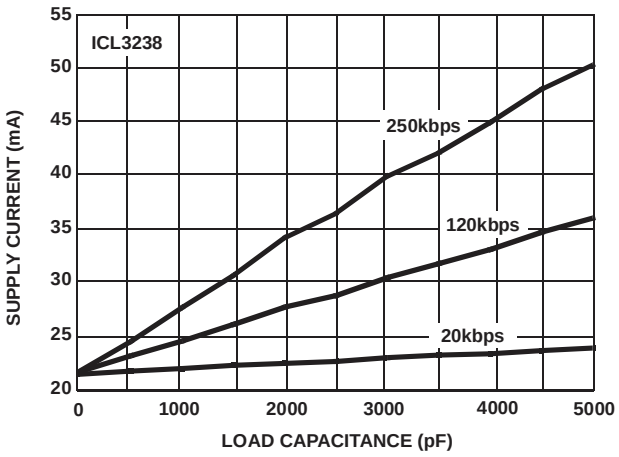


FIGURE 20. SUPPLY CURRENT vs LOAD CAPACITANCE WHEN TRANSMITTING DATA

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

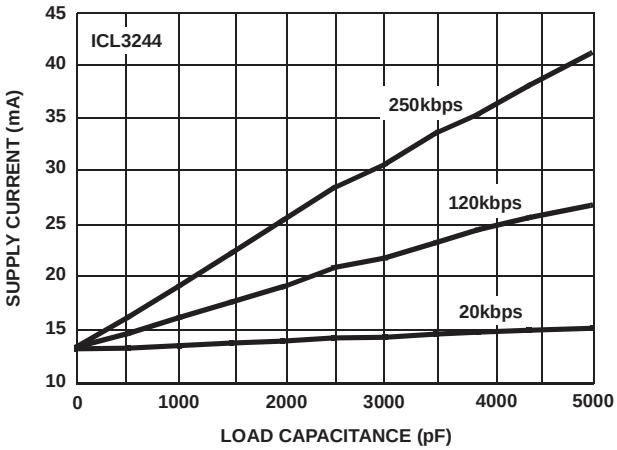


FIGURE 21. SUPPLY CURRENT vs LOAD CAPACITANCE WHEN TRANSMITTING DATA

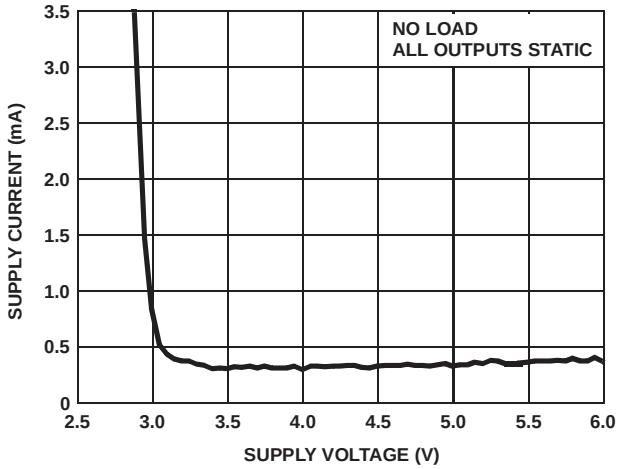


FIGURE 22. SUPPLY CURRENT vs SUPPLY VOLTAGE

Die Characteristics

DIE DIMENSIONS:

ICL3224/26:
101 mils x 110 mils (2580µm x 2810µm)
ICL3238:
106 mils x 128 mils (2700µm x 3250µm)
ICL3244:
100 mils x 127 mils (2550µm x 3230µm)

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

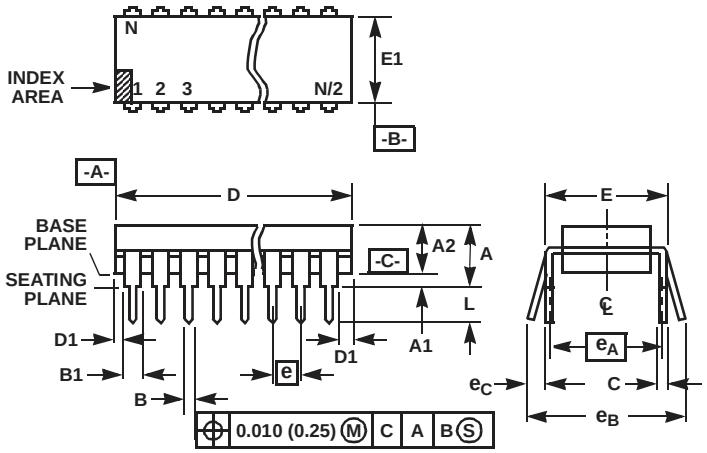
TRANSISTOR COUNT:

ICL3224: 937
ICL3226: 825
ICL3238: 1235
ICL3244: 1109

PROCESS:

Si Gate CMOS

Dual-In-Line Plastic Packages (PDIP)



NOTES:

1. Controlling Dimensions: INCH. In case of conflict between English and Metric dimensions, the inch dimensions control.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication No. 95.
4. Dimensions A, A1 and L are measured with the package seated in JEDEC seating plane gauge GS-3.
5. D, D1, and E1 dimensions do not include mold flash or protrusions. Mold flash or protrusions shall not exceed 0.010 inch (0.25mm).
6. E and e_A are measured with the leads constrained to be perpendicular to datum -C-.
7. e_B and e_C are measured at the lead tips with the leads unconstrained. e_C must be zero or greater.
8. B1 maximum dimensions do not include dambar protrusions. Dambar protrusions shall not exceed 0.010 inch (0.25mm).
9. N is the maximum number of terminal positions.
10. Corner leads (1, N, N/2 and N/2 + 1) for E8.3, E16.3, E18.3, E28.3, E42.6 will have a B1 dimension of 0.030 - 0.045 inch (0.76 - 1.14mm).

E20.3 (JEDEC MS-001-AD ISSUE D)
20 LEAD DUAL-IN-LINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.210	-	5.33	4
A1	0.015	-	0.39	-	4
A2	0.115	0.195	2.93	4.95	-
B	0.014	0.022	0.356	0.558	-
B1	0.045	0.070	1.55	1.77	8
C	0.008	0.014	0.204	0.355	-
D	0.980	1.060	24.89	26.9	5
D1	0.005	-	0.13	-	5
E	0.300	0.325	7.62	8.25	6
E1	0.240	0.280	6.10	7.11	5
e	0.100 BSC		2.54 BSC		-
e_A	0.300 BSC		7.62 BSC		6
e_B	-	0.430	-	10.92	7
L	0.115	0.150	2.93	3.81	4
N	20		20		9

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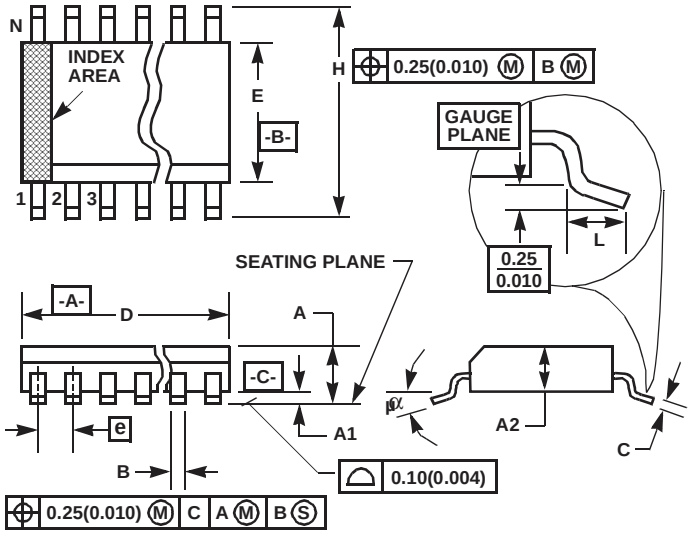
Small Outline Plastic Packages (SSOP)



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.

M16.209 (JEDEC MO-150-AC ISSUE B)
16 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	0.233	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^o	8^o	0^o	8^o	-

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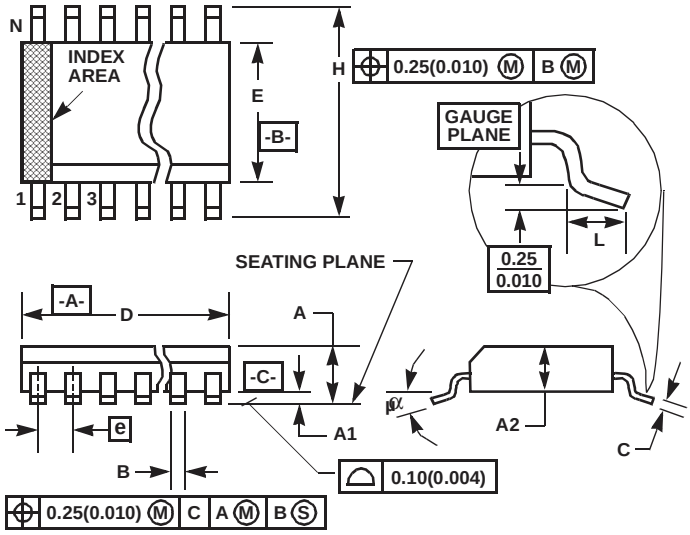
Shrink Small Outline Plastic Packages (SSOP)



NOTES:

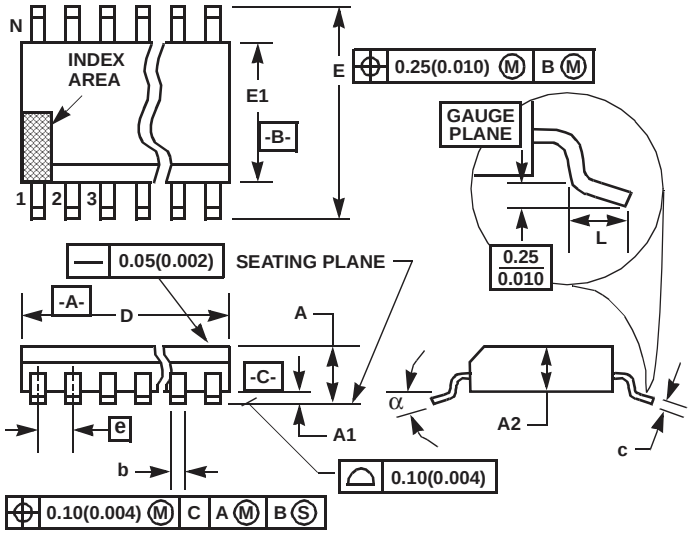
1. Symbols are defined in the “MO Series Symbol List” in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension “D” does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.20mm (0.0078 inch) per 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.

M20.209 (JEDEC MO-150-AE ISSUE B)
20 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	0.272	0.295	6.90	7.50	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	20		20		7
α	0^o	8^o	0^o	8^o	-

Rev. 2 4/95

Thin Shrink Small Outline Plastic Packages (TSSOP)



NOTES:

1. These package dimensions are within allowable dimensions of JEDEC MO-153-AE, Issue E.
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 0.15mm (0.006 inch) per side.
4. Dimension “E1” does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.15mm (0.006 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 0.08mm (0.003 inch) total in excess of “b” dimension at maximum material condition. Minimum space between protrusion and adjacent lead is 0.07mm (0.0027 inch).
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact. (Angles in degrees)

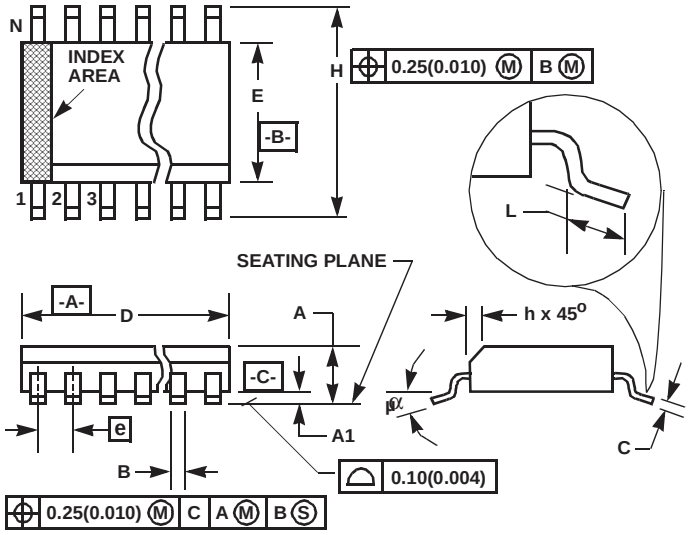
M28.173

28 LEAD THIN SHRINK SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	-	0.047	-	1.20	-
A1	0.002	0.006	0.05	0.15	-
A2	0.031	0.051	0.80	1.05	-
b	0.0075	0.0118	0.19	0.30	9
c	0.0035	0.0079	0.09	0.20	-
D	0.378	0.386	9.60	9.80	3
E1	0.169	0.177	4.30	4.50	4
e	0.026 BSC		0.65 BSC		-
E	0.246	0.256	6.25	6.50	-
L	0.0177	0.0295	0.45	0.75	6
N	28		28		7
α	0^o	8^o	0^o	8^o	-

Rev. 0 6/98

Small Outline Plastic Packages (SOIC)



NOTES:

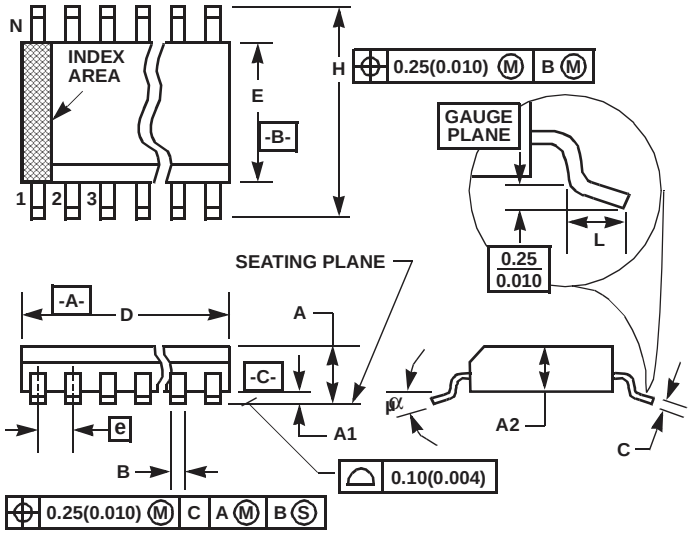
1. Symbols are defined in the "MO Series Symbol List" in Section 2.2 of Publication Number 95.
2. Dimensioning and tolerancing per ANSI Y14.5M-1982.
3. Dimension "D" does not include mold flash, protrusions or gate burrs. Mold flash, protrusion and gate burrs shall not exceed 0.15mm (0.006 inch) per side.
4. Dimension "E" does not include interlead flash or protrusions. Interlead flash and protrusions shall not exceed 0.25mm (0.010 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. The lead width "B", as measured 0.36mm (0.014 inch) or greater above the seating plane, shall not exceed a maximum value of 0.61mm (0.024 inch)
10. Controlling dimension: MILLIMETER. Converted inch dimensions are not necessarily exact.

M28.3 (JEDEC MS-013-AE ISSUE C)
28 LEAD WIDE BODY SMALL OUTLINE PLASTIC PACKAGE

SYMBOL	INCHES		MILLIMETERS		NOTES
	MIN	MAX	MIN	MAX	
A	0.0926	0.1043	2.35	2.65	-
A1	0.0040	0.0118	0.10	0.30	-
B	0.013	0.0200	0.33	0.51	9
C	0.0091	0.0125	0.23	0.32	-
D	0.6969	0.7125	17.70	18.10	3
E	0.2914	0.2992	7.40	7.60	4
e	0.05 BSC		1.27 BSC		-
H	0.394	0.419	10.00	10.65	-
h	0.01	0.029	0.25	0.75	5
L	0.016	0.050	0.40	1.27	6
N	28		28		7
α	0^o	8^o	0^o	8^o	-

Rev. 0 12/93

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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