QUALITY SEMICONDUCTOR, INC.

# High Speed CMOS 3.3V 18-Bit Registered Transceivers

**QS74LCX16500**

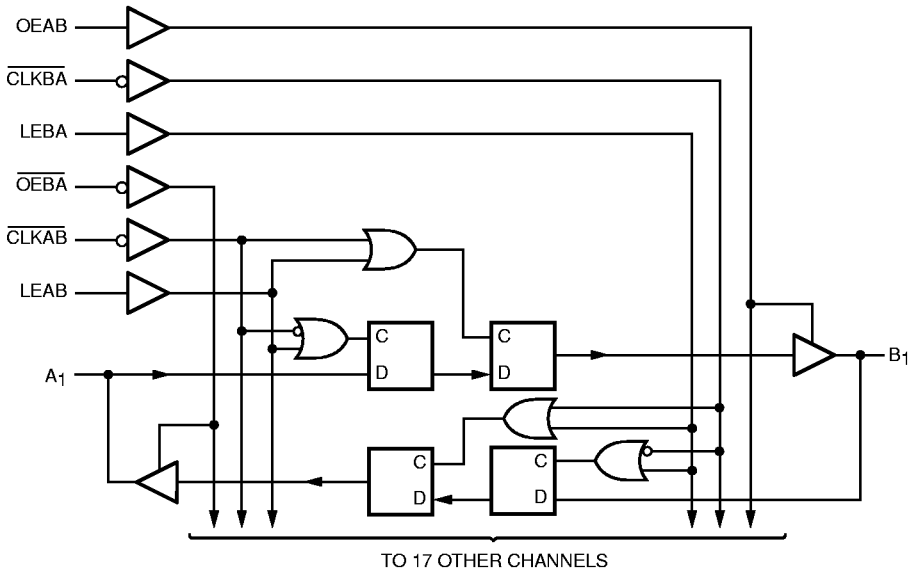
## FEATURES/BENEFITS

- 5V tolerant inputs and outputs
- Industry standard pinouts
- 10µA $I_{CCQ}$ quiescent power supply current
- Hot insertable
- 2.0V – 3.6V $V_{CC}$ supply operation
- ±24mA balanced output drive
- Meets or exceeds JEDEC Standard 36 specifications
- $t_{PD}$ = 4.6ns
- Input hysteresis for noise immunity
- Multiple power and ground pins for low noise
- Operating temperature range: –40°C to +85°C
- Latch-up performance exceeds 500mA
- ESD performance:
  - Human body model > 2000V
  - Machine model > 200V
- Packages available:
  - 56-pin TSSOP
  - 56-pin SSOP

## DESCRIPTION

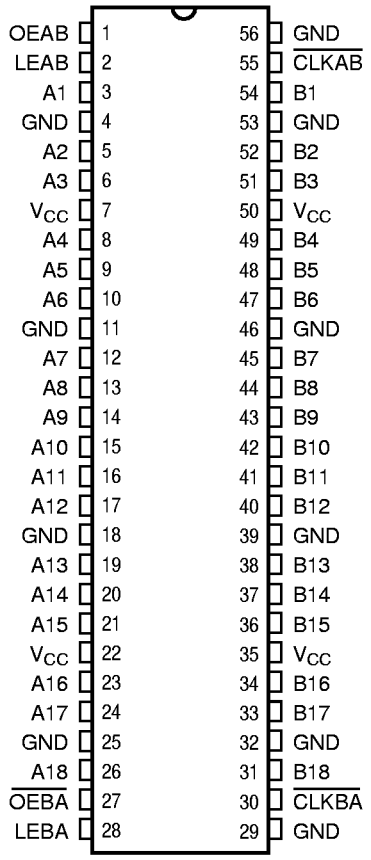
The LCX16500 is an 18-bit registered bus transceiver with three-state outputs that are ideal for driving address and data buses. These high-speed, low-power registered transceivers combine D-type latches and D-type flip-flops to allow data flow in transparent, latched and clocked modes. The 3.3V LCX family features low power, low switching noise, and fast switching speeds for low power portable applications as well as high-end advanced workstation applications. 5V tolerant inputs and outputs allow this LCX product to be used in mixed 5V and 3.3V applications. Easy board layout is facilitated by the use of flow-through pinouts and byte enable controls provide architectural flexibility for systems designers. To accommodate hot-plug or live insertion applications, this product is designed not to load an active bus when $V_{CC}$ is removed.

## Figure 1. Functional Block Diagram



## Figure 2. Pin Configuration
(All Pins Top View)

**SSOP, TSSOP**




## Table 1. Pin Description

| Name | Description |
|---|---|
| OEAB | A-to-B Output Enable Input |
| $\overline{OEBA}$ | B-to-A Output Enable Input (Active Low) |
| LEAB | A-to-B Latch Enable Input |
| LEBA | B-to-A Latch Enable Input |
| $\overline{CLKAB}$ | A-to-B Clock Input (Active Low) |
| $\overline{CLKBA}$ | B-to-A Clock Input (Active Low) |
| Ax | A-to-B Data Inputs or B-to-A 3-State Outputs |
| Bx | B-to-A Data Inputs or A-to-B 3-State Outputs |

## Table 2. Function Table [1]

| Inputs | | | | Outputs |
|---|---|---|---|---|
| OEAB | LEAB | $\overline{CLKAB}$ | Ax | Bx |
| L | X | X | X | Z |
| H | H | X | L | L |
| H | H | X | H | H |
| H | L | ↓ | L | L |
| H | L | ↓ | H | H |
| H | L | H | X | B[2] |
| H | L | L | X | B[3] |

**Notes**:
1. A-to-B data flow is shown. B-to-A data flow is similar but uses $\overline{OEBA}$, LEBA, and $\overline{CLKBA}$.
2. Output level before the indicated steady-state input conditions were established.
3. Output level before the indicated steady-state input conditions were established, provided that $\overline{CLKAB}$ was LOW before LEAB went LOW.

## Table 3. Capacitance

| Symbol | Pins | Typ | Unit | Conditions |
|---|---|---|---|---|
| $C_{IN}$ | Input Capacitance | 7.0 | pF | $V_{IN}$ = 0V, $V_{OUT}$ = 0V, f = 1MHz |
| $C_{I/O}$ | I/O Capacitance | 8.0 | pF | $V_{IN}$ = 0V, $V_{OUT}$ = 0V, f = 1MHz |
| $C_{PD}$ | Power Dissipation Capacitance | 25 | pF | $V_{CC}$ = 3.3V, $V_{IN}$ = 0 or $V_{CC}$ f = 10MHz |

**Note:** Capacitance is characterized but not production tested.

## Table 4. Absolute Maximum Ratings

Supply Voltage to Ground ..... –0.5V to +7.0V
DC Output Voltage $V_{OUT}$
  Outputs HIGH-Z ..... –0.5V to +7.0V
  Outputs Active ..... –0.5V to $V_{CC}$ +0.5V
DC Input Voltage $V_{IN}$ ..... –0.5V to +7.0V
DC Input Diode Current with $V_{IN}$ < 0 ..... –50mA
DC Output Diode Current
  $V_O$ < 0 ..... –50mA
  $V_O$ > $V_{CC}$ ..... +50mA
DC Output Source/Sink Current ($I_{OH}/I_{OL}$) ..... ±50mA
DC Supply Current per Supply Pin ..... ±100mA
DC Ground Current per Ground Pin ..... ±100mA
$T_{STG}$ Storage Temperature ..... –65° to +150°C

**Note:** Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to this device resulting in functional or reliability type failures.

## Table 5. Recommended Operating Conditions

| Symbol | Parameter | | Min | Max | Unit |
|---|---|---|---|---|---|
| $V_{CC}$ | Supply Voltage, Operating | | 2.0 | 3.6 | V |
| | Supply Voltage, Data Retention Only | | 1.5 | 3.6 | |
| $V_{IN}$ | Input Voltage | | 0 | 5.5 | V |
| $V_{OUT}$ | Output Voltage in Active State | | 0 | $V_{CC}$ | V |
| | Output Voltage in "OFF" State | | 0 | 5.5 | |
| $I_{OH}/I_{OL}$ | Output Current | $V_{CC}$ = 3.0 – 3.6V | — | ±24 | mA |
| | | $V_{CC}$ = 2.7V | — | ±12 | |
| $\Delta t/\Delta v$ | Input Transition Slew Rate | | — | 10 | ns/V |
| $T_A$ | Operating Free Air Temperature | | –40 | +85 | °C |

## Table 6. DC Electrical Characteristics Over Operating Range

Industrial Temperature Range, $T_A$ = –40°C to +85°C

| Symbol | Parameter | Test Conditions | Min | Typ(1) | Max | Unit |
|---|---|---|---|---|---|---|
| $V_{IH}$ | Input HIGH Voltage | Logic HIGH for All Inputs | 2.0 | — | — | V |
| $V_{IL}$ | Input LOW Voltage | Logic LOW for All Inputs | — | — | 0.8 | V |
| $V_{OH}$ | Output HIGH Voltage | $V_{CC}$ = 2.7V, $I_{OH}$ = –100µA<br>$V_{CC}$ = 2.7V, $I_{OH}$ = –12mA<br>$V_{CC}$ = 3.0V, $I_{OH}$ = –18mA<br>$V_{CC}$ = 3.0V, $I_{OH}$ = –24mA | $V_{CC}$ –0.2<br>2.2<br>2.4<br>2.2 | —<br>—<br>—<br>— | —<br>—<br>—<br>— | V |
| $V_{OL}$ | Output LOW Voltage | $V_{CC}$ = 2.7V, $I_{OL}$ = 100µA<br>$V_{CC}$ = 2.7V, $I_{OL}$ = 12mA<br>$V_{CC}$ = 3.0V, $I_{OL}$ = 16mA<br>$V_{CC}$ = 3.0V, $I_{OL}$ = 24mA | —<br>—<br>—<br>— | —<br>—<br>—<br>— | 0.2<br>0.4<br>0.4<br>0.5 | V |
| $\Delta V_T$ | Input Hysteresis(2) | $V_{TLH}$ – $V_{THL}$ for All Inputs | — | 150 | — | mV |
| $I_I$ | Input Leakage Current | $V_I$ = 0V, $V_I$ = 5.5V | — | — | ±1.0 | µA |
| $I_{OZ}$ | High-Z I/O Leakage | $V_O$ = 0V, $V_O$ = 5.5V<br>$V_I$ = $V_{IH}$ or $V_{IL}$ | — | — | ±1.0 | µA |
| $I_{OS}$ | Short Circuit Current(2,3) | $V_{CC}$ = 3.6V, $V_O$ = GND | –60 | — | –240 | mA |
| $I_{OFF}$ | Power Off Leakage | $V_{CC}$ = 0V, $V_I$ or $V_O$ = 5.5V | — | — | 10 | µA |
| $V_{IK}$ | Input Clamp Voltage | $V_{CC}$ = 2.7V, $I_{IN}$ = –18mA | — | –0.7 | –1.2 | V |

**Notes**: 1. Typical values are at $V_{CC}$ = 3.3V, and $T_A$ = 25°C.
2. These parameters are guaranteed by characterization but not production tested.
3. Not more than one output should be tested at one time. Duration of test should not exceed one second.

## Table 7. Power Supply Characteristics

| Symbol | Parameter | Test Conditions[1] | | Typ[2] | Max | Unit |
|---|---|---|---|---|---|---|
| $I_{CC}$ | Quiescent Power Supply Current | $V_{CC}$ = 3.6V, Freq. = 0<br>$V_{IN}$ = GND or $V_{CC}$ | | 0.1 | 10 | µA |
| $\Delta I_{cc}$ | Supply Current per Input @ TTL HIGH | $V_{CC}$ = 3.6V,<br>$V_{IN}$ = $V_{CC}$ –0.6V[3] | | 2.0 | 30 | µA |
| $I_{CCD}$ | Supply Current per Input per MHz[4] | $V_{CC}$ = 3.6V, Outputs Open<br>One Bit Toggling<br>@ 50% Duty Cycle<br>OEAB = $\overline{OEBA}$ = $V_{CC}$<br>LEAB= GND | $V_{IN}$ = $V_{CC}$<br>$V_{IN}$ = GND | 65 | 100 | µA/ MHz |
| $I_C$ | Total Power Supply Current[6] | $V_{CC}$ = 3.6V, Outputs Open<br>One Bit Toggling<br>@ 50% Duty Cycle<br>$f_{CP}$ = 10MHz ($\overline{CLKBA}$)<br>OEAB = $\overline{OEBA}$ = $V_{CC}$<br>LEAB= GND, $f_I$ = 5MHz | $V_{IN}$ = $V_{CC}$–0.6V<br>$V_{IN}$ = GND | 0.5[5] | 0.8[5] | mA |
| | | $V_{CC}$ = 3.6V, Outputs Open<br>Sixteen Bits Toggling<br>@ 50% Duty Cycle<br>$f_{CP}$ = 10MHz ($\overline{CLKBA}$)<br>OEAB = $\overline{OEBA}$ = $V_{CC}$<br>LEAB= GND, $f_I$ = 2.5MHz | $V_{IN}$ = $V_{CC}$–0.6V<br>$V_{IN}$ = GND | 2.0[5] | 3.3[5] | mA |

**Notes:**
1. For conditions shown as Min. or Max., use the appropriate values specified under Recommended Operating Conditions for applicable device type.
2. Typical values are at $V_{CC}$ = 3.3V, +25°C ambient.
3. Per TTL driven input. All Other Inputs at $V_{CC}$ or GND.
4. This parameter is not directly testable, but is derived for use in Total Power Supply Calculations.
5. Values for these conditions are examples of the Icc formula. These limits are guaranteed by design but not tested.
6. $I_C = I_{QUIESCENT} + I_{INPUTS} + I_{DYNAMIC}$.
   $I_C = I_{CCQ} + \Delta I_{CC} D_H N_T + I_{CCD} f N_O$.
   $I_{CCQ}$ = Quiescent Current ($I_{CCL}$, $I_{CCH}$, and $I_{CCZ}$).
   $\Delta I_{CC}$ = Power Supply Current for a TTL-High Input ($V_{IN}$ = $V_{CC}$ –0.6V).
   $D_H$ = Duty Cycle for TTL High Inputs.
   $N_T$ = Number of TTL High Inputs.
   $I_{CCD}$ = Dynamic Current Caused by an Input Transition Pair (HLH or LHL).
   f = Average Switching Frequency per Output.
   $N_O$ = Number of Outputs Switching.

## Table 8. Dynamic Switching Characteristics[1]

| Symbol | Parameter | Conditions | $V_{CC}$ (V) | $T_A$ = 25°C Typical | Units |
|---|---|---|---|---|---|
| $V_{OLP}$ | Quiet Output Dynamic Peak $V_{OL}$ | $C_L$ = 50pF, $V_{IH}$ = 3.3V, $V_{IL}$ = 0V | 3.3 | 0.8 | V |
| $V_{OLV}$ | Quiet Output Dynamic Valley $V_{OL}$ | $C_L$ = 50pF, $V_{IH}$ = 3.3V, $V_{IL}$ = 0V | 3.3 | 0.8 | V |

**Note:**
1. Characterized but not production tested.

## Table 9. Switching Characteristics Over Operating Range

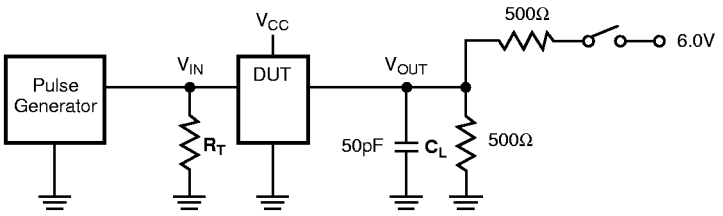
Industrial Temperature Range, $T_A$ = –40°C to +85°C
$C_{LOAD}$ = 50pF, $R_{LOAD}$ = 500Ω unless otherwise noted.

| Symbol | Description[1] | | LCX16500 $V_{CC}$ = 3.3 ± 0.3V Min. | LCX16500 $V_{CC}$ = 3.3 ± 0.3V Max. | LCX16500 $V_{CC}$ = 2.7V[2] Min. | LCX16500 $V_{CC}$ = 2.7V[2] Max. | LCX16500C $V_{CC}$ = 3.3 ± 0.3V Min. | LCX16500C $V_{CC}$ = 3.3 ± 0.3V Max. | Unit |
|---|---|---|---|---|---|---|---|---|---|
| $f_{MAX}$ | $\overline{CLKAB}$ or $\overline{CLKBA}$ Frequency[2] | | 170 | — | — | — | 170 | — | MHz |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay Ax to Bx or Bx to Ax | | 1.5 | 6.0 | 1.5 | 7.0 | 1.5 | 4.6 | ns |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay LEBA to Ax, LEAB to Bx | | 1.5 | 7.0 | 1.5 | 8.0 | 1.5 | 5.3 | ns |
| $t_{PHL}$ $t_{PLH}$ | Propagation Delay $\overline{CLKBA}$ to Ax, $\overline{CLKAB}$ to Bx | | 1.5 | 6.7 | 1.5 | 8.0 | 1.5 | 5.3 | ns |
| $t_{PZH}$ $t_{PZL}$ | Output Enable Time $\overline{OEBA}$ to Ax, OEAB to Bx | | 1.5 | 7.2 | 1.5 | 8.2 | 1.5 | 5.6 | ns |
| $t_{PHZ}$ $t_{PLZ}$ | Output Disable Time[2] $\overline{OEBA}$ to Ax, OEAB to Bx | | 1.5 | 7.0 | 1.5 | 8.0 | 1.5 | 5.2 | ns |
| $t_{SU}$ | Setup Time HIGH or LOW Ax to $\overline{CLKAB}$, Bx to $\overline{CLKBA}$ | | 3.0 | — | 3.0 | — | 3.0 | — | ns |
| $t_H$ | Hold Time HIGH or LOW Ax to $\overline{CLKAB}$, Bx to $\overline{CLKBA}$ | | 0 | — | 0 | — | 0 | — | ns |
| $t_{SU}$ | Setup Time HIGH or Low | Clock LOW | 2.5 | — | 2.5 | — | 3.0 | — | ns |
| | Ax to LEAB Bx to LEBA | Clock HIGH | 2.5 | — | 2.5 | — | 1.5 | — | ns |
| $t_H$ | Hold Time HIGH or LOW Ax to LEAB, Bx to LEBA | | 1.5 | — | 1.5 | — | 1.5 | — | ns |
| $t_W$ | Pulse Width[2] | | 3.0 | — | 3.0 | — | 3.0 | — | ns |
| $t_{SK(O)}$ | Output Skew[3] | | — | 0.5 | — | 0.5 | — | 0.5 | ns |

**Notes:**
1. See test circuit and waveforms. Minimum Limits are guaranteed but not tested on Propagation Delays.
2. Guaranteed by characterization but not production tested.
3. Skew between any two outputs, of the same package, switching in the same direction. This parameter is guaranteed by characterization but not production tested.

## TEST CIRCUIT AND WAVEFORMS

### Figure 3. Test Circuit

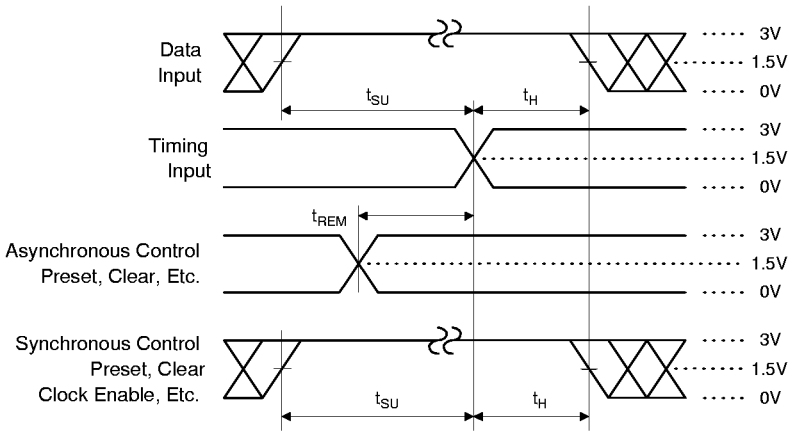



**SWITCH POSITION**

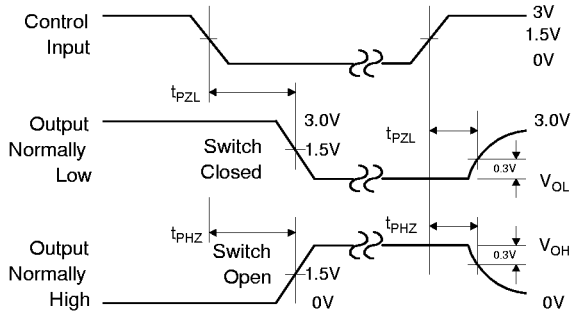
| Test | Switch |
|---|---|
| Open Drain<br>Disable LOW<br>Enable LOW | 6V |
| Disable HIGH<br>Enable HIGH | GND |
| All Other Inputs | Open |

DEFINITIONS:
$C_L$ = Load capacitance: includes jig and probe capacitance.
$R_T$ = Termination resistance: should be equal to $Z_{OUT}$ of the Pulse generator.

### Figure 4. Setup, Hold, and Release Timing

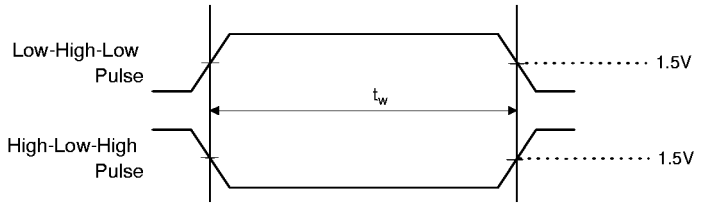



### Figure 5. Enable and Disable Timing

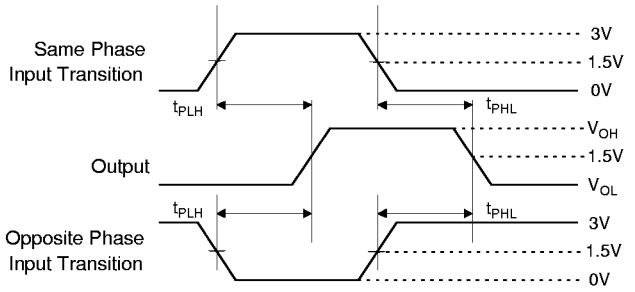



Notes:
1. Input Control Enable = LOW and input Control Disable = HIGH.
2. Pulse Generator for All Pulses: Rate ≤ 1.0MHz; $Z_{OUT}$ ≤ 50Ω; $t_F$, $t_R$ ≤ 2.5ns.

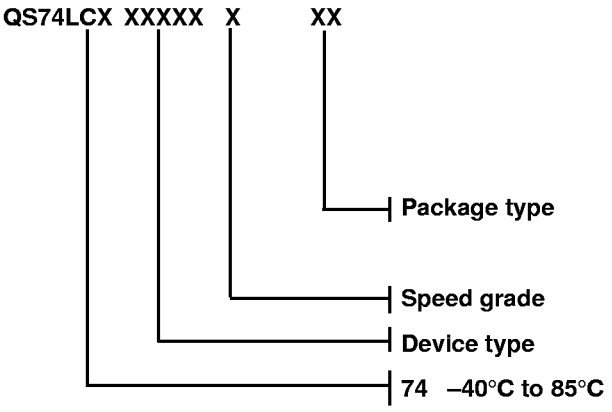
## Figure 6. Pulse Width




## Figure 7. Propagation Delay




## ORDERING INFORMATION



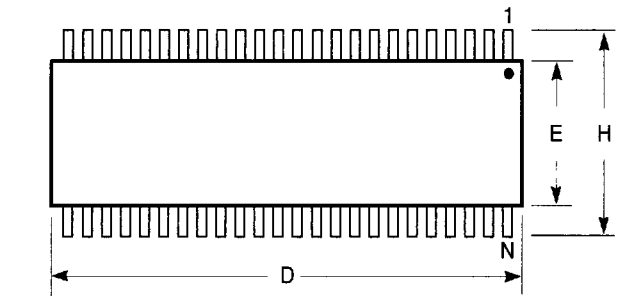

**Device Type:**
16500

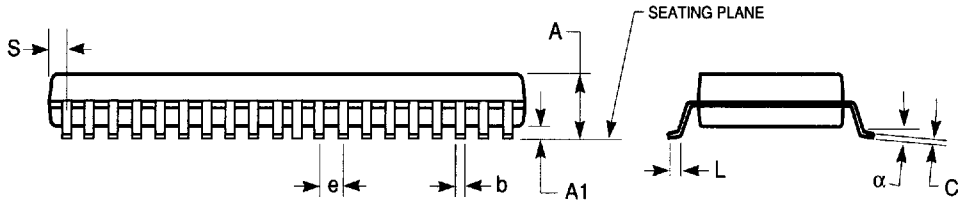
**Speed Grades:**
Blank – Standard
C

**Package Type:**
PV – SSOP, 300 mil
PA – TSSOP, 240 mil

# 300-MIL SSOP - Package Code PV

**Shrink Small Outline Package**
**Plastic Small Outline Gull-Wing**



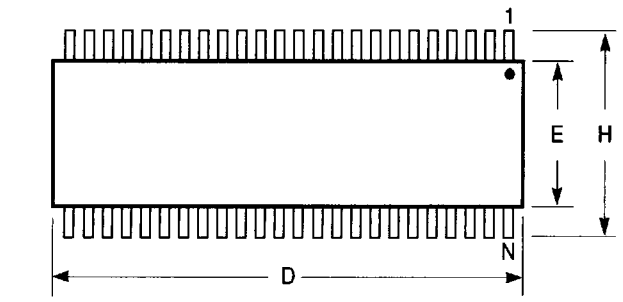



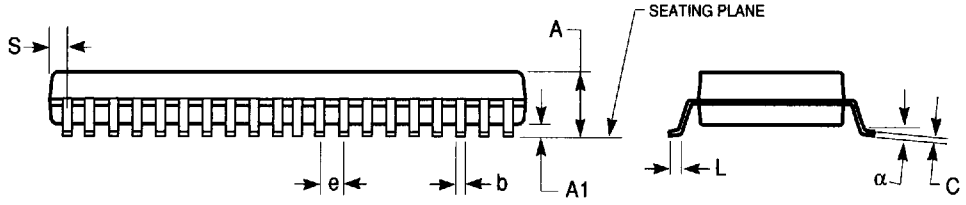

**Notes:**
1. Refer to applicable symbol list.
2. All dimensions are in inches.
3. N is the number of lead positions.
4. Dimensions D and E are to be measured at maximum material condition but do not include mold flash. Allowable mold flash is 0.006in. per side.
5. Lead coplanarity is 0.004in. maximum.

| JEDEC# | MO-118AA | | | MO-118AB | | |
|---|---|---|---|---|---|---|
| DWG# | PSS-48B | | | PSS-56B | | |
| Symbol | Min | Nom | Max | Min | Nom | Max |
| A | 0.095 | 0.102 | 0.110 | 0.095 | 0.102 | 0.110 |
| A1 | 0.008 | 0.012 | 0.016 | 0.008 | 0.012 | 0.016 |
| b | 0.008 | 0.010 | 0.0135 | 0.008 | 0.010 | 0.0135 |
| C | 0.005 | 0.008 | 0.010 | 0.005 | 0.008 | 0.010 |
| D | 0.620 | 0.625 | 0.630 | 0.720 | 0.725 | 0.730 |
| E | 0.291 | 0.295 | 0.299 | 0.291 | 0.295 | 0.299 |
| e | 0.025 BSC | | | 0.025 BSC | | |
| H | 0.395 | 0.410 | 0.420 | 0.395 | 0.410 | 0.420 |
| L | 0.020 | 0.030 | 0.040 | 0.020 | 0.030 | 0.040 |
| N | 48 | | | 56 | | |
| α | 0° | 5° | 8° | 0° | 5° | 8° |
| S | 0.022 | 0.025 | 0.028 | 0.022 | 0.025 | 0.028 |

# 240-MIL TSSOP - Package Code PA

**Thin Shrink Small Outline Package**
**Plastic Small Outline Gull-Wing**




**Notes:**
1. Refer to applicable symbol list.
2. N is the number of lead positions.
3. Dimensions D, E, and S are to be measured at maximum material condition but do not include mold flash. Allowable mold flash is 0.006 in. per side.
4. Lead coplanarity is 0.004in. maximum.

| JEDEC# | MO-153ED | | | MO-153EE | | | MO-153ED | | | MO-153EE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| DWG# | PSS-48C | | | PSS-56C | | | PSS-48C | | | PSS-56C | | |
| Symbol | Min | Nom | Max | Min | Nom | Max | Min | Nom | Max | Min | Nom | Max |
| A | 0.039 | 0.043 | 0.047 | 0.039 | 0.043 | 0.047 | 1.00 | 1.10 | 1.20 | 1.00 | 1.10 | 1.20 |
| A1 | 0.002 | 0.004 | 0.006 | 0.002 | 0.004 | 0.006 | 0.05 | 0.10 | 0.15 | 0.05 | 0.10 | 0.15 |
| b | 0.006 | 0.008 | 0.011 | 0.006 | 0.008 | 0.011 | 0.17 | 0.20 | 0.27 | 0.17 | 0.20 | 0.27 |
| C | 0.004 | 0.006 | 0.008 | 0.004 | 0.006 | 0.008 | 0.09 | 0.15 | 0.20 | 0.09 | 0.15 | 0.20 |
| D | 0.488 | 0.492 | 0.496 | 0.547 | 0.551 | 0.555 | 12.40 | 12.50 | 12.60 | 13.90 | 14.00 | 14.10 |
| E | 0.236 | 0.240 | 0.244 | 0.236 | 0.240 | 0.244 | 6.00 | 6.10 | 6.20 | 6.00 | 6.10 | 6.20 |
| e | 0.0197 BSC | | | 0.0197 BSC | | | 0.50 BSC | | | 0.50 BSC | | |
| H | 0.315 | 0.319 | 0.323 | 0.315 | 0.319 | 0.323 | 8.00 | 8.10 | 8.20 | 8.00 | 8.10 | 8.20 |
| L | 0.018 | 0.024 | 0.030 | 0.018 | 0.024 | 0.030 | 0.45 | 0.60 | 0.75 | 0.45 | 0.60 | 0.75 |
| N | 48 | | | 56 | | | 48 | | | 56 | | |
| α | 0° | 5° | 8° | 0° | 5° | 8° | 0° | 5° | 8° | 0° | 5° | 8° |
| S | 0.015 | 0.020 | 0.025 | 0.006 | 0.010 | 0.014 | 0.38 | 0.50 | 0.65 | 0.15 | 0.25 | 0.35 |

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