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# 3.3V CMOS 18-BIT REGISTERED TRANSCEIVER WITH 3-STATE OUTPUTS, 5 VOLT TOLERANT I/O

**IDT74LVC16501A**

## FEATURES:

- **Typical $t_{SK(o)}$ (Output Skew) < 250ps**
- **ESD > 2000V per MIL-STD-883, Method 3015; > 200V using machine model (C = 200pF, R = 0)**
- **Vcc = 3.3V ± 0.3V, Normal Range**
- **Vcc = 2.7V to 3.6V, Extended Range**
- **CMOS power levels (0.4µ W typ. static)**
- **All inputs, outputs, and I/O are 5V tolerant**
- **Supports hot insertion**
- **Available in SSOP and TSSOP packages**

## DRIVE FEATURES:

- **High Output Drivers: ±24mA**
- **Reduced system switching noise**

## APPLICATIONS:

- **5V and 3.3V mixed voltage systems**
- **Data communication and telecommunication systems**

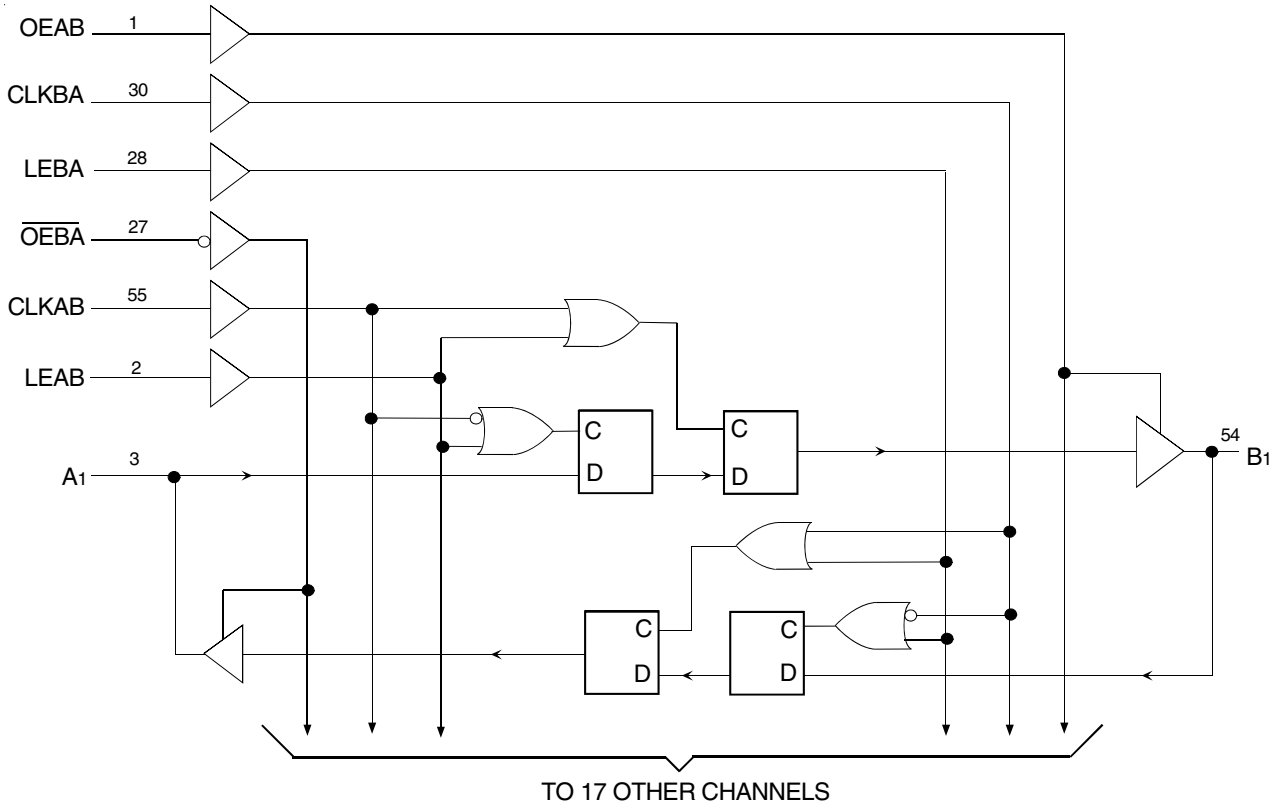
## DESCRIPTION:

The LVC16501A is built using advanced dual metal CMOS technology. This high-speed, low power 18-bit registered bus transceiver combines D-type latches and D-type flip-flops to allow data flow in transparent, latched, and clocked modes. Data flow in each direction is controlled by output-enable (OEAB and $\overline{OEBA}$), latch enable (LEAB and LEBA) and clock (CLKAB and CLKBA) inputs. For A-to-B data flow, the device operates in transparent mode when LEAB is high. When LEAB is low, the A data is latched if CLKAB is held at a high or low logic level. If LEAB is low, the A bus data is stored in the latch/flip-flop on the low-to-high transition of CLKAB. OEAB performs the output enable function on the B port. Data flow from B port to A port is similar but requires using $\overline{OEBA}$, LEBA and CLKBA. Flow-through organization of signal pins simplifies layout. All inputs are designed with hysteresis for improved noise margin.

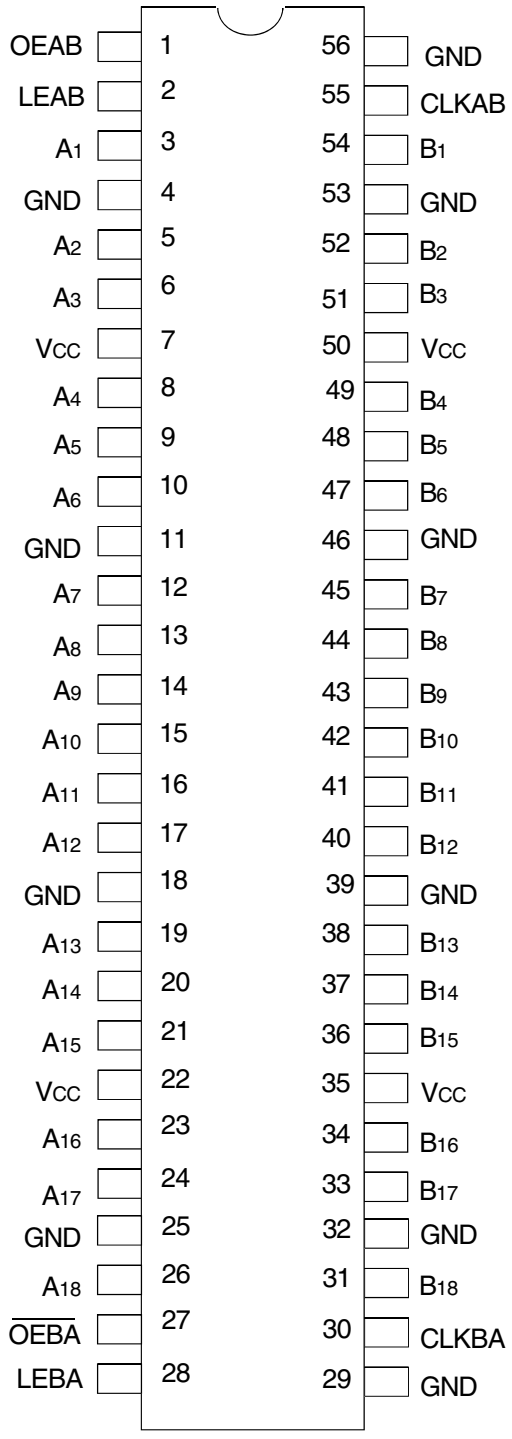
The LVC16501A has been designed with a ±24mA output driver. This driver is capable of driving a moderate to heavy load while maintaining speed performance.

Inputs can be driven from either 3.3V or 5V devices. This feature allows the use of this device as a translator in a mixed 3.3V/5V supply system.

## FUNCTIONAL BLOCK DIAGRAM



## PIN CONFIGURATION




**SSOP/ TSSOP**
**TOP VIEW**

## ABSOLUTE MAXIMUM RATINGS(1)

| Symbol | Description | Max | Unit |
|---|---|---|---|
| $V_{TERM}$ | Terminal Voltage with Respect to GND | –0.5 to +6.5 | V |
| $T_{STG}$ | Storage Temperature | –65 to +150 | °C |
| $I_{OUT}$ | DC Output Current | –50 to +50 | mA |
| $I_{IK}$<br>$I_{OK}$ | Continuous Clamp Current,<br>$V_I < 0$ or $V_O < 0$ | –50 | mA |
| $I_{CC}$<br>$I_{SS}$ | Continuous Current through each<br>$V_{CC}$ or GND | ±100 | mA |

**NOTE:**
1. Stresses greater than those listed under ABSOLUTE MAXIMUM RATINGS may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions above those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect reliability.

## CAPACITANCE ($T_A$ = +25°C, F = 1.0MHz)

| Symbol | Parameter(1) | Conditions | Typ. | Max. | Unit |
|---|---|---|---|---|---|
| $C_{IN}$ | Input Capacitance | $V_{IN}$ = 0V | 4.5 | 6 | pF |
| $C_{OUT}$ | Output Capacitance | $V_{OUT}$ = 0V | 6.5 | 8 | pF |
| $C_{I/O}$ | I/O Port Capacitance | $V_{IN}$ = 0V | 6.5 | 8 | pF |

**NOTE:**
1. As applicable to the device type.

## PIN DESCRIPTION

| Pin Names | Description |
|---|---|
| OEAB | A-to-B Output Enable Input (Active HIGH) |
| $\overline{OEBA}$ | B-to-A Output Enable Input (Active LOW) |
| LEAB | A-to-B Latch Enable Input |
| LEBA | B-to-A Latch Enable Input |
| CLKAB | A-to-B Clock Input |
| CLKBA | B-to-A Clock Input |
| 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 |

## FUNCTION TABLE(1,2)

| Inputs | | | | Outputs |
|---|---|---|---|---|
| OEAB | LEAB | 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 | L | X | B(3) |
| H | L | H | X | B(4) |

**NOTES:**
1. H = HIGH Voltage Level
   X = Don't Care
   L = LOW Voltage Level
   Z = High-Impedance
   ↑ = LOW-to-HIGH transition
2. A-to-B data flow is shown. B-to-A data flow is similar but uses $\overline{OEBA}$, LEBA, and CLKBA.
3. Output level before the indicated steady-state input conditions were established.
4. Output level before the indicated steady-state input conditions were established, provided that CLKAB was HIGH before LEAB went LOW.

## DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE

Following Conditions Apply Unless Otherwise Specified:
Operating Condition: $T_A$ = –40°C to +85°C

| Symbol | Parameter | Test Conditions | | Min. | Typ.(1) | Max. | Unit |
|---|---|---|---|---|---|---|---|
| $V_{IH}$ | Input HIGH Voltage Level | $V_{CC}$ = 2.3V to 2.7V | | 1.7 | — | — | V |
| | | $V_{CC}$ = 2.7V to 3.6V | | 2 | — | — | |
| $V_{IL}$ | Input LOW Voltage Level | $V_{CC}$ = 2.3V to 2.7V | | — | — | 0.7 | V |
| | | $V_{CC}$ = 2.7V to 3.6V | | — | — | 0.8 | |
| $I_{IH}$<br>$I_{IL}$ | Input Leakage Current | $V_{CC}$ = 3.6V | $V_I$ = 0 to 5.5V | — | — | ±5 | µA |
| $I_{OZH}$<br>$I_{OZL}$ | High Impedance Output Current (3-State Output pins) | $V_{CC}$ = 3.6V | $V_O$ = 0 to 5.5V | — | — | ±10 | µA |
| $I_{OFF}$ | Input/Output Power Off Leakage | $V_{CC}$ = 0V, $V_{IN}$ or $V_O \leq$ 5.5V | | — | — | ±50 | µA |
| $V_{IK}$ | Clamp Diode Voltage | $V_{CC}$ = 2.3V, $I_{IN}$ = –18mA | | — | –0.7 | –1.2 | V |
| $V_H$ | Input Hysteresis | $V_{CC}$ = 3.3V | | — | 100 | — | mV |
| $I_{CCL}$<br>$I_{CCH}$ | Quiescent Power Supply Current | $V_{CC}$ = 3.6V | $V_{IN}$ = GND or $V_{CC}$ | — | — | 10 | µA |
| $I_{CCZ}$ | | | 3.6 ≤ $V_{IN}$ ≤ 5.5V(2) | — | — | 10 | |
| $\Delta I_{CC}$ | Quiescent Power Supply Current Variation | One input at $V_{CC}$ - 0.6V, other inputs at $V_{CC}$ or GND | | — | — | 500 | µA |

**NOTES:**
1. Typical values are at $V_{CC}$ = 3.3V, +25°C ambient.
2. This applies in the disabled state only.

## OUTPUT DRIVE CHARACTERISTICS

| Symbol | Parameter | Test Conditions[1] | | Min. | Max. | Unit |
|---|---|---|---|---|---|---|
| $V_{OH}$ | Output HIGH Voltage | $V_{CC}$ = 2.3V to 3.6V | $I_{OH}$ = – 0.1mA | $V_{CC}$ – 0.2 | — | V |
| | | $V_{CC}$ = 2.3V | $I_{OH}$ = – 6mA | 2 | — | |
| | | $V_{CC}$ = 2.3V | $I_{OH}$ = – 12mA | 1.7 | — | |
| | | $V_{CC}$ = 2.7V | | 2.2 | — | |
| | | $V_{CC}$ = 3V | | 2.4 | — | |
| | | $V_{CC}$ = 3V | $I_{OH}$ = – 24mA | 2.2 | — | |
| $V_{OL}$ | Output LOW Voltage | $V_{CC}$ = 2.3V to 3.6V | $I_{OL}$ = 0.1mA | — | 0.2 | V |
| | | $V_{CC}$ = 2.3V | $I_{OL}$ = 6mA | — | 0.4 | |
| | | | $I_{OL}$ = 12mA | — | 0.7 | |
| | | $V_{CC}$ = 2.7V | $I_{OL}$ = 12mA | — | 0.4 | |
| | | $V_{CC}$ = 3V | $I_{OL}$ = 24mA | — | 0.55 | |

**NOTE:**
1. $V_{IH}$ and $V_{IL}$ must be within the min. or max. range shown in the DC ELECTRICAL CHARACTERISTICS OVER OPERATING RANGE table for the appropriate $V_{CC}$ range. $T_A$ = – 40°C to + 85°C.

## OPERATING CHARACTERISTICS, $V_{CC}$ = 3.3V ± 0.3V, $T_A$ = 25°C

| Symbol | Parameter | Test Conditions | Typical | Unit |
|---|---|---|---|---|
| $C_{PD}$ | Power Dissipation Capacitance per Transceiver Outputs enabled | $C_L$ = 0pF, f = 10Mhz | | pF |
| $C_{PD}$ | Power Dissipation Capacitance per Transceiver Outputs disabled | | | |

## SWITCHING CHARACTERISTICS[1]

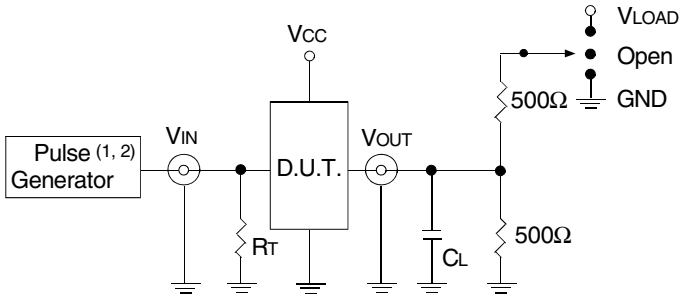
| Symbol | Parameter | | Vcc = 2.7V | | Vcc = 3.3V ± 0.3V | | Unit |
|---|---|---|---|---|---|---|---|
| | | | Min. | Max. | Min. | Max. | |
| $f_{MAX}$ | | | 150 | — | 150 | — | MHz |
| $t_{PLH}$<br>$t_{PHL}$ | Propagation Delay<br>Ax to Bx or Bx to Ax | | 1.5 | 5.1 | 1.5 | 4.6 | ns |
| $t_{PLH}$<br>$t_{PHL}$ | Propagation Delay<br>LEBA to Ax, LEAB to Bx | | 1.5 | 5.6 | 1.5 | 5.3 | ns |
| $t_{PLH}$<br>$t_{PHL}$ | Propagation Delay<br>CLKBA to Ax, CLKAB to Bx | | 1.5 | 5.6 | 1.5 | 5.3 | ns |
| $t_{PZH}$<br>$t_{PZL}$ | Output Enable Time<br>$\overline{OEBA}$ to Ax, OEAB to Bx | | 1.5 | 6 | 1.5 | 5.6 | ns |
| $t_{PHZ}$<br>$t_{PLZ}$ | Output Disable Time<br>$\overline{OEBA}$ to Ax, OEAB to Bx | | 1.5 | 5.6 | 1.5 | 5.2 | ns |
| $t_{SU}$ | Set-up Time HIGH or LOW, Ax to CLKAB, Bx to CLKBA | | 3 | — | 3 | — | ns |
| $t_H$ | Hold Time HIGH or LOW, Ax to CLKAB, Bx to CLKBA | | 0 | — | 0 | — | ns |
| $t_{SU}$ | Set-up Time HIGH or LOW<br>Ax to LEAB, Bx to LEBA | Clock LOW | 2.5 | — | 2.5 | — | ns |
| | | Clock HIGH | 2.5 | — | 2.5 | — | |
| $t_H$ | Hold Time HIGH or LOW, Ax to LEAB, Bx to LEBA | | 1.5 | — | 1.5 | — | ns |
| $t_W$ | LEAB or LEBA Pulse Width HIGH or LOW | | 3 | — | 3 | — | ns |
| $t_W$ | CLKAB or CLKBA Pulse Width HIGH or LOW | | 3 | — | 3 | — | ns |
| $t_{SK(o)}$ | Output Skew[2] | | — | — | — | 500 | ps |

**NOTES:**
1. See TEST CIRCUITS AND WAVEFORMS. $T_A$ = – 40°C to + 85°C.
2. Skew between any two outputs of the same package and switching in the same direction.

# TEST CIRCUITS AND WAVEFORMS

## TEST CONDITIONS

| Symbol | $V_{CC}^{(1)}$=3.3V±0.3V | $V_{CC}^{(1)}$=2.7V | $V_{CC}^{(2)}$=2.5V±0.2V | Unit |
|---|---|---|---|---|
| $V_{LOAD}$ | 6 | 6 | 2 x Vcc | V |
| $V_{IH}$ | 2.7 | 2.7 | Vcc | V |
| $V_T$ | 1.5 | 1.5 | Vcc / 2 | V |
| $V_{LZ}$ | 300 | 300 | 150 | mV |
| $V_{HZ}$ | 300 | 300 | 150 | mV |
| $C_L$ | 50 | 50 | 30 | pF |




***Test Circuit for All Outputs***

**DEFINITIONS:**

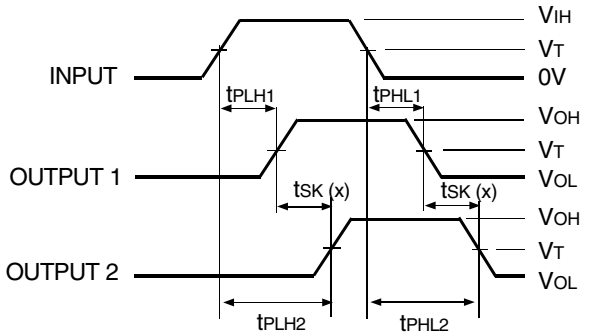
$C_L$ = Load capacitance: includes jig and probe capacitance.
$R_T$ = Termination resistance: should be equal to $Z_{OUT}$ of the Pulse Generator.

**NOTES:**

1. Pulse Generator for All Pulses: Rate ≤ 10MHz; $t_F$ ≤ 2.5ns; $t_R$ ≤ 2.5ns.
2. Pulse Generator for All Pulses: Rate ≤ 10MHz; $t_F$ ≤ 2ns; $t_R$ ≤ 2ns.

## SWITCH POSITION

| Test | Switch |
|---|---|
| Open Drain<br>Disable Low<br>Enable Low | $V_{LOAD}$ |
| Disable High<br>Enable High | GND |
| All Other Tests | Open |

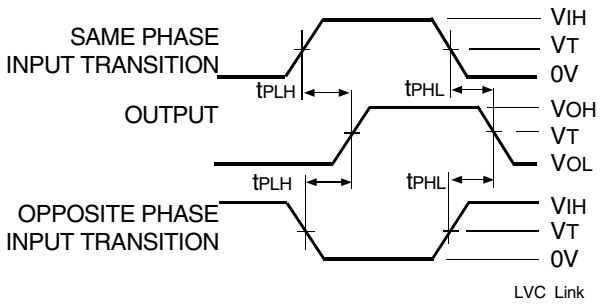



$t_{SK(x)} = |t_{PLH2} - t_{PLH1}|$ or $|t_{PHL2} - t_{PHL1}|$

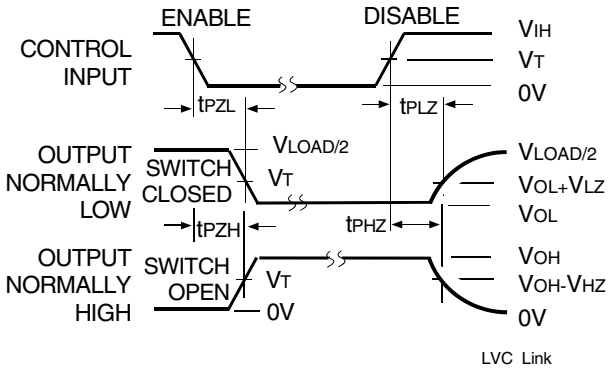
***Output Skew - $t_{SK(x)}$***

**NOTES:**

1. For $t_{SK}$(o) OUTPUT1 and OUTPUT2 are any two outputs.
2. For $t_{SK}$(b) OUTPUT1 and OUTPUT2 are in the same bank.



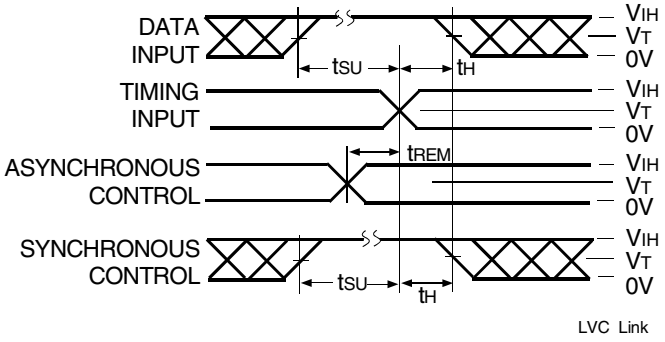

***Propagation Delay***



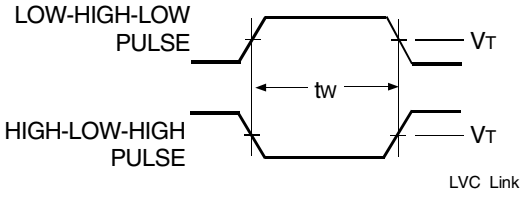

***Enable and Disable Times***

**NOTE:**

1. Diagram shown for input Control Enable-LOW and input Control Disable-HIGH.

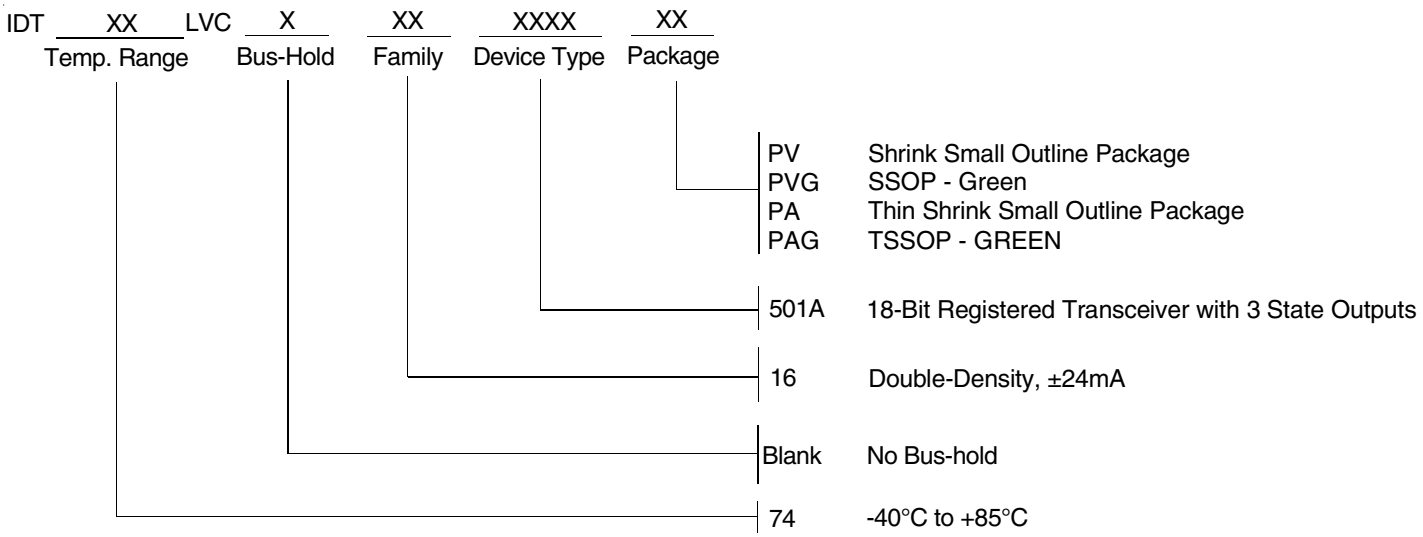



***Set-up, Hold, and Release Times***




***Pulse Width***

## ORDERING INFORMATION

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