

TP3064, TP3067 "Enhanced" Serial Interface CMOS CODEC/Filter COMBO®

General Description

The TP3064 (μ -law) and TP3067 (A-law) are monolithic PCM CODEC/Filters utilizing the A/D and D/A conversion architecture shown in *Figure 1*, and a serial PCM interface. The devices are fabricated using National's advanced double-poly CMOS process (microCMOS).

Similar to the TP305X family, these devices feature an additional Receive Power Amplifier to provide push-pull balanced output drive capability. The receive gain can be adjusted by means of two external resistors for an output level of up to $\pm 6.6V$ across a balanced 600Ω load.

Also included is an Analog Loopback switch and a \overline{TSx} output.

See also AN-370, "Techniques for Designing with CODEC/Filter COMBO Circuits."

Features

- Complete CODEC and filtering system including:
 - Transmit high-pass and low-pass filtering
 - Receive low-pass filter with $\sin x/x$ correction
 - Active RC noise filters
 - μ -law or A-law compatible COder and DECoder
 - Internal precision voltage reference
 - Serial I/O interface
 - Internal auto-zero circuitry
 - Receive push-pull power amplifiers
- μ -law—TP3064
- A-law—TP3067
- Designed for D3/D4 and CCITT applications
- $\pm 5V$ operation
- Low operating power—typically 70 mW
- Power-down standby mode—typically 3 mW
- Automatic power-down
- TTL or CMOS compatible digital interfaces
- Maximizes line interface card circuit density

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Block Diagram

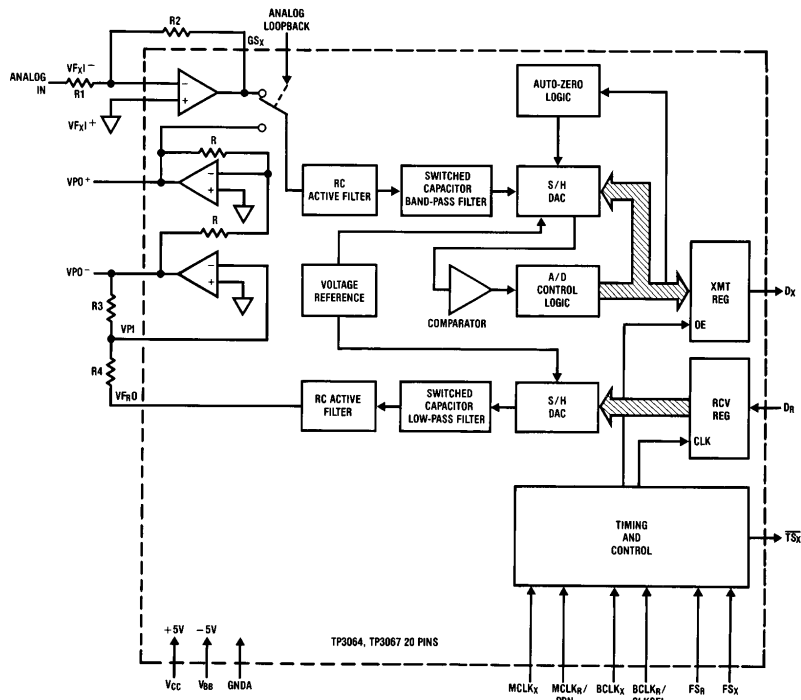
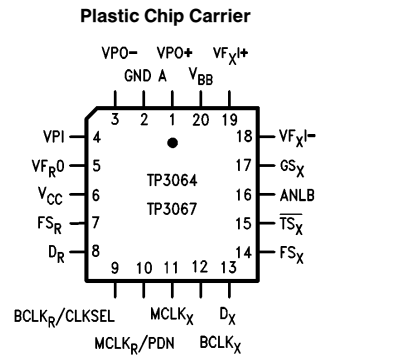
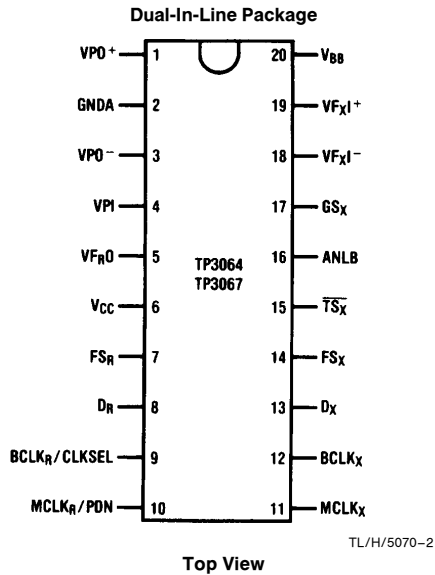


FIGURE 1

TL/H/5070-1

Connection Diagrams



Order Number TP3064J or TP3067J
See NS Package J20A

Order Number TP3064WM or TP3067WM
See NS Package M20B

Order Number TP3064N or TP3067N
See NS Package N20A

Order Number TP3064V or TP3067V
See NS Package V20A

Pin Description

| Symbol | Function | Symbol | Function |
|---------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| VPO ⁺ | The non-inverted output of the receive power amplifier. | MCLK _x | Transmit master clock. Must be 1.536 MHz, 1.544 MHz or 2.048 MHz. May be asynchronous with MCLK _R . Best performance is realized from synchronous operation. |
| GNDA | Analog ground. All signals are referenced to this pin. | BCLK _x | The bit clock which shifts out the PCM data on D _x . May vary from 64 kHz to 2.048 MHz, but must be synchronous with MCLK _x . |
| VPO ⁻ | The inverted output of the receive power amplifier. | D _x | The TRI-STATE [®] PCM data output which is enabled by FS _x . |
| VPI | Inverting input to the receive power amplifier. | FS _x | Transmit frame sync pulse input which enables BCLK _x to shift out the PCM data on D _x . FS _x is an 8 kHz pulse train, see Figures 2 and 3 for timing details. |
| VFR ₀ | Analog output of the receive filter. | TS _x | Open drain output which pulses low during the encoder time slot. |
| V _{CC} | Positive power supply pin. V _{CC} = +5V ± 5%. | ANLB | Analog Loopback control input. Must be set to logic '0' for normal operation. When pulled to logic '1', the transmit filter input is disconnected from the output of the transmit preamplifier and connected to the VPO ⁺ output of the receive power amplifier. |
| FS _R | Receive frame sync pulse which enables BCLK _R to shift PCM data into D _R . FS _R is an 8 kHz pulse train. See Figures 2 and 3 for timing details. | GS _x | Analog output of the transmit input amplifier. Used to externally set gain. |
| D _R | Receive data input. PCM data is shifted into D _R following the FS _R leading edge. | VF _{xI} ⁻ | Inverting input of the transmit input amplifier. |
| BCLK _R /CLKSEL | The bit clock which shifts data into D _R after the FS _R leading edge. May vary from 64 kHz to 2.048 MHz. Alternatively, may be a logic input which selects either 1.536 MHz/1.544 MHz or 2.048 MHz for master clock in synchronous mode and BCLK _x is used for both transmit and receive directions (see Table I). | VF _{xI} ⁺ | Non-inverting input of the transmit input amplifier. |
| MCLK _R /PDN | Receive master clock. Must be 1.536 MHz, 1.544 MHz or 2.048 MHz. May be asynchronous with MCLK _x , but should be synchronous with MCLK _x for best performance. When MCLK _R is connected continuously low, MCLK _x is selected for all internal timing. When MCLK _R is connected continuously high, the device is powered down. | V _{BB} | Negative power supply pin. V _{BB} = -5V ± 5%. |

Functional Description

POWER-UP

When power is first applied, power-on reset circuitry initializes the COMBO™ and places it into a power-down state. All non-essential circuits are deactivated and the D_X , V_{FO} , V_{PO-} and V_{PO+} outputs are put in high impedance states. To power-up the device, a logical low level or clock must be applied to the $MCLK_R/PDN$ pin and FS_X and/or FS_R pulses must be present. Thus, 2 power-down control modes are available. The first is to pull the $MCLK_R/PDN$ pin high; the alternative is to hold both FS_X and FS_R inputs continuously low—the device will power-down approximately 2 ms after the last FS_X or FS_R pulse. Power-up will occur on the first FS_X or FS_R pulse. The TRI-STATE PCM data output, D_X , will remain in the high impedance state until the second FS_X pulse.

SYNCHRONOUS OPERATION

For synchronous operation, the same master clock and bit clock should be used for both the transmit and receive directions. In this mode, a clock must be applied to $MCLK_X$ and the $MCLK_R/PDN$ pin can be used as a power-down control. A low level on $MCLK_R/PDN$ powers up the device and a high level powers down the device. In either case, $MCLK_X$ will be selected as the master clock for both the transmit and receive circuits. A bit clock must also be applied to $BCLK_X$ and the $BCLK_R/CLKSEL$ can be used to select the proper internal divider for a master clock of 1.536 MHz, 1.544 MHz or 2.048 MHz. For 1.544 MHz operation, the device automatically compensates for the 193rd clock pulse each frame.

With a fixed level on the $BCLK_R/CLKSEL$ pin, $BCLK_X$ will be selected as the bit clock for both the transmit and receive directions. Table I indicates the frequencies of operation which can be selected, depending on the state of $BCLK_R/CLKSEL$. In this synchronous mode, the bit clock, $BCLK_X$, may be from 64 kHz to 2.048 MHz, but must be synchronous with $MCLK_X$.

Each FS_X pulse begins the encoding cycle and the PCM data from the previous encode cycle is shifted out of the enabled D_X output on the positive edge of $BCLK_X$. After 8 bit clock periods, the TRI-STATE D_X output is returned to a high impedance state. With an FS_R pulse, PCM data is latched via the D_R input on the negative edge of $BCLK_X$ (or $BCLK_R$ if running). FS_X and FS_R must be synchronous with $MCLK_X/R$.

TABLE I. Selection of Master Clock Frequencies

| BCLK _R /CLKSEL | Master Clock Frequency Selected | |
|---------------------------|---------------------------------|------------------------|
| | TP3067 | TP3064 |
| Clocked | 2.048 MHz | 1.536 MHz or 1.544 MHz |
| 0 | 1.536 MHz or 1.544 MHz | 2.048 MHz |
| 1 | 2.048 MHz | 1.536 MHz or 1.544 MHz |

ASYNCHRONOUS OPERATION

For asynchronous operation, separate transmit and receive clocks may be applied. $MCLK_X$ and $MCLK_R$ must be 2.048 MHz for the TP3067, or 1.536 MHz, 1.544 MHz for the TP3064, and need not be synchronous. For best transmis-

sion performance, however, $MCLK_R$ should be synchronous with $MCLK_X$, which is easily achieved by applying only static logic levels to the $MCLK_R/PDN$ pin. This will automatically connect $MCLK_X$ to all internal $MCLK_R$ functions (see Pin Description). For 1.544 MHz operation, the device automatically compensates for the 193rd clock pulse each frame. FS_X starts each encoding cycle and must be synchronous with $MCLK_X$ and $BCLK_X$. FS_R starts each decoding cycle and must be synchronous with $BCLK_R$. $BCLK_R$ must be a clock, the logic levels shown in Table I are not valid in asynchronous mode. $BCLK_X$ and $BCLK_R$ may operate from 64 kHz to 2.048 MHz.

SHORT FRAME SYNC OPERATION

The COMBO can utilize either a short frame sync pulse (the same as the TP3020/21 CODECs) or a long frame sync pulse. Upon power initialization, the device assumes a short frame mode. In this mode, both frame sync pulses, FS_X and FS_R , must be one bit clock period long, with timing relationships specified in Figure 2. With FS_X high during a falling edge of $BCLK_X$, the next rising edge of $BCLK_X$ enables the D_X TRI-STATE output buffer, which will output the sign bit. The following seven rising edges clock out the remaining seven bits, and the next falling edge disables the D_X output. With FS_R high during a falling edge of $BCLK_R$ ($BCLK_X$ in synchronous mode), the next falling edge of $BCLK_R$ latches in the sign bit. The following seven falling edges latch in the seven remaining bits. All devices may utilize the short frame sync pulse in synchronous or asynchronous operating mode.

LONG FRAME SYNC OPERATION

To use the long (TP5116A/56 CODECs) frame mode, both the frame sync pulses, FS_X and FS_R , must be three or more bit clock periods long, with timing relationships specified in Figure 3. Based on the transmit frame sync, FS_X , the COMBO will sense whether short or long frame sync pulses are being used. For 64 kHz operation, the frame sync pulse must be kept low for a minimum of 160 ns. The D_X TRI-STATE output buffer is enabled with the rising edge of FS_X or the rising edge of $BCLK_X$, whichever comes later, and the first bit clocked out is the sign bit. The following seven $BCLK_X$ rising edges clock out the remaining seven bits. The D_X output is disabled by the falling $BCLK_X$ edge following the eighth rising edge, or by FS_X going low, whichever comes later. A rising edge on the receive frame sync pulse, FS_R , will cause the PCM data at D_R to be latched in on the next eight falling edges of $BCLK_R$ ($BCLK_X$ in synchronous mode). All devices may utilize the long frame sync pulse in synchronous or asynchronous mode.

TRANSMIT SECTION

The transmit section input is an operational amplifier with provision for gain adjustment using two external resistors, see Figure 4. The low noise and wide bandwidth allow gains in excess of 20 dB across the audio passband to be realized. The op amp drives a unity-gain filter consisting of RC active pre-filter, followed by an eighth order switched-capacitor bandpass filter clocked at 256 kHz. The output of this filter directly drives the encoder sample-and-hold circuit. The A/D is of companding type according to μ -law (TP3064) or A-law (TP3067) coding conventions. A precision voltage reference is trimmed in manufacturing to provide an input overload (t_{MAX}) of nominally 2.5V peak (see

Functional Description (Continued)

table of Transmission Characteristics). The FS_X frame sync pulse controls the sampling of the filter output, and then the successive-approximation encoding cycle begins. The 8-bit code is then loaded into a buffer and shifted out through D_X at the next FS_X pulse. The total encoding delay will be approximately $165 \mu s$ (due to the transmit filter) plus $125 \mu s$ (due to encoding delay), which totals $290 \mu s$. Any offset voltage due to the filters or comparator is cancelled by sign bit integration.

RECEIVE SECTION

The receive section consists of an expanding DAC which drives a fifth order switched-capacitor low pass filter clocked at 256 kHz. The decoder is A-law (TP3067) or μ -law (TP3064) and the 5th order low pass filter corrects for the $\sin x/x$ attenuation due to the 8 kHz sample/hold. The filter is then followed by a 2nd order RC active post-filter with its output at VF_{RO} . The receive section is unity-gain, but gain can be added by using the power amplifiers. Upon the occurrence of FS_R , the data at the D_R input is clocked in on the falling edge of the next eight $BCLK_R$ ($BCLK_X$) peri-

ods. At the end of the decoder time slot, the decoding cycle begins, and $10 \mu s$ later the decoder DAC output is updated. The total decoder delay is $\sim 10 \mu s$ (decoder update) plus $110 \mu s$ (filter delay) plus $62.5 \mu s$ ($1/2$ frame), which gives approximately $180 \mu s$.

RECEIVE POWER AMPLIFIERS

Two inverting mode power amplifiers are provided for directly driving a matched line interface transformer. The gain of the first power amplifier can be adjusted to boost the $\pm 2.5V$ peak output signal from the receive filter up to $\pm 3.3V$ peak into an unbalanced 300Ω load, or $\pm 4.0V$ into an unbalanced $15 k\Omega$ load. The second power amplifier is internally connected in unity-gain inverting mode to give 6 dB of signal gain for balanced loads.

Maximum power transfer to a 600Ω subscriber line termination is obtained by differentially driving a balanced transformer with a $\sqrt{2}:1$ turns ratio, as shown in *Figure 4*. A total peak power of 15.6 dBm can be delivered to the load plus termination.

ENCODING FORMAT AT D_X OUTPUT

| | TP3064 μ -Law | | | | | | | | TP3067 A-Law (Includes Even Bit Inversion) | | | | | | | |
|-------------------------------|----------------------|---|---|---|---|---|---|---|--------------------------------------------------|---|---|---|---|---|---|---|
| $V_{IN} = +\text{Full-Scale}$ | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| $V_{IN} = 0V$ | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| $V_{IN} = -\text{Full-Scale}$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

| | |
|---------------------------------------|------------------------------------|
| V_{CC} to GNDA | 7V |
| V_{BB} to GNDA | -7V |
| Voltage at any Analog Input or Output | $V_{CC} + 0.3V$ to $V_{BB} - 0.3V$ |

| | |
|----------------------------------------|----------------------------------|
| Voltage at any Digital Input or Output | $V_{CC} + 0.3V$ to $GNDA - 0.3V$ |
| Operating Temperature Range | -25°C to +125°C |
| Storage Temperature Range | -65°C to +150°C |
| Lead Temp. (Soldering, 10 sec.) | 300°C |
| ESD (Human Body Model) J | 1000V |
| ESD (Human Body Model) N | 1500V |
| Latch-Up Immunity | 100 mA on Any Pin |

Electrical Characteristics Unless otherwise noted, limits printed in **BOLD** characters are guaranteed for $V_{CC} = +5.0V \pm 5\%$, $V_{BB} = -5.0V \pm 5\%$; $T_A = 0^\circ C$ to $70^\circ C$ by correlation with 100% electrical testing at $T_A = 25^\circ C$. All other limits are assured by correlation with other production tests and/or product design and characterization. All signals referenced to GNDA. Typical values specified at $V_{CC} = +5.0V$, $V_{BB} = -5.0V$, $T_A = 25^\circ C$.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|----------------------------------------|----------------------------------------------------|----------------------------------------------------------------|------------|------|-------------|---------|
| POWER DISSIPATION (ALL DEVICES) | | | | | | |
| I_{CC0} | Power-Down Current | (Note) | | 0.5 | 1.5 | mA |
| I_{BB0} | Power-Down Current | (Note) | | 0.05 | 0.3 | mA |
| I_{CC1} | Active Current | $V_{PI} = 0V$; V_{FRO} , V_{PO}^+ and V_{PO}^- unloaded | | 7.0 | 10.0 | mA |
| I_{BB1} | Active Current | $V_{PI} = 0V$; V_{FRO} , V_{PO}^+ and V_{PO}^- unloaded | | 7.0 | 10.0 | mA |
| DIGITAL INTERFACE | | | | | | |
| V_{IL} | Input Low Voltage | | | | 0.6 | V |
| V_{IH} | Input High Voltage | | 2.2 | | | V |
| V_{OL} | Output Low Voltage | D_X , $I_L = 3.2$ mA | | | 0.4 | V |
| | | \overline{TS}_X , $I_L = 3.2$ mA, Open Drain | | | 0.4 | V |
| V_{OH} | Output High Voltage | D_X , $I_H = -3.2$ mA | 2.4 | | | V |
| I_{IL} | Input Low Current | $GNDA \leq V_{IN} \leq V_{IL}$, All Digital Inputs | -10 | | 10 | μA |
| I_{IH} | Input High Current | $V_{IH} \leq V_{IN} \leq V_{CC}$ | -10 | | 10 | μA |
| I_{OZ} | Output Current in High Impedance State (TRI-STATE) | D_X , $GNDA \leq V_O \leq V_{CC}$ | -10 | | 10 | μA |

Note: I_{CC0} and I_{BB0} are measured after first achieving a power-up state.

Electrical Characteristics (Continued)

Unless otherwise noted, limits printed in **BOLD** characters are guaranteed for $V_{CC} = +5.0V \pm 5\%$, $V_{BB} = -5.0V \pm 5\%$; $T_A = 0^\circ\text{C}$ to 70°C by correlation with 100% electrical testing at $T_A = 25^\circ\text{C}$. All other limits are assured by correlation with other production tests and/or product design and characterization. All signals referenced to GNDA. Typical values specified at $V_{CC} = +5.0V$, $V_{BB} = -5.0V$, $T_A = 25^\circ\text{C}$.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---------------------------------------------------------------------|------------------------------------------------|-------------------------------------------------------------------------------|-------------|-----|-------------|------------|
| ANALOG INTERFACE WITH TRANSMIT INPUT AMPLIFIER (ALL DEVICES) | | | | | | |
| I_{IXA} | Input Leakage Current | $-2.5V \leq V \leq +2.5V$, V_{FXL}^+ or V_{FXL}^- | -200 | | 200 | nA |
| R_{IXA} | Input Resistance | $-2.5V \leq V \leq +2.5V$, V_{FXL}^+ or V_{FXL}^- | 10 | | | M Ω |
| R_{OXA} | Output Resistance | Closed Loop, Unity Gain | | 1 | 3 | Ω |
| R_{LXA} | Load Resistance | GS_X | 10 | | | k Ω |
| C_{LXA} | Load Capacitance | GS_X | | | 50 | pF |
| V_{OXA} | Output Dynamic Range | GS_X , $R_L \geq 10$ k Ω | -2.8 | | +2.8 | V |
| A_{VXA} | Voltage Gain | V_{FXL}^+ to GS_X | 5000 | | | V/V |
| F_{UXA} | Unity-Gain Bandwidth | | 1 | 2 | | MHz |
| V_{OSXA} | Offset Voltage | | -20 | | 20 | mV |
| V_{CMXA} | Common-Mode Voltage | CMRRXA > 60 dB | -2.5 | | 2.5 | V |
| CMRRXA | Common-Mode Rejection Ratio | DC Test | 60 | | | dB |
| PSRRXA | Power Supply Rejection Ratio | DC Test | 60 | | | dB |
| ANALOG INTERFACE WITH RECEIVE FILTER (ALL DEVICES) | | | | | | |
| R_{ORF} | Output Resistance | Pin V_{FR0} | | 1 | 3 | Ω |
| R_{LRF} | Load Resistance | $V_{FR0} = \pm 2.5V$ | 10 | | | k Ω |
| C_{LRF} | Load Capacitance | Connect from V_{FR0} to GNDA | | | 25 | pF |
| V_{OSR0} | Output DC Offset Voltage | Measure from V_{FR0} to GNDA | -200 | | 200 | mV |
| ANALOG INTERFACE WITH POWER AMPLIFIERS (ALL DEVICES) | | | | | | |
| I_{PI} | Input Leakage Current | $-1.0V \leq V_{PI} \leq 1.0V$ | -100 | | 100 | nA |
| R_{PI} | Input Resistance | $-1.0V \leq V_{PI} \leq 1.0V$ | 10 | | | M Ω |
| V_{IOS} | Input Offset Voltage | | -25 | | 25 | mV |
| R_{OP} | Output Resistance | Inverting Unity-Gain at V_{PO}^+ or V_{PO}^- | | 1 | | Ω |
| F_C | Unity-Gain Bandwidth | Open Loop (V_{PO}^-) | | 400 | | kHz |
| C_{LP} | Load Capacitance | | | | 100 | pF |
| GA_{P^+} | Gain from V_{PO}^- to V_{PO}^+ | $R_L = 600\Omega$ V_{PO}^+ to V_{PO}^- Level at $V_{PO}^- = 1.77$ Vrms | | -1 | | V/V |
| PSRR _P | Power Supply Rejection of V_{CC} or V_{BB} | V_{PO}^- Connected to V_{PI} 0 kHz – 4 kHz | 60 | | | dB |
| | | 4 kHz – 50 kHz | 36 | | | dB |
| R_{LP} | Load Resistance | Connect from V_{PO}^+ to V_{PO}^- | 600 | | | Ω |

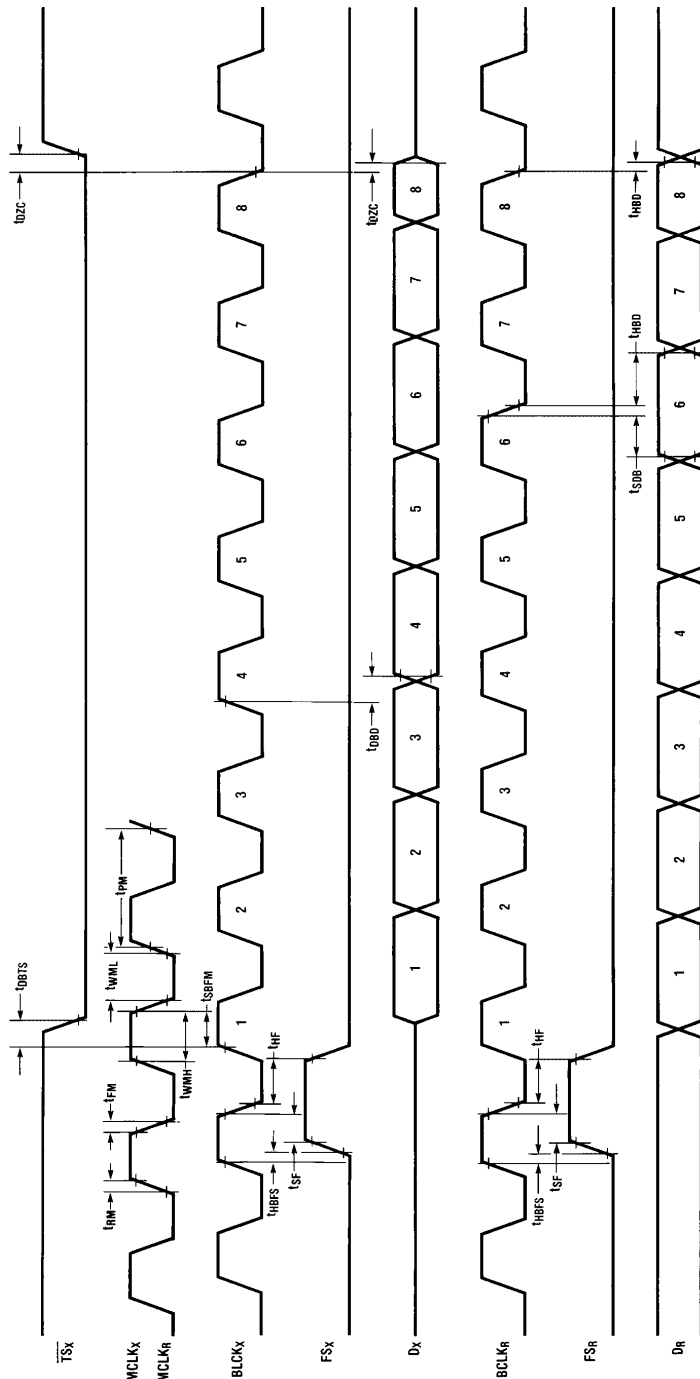
Timing Specifications

Unless otherwise noted, limits printed in **BOLD** characters are guaranteed for $V_{CC} = +5.0V \pm 5\%$, $V_{BB} = -5.0V \pm 5\%$, $T_A = 0^\circ C$ to $70^\circ C$ by correlation with 100% electrical testing at $T_A = 25^\circ C$. All other limits are assured by correlation with other production tests and/or product design and characterization. All signals are referenced to GND. Typical values specified at $V_{CC} = +5.0V$, $V_{BB} = -5.0V$, $T_A = 25^\circ C$. All timing parameters are measured at $V_{OH} = 2.0V$ and $V_{OL} = 0.7V$.

See Definitions and Timing Conventions section for test methods information.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|------------|------------------------------------------------------------------------------------------------|------------------------------------------------------------|------------|--------------|-------|-------|
| $1/t_{PM}$ | Frequency of Master Clock | MCLK _X and MCLK _R | | 1.536 | | MHz |
| | | | | 1.544 | | |
| | | | | 2.048 | | MHz |
| t_{RM} | Rise Time of Master Clock | MCLK _X and MCLK _R | | | 50 | ns |
| t_{FM} | Fall Time of Master Clock | MCLK _X and MCLK _R | | | 50 | ns |
| t_{PB} | Period Bit of Clock | | 485 | 488 | 15725 | ns |
| t_{RB} | Rise Time of Bit Clock | BCLK _X and BCLK _R | | | 50 | ns |
| t_{FB} | Fall Time of Bit Clock | BCLK _X and BCLK _R | | | 50 | ns |
| t_{WMH} | Width of Master Clock High | MCLK _X and MCLK _R | 160 | | | ns |
| t_{WML} | Width of Master Clock Low | MCLK _X and MCLK _R | 160 | | | ns |
| t_{SBFM} | Set-Up Time from BCLK _X High to MCLK _X Falling Edge | | 100 | | | ns |
| t_{SFFM} | Set-Up Time from FS _X High to MCLK _X Falling Edge | Long Frame Only | 100 | | | ns |
| t_{WBH} | Width of Bit Clock High | | 160 | | | ns |
| t_{WBL} | Width of Bit Clock Low | | 160 | | | ns |
| t_{HBFL} | Holding Time from Bit Clock Low to Frame Sync | Long Frame Only | 0 | | | ns |
| t_{HBFS} | Holding Time from Bit Clock High to Frame Sync | Short Frame Only | 0 | | | ns |
| t_{SFB} | Set-Up Time for Frame Sync to Bit Clock Low | Long Frame Only | 80 | | | ns |
| t_{DBD} | Delay Time from BCLK _X High to Data Valid | Load = 150 pF plus 2 LSTTL Loads | 0 | | 180 | ns |
| t_{DBTS} | Delay Time to \overline{TS}_X Low | Load = 150 pF plus 2 LSTTL Loads | | | 140 | ns |
| t_{DZC} | Delay Time from BCLK _X Low to Data Output Disabled | | 50 | | 165 | ns |
| t_{DZF} | Delay Time to Valid Data from FS _X or BCLK _X , Whichever Comes Later | $C_L = 0$ pF to 150 pF | 20 | | 165 | ns |
| t_{SDB} | Set-Up Time from D _R Valid to BCLK _{R/X} Low | | 50 | | | ns |
| t_{HBD} | Hold Time from BCLK _{R/X} Low to D _R Invalid | | 50 | | | ns |
| t_{SF} | Set-Up Time from FS _{X/R} to BCLK _{X/R} Low | Short Frame Sync Pulse (1 Bit Clock Period Long) | 50 | | | ns |
| t_{HF} | Hold Time from BCLK _{X/R} Low to FS _{X/R} Low | Short Frame Sync Pulse (1 Bit Clock Period Long) | 100 | | | ns |
| t_{HBF1} | Hold Time from 3rd Period of Bit Clock Low to Frame Sync (FS _X or FS _R) | Long Frame Sync Pulse (from 3 to 8 Bit Clock Periods Long) | 100 | | | ns |
| t_{WFL} | Minimum Width of the Frame Sync Pulse (Low Level) | 64k Bit/s Operating Mode | 160 | | | ns |

Timing Diagrams



TL/H/5070-3

FIGURE 2. Short Frame Sync Timing

Timing Diagrams (Continued)

TL/H/5070-4

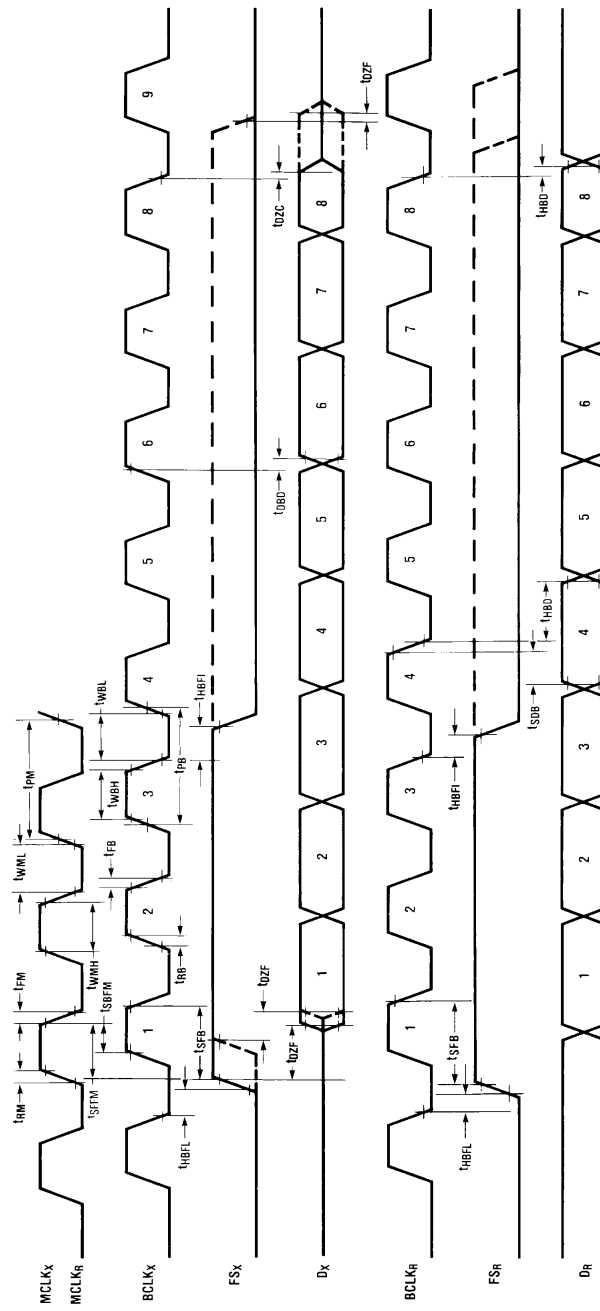


FIGURE 3. Long Frame Sync Timing

Transmission Characteristics

Unless otherwise noted, limits printed in **BOLD** characters are guaranteed for $V_{CC} = +5.0V \pm 5\%$, $V_{BB} = -5.0V \pm 5\%$; $T_A = 0^\circ C$ to $70^\circ C$ by correlation with 100% electrical testing at $T_A = 25^\circ C$. All other limits are assured by correlation with other production tests and/or product design and characterization. $G_{NDA} = 0V$, $f = 1.02 \text{ kHz}$, $V_{IN} = 0 \text{ dbm0}$, transmit input amplifier connected for unity gain non-inverting. Typical values specified at $V_{CC} = +5.0V$, $V_{BB} = -5.0V$, $T_A = 25^\circ C$.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|---------------------------|------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------|----------------|------------------------------------------------------------------------------------------------|----------------------------------------------|
| AMPLITUDE RESPONSE | | | | | | |
| | Absolute Levels (Definition of nominal gain) | Nominal 0 dBm0 Level is 4 dBm (600Ω) 0 dBm0 | | 1.2276 | | Vrms |
| t _{MAX} | Virtual Decision Value Defined per CCITT Rec. G711 | Max Transmit Overload Level TP3064 (3.17 dBm0) TP3067 (3.14 dBm0) | | 2.501 2.492 | | V _{PK} V _{PK} |
| G _{XA} | Transmit Gain, Absolute | T _A = 25°C, V _{CC} = 5V, V _{BB} = -5V | -0.15 | | 0.15 | dB |
| G _{XR} | Transmit Gain, Relative to G _{XA} | f = 16 Hz f = 50 Hz f = 60 Hz f = 200 Hz f = 300 Hz-3000 Hz f = 3300 Hz f = 3400 Hz f = 4000 Hz f = 4600 Hz and Up, Measure Response from 0 Hz to 4000 Hz | -1.8 -0.15 -0.35 -0.7 | | -40 -30 -26 -0.1 0.15 0 -14 -32 | dB dB dB dB dB dB dB dB |
| G _{XAT} | Absolute Transmit Gain Variation with Temperature | Relative to G _{XA} | -0.1 | | 0.1 | dB |
| G _{XAV} | Absolute Transmit Gain Variation with Supply Voltage | Relative to G _{XA} | -0.05 | | 0.05 | dB |
| G _{XRL} | Transmit Gain Variations with Level | Sinusoidal Test Method Reference Level = -10 dBm0 V _{F_XL} ⁺ = -40 dBm0 to +3 dBm0 V _{F_XL} ⁺ = -50 dBm0 to -40 dBm0 V _{F_XL} ⁺ = -55 dBm0 to -50 dBm0 | -0.2 -0.4 -1.2 | | 0.2 0.4 1.2 | dB dB dB |
| G _{RA} | Receive Gain, Absolute | T _A = 25°C, V _{CC} = 5V, V _{BB} = -5V Input = Digital Code Sequence for 0 dBm0 Signal | -0.15 | | 0.15 | dB |
| G _{RR} | Receive Gain, Relative to G _{RA} | f = 0 Hz to 3000 Hz f = 3300 Hz f = 3400 Hz f = 4000 Hz | -0.15 -0.35 -0.7 | | 0.15 0.05 0 -14 | dB dB dB dB |
| G _{RAT} | Absolute Receive Gain Variation with Temperature | Relative to G _{RA} | -0.1 | | 0.1 | dB |
| G _{RAV} | Absolute Receive Gain Variation with Supply Voltage | Relative to G _{RA} | -0.05 | | 0.05 | dB |
| G _{RRRL} | Receive Gain Variations with Level | Sinusoidal Test Method; Reference Input PCM Code Corresponds to an Ideally Encoded -10 dBm0 Signal PCM Level = -40 dBm0 to +3 dBm0 PCM Level = -50 dBm0 to -40 dBm0 PCM Level = -55 dBm0 to -50 dBm0 | -0.2 -0.4 -1.2 | | 0.2 0.4 1.2 | dB dB dB |
| V _{RO} | Receive Filter Output at V _{RO} | RL = 10 kΩ | -2.5 | | 2.5 | V |

Transmission Characteristics (Continued)

Unless otherwise noted, limits printed in **BOLD** characters are guaranteed for $V_{CC} = +5.0V \pm 5\%$, $V_{BB} = -5.0V \pm 5\%$; $T_A = 0^\circ\text{C}$ to 70°C by correlation with 100% electrical testing at $T_A = 25^\circ\text{C}$. All other limits are assured by correlation with other production tests and/or product design and characterization. $G_{ND A} = 0V$, $f = 1.02\text{ kHz}$, $V_{IN} = 0\text{ dBm0}$, transmit input amplifier connected for unity gain non-inverting. Typical values specified at $V_{CC} = +5.0V$, $V_{BB} = -5.0V$, $T_A = 25^\circ\text{C}$.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|-------------------------------------------------|----------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-----|---------------------------------|----------------|
| ENVELOPE DELAY DISTORTION WITH FREQUENCY | | | | | | |
| D_{XA} | Transmit Delay, Absolute | $f = 1600\text{ Hz}$ | | 290 | 315 | μs |
| D_{XR} | Transmit Delay, Relative to D_{XA} | $f = 500\text{ Hz} - 600\text{ Hz}$ | | 195 | 220 | μs |
| | | $f = 600\text{ Hz} - 800\text{ Hz}$ | | 120 | 145 | μs |
| | | $f = 800\text{ Hz} - 1000\text{ Hz}$ | | 50 | 75 | μs |
| | | $f = 1000\text{ Hz} - 1600\text{ Hz}$ | | 20 | 40 | μs |
| | | $f = 1600\text{ Hz} - 2600\text{ Hz}$ | | 55 | 75 | μs |
| | | $f = 2600\text{ Hz} - 2800\text{ Hz}$ | | 80 | 105 | μs |
| | | $f = 2800\text{ Hz} - 3000\text{ Hz}$ | | 130 | 155 | μs |
| D_{RA} | Receive Delay, Absolute | $f = 1600\text{ Hz}$ | | 180 | 200 | μs |
| D_{RR} | Receive Delay, Relative to D_{RA} | $f = 500\text{ Hz} - 1000\text{ Hz}$ | -40 | -25 | | μs |
| | | $f = 1000\text{ Hz} - 1600\text{ Hz}$ | -30 | -20 | | μs |
| | | $f = 1600\text{ Hz} - 2600\text{ Hz}$ | | 70 | 90 | μs |
| | | $f = 2600\text{ Hz} - 2800\text{ Hz}$ | | 100 | 125 | μs |
| | | $f = 2800\text{ Hz} - 3000\text{ Hz}$ | | 145 | 175 | μs |
| NOISE | | | | | | |
| N_{XC} | Transmit Noise, C Message Weighted | TP3064 (Note 1) | | 12 | 15 | dBrnC0 |
| N_{XP} | Transmit Noise, Psophometric Weighted | TP3067 (Note 1) | | -74 | -67 | dBm0p |
| N_{RC} | Receive Noise, C Message Weighted | PCM Code Equals Alternating Positive and Negative Zero TP3064 | | 8 | 11 | dBrnC0 |
| N_{RP} | Receive Noise, Psophometric Weighted | PCM Code Equals Positive Zero TP3067 | | -82 | -79 | dBm0p |
| N_{RS} | Noise, Single Frequency | $f = 0\text{ kHz}$ to 100 kHz , Loop Around Measurement, $V_{FXI} = 0\text{ Vrms}$ | | | -53 | dBm0 |
| $PPSR_X$ | Positive Power Supply Rejection, Transmit | $V_{CC} = 5.0\text{ V}_{DC} + 100\text{ mVrms}$ $f = 0\text{ kHz} - 50\text{ kHz}$ (Note 2) | 40 | | | dB |
| $NPSR_X$ | Negative Power Supply Rejection, Transmit | $V_{BB} = -5.0\text{ V}_{DC} + 100\text{ mVrms}$ $f = 0\text{ kHz} - 50\text{ kHz}$ (Note 2) | 40 | | | dB |
| $PPSR_R$ | Positive Power Supply Rejection, Receive | PCM Code Equals Positive Zero $V_{CC} = 5.0\text{ V}_{DC} + 100\text{ mVrms}$ Measure V_{FR0} $f = 0\text{ Hz} - 4000\text{ Hz}$ $f = 4\text{ kHz} - 50\text{ kHz}$ | 38 25 | | | dB dB |
| $NPSR_R$ | Negative Power Supply Rejection, Receive | PCM Code Equals Positive Zero $V_{BB} = -5.0\text{ V}_{DC} + 100\text{ mVrms}$ Measure V_{FR0} $f = 0\text{ Hz} - 4000\text{ Hz}$ $f = 4\text{ kHz} - 25\text{ kHz}$ $f = 25\text{ kHz} - 50\text{ kHz}$ | 40 40 36 | | | dB dB dB |
| SOS | Spurious Out-of-Band Signals at the Channel Output | 0 dBm0, 300 Hz - 3400 Hz Input PCM Code Applied at DR Measure Individual Image Signals at V_{FR0} 4600 Hz - 7600 Hz 7600 Hz - 8400 Hz 8400 Hz - 100,000 Hz | | | -32 -40 -32 | dB dB dB |

Transmission Characteristics (Continued)

Unless otherwise noted, limits printed in **BOLD** characters are guaranteed for $V_{CC} = +5.0V \pm 5\%$, $V_{BB} = -5.0V \pm 5\%$; $T_A = 0^\circ\text{C}$ to 70°C by correlation with 100% electrical testing at $T_A = 25^\circ\text{C}$. All other limits are assured by correlation with other production tests and/or product design and characterization. $G_NDA = 0V$, $f = 1.02\text{ kHz}$, $V_{IN} = 0\text{ dBm0}$, transmit input amplifier connected for unity gain non-inverting. Typicals specified at $V_{CC} = +5.0V$, $V_{BB} = -5.0V$, $T_A = 25^\circ\text{C}$.

| Symbol | Parameter | Conditions | Min | Typ | Max | Units |
|----------------------------------------|------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|-----|------------|----------------------------------------|
| DISTORTION | | | | | | |
| STD _X , STD _R | Signal to Total Distortion Transmit or Receive Half-Channel | Sinusoidal Test Method (Note 3) Level = 3.0 dBm0 = 0 dBm0 to -30 dBm0 = -40 dBm0 XMT RCV = -55 dBm0 XMT RCV | 33 36 29 30 14 15 | | | dBc dBc dBc dBc dBc dBc |
| SFD _X | Single Frequency Distortion, Transmit | | | | -46 | dB |
| SFD _R | Single Frequency Distortion, Receive | | | | -46 | dB |
| IMD | Intermodulation Distortion | Loop Around Measurement, $V_{FX1}^+ = -4\text{ dBm0}$ to -21 dBm0 , Two Frequencies in the Range 300 Hz - 3400 Hz | | | -41 | dB |
| CROSSTALK | | | | | | |
| CT _{X-R} | Transmit to Receive Crosstalk | $f = 300\text{ Hz} - 3000\text{ Hz}$ $D_R = \text{Quiet PCM Code}$ | | -90 | -75 | dB |
| CT _{R-X} | Receive to Transmit Crosstalk | $f = 300\text{ Hz} - 3000\text{ Hz}$, $V_{FX1} = 0V$ (Note 2) | | -90 | -70 | dB |
| POWER AMPLIFIERS | | | | | | |
| V _{OPA} | Maximum 0 dBm0 Level (Better than $\pm 0.1\text{ dB}$ Linearity over the Range -10 dBm0 to $+3\text{ dBm0}$) | Balanced Load, R_L Connected Between V_{PO}^+ and V_{PO}^- . $R_L = 600\Omega$ $R_L = 1200\Omega$ | 3.3 3.5 | | | Vrms Vrms |
| S/D _P | Signal/Distortion | $R_L = 600\Omega$ | 50 | | | dB |

Note 1: Measured by extrapolation from the distortion test result at -50 dBm0 .

Note 2: PPSR_X, NPSR_X, and CT_{R-X} are measured with a -50 dBm0 activation signal applied to V_{FX1}^+ .

Note 3: TP3064 is measured using C message weighted filter. TP3067 is measured using psophometric weighted filter.

Applications Information

POWER SUPPLIES

While the pins of the TP3060 family are well protected against electrical misuse, it is recommended that the standard CMOS practice be followed, ensuring that ground is connected to the device before any other connections are made. In applications where the printed circuit board may be plugged into a "hot" socket with power and clocks already present, an extra long ground pin in the connector should be used.

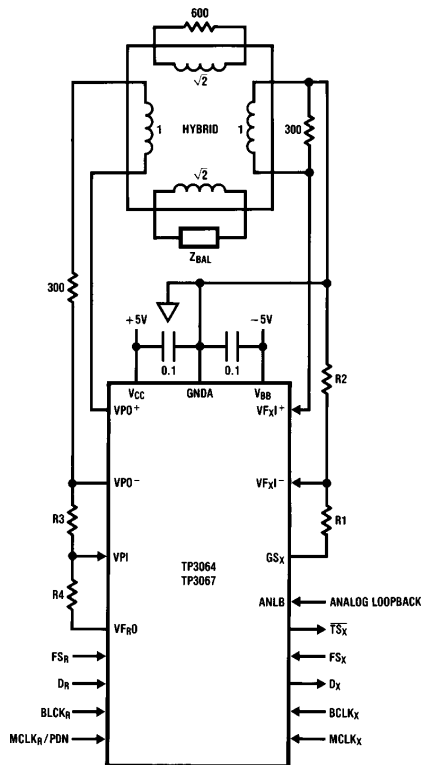
All ground connections to each device should meet at a common point as close as possible to the GNDA pin. This

minimizes the interaction of ground return currents flowing through a common bus impedance. 0.1 μF supply decoupling capacitors should be connected from this common ground point to V_{CC} and V_{BB} , as close to the device as possible.

For best performance, the ground point of each CODEC/FILTER on a card should be connected to a common card ground in "STAR" formation, rather than via a ground bus. This common ground point should be decoupled to V_{CC} and V_{BB} with 10 μF capacitors.

Note: See Application Note 370 for further details

Typical Asynchronous Application



TL/H/5070-5

Note 1: Transmit gain = $20 \times \log \left(\frac{R1 + R2}{R2} \right)$, $(R1 + R2) \geq 10 \text{ k}\Omega$

Note 2: Receive gain = $20 \times \log \left(\frac{2 \times R3}{R4} \right)$, $R4 \geq 10 \text{ k}\Omega$

FIGURE 4

Definitions and Timing Conventions

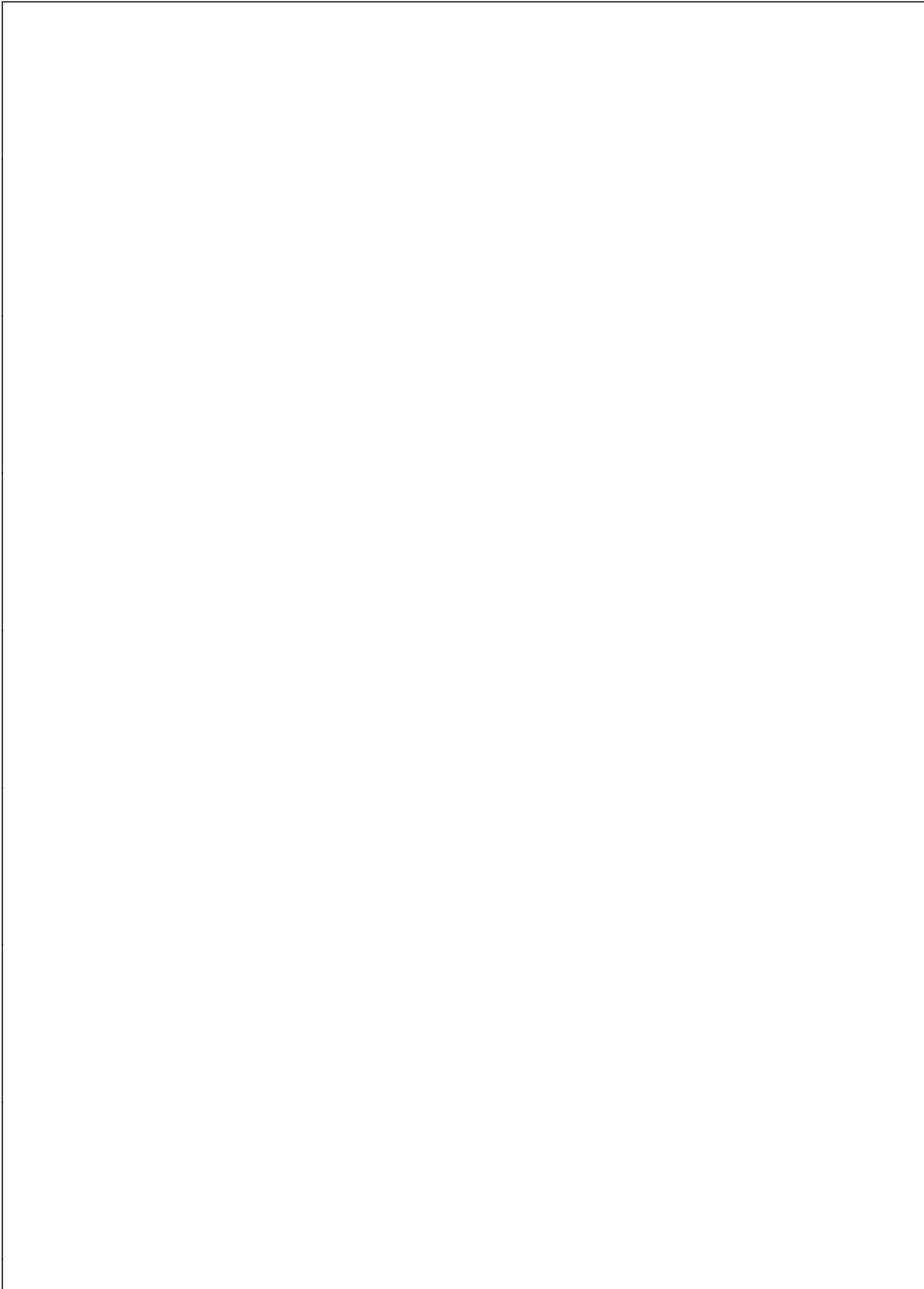
DEFINITIONS

| | |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| V_{IH} | V_{IH} is the d.c. input level above which an input level is guaranteed to appear as a logical one. This parameter is to be measured by performing a functional test at reduced clock speeds and nominal timing, (i.e. not minimum setup and hold times or output strobes), with the high level of all driving signals set to V_{IH} and maximum supply voltages applied to the device |
| V_{IL} | V_{IL} is the d.c. input level below which an input level is guaranteed to appear as a logical zero to the device. This parameter is measured in the same manner as V_{IH} but with all driving signal low levels set to V_{IL} and minimum supply voltages applied to the device. |
| V_{OH} | V_{OH} is the minimum d.c. output level to which an output placed in a logical one state will converge when loaded at the maximum specified load current. |
| V_{OL} | V_{OL} is the maximum d.c. output level to which an output placed in a logical zero state will converge when loaded at the maximum specified load current. |
| Threshold Region | The threshold region is the range of input voltages between V_{IL} and V_{IH} . |
| Valid Signal | A signal is Valid if it is in one of the valid logic states, (i.e. above V_{IH} or below V_{IL}). In timing specifications, a signal is deemed valid at the instant it enters a valid state. |
| Invalid Signal | A signal is Invalid if it is not in a valid logic state, i.e. when it is in the threshold region between V_{IL} and V_{IH} . In timing specifications, a signal is deemed Invalid at the instant it enters the threshold region. |

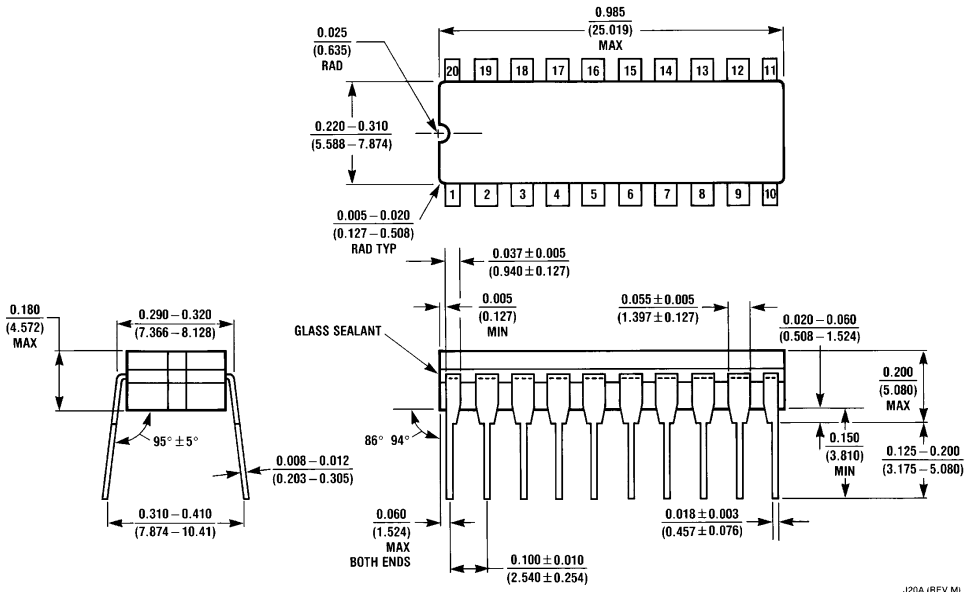
TIMING CONVENTIONS

For the purposes of this timing specification, the following conventions apply:

| | |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Input Signals | All input signals may be characterized as: $V_L = 0.4V$, $V_H = 2.4V$, $t_R < 10$ ns, $t_F < 10$ ns. |
| Period | The period of clock signal is designated as t_{Pxx} where xx represents the mnemonic of the clock signal being specified. |
| Rise Time | Rise times are designated as t_{Ryy} , where yy represents a mnemonic of the signal whose rise time is being specified. t_{Ryy} is measured from V_{IL} to V_{IH} . |
| Fall Time | Fall times are designated as t_{Fyy} , where yy represents a mnemonic of the signal whose fall time is being specified. t_{Fyy} is measured from V_{IH} to V_{IL} . |
| Pulse Width High | The high pulse width is designated as t_{WzzH} , where zz represents the mnemonic of the input or output signal whose pulse width is being specified. High pulse widths are measured from V_{IH} to V_{IH} . |
| Pulse Width Low | The low pulse width is designated as t_{WzzL} , where zz represents the mnemonic of the input or output signal whose pulse width is being specified. Low pulse widths are measured from V_{IL} to V_{IL} . |
| Setup Time | Setup times are designated as t_{Swwxx} , where ww represents the mnemonic of the input signal whose setup time is being specified relative to a clock or strobe input represented by mnemonic xx. Setup times are measured from the ww Valid to xx Invalid. |
| Hold Time | Hold times are designated as t_{Hxxww} , where ww represents the mnemonic of the input signal whose hold time is being specified relative to a clock or strobe input represented by mnemonic xx. Hold times are measured from xx Valid to ww Invalid. |
| Delay Time | Delay times are designated as t_{Dxxyy} Hi to Low, where xx represents the mnemonic of the input reference signal and yy represents the mnemonic of the output signal whose timing is being specified relative to xx. The mnemonic may optionally be terminated by an H or L to specify the high going or low going transition of the output signal. Maximum delay times are measured from xx Valid to yy Valid. Minimum delay times are measured from xx Valid to yy Invalid. This parameter is tested under the load conditions specified in the Conditions column of the Timing Specifications section of this data sheet. |

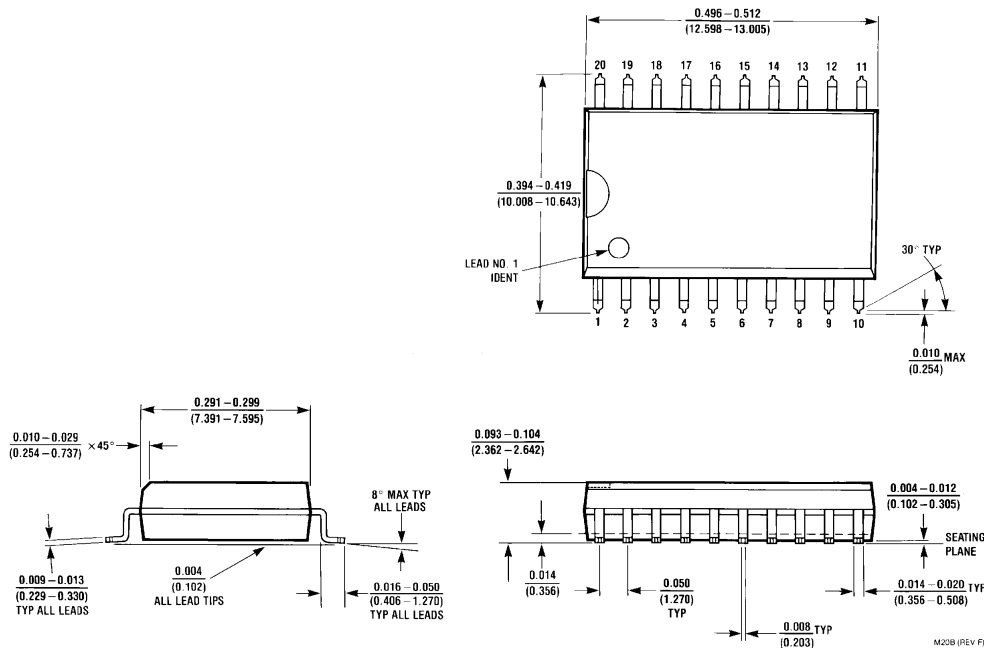


Physical Dimensions inches (millimeters)



J20A (REV M)

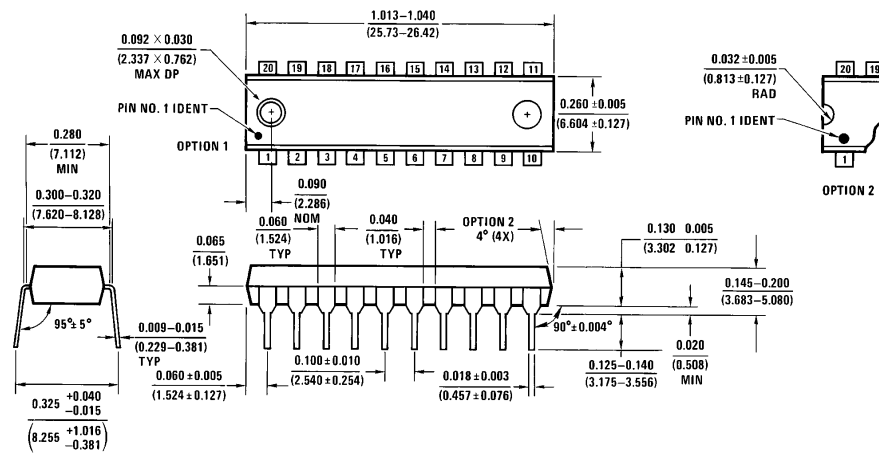
Cavity Dual-In-Line Package (J)
 Order Number TP3064J or TP3067J
 NS Package Number J20A



M20B (REV F)

Molded Small Outline Package (WM)
 Order Number TP3064WM or TP3067WM
 NS Package Number M20B

Physical Dimensions inches (millimeters) (Continued)

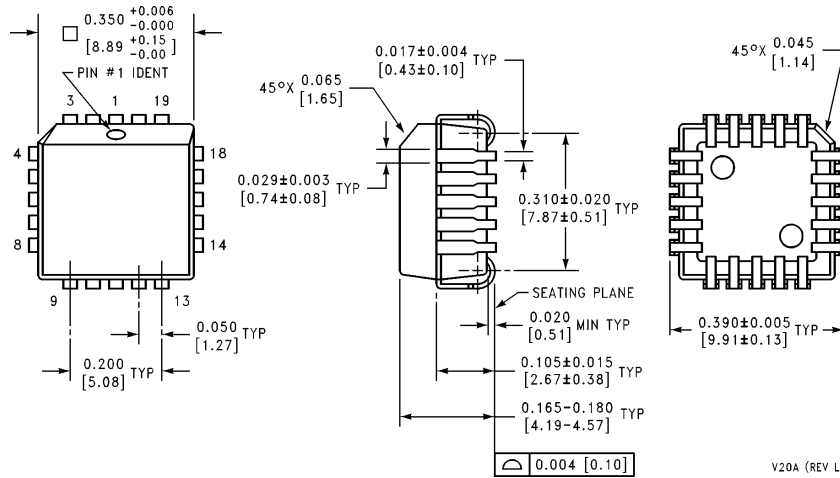


Molded Dual-In-Line Package (N)
Order Number TP3064N or TP3067N
NS Package Number N20A

N20A (REV GI)

Physical Dimensions inches (millimeters) (Continued)

Lit. # 113975



Plastic Chip Carrier (V)
Order Number TP3064V or TP3067V
NS Package Number V20A

V20A (REV L)

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