

TP3064B, TP3067B, TP13064B, TP13067B MONOLITHIC SERIAL INTERFACE COMBINED PCM CODEC AND FILTER

SCTS031D – MAY 1990 – REVISED JULY 1996

- **Complete PCM Codec and Filtering Systems include:**
 - 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 Autozero Circuitry
- μ -Law – TP13064B and TP3064B
- A-Law – TP13067B and TP3067B
- ± 5 -V Operation
- Low Operating Power . . . 70 mW Typ
- Power-Down Standby Mode . . . 3 mW Typ
- Automatic Power Down
- TTL- or CMOS-Compatible Digital Interface
- Maximizes Line Interface Card Circuit Density
- Improved Versions of National Semiconductor TP3064, TP3067, TP3064-X, and TP3067-X

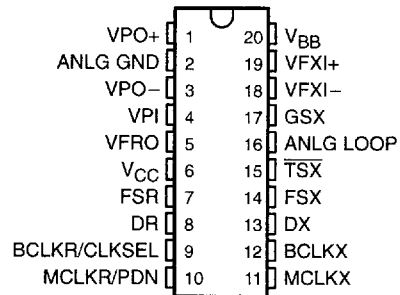
description

The TP3064B, TP3067B, TP13064B, and TP13067B each comprise a single-chip pulse-code-modulation encoder and decoder (PCM codec), and PCM line filter. They also provide band-pass filtering of the analog signals prior to the encoding, and low-pass filtering after the decoding of voice signals and call-progress tones. All the functions required to interface a full-duplex (2-wire) voice telephone circuit with a time-division-multiplexed (TDM) system are included on-chip. These devices are pin-for-pin compatible with the National Semiconductor TP3064 and TP3067. Primary applications include:

- Line interface for digital transmission and switching of T1 carrier, PABX (private automated branch exchange), and central office telephone systems
- Subscriber line concentrators
- Digital-encryption systems
- Digital voice-band data-storage systems
- Digital signal processing

These devices are designed to perform the transmit encoding (A/D conversion) and receive decoding (D/A conversion) as well as the transmit and receive filtering functions in a PCM system, and are intended to be used at the analog termination of a PCM line or trunk. They require a transmit master clock and a receive master clock that may be asynchronous (1.536 MHz, 1.544 MHz, or 2.048 MHz), transmit and receive data clocks that are synchronous with the master clock (but can vary from 64 kHz to 2.048 MHz), and transmit and receive frame-sync pulses. The TP3064B and TP13064B contain patented circuitry to achieve low transmit channel idle noise and are not recommended for applications in which the composite signals on the transmit side are below -55 dBm0.

DW OR N PACKAGE
(TOP VIEW)



These devices have limited built-in ESD protection. The leads should be shorted together or the device placed in conductive foam during storage or handling to prevent electrostatic damage to the CMOS gates.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

 **TEXAS
INSTRUMENTS**

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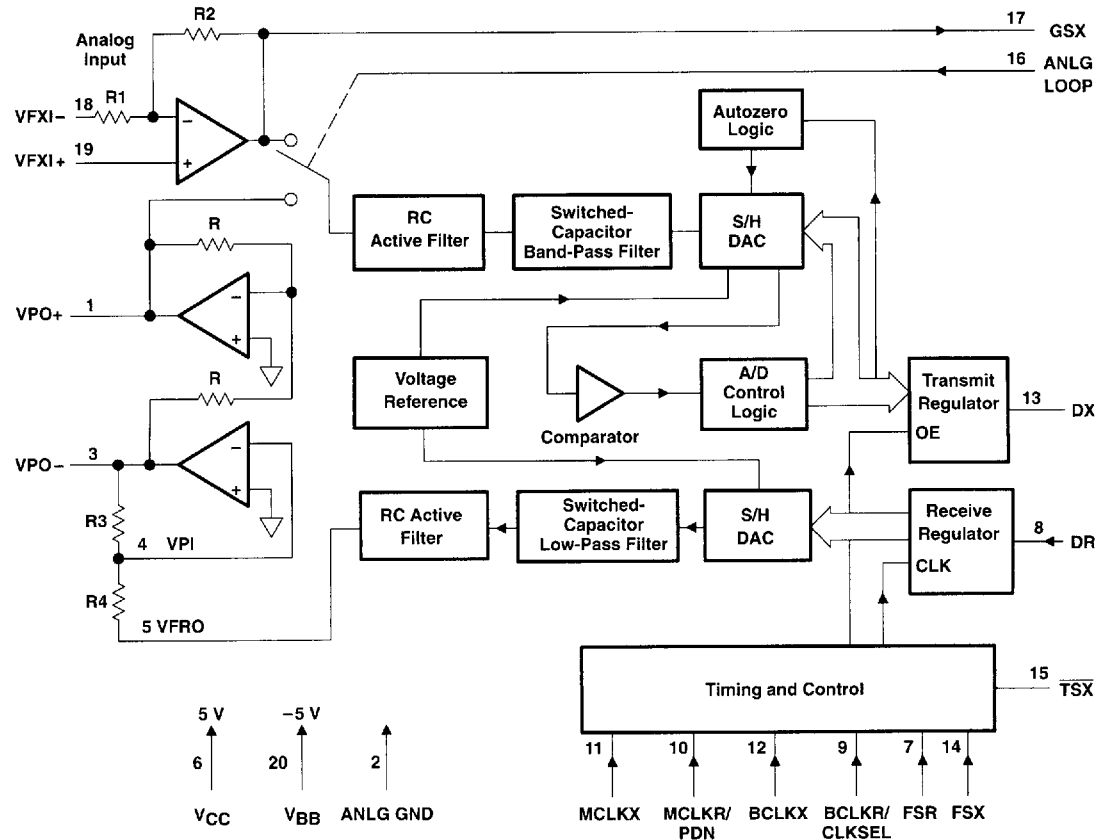
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TP3064B, TP3067B, TP13064B, TP13067B
MONOLITHIC SERIAL INTERFACE
COMBINED PCM CODEC AND FILTER

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The TP3064B and TP3067B are characterized for operation from 0°C to 70°C. The TP13064B and TP13067B are characterized for operation from -40°C to 85°C.

functional block diagram



TP3064B, TP3067B, TP13064B, TP13067B
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Terminal Functions

| TERMINAL NAME | NO. | DESCRIPTION |
|------------------|-----|---|
| ANLG GND | 2 | Analog ground. All signals are referenced to ANLG GND. |
| ANLG LOOP | 16 | Analog loopback control input. Must be set to logic low for normal operation. When pulled to logic high, the transmit filter input is disconnected from the output of the transmit preamplifier and connected to the VPO+ output of the receive power amplifier. |
| BCLKR/CLKSEL | 9 | The bit clock that shifts data into DR after the FSR leading edge. May vary from 64 kHz to 2.048 MHz. Alternately, can be a logic input that selects either 1.536 MHz/1.544 MHz or 2.048 MHz for master clock in synchronous mode. BCLKX is used for both transmit and receive directions (see Table 1). |
| BCLKX | 12 | The bit clock that shifts out the PCM data on DX. May vary from 64 kHz to 2.048 MHz, but must be synchronous with MCLKX |
| DR | 8 | Receive data input. PCM data is shifted into DR following the FSR leading edge. |
| DX | 13 | The 3-state PCM data output that is enabled by FSX |
| FSR | 7 | Receive frame-sync pulse input that enables BCLKR to shift PCM data in DR. FSR is an 8-kHz pulse train (see Figures 1 and 2 for timing details). |
| FSX | 14 | Transmit frame-sync pulse that enables BCLKX to shift out the PCM data on DX. FSX is an 8-kHz pulse train (see Figures 1 and 2 for timing details). |
| GSX | 17 | Analog output of the transmit input amplifier. GSX is used to externally set gain. |
| MCLKR/PDN | 10 | Receive master clock (must be 1.536 MHz, 1.544 MHz, or 2.048 MHz). May be synchronous with MCLKX, but should be synchronous for best performance. When MCLKR is connected continuously low, MCLKX is selected for all internal timing. When MCLKR is connected continuously high, the device is powered down. |
| MCLKX | 11 | Transmit master clock (must be 1.536 MHz, 1.544 MHz, or 2.048 MHz). May be asynchronous with MCLKR |
| TSX | 15 | Open-drain output that pulses low during the encoder time slot |
| V _{BB} | 20 | Negative power supply. V _{BB} = -5 V ± 5% |
| V _{CC} | 6 | Positive power supply. V _{CC} = 5 V ± 5% |
| VFRO | 5 | Analog output of the receive filter |
| VFXI+ | 19 | Noninverting input of the transmit input amplifier |
| VFXI- | 18 | Inverting input of the transmit input amplifier |
| VPI | 4 | Inverting input to the receive power amplifier. Also powers down both amplifiers when connected to V _{BB} . |
| VPO+ | 1 | The noninverted output of the receive power amplifier |
| VPO- | 3 | The inverted output of the receive power amplifier |



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absolute maximum ratings over operating free-air temperature range (unless otherwise noted)†

| | |
|---|--------------------------------------|
| Supply voltage, V_{CC} (see Note 1) | 7 V |
| Supply voltage, V_{BB} (see Note 1) | -7 V |
| Voltage range at any analog input or output | $V_{CC} + 0.3$ V to $V_{BB} - 0.3$ V |
| Voltage range at any digital input or output | $V_{CC} + 0.3$ V to GND - 0.3 V |
| Continuous total dissipation | See Dissipation Rating Table |
| Operating free-air temperature range: TP3064B, TP3067B | 0°C to 70°C |
| TP13064B, TP13067B | -40°C to 85°C |
| Storage temperature range | -65°C to 150°C |
| Lead temperature 1,6 mm (1/16 inch) from case for 10 seconds: DW or N package | 260°C |

† Stresses beyond those listed under "absolute maximum ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under "recommended operating conditions" is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

NOTE 1: All voltages are with respect to GND.

DISSIPATION RATING TABLE

| PACKAGE | $T_A \leq 25^\circ\text{C}$ POWER RATING | DERATING FACTOR ABOVE $T_A = 25^\circ\text{C}$ | $T_A = 70^\circ\text{C}$ POWER RATING | $T_A = 85^\circ\text{C}$ POWER RATING |
|---------|---|---|--|--|
| DW | 1025 mW | 8.2 mW/°C | 656 mW | 533 mW |
| N | 1150 mW | 9.2 mW/°C | 736 mW | 598 mW |

recommended operating conditions (see Note 2)

| | MIN | NOM | MAX | UNIT |
|--|--------------------|-----|-------|------|
| Supply voltage, V_{CC} | 4.75 | 5 | 5.25 | V |
| Supply voltage, V_{BB} | -4.75 | -5 | -5.25 | V |
| High-level input voltage, V_{IH} | 2.2 | | | V |
| Low-level input voltage, V_{IL} | | | 0.6 | V |
| Common-mode input voltage range, V_{ICR}^\dagger | | | ±2.5 | V |
| Load resistance at GSX, R_L | 10 | | | kΩ |
| Load capacitance at GSX, C_L | | | 50 | pF |
| Operating free-air temperature, T_A | TP3064B, TP3067B | | 0 | 70 |
| | TP13064B, TP13067B | | -40 | 85 |
| | | | | °C |

† Measure with CMRR > 60 dB.

NOTE 2: To avoid possible damage to these CMOS devices and resulting reliability problems, the power-up procedure described in the device power-up sequence paragraphs later in this document should be followed.



TP3064B, TP3067B, TP13064B, TP13067B
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electrical characteristics over power supply variations and recommended free-air temperature range (unless otherwise noted)

supply current

| PARAMETER | | TEST CONDITIONS | TP306xB | | TP1306xB | | UNIT | |
|-----------------|-------------------------------------|-----------------|---------|------|----------|-----|------|------|
| | | | MIN | TYP† | MAX | MIN | | TYP† |
| I _{CC} | Supply current from V _{CC} | Power down | No load | 0.5 | 1 | 0.5 | 1.2 | mA |
| | | Active | | 6 | 10 | 6 | 11 | |
| I _{BB} | Supply current from V _{BB} | Power down | No load | 0.5 | 1 | 0.5 | 1.2 | mA |
| | | Active | | 6 | 10 | 6 | 11 | |

† All typical values are at V_{CC} = 5 V, V_{BB} = -5 V, and T_A = 25°C.

electrical characteristics at V_{CC} = 5 V ± 5%, V_{BB} = -5 V ± 5%, GND at 0 V, T_A = 25°C (unless otherwise noted)

digital interface

| PARAMETER | | TEST CONDITIONS | MIN | MAX | UNIT |
|-----------------|--|---|-------------------------------------|-----|------|
| V _{OH} | High-level output voltage | DX I _H = -3.2 mA | 2.4 | | V |
| V _{OL} | Low-level output voltage | DX | | 0.4 | V |
| | | TSX | I _L = 3.2 mA, Drain open | 0.4 | |
| I _{IH} | High-level input current | V _I = V _{IH} to V _{CC} | | ±10 | μA |
| I _{IL} | Low-level input current | All digital inputs V _I = GND to V _{IL} | | ±10 | μA |
| I _{OZ} | Output current in high-impedance state | DX V _O = GND to V _{CC} | | ±10 | μA |

analog interface with transmit amplifier input

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|------------------|---------------------------------|--|-----|------|------|------|
| I _I | Input current | VFXI+ or VFXI- V _I = -2.5 V to 2.5 V | | | ±200 | nA |
| r _i | Input resistance | VFXI+ or VFXI- V _I = -2.5 V to 2.5 V | 10 | | | MΩ |
| r _o | Output resistance | Closed loop, Unit gain | | 1 | 3 | Ω |
| | Output dynamic range | GSX R _L ≥ 10 kΩ | | | ±2.8 | V |
| A _V | Open-loop voltage amplification | VFXI+ to GSX | | 5000 | | |
| B _I | Unity-gain bandwidth | GSX | | 1 | 2 | MHz |
| V _{IO} | Input offset voltage | VFXI+ or VFXI- | | | ±20 | mV |
| CMRR | Common-mode rejection ratio | | | 60 | | dB |
| k _{SVR} | Supply-voltage rejection ratio | | | 60 | | dB |

† All typical values are at V_{CC} = 5 V, V_{BB} = -5 V, and T_A = 25°C.

analog interface with receive filter

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|--------------------------|-------------|-----------------|-----|------|------|------|
| Output resistance | VFRO | | | 1 | 3 | Ω |
| Load resistance | | VFRO = ±2.5 V | 600 | | | Ω |
| Load capacitance | VFRO to GND | | | | 500 | pF |
| Output dc offset voltage | VFRO to GND | | | | ±200 | mV |

† All typical values are at V_{CC} = 5 V, V_{BB} = -5 V, and T_A = 25°C.



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analog interface with power amplifiers

| PARAMETER | | TEST CONDITIONS | | MIN | TYP† | MAX | UNIT |
|-----------|--|-----------------------------|--------------------------------------|-----|------|------|------|
| I_i | Input current | VPI = -1 V to 1 V | | | | ±100 | nA |
| r_i | Input resistance | VPI = -1 V to 1 V | | 10 | | | MΩ |
| r_o | Output resistance | VPO+ or VPO- | Inverting unity gain | | 1 | | Ω |
| A_V | Voltage amplification | VPO- or VPO+ | VPO- = 1.77 Vrms, $R_L = 600 \Omega$ | | -1 | | |
| B_1 | Unity-gain bandwidth | VPO- | Open loop | | 400 | | kHz |
| V_{IO} | Input offset voltage | | | | | ±25 | mV |
| k_{SVR} | Supply-voltage rejection ratio of V_{CC} or V_{BB} | VPO- connected to VPI | 0 kHz to 4 kHz | 60 | | | dB |
| | | | 4 kHz to 50 kHz | 36 | | | |
| R_L | Load resistance | Connected from VPO+ to VPO- | | 600 | | | Ω |
| C_L | Load capacitance | | | | | 100 | pF |

† All typical values are at $V_{CC} = 5 \text{ V}$, $V_{BB} = -5 \text{ V}$, and $T_A = 25^\circ\text{C}$.



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timing requirements

| PARAMETER | | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|-----------------------|---|--|-----|-------------------------|-------|------|
| f _{clock(M)} | Frequency of master clock | MCLX and MCLKR Depends on the device used and BCLKX/CLKSEL | | 1.536 1.544 2.048 | | MHz |
| f _{clock(B)} | Frequency of bit clock, transmit | BCLKX | 64 | | 2.048 | MHz |
| t _{r1} | Rise time of master clock | MCLKX and MCLKR Measured from 20% to 80% | | | 50 | ns |
| t _{f1} | Fall time of master clock | MCLKX and MCLKR Measured from 20% to 80% | | | 50 | ns |
| t _{r2} | Rise time of bit clock, transmit | BCLKX Measured from 20% to 80% | | | 50 | ns |
| t _{f2} | Fall time of bit clock, transmit | BCLKX Measured from 20% to 80% | | | 50 | ns |
| t _{w1} | Pulse duration, MCLKX and MCLKR high | | 160 | | | ns |
| t _{w2} | Pulse duration, MCLKX and MCLKR low | | 160 | | | ns |
| t _{su1} | Setup time, BCLKX high (and FSX in long-frame sync mode) before MCLKX↓ | First bit clock after the leading edge of FSX | 100 | | | ns |
| t _{w3} | Pulse duration, BCLKX and BCLKR high | V _{IH} = 2.2 V | 160 | | | ns |
| t _{w4} | Pulse duration, BCLKX and BCLKR low | V _{IL} = 0.6 V | 160 | | | ns |
| t _{h1} | Hold time, frame sync low after bit clock low (long frame only) | | 0 | | | ns |
| t _{h2} | Hold time, BCLKX high after frame sync↑ (short frame only) | | 0 | | | ns |
| t _{su2} | Setup time, frame sync high before bit clock↓ (long frame only) | | 80 | | | ns |
| t _{d1} | Delay time, BCLKX high to data valid | Load = 150 pF plus 2 LSTTL loads‡ | 0 | | 140 | ns |
| t _{d2} | Delay time, BCLKX high to TSX low | Load = 150 pF plus 2 LSTTL loads‡ | | | 140 | ns |
| t _{d3} | Delay time, BCLKX (or 8 clock FSX in long frame only) low to data output disabled | | 50 | | 165 | ns |
| t _{d4} | Delay time, FSX or BCLKX high to data valid (long frame only) | C _L = 0 pF to 150 pF | 20 | | 165 | ns |
| t _{su3} | Setup time, DR valid before BCLKR↓ | | 50 | | | ns |
| t _{h3} | Hold time, DR valid after BCLKR or BCLKX↓ | | 50 | | | ns |
| t _{su4} | Setup time, FSR or FSX high before BCLKR or BCLKX↓ | Short-frame sync pulse (1- or 2-bit clock periods long) (see Note 3) | 50 | | | ns |
| t _{h4} | Hold time, FSX or FSR high after BCLKX or BCLKR↓ | Short-frame sync pulse (1- or 2-bit clock periods long) (see Note 3) | 100 | | | ns |
| t _{h5} | Hold time, frame sync high after bit clock↓ | Long-frame sync pulse (from 3- to 8-bit clock periods long) | 100 | | | ns |
| t _{w5} | Pulse duration of the frame sync pulse (low level) | 64 kbps operating mode | 160 | | | ns |

† All typical values are at V_{CC} = 5 V, V_{BB} = -5 V, and T_A = 25°C.

‡ Nominal input value for an LSTTL load is 18 kΩ.

NOTE 3: For short-frame sync timing, FSR and FSX must go high while their respective bit clocks are high.



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operating characteristics over operating free-air temperature range, $V_{CC} = 5 V \pm 5\%$,
 $V_{BB} = -5 V \pm 5\%$, GND at 0 V, $V_I = 1.2276 V$, $f = 1.02 \text{ kHz}$, transmit input amplifier connected for unity
gain, noninverting (unless otherwise noted)

filter gains and tracking errors

| PARAMETER | | TEST CONDITIONS‡ | MIN | TYP‡ | MAX | UNIT |
|---|-------------------|--|-------|-------|------------|------|
| Maximum peak transmit overload level | TP3064B, TP13064B | 3.17 dBm0 | | 2.501 | | V |
| | TP3067B, TP13067B | 3.14 dBm0 | | 2.492 | | |
| Transmit filter gain, absolute (at 0 dBm0) | | $T_A = 25^\circ\text{C}$ | -0.15 | | 0.15 | dB |
| Transmit filter gain, relative to absolute | | $f = 16 \text{ Hz}$ | | | -40 | dB |
| | | $f = 50 \text{ Hz}$ | | | -30 | |
| | | $f = 60 \text{ Hz}$ | | | -26 | |
| | | $f = 200 \text{ Hz}$ | -1.8 | | -0.1 | |
| | | $f = 300 \text{ Hz to } 3000 \text{ Hz}$ | -0.15 | | 0.15 | |
| | | $f = 3300 \text{ Hz}$ | -0.35 | | 0.05 | |
| | | $f = 3400 \text{ Hz}$ | -0.8 | | 0 | |
| | | $f = 4000 \text{ Hz}$ | | | -14 | |
| | | $f \geq 4600 \text{ Hz (measure response from } 0 \text{ Hz to } 4000 \text{ Hz)}$ | | | -32 | |
| Absolute transmit gain variation with temperature and supply voltage | | Relative to absolute transmit gain | -0.1 | | 0.1 | dB |
| Transmit gain tracking error with level | | Sinusoidal test method; Reference level = -10 dBm0 | | | | dB |
| | | $3 \text{ dBm0} \geq \text{input level} \geq -40 \text{ dBm0}$ | | | ± 0.2 | |
| | | $-40 \text{ dBm0} > \text{input level} \geq -50 \text{ dBm0}$ | | | ± 0.4 | |
| | | $-50 \text{ dBm0} > \text{input level} \geq -55 \text{ dBm0}$ | | | ± 0.8 | |
| Receive filter gain, absolute (at 0 dBm0) | | Input is digital code sequence for 0 dBm0 signal, $T_A = 25^\circ\text{C}$ | -0.15 | | 0.15 | dB |
| Receive filter gain, relative to absolute | | $f = 0 \text{ Hz to } 3000 \text{ Hz}, T_A = 25^\circ\text{C}$ | -0.15 | | 0.15 | dB |
| | | $f = 3300 \text{ Hz}$ | -0.35 | | 0.05 | |
| | | $f = 3400 \text{ Hz}$ | -0.8 | | 0 | |
| | | $f = 4000 \text{ Hz}$ | | | -14 | |
| Absolute receive gain variation with temperature and supply voltage | | $T_A = \text{full range, See Note 4}$ | -0.1 | | 0.1 | dB |
| Receive gain tracking error with level | | Sinusoidal test method; reference input PCM code corresponds to an ideally encoded -10 dBm0 signal | | | | dB |
| | | $3 \text{ dBm0} \geq \text{input level} \geq -40 \text{ dBm0}$ | | | ± 0.2 | |
| | | $-40 \text{ dBm0} > \text{input level} \geq -50 \text{ dBm0}$ | | | ± 0.4 | |
| | | $-50 \text{ dBm0} > \text{input level} \geq -55 \text{ dBm0}$ | | | ± 0.8 | |
| Receive output drive voltage | | $R_L = 10 \text{ k}\Omega$ | | | ± 2.5 | V |
| Transmit and receive gain tracking error with level (A-law, CCITT C712) | | Pseudo-noise test method; reference input PCM code corresponds to an ideally encoded -10 dBm0 signal | | | | dB |
| | | $3 \text{ dBm0} \geq \text{input level} \geq -40 \text{ dBm0}$ | | | ± 0.25 | |
| | | $-40 \text{ dBm0} > \text{input level} \geq -50 \text{ dBm0}$ | | | ± 0.3 | |
| | | $-50 \text{ dBm0} > \text{input level} \geq -55 \text{ dBm0}$ | | | ± 0.45 | |

† All typical values are at $V_{CC} = 5 V$, $V_{BB} = -5 V$, and $T_A = 25^\circ\text{C}$.

‡ Absolute rms signal levels are defined as follows: $V_I = 1.2276 V = 0 \text{ dBm0} = 4 \text{ dBm}$ at $f = 1.02 \text{ kHz}$ with $R_L = 600 \Omega$.

NOTE 4: Full range for the TP3064B and TP3067B is 0°C to 70°C . Full range for the TP13064B and TP13067B is -40°C to 85°C .



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envelope delay distortion with frequency

| PARAMETER | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|--|------------------------|-----|------|-----|------|
| Transmit delay, absolute (at 0 dBm0) | f = 1600 Hz | | 290 | 315 | μs |
| Transmit filter gain, relative to absolute | f = 500 Hz to 600 Hz | | 195 | 220 | μs |
| | f = 600 Hz to 800 Hz | | 120 | 145 | |
| | f = 800 Hz to 1000 Hz | | 50 | 75 | |
| | f = 1000 Hz to 1600 Hz | | 20 | 40 | |
| | f = 1600 Hz to 2600 Hz | | 55 | 75 | |
| | f = 2600 Hz to 2800 Hz | | 80 | 105 | |
| | f = 2800 Hz to 3000 Hz | | 130 | 155 | |
| Receive delay, absolute (at 0 dBm0) | f = 1600 Hz | | 180 | 200 | μs |
| Receive delay, relative to absolute | f = 500 Hz to 1000 Hz | -40 | -25 | | μs |
| | f = 1000 Hz to 1600 Hz | -30 | -20 | | |
| | f = 1600 Hz to 2600 Hz | | 70 | 90 | |
| | f = 2600 Hz to 2800 Hz | | 100 | 125 | |
| | f = 2800 Hz to 3000 Hz | | 140 | 175 | |

† All typical values are at $V_{CC} = 5\text{ V}$, $V_{BB} = -5\text{ V}$, and $T_A = 25^\circ\text{C}$.

noise

| PARAMETER | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|--|---|-----|------|-----|--------|
| Transmit noise, C-message weighted‡ | TP3064B, TP13064B VFXI = 0 V | | 5 | 9 | dBrnC0 |
| Transmit noise, psophometric weighted (see Note 5) | TP3067B, TP13067B VFXI = 0 V | | -74 | -69 | dBm0p |
| Receive noise, C-message weighted | TP3064B, TP13064B PCM code equals alternating positive and negative zero | | 2 | 4 | dBrnC0 |
| Receive noise, psophometric weighted | TP3067B, TP13067B PCM code equals positive zero | | -86 | -83 | dBm0p |
| Noise, single frequency | VFXI+ = 0 V, f = 0 kHz to 100 kHz, Loop-around measurement | | | -53 | dBm0 |

† All typical values are at $V_{CC} = 5\text{ V}$, $V_{BB} = -5\text{ V}$, and $T_A = 25^\circ\text{C}$.

‡ This parameter is achieved through use of patented circuitry and is not recommended for applications in which the composite signals on the transmit side are below -55 dBm0.

NOTE 5: Measured by extrapolation from the distortion test result



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power supply rejection

| PARAMETER | TEST CONDITIONS | | MIN | MAX | UNIT |
|---|--|---------------------|------------|-----|------|
| Positive power-supply rejection, transmit | $V_{CC} = 5\text{ V} + 100\text{ mVrms}$, $V_{FXI+} = -50\text{ dBm0}$ | f = 0 Hz to 4 kHz | A-law | 38 | dB |
| | | | μ -law | 38 | |
| | | f = 4 kHz to 50 kHz | | 40 | dB |
| Negative power-supply rejection, transmit | $V_{BB} = -5\text{ V} + 100\text{ mVrms}$, $V_{FXI+} = -50\text{ dBm0}$ | f = 0 Hz to 4 kHz | A-law | 35 | dB |
| | | | μ -law | 35 | |
| | | f = 4 kHz to 50 kHz | | 40 | dB |
| Positive power-supply rejection, receive | PCM code equals positive zero, $V_{CC} = 5\text{ V} + 100\text{ mVrms}$ | f = 0 Hz to 4 kHz | A-law | 40 | dB |
| | | | μ -law | 40 | |
| | | f = 4 kHz to 50 kHz | | 40 | dB |
| Negative power-supply rejection, receive | PCM code equals positive zero, $V_{BB} = -5\text{ V} + 100\text{ mVrms}$ | f = 0 Hz to 4 kHz | A-law | 38 | dB |
| | | | μ -law | 38 | |
| | | f = 4 kHz to 50 kHz | | 40 | dB |
| Spurious out-of-band signals at the channel output (VFRO) | 0 dBm0, 300-Hz to 3400-Hz input applied to DR (measure individual image signals at VFRO) | | | -30 | dB |
| | f = 4600 Hz to 7600 Hz | | | -33 | |
| | f = 7600 Hz to 8400 Hz | | | -40 | |
| | f = 8400 Hz to 100 kHz | | | -40 | |

† The unit dBC applies to C-message weighting.

distortion

| PARAMETER | TEST CONDITIONS | MIN | MAX | UNIT | |
|--|---|----------|------|------|--|
| Signal-to-distortion ratio, transmit or receive half-channel† | Level = 3 dBm0 | | 33 | dBC† | |
| | Level = 0 dBm0 to -30 dBm0 | | 36 | | |
| | Level = -40 dBm0 | Transmit | 29 | | |
| | | Receive | 30 | | |
| | Level = -55 dBm0 | Transmit | 14 | | |
| Receive | | 15 | | | |
| Single-frequency distortion products, transmit | | | -46 | dB | |
| Single-frequency distortion products, receive | | | -46 | dB | |
| Intermodulation distortion | Loop-around measurement, $V_{FXI+} = -4\text{ dBm0}$ to -21 dBm0 , Two frequencies in the range of 300 Hz to 3400 Hz | | -41 | dB | |
| Signal-to-distortion ratio, transmit half-channel (A-law) (CCITT G.714)§ | Level = -3 dBm0 | | 33 | dB | |
| | Level = -6 dBm0 to -27 dBm0 | | 36 | | |
| | Level = -34 dBm0 | | 33.5 | | |
| | Level = -40 dBm0 | | 28.5 | | |
| | Level = -55 dBm0 | | 13.5 | | |
| Signal-to-distortion ratio, receive half-channel (A-law) (CCITT G.714)§ | Level = -3 dBm0 | | 33 | dB | |
| | Level = -6 dBm0 to -27 dBm0 | | 36 | | |
| | Level = -34 dBm0 | | 34.2 | | |
| | Level = -40 dBm0 | | 30 | | |
| | Level = -55 dBm0 | | 15 | | |

† The unit dBC applies to C-message weighting.

‡ Sinusoidal test method (see Note 6).

§ Pseudo-noise test method

NOTE 6: The TP13064A and TP3064A are measured using a C-message filter. The TP13067A and TP3067A are measured using a psophometric weighted filter.



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TP3064B, TP3067B, TP13064B, TP13067B
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crosstalk

| PARAMETER | TEST CONDITIONS | MIN | TYP† | MAX | UNIT |
|---|--|-----|------|-----|------|
| Crosstalk, transmit to receive | f = 300 Hz to 3000 Hz, DR at steady PCM code | | -90 | -75 | dB |
| Crosstalk, receive to transmit (see Note 7) | VFXI = 0 V, f = 300 Hz to 3000 Hz | | -90 | -72 | dB |

† All typical values are at $V_{CC} = 5$ V, $V_{BB} = -5$ V, and $T_A = 25^\circ\text{C}$.

NOTE 7: Receive-to-transmit crosstalk is measured with a -50 dBm0 activation signal applied to VFXI+.

power amplifiers

| PARAMETER | TEST CONDITIONS | MIN | MAX | UNIT |
|--|--|-----|-----|------------------|
| Maximum 0 dBm0 rms level for better than ± 0.1 dB linearity over the range if -10 dBm0 to 3 dBm0 | Balanced load, R_L , connected between VPO+ and VPO- | | | V _{RMS} |
| | $R_L = 600 \Omega$ | | 3.3 | |
| | $R_L = 1200 \Omega$ | | 3.5 | |
| | $R_L = 30 \text{ k}\Omega$ | | 4 | |
| Signal/distortion | $R_L = 600 \Omega$ | | 50 | dB |



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PARAMETER MEASUREMENT INFORMATION

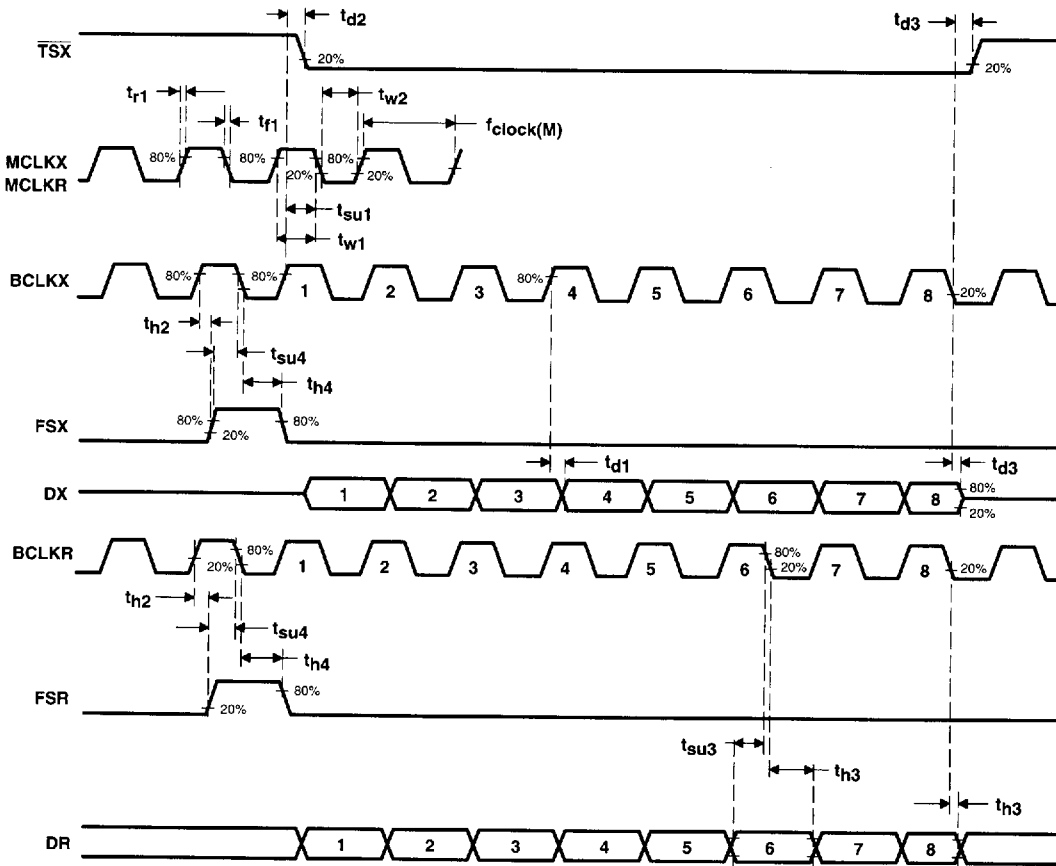


Figure 1. Short-Frame Sync Timing

PARAMETER MEASUREMENT INFORMATION

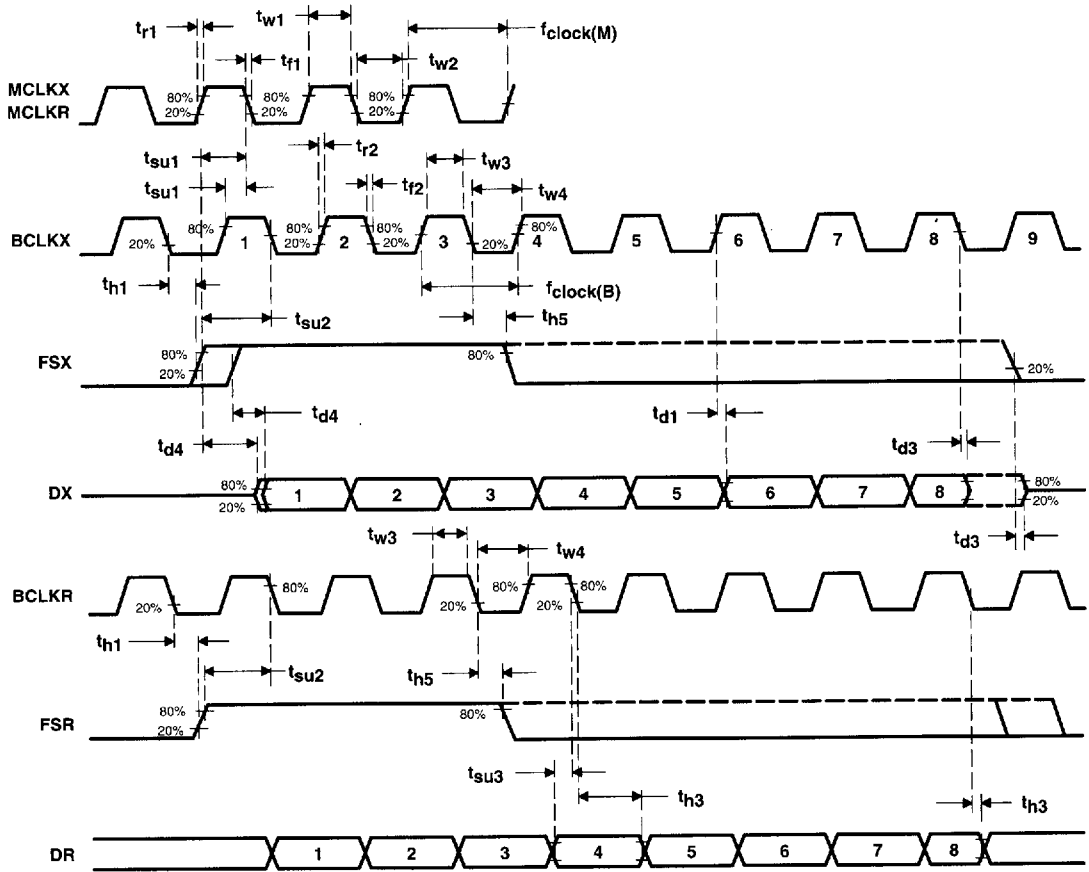


Figure 2. Long-Frame Sync Timing

TP3064B, TP3067B, TP13064B, TP13067B
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PRINCIPLES OF OPERATION

system reliability and design considerations

TP306xB, TP1306xB system reliability and design considerations are detailed in the following paragraphs.

latch-up

Latch-up is possible in all CMOS devices. It is caused by the firing of a parasitic SCR that is present due to the inherent nature of CMOS. When a latch-up occurs, the device draws excessive amounts of current and will continue to draw heavy current until power is removed. Latch-up can result in permanent damage to the device if supply current to the device is not limited.

Even though the TP306xB and TP1306xB devices are heavily protected against latch-up, it is still possible to cause latch-up under certain conditions in which excess current is forced into or out of one or more terminals. Latch-up can occur when the positive supply voltage drops momentarily below ground, when the negative supply voltage rises momentarily above ground, or possibly if a signal is applied to a terminal after power has been applied but before the ground is connected. This can happen if the device is hot-inserted into a card with the power applied, or if the device is mounted on a card with an edge connector, and the card is hot-inserted into a system with the power on.

To help ensure that latch-up does not occur, it is considered good design practice to connect a reversed biased Schottky diode (with a forward voltage drop of less than or equal to 0.4 V — 1N5711 or equivalent), between each power supply and GND (see Figure 3). If it is possible that a TP306xB- or TP1306xB-equipped card that has an edge connector could be hot-inserted into a powered-up system, it is also important to ensure that the ground edge connector traces are longer than the power and signal traces so that the card ground is always the first to make contact.

device power-up sequence

Latch-up can also occur if a signal source is connected without the device being properly grounded. A signal applied to one terminal could then find a ground through another signal terminal on the device. To ensure proper operation of the device and as a safeguard against this sort of latch-up, it is recommended the following power-up sequence always be used:

1. Ensure no signals are applied to the device before the power-up sequence is complete.
2. Connect GND.
3. Apply V_{BB} (most negative voltage).
4. Apply V_{CC} (most positive voltage).
5. Force a power down condition in the device.
6. Connect clocks.
7. Release power down condition.
8. Apply FSX and/or FXR synchronization pulses.
9. Apply signal inputs.

When powering down the device, this procedure should be followed in the reverse order.



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PRINCIPALS OF OPERATION

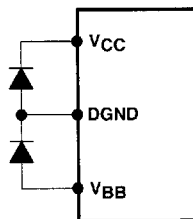


Figure 3. Diode Configuration for Latch-Up Protection Circuitry

internal sequencing

Power-on reset circuitry initializes the TP3064B, TP3067B, TP13064B, and TP13067B devices when power is first applied, placing it into the power-down mode. DX and VFRO outputs go into high-impedance states and all nonessential circuitry is disabled. A low level or clock applied to MCLKR/PDN powers up the device and activates all circuits. DX, a 3-state PCM data output, remains in the high-impedance state until the arrival of the second FSX pulse.

power supplies

All ground connections to each device should meet at a common point as close as possible to ANLG-GND. This minimizes the interaction of ground return currents flowing through a common bus impedance. V_{CC} and V_{BB} supplies should be decoupled by connecting 0.1- μF decoupling capacitors between each power rail and this common point. These bypass capacitors must be connected as close as possible to V_{CC} and V_{BB} .

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 through a ground bus. This common ground point should be decoupled to V_{CC} and V_{BB} with 10- μF capacitors.

synchronous operation

For synchronous operation, a clock is applied to MCLKX. MCLKR/PDN is used as a power-down control. A logic 0 applied to MCLKR powers-up the device and a high level powers it down. In either case, MCLKX is selected as the master clock for both receive and transmit direction. BCLKX must also have a bit clock applied to it. The selection of the proper internal divider for a master-clock frequency of 1.536 MHz, 1.544 MHz, or 2.048 MHz can be done using BCLKR/CLKSEL. The device automatically compensates for the 193rd clock pulse of each frame.

A fixed level on BCLKR/CLKSEL selects BCLKX as the bit clock for both the transmit and receive directions. Table 1 indicates the frequencies of operation that can be selected depending on the state of BCLKR/CLKSEL. In the synchronous mode, BCLKX may be in the range from 64 kHz to 2.048 MHz but must be synchronous with MCLKX.

The encoding cycle begins with each FSX pulse, and the PCM data from the previous cycle is shifted out of the enabled DX output on the rising edge of BCLKX. After eight-bit clock periods, the 3-state DX output is returned to the high-impedance state. With an FSR pulse, PCM data is latched via DR on the falling edge of BCLKX (or BCLKR, if running). FSX and FSR must be synchronous with MCLKX and MCLKR.

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asynchronous operation

For asynchronous operation, separate transmit and receive clocks can be applied. MCLKX and MCLKR must be 2.048 MHz for the TP3064B and TP13064B, 1.536 MHz or 1.544 MHz for the TP3067B and TP13067B and need not be synchronous. However, for best performance, MCLKR should be synchronous with MCLKX. This is easily achieved by applying only static logic levels to MCLKR/PDN. This connects MCLKX to all internal MCLKR functions. For 1.544-MHz operation, the device compensates for the 193rd clock pulse of each frame. Each encoding cycle is started with FSX, and FSX must be synchronous with MCLKX and BCLKX. Each decoding cycle is started with FSR, and FSR must be synchronous with BCLKR. The logic levels shown in Table 1 are not valid in the asynchronous mode. BCLKX and BCLKR can operate from 64 kHz to 2.048 MHz.

short-frame sync operation

The device can operate with either a short- or a long-frame sync pulse. On power up, the device automatically goes into the short-frame mode where both FSX and FSR must be one bit-clock period long, with timing relationships specified in Figure 1. With FSX high during a falling edge of BCLKX, the next rising edge of BCLKX enables the 3-state output buffer, DX, which outputs the sign bit. The remaining seven bits are clocked out on the following seven rising edges, and the next falling edge disables DX. With FSR high during a falling edge of BCLKR (BCLKX in synchronous mode), the next falling edge of BCLKR latches in the sign bit. The following seven falling edges latch in the seven remaining bits. The short-frame sync pulse may be utilized in either the synchronous or asynchronous mode.

Table 1. Selection of Master-Clock Frequencies

| BCLKR/CLKSEL | MASTER-CLOCK FREQUENCY SELECTED | |
|--|---------------------------------|------------------------|
| | TP3064B, TP13064B | TP3067B, TP13067B |
| Clock Input | 1.536 MHz or 1.544 MHz | 2.048 MHz |
| Logic Input L (sync mode only) | 2.048 MHz | 1.536 MHz or 1.544 MHz |
| Logic Input H (open) (sync mode only) | 1.536 MHz or 1.544 MHz | 2.048 MHz |

long-frame sync operation

Both FSX and FSR must be three or more bit-clock periods long to use the long-frame sync mode with timing relationships as shown in Figure 2. Using the transmit frame sync (FSX), the device detects whether a short- or long-frame sync pulse is being used. For 64-kHz operation, the frame-sync pulse must be kept low for a minimum of 160 ns. The rising edge of FSX or BCLKX, whichever occurs later, enables the DX 3-state output buffer. The first bit clocked out is the sign bit. The next seven rising edges of BCLKX edges clock out the remaining seven bits. The falling edge of BCLKX following the eighth rising edge or FSX going low, whichever occurs later, disables DX. A rising edge on FSR, the receive frame sync pulse, causes the PCM data at DR to be latched in on the next eight falling edges of BCLKR (BCLKX in synchronous mode). The long-frame sync pulse can be used in either the synchronous or asynchronous mode.



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PRINCIPALS OF OPERATION

transmit section

The transmit section input is an operational amplifier with provision for gain adjustment using two external resistors. Gains in excess of 20 dB across the audio pass band are possible via low noise and wide bandwidth. The operational amplifier drives a unity-gain filter consisting of an RC active prefilter followed by an eight-order switched-capacitor band-pass filter clocked at 256 kHz. The output of this filter directly drives the encoder sample-and-hold circuit. As per μ -law (TP3064B and TP13064B) or A-law (TP3067B and TP13067B) coding conventions, the ADC is a companding type. A precision voltage reference provides a input overload of nominally 2.5-V peak. The sampling of the filter output is controlled by the FSX frame-sync pulse. Then the successive-approximation encoding cycle begins. The 8-bit code is loaded into a buffer and shifted out through DX at the next FSX pulse. The total encoding delay is approximately 290 μ s. Any offset voltage due to the filters or comparator is cancelled by sign bit integration (see Table 2).

Table 2. Encoding Format at DX Output

| | TP3064B, TP13064B μ -LAW | TP3067B, TP13067B A-LAW (INCLUDES EVEN-BIT INVERSION) |
|----------------------|------------------------------------|---|
| $V_I = +$ Full scale | 1 0 0 0 0 0 0 0 | 1 0 1 0 1 0 1 0 |
| $V_I = 0$ | 1 1 1 1 1 1 1 1 0 1 1 1 1 1 1 1 | 1 1 0 1 0 1 0 1 0 1 0 1 0 1 0 1 |
| $V_I = -$ Full scale | 0 0 0 0 0 0 0 0 | 0 0 1 0 1 0 1 0 |

receive section

The receive section consists of an expanding DAC that drives a fifth-order low-pass filter clocked at 256 kHz. The decoder is μ -law (TP3064B and TP13064B) or A-law (TP3067B and TP13067B) and the fifth-order low-pass filter corrects for the $(\sin x)/x$ attenuation caused by the 8-kHz sample/hold. The filter is followed by a second-order RC active post-filter with its output at VFRO. The receive section is unity-gain but gain can be added by using the power amplifiers. At FSR, the data at DR is clocked in on the falling edge of the next eight BCLKR (BCLKX) periods. At the end of the decoder time slot, the decoding cycle begins and 10 μ s later the decoder DAC output is updated. The decoder delay is about 10 μ s (decoder update) plus 110 μ s (filter delay) plus 62.5 μ s (1/2 frame), or a total of approximately 180 μ s.

receive power amplifiers

Two inverting-mode power amplifiers are provided for directly driving a match-line interface transformer. The gain of the first power amplifier can be adjusted to boost the ± 2.5 -V peak output signal from the receive filter up to the ± 3.3 -V peak into an unbalanced 300- Ω load, or ± 4 V into an unbalanced 15-k Ω load. The second power amplifier is internally connected in unity-gain inverting mode to give 6-dB signal gain for balanced loads.

Maximum power transfer to a 600- Ω subscriber line termination is obtained by differentially driving a balanced transformer with $\sqrt{2}:1$ turns ratio, as shown in Figure 3. A total peak power of 15.6 dBm can be delivered to the load plus termination.

APPLICATION INFORMATION

power supplies

While the pins of the TP1306xB and TP306xB families 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 can 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 ANLG GND. This minimizes the interaction of ground return currents flowing through a common bus impedance. V_{CC} and V_{BB} supplies should be decoupled by connecting 0.1- μ F decoupling capacitors to this common point. These bypass capacitors must be connected as close as possible to V_{CC} and V_{BB} .

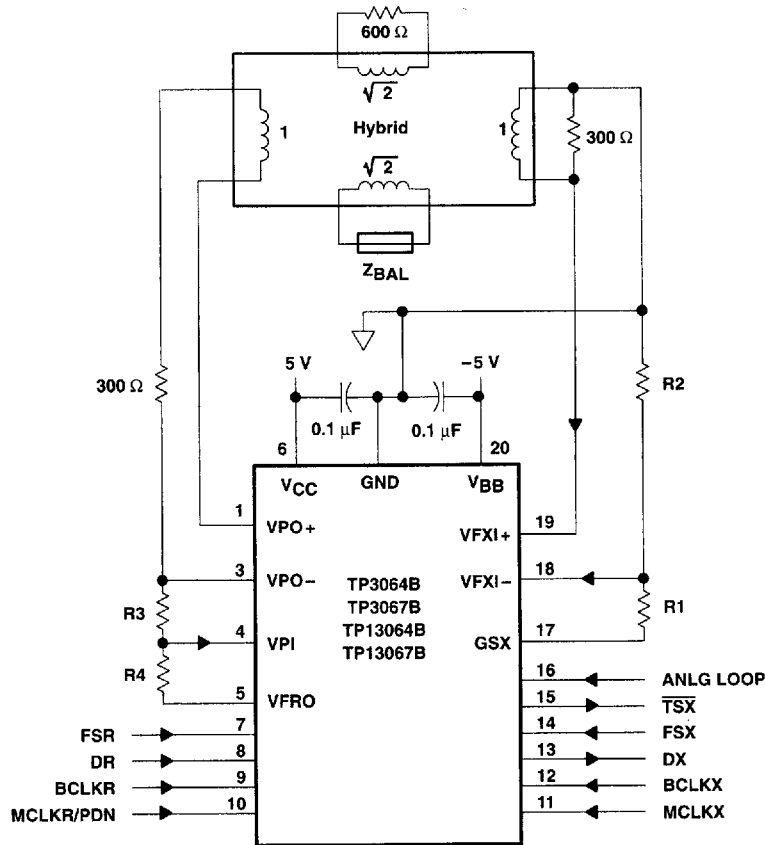
For best performance, the ground point of each codec/filter on a card should be connected to a common card ground in star formation rather than via a ground bus. This common ground point should be decoupled to V_{CC} and V_{BB} with 10- μ F capacitors.



TP3064B, TP3067B, TP13064B, TP13067B
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APPLICATION INFORMATION



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

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

Figure 4. Typical Synchronous Application

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