

## TP3210 SLIM™ Subscriber Line Interface Module

### General Description

The TP3210 is a complete electronic SLIC and PCM COMBO® CODEC/Filter module intended to interface the analog subscriber line to a PCM highway. It is designed to meet the requirements for U.S. central office and remote switching applications. When used in conjunction with a simple, non-critical, external protection network, two resistors and a ring relay, the TP3210 forms a complete line circuit, handling all the BORSCHT functions.

The TP3210 module consists of a line driver, a line receiver, a line impedance control circuit, a hybrid balance circuit, a line supervision circuit, a ring supervision circuit, three positive relay drivers, a TP3054  $\mu$ -Law COMBO CODEC/Filter and a serial control interface. Any changes in the status of the subscriber loop generate an interrupt, allowing the device to be used in either polled or interrupt driven applications.

### Features

- Complete COMBO CODEC/Filter and SLIC functions
- Exceeds LSSGR central office specifications
- In-band on-hook transmission capability
- Resistive loop feed with current limit
- Power denial mode
- Compatible with loop start and ground start signalling
- Automatic ring trip compatible with all U.S. ringing conditions
- Four selectable hybrid balance networks
- Three relay drivers
- Thermal overload protection
- Compatible with inexpensive protection networks
- Withstands 500V RTN to GND surge
- Compatible with standard PCM highway
- Small physical size and minimal external components

### Simplified Block Diagram

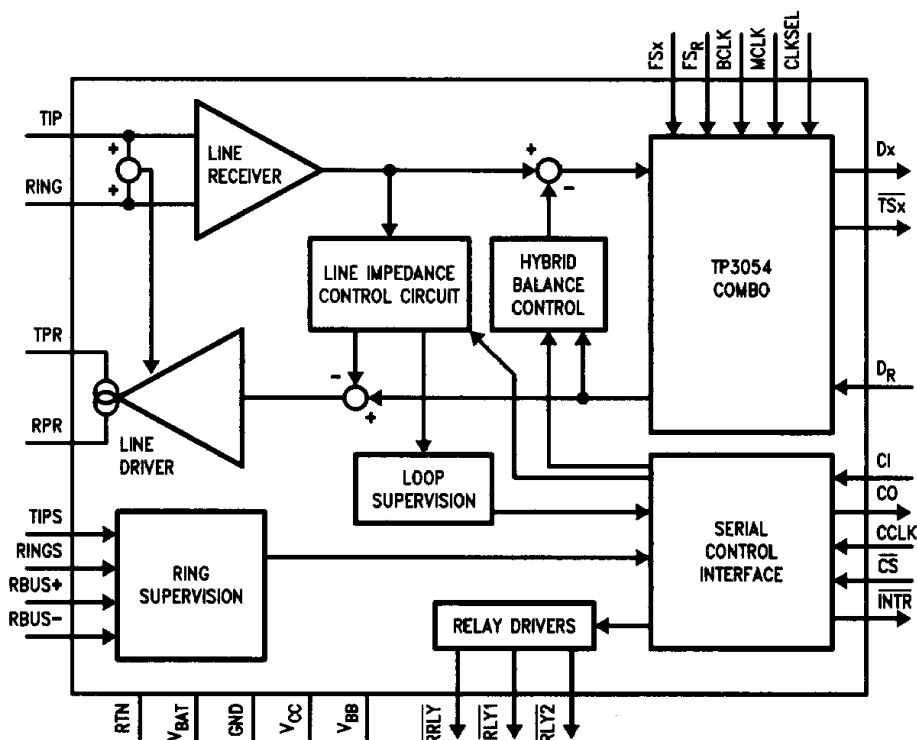
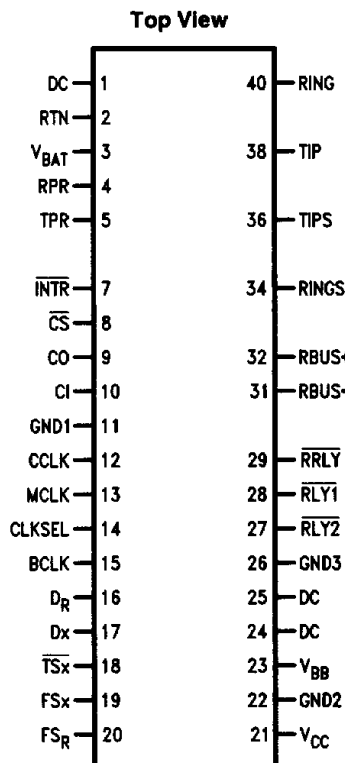


FIGURE 1. Simplified Block Diagram

TL/H/9422-1

## Connection Diagram



Order Number TP3210J  
NS Package Number HY40C

TL/H/9422-2

## Pin Descriptions

| Pin    | Description                                                                                                                                    |
|--------|------------------------------------------------------------------------------------------------------------------------------------------------|
| TIP    | Normally positive side of the subscriber line.                                                                                                 |
| RING   | Normally negative side of the subscriber line.                                                                                                 |
| TPR    | High voltage line driver output. Connects to TIP via an external protection network.                                                           |
| RPR    | High voltage line driver output. Connects to RING via an external protection network.                                                          |
| TIPS   | Positive ring sensing input. Connected to the positive side of the subscriber loop during ringing.                                             |
| RINGS  | Negative ring sensing input. Connected to the negative side of the subscriber loop during ringing.                                             |
| RBUS + | Positive ring bus sensing input. Connected to the positive side of the ring bus.                                                               |
| RBUS - | Negative ring bus sensing input. Connected to the negative side of the ring bus.                                                               |
| BCLK   | Bit Clock used to shift PCM information into D <sub>R</sub> and out of D <sub>x</sub> . May vary from 64 kHz to 2.048 MHz in 8 kHz increments. |
| MCLK   | Master Clock. Must be 1.536, 1.544 or 2.048 MHz.                                                                                               |
| CLKSEL | Master Clock Select Input. Must be connected high for 1.536 or 1.544 MHz operation. Must be connected low for 2.048 MHz operation.             |

| Pin                  | Description                                                                                                                                                                                                                                               |
|----------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| FS <sub>x</sub>      | Transmit frame synchronization pulse input which enables BCLK to shift the PCM information out of D <sub>x</sub> . FS <sub>x</sub> is an 8 kHz pulse train. See Figures 8 and 9 for timing details.                                                       |
| D <sub>x</sub>       | The TRI-STATE <sup>®</sup> PCM data output which is enabled by FS <sub>x</sub> .                                                                                                                                                                          |
| TS <sub>x</sub>      | Open drain output which pulses low during the period when the D <sub>x</sub> output is enabled.                                                                                                                                                           |
| FS <sub>R</sub>      | Receive frame synchronization pulse input which enables BCLK to shift the PCM information into D <sub>R</sub> . FS <sub>R</sub> is an 8 kHz pulse train. See Figures 8 and 9 for timing details.                                                          |
| D <sub>R</sub>       | Receive data input. PCM data is shifted into D <sub>R</sub> during the receive timeslot determined by FS <sub>R</sub> .                                                                                                                                   |
| CCLK                 | Control clock used to shift control data into CI and out of CO during CS low.                                                                                                                                                                             |
| CS                   | Chip select input. Must be low to enable the shifting of control data into CI and out of CO.                                                                                                                                                              |
| CI                   | The serial control data input used to set the operating state of the module.                                                                                                                                                                              |
| CO                   | The serial status output used to monitor the operating state of the module. CO is TRI-STATE when CS is high. See Figure 3 for timing diagram.                                                                                                             |
| INTR                 | Open drain interrupt output. A logic low indicates a change in the status of the subscriber loop, or a change in thermal shutdown.                                                                                                                        |
| V <sub>BB</sub>      | Negative power supply. V <sub>BB</sub> = 5V ± 5%. Decoupled by internal 0.047 μF to ground.                                                                                                                                                               |
| V <sub>CC</sub>      | Positive power supply. V <sub>CC</sub> = 5V ± 5%. Decoupled by internal 0.047 μF to ground.                                                                                                                                                               |
| RRLY                 | Ring Relay Driver. Controlled by State Control Data Word bit D4 (see Table I). It is automatically turned off when ring trip is detected.                                                                                                                 |
| RLY1                 | General purpose relay driver controlled by State Control Data Word bit D5.                                                                                                                                                                                |
| RLY2                 | General purpose relay driver controlled by State Control Data Word bit D6.                                                                                                                                                                                |
| GND1<br>GND2<br>GND3 | Low Voltage Ground. V <sub>BB</sub> , V <sub>CC</sub> and all digital signals are referenced to these pins. GND1, GND2 and GND3 should be externally connected together close to the module. Collectively referenced as GND in electrical specifications. |
| V <sub>BAT</sub>     | Negative high voltage supply. V <sub>BAT</sub> = -55V to -59V.                                                                                                                                                                                            |
| RTN                  | High voltage ground return. V <sub>BAT</sub> and all analog signals are referenced to this pin.                                                                                                                                                           |
| DC                   | Don't connect. Do not make external connections to these pins.                                                                                                                                                                                            |

## Functional Block Description

| Functional Block       | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Line Driver            | The Line Driver is a differential output transconductance amplifier which provides the d.c. power and balanced a.c. signals to the subscriber line. The d.c. power is determined by the d.c. Loop Impedance Control circuit. The a.c. signal applied to the line is controlled by the a.c. Loop Impedance Control and the analog signal generated by the TP3054 COMBO CODEC/Filter from the received PCM information. Feedback from the TIP and RING lines produces an effective longitudinal input impedance of about $150\Omega$ from TIP and RING to RTN ( $75\Omega$ total). In the presence of large longitudinal currents, each output of the Line Driver is capable of sourcing or sinking current to limit the longitudinal voltage. |
| Line Receiver          | The Line Receiver monitors the metallic (differential) voltage on the line in the presence of large longitudinal (common mode) voltages.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Loop Impedance Control | The Loop Impedance Control feeds back the line voltage to produce a resistive/inductive d.c. feed impedance for longer loops and a constant current d.c. feed for shorter loops while maintaining an a.c. 2-wire input impedance of $900\Omega + 2.16\mu F$ over the voice band, easily meeting the 2-wire return loss requirements.                                                                                                                                                                                                                                                                                                                                                                                                         |
| Hybrid Balance Control | The Hybrid Balance Control circuit consists of four software selectable networks, assuring that the 4-wire return loss requirements are met for a variety of conditions.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Loop Supervision       | The Loop Supervision circuit monitors the d.c. current flow in the subscriber loop under non-ringing state and detects on-hook, off-hook and replicates dial pulses.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Ring Supervision       | The Ring Supervision circuit monitors the d.c. current flow in the subscriber loop during the ringing state. This circuit is capable of detecting an off-hook condition in less than 200 ms in the presence of large a.c. ringing signals. It operates on loops with ringing superimposed on TIP or RING or with balanced ringing. It supports bridged ringers, ringers to ground on either TIP or RING and with superimposed ringers.                                                                                                                                                                                                                                                                                                       |
| Relay Drivers          | The three NPN relay drivers are capable of driving +5V or +12V relays directly. RRLY is dedicated to the ring relay and is automatically turned off when ring trip is detected by the Ring Supervision circuit. RLY1 and RLY2 are general purpose. Relay current will be returned to GND3 at pin 26.                                                                                                                                                                                                                                                                                                                                                                                                                                         |

| Functional Block  | Description                                                                                                                                                                                                                                                                           |
|-------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| COMBO             | The COMBO provides the PCM filtering, encoding and decoding functions necessary to interface the PCM highway to the analog signals on the subscriber loop. This function is identical to the industry standard TP3054 COMBO CODEC/Filter (see the TP3054 datasheet for full details). |
| Control Interface | The Control Interface circuit provides easy control and monitoring of the state of the TP3210 via a simple serial interface. Via this circuit the user can program the operating mode of the module, and monitor the line status (see Table I for details).                           |

## Functional Description

### Power-On

When power is first applied, the power-on reset circuitry initializes the TP3210 and places it in a standby mode. The State Control Data Word is cleared to "0". All unnecessary circuitry is powered down. The serial control interface and the loop supervision circuitry remain fully functional. The device is now ready for activation, either by the user programming it into the ring mode by writing into the State Control Data Word or by the subscriber going off-hook, powering-up the device automatically.

### The State Control Data Word

The State Control Data word is a single eight-bit word as shown in Table I. Bits D0–D7 of the control word program the operating state of the device. The module can override the control bits D2 and D3 to activate the power denial mode in order to protect itself from damage under a thermal overload condition.

### Status Word

The eight-bit Status Word indicates the status of the TP3210 at the instant a read operation is performed. Table IV shows the definitions of the status word. A logic high indicates that the state or function is enabled, a low indicates that it is disabled.

### The Control Interface

The Control Interface consists of a single eight-bit shift register and a buffer register. The shift register is written via the serial input CI, under the control of  $\overline{CS}$  and CCLK, to program the device's operating state. Several bits of the shift register may be altered by the device itself in response to changes in the subscriber loop status. These changes in state may be read via the serial output CO. The S2 and S3 status bits are over-written by the occurrence of a thermal overload, forcing the device into the Power-Denial mode. S7 is the hook-switch status bit. A logic "0" for S7 indicates an Off-Hook or Ring-Trip condition exists at the instant of access and a logic "1" indicates on-hook. Any changes in line status, or thermal shutdown condition will generate an interrupt at INTR output.

## Functional Description (Continued)

**TABLE I. State Control Data Word**

| Control Bit | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|-------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| D7          | Don't Care. This bit is overwritten by the line supervision circuitry.                                                                                                                                                                                                                                                                                                                                                                                                                     |
| D6          | A logic "1" turns on $\overline{\text{RLY2}}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| D5          | A logic "1" turns on $\overline{\text{RLY1}}$ .                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| D4          | A logic "1" enables Ring mode, turns on $\overline{\text{RLY}}$ and Ring Supervision circuit. Status Bit S7 indicates ring-trip. Logic "0" at D4 enables the normal non-ringing mode.                                                                                                                                                                                                                                                                                                      |
| D3          | Used with D2 to select Power Denial, Battery Reversal and On-Hook Transmission modes. See Table II. Under Power Denial mode, the Line Driver is disabled, denying power to the subscriber loop. It can be set or cleared by a write operation. Under a thermal overload condition, D2 is forced to "0" and D3 is forced to "1" in order to protect the device from damage. As long as the thermal overload condition exists, the Power Denial mode cannot be cleared by a write operation. |
| D2          | Used with D3 to select Power Denial, Battery Reversal and On-Hook Transmission modes. See Table II.                                                                                                                                                                                                                                                                                                                                                                                        |
| D1          | Used with D0 to select hybrid balance network. See Table III.                                                                                                                                                                                                                                                                                                                                                                                                                              |
| D0          | Used with D1 to select hybrid balance network. See Table III.                                                                                                                                                                                                                                                                                                                                                                                                                              |

**TABLE II. Operating Modes of TP3210**

| D4 | D3 | D2 | Mode                 |
|----|----|----|----------------------|
| 0  | 0  | 0  | Normal               |
| 0  | 0  | 1  | Reverse Battery      |
| 0  | 1  | 0  | Power Denial         |
| 0  | 1  | 1  | On-Hook Transmission |
| 1  | X  | X  | Ring                 |

**TABLE III. Hybrid Balance Test Networks**

| D1 | D0 | Reference Test Network                                  |
|----|----|---------------------------------------------------------|
| 0  | 0  | 900 $\Omega$                                            |
| 0  | 1  | 1650 $\Omega \parallel (100\Omega + 0.005 \mu\text{F})$ |
| 1  | 0  | 800 $\Omega \parallel (100\Omega + 0.05 \mu\text{F})$   |
| 1  | 1  | 900 $\Omega + 2.16 \mu\text{F}$                         |

There are several ways of accessing the serial control interface. They are:

- Write/Read
- Read/Write
- Quick Status Read

In the Write/Read operation, the objective is to change the state of the device. While shifting the new state control data into CI, the previous status information is shifted out of CO. This data should be compared with the previous status information to determine if a change had occurred since the last access.

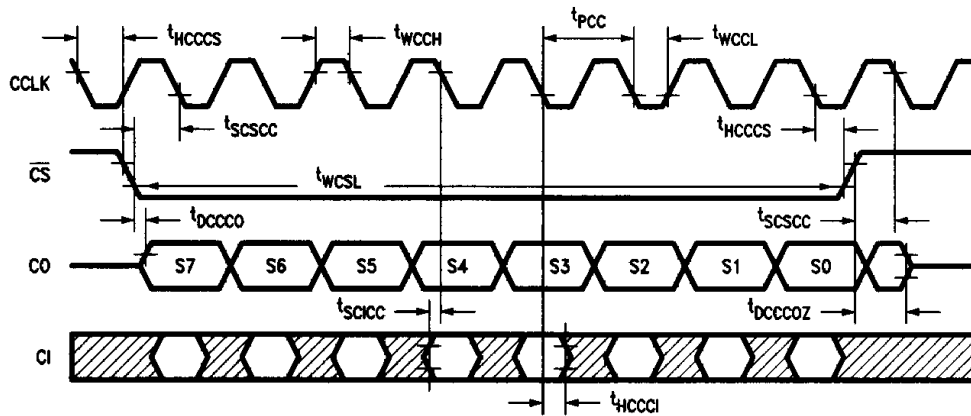
In the Read/Write operation, the objective is to monitor the state of the module. While the current status is shifted out at CO, the last known state of the device is shifted into CI externally. If a thermal overload condition has occurred since the last access, the device will automatically set itself to the power denial mode (S2 bit will be forced to "0" and S3 bit will be forced to "1") prior to the access and will be reset by writing the previous state. This has no detrimental effect, however, since the power-denial mode will immediately be set again and the device will remain in the Power-Denial mode as long as the thermal overload continues to exist. If ring trip has occurred or the hook switch status has changed since the last access, the S7 bit will also be altered by the device. The timing for the Write/Read or Read/Write modes is shown in *Figure 2*.

The Quick Status Read operation allows a fast read of the S7 status bit, which indicates if a Ring-Trip or Off-Hook condition exists. It does not cause the shift register to shift, thus no control data is required. *Figure 3* is the timing diagram for the Quick Status Read Mode.

# Functional Description (Continued)

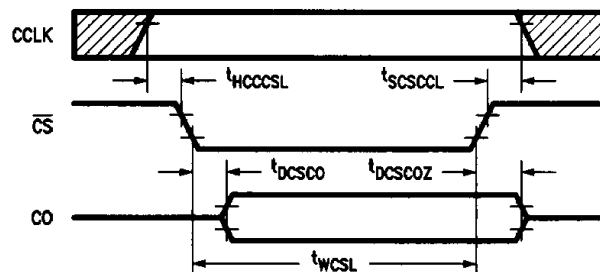
TABLE IV. Status Information Word

| Status Bit | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| S7         | Indicates switch hook status. S7 is a "1" if the subscriber is on-hook. If D4 is programmed to be "0" for normal mode, a logic "0" at S7 indicates off-hook. If the device is in the Ring mode (D4 = "1"), a logic "0" at S7 indicates ring-trip.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| S6         | A logic "1" indicates that $\overline{\text{RLY2}}$ is on.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| S5         | A logic "1" indicates that $\overline{\text{RLY1}}$ is on.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| S4         | A logic "1" indicates Ring mode is on. $\overline{\text{RRLY}}$ is turned on, and the Ring Supervision circuit is activated. A logic "0" at S7 indicates that a ring trip has occurred, forcing $\overline{\text{RRLY}}$ to be deactivated. D4 should be cleared to "0" by a write/read operation in order to program the device into the normal mode.                                                                                                                                                                                                                                                                                                                                                                                                             |
| S3         | S2 and S3 indicate Power-Denial, Battery Reversal and On-Hook Transmission modes. See Table II. When an overload condition exists which raises the junction temperature to exceed about 170°C, the TP3210 will automatically initialize a power denial mode (S2 forced to "0" and S3 forced to "1") to protect itself from damage. The device will not go back to the normal mode even if the thermal overload ceased to exist. The system can determine if the thermal overload condition has cleared itself by programming the TP3210 into the desired operating mode and read back status bits S2 and S3. If the overload still exists, the power denial mode will be activated again as long as the device's junction temperature exceeds approximately 170°C. |
| S2         | S2 and S3 indicate Power-Denial, Battery Reversal and On-Hook Transmission modes. See Table II.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| S1         | S0 and S1 indicate the selected hybrid balance test network. See Table III.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| S0         | S0 and S1 indicate the selected hybrid balance test network. See Table III.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |



TL/H/9422-3

FIGURE 2. Control Interface Timing—Write/Read or Read/Write Modes



TL/H/9422-4

FIGURE 3. Control Interface Timing—Quick Status Read Mode

## Functional Description (Continued)

### Battery Feed

The apparent battery voltage across the line is approximately  $0.86 \times V_{BAT}$ . With  $V_{BAT} = -56V$ , the TP3210 provides a nominal apparent battery voltage of  $-48V$  across TIP and RING. The module provides a resistive/inductive feed at longer loops. The d.c. current feed has been designed to guarantee 21 mA into a  $1900\Omega$  loop at nominal battery. At shorter loops, the d.c. feed is current-limited to nominally 43 mA in order to conserve power. At normal battery polarity ( $D2=0$  and  $D3=0$ ), TIP is more positive than RING. The current feed characteristic is shown in Figure 4.

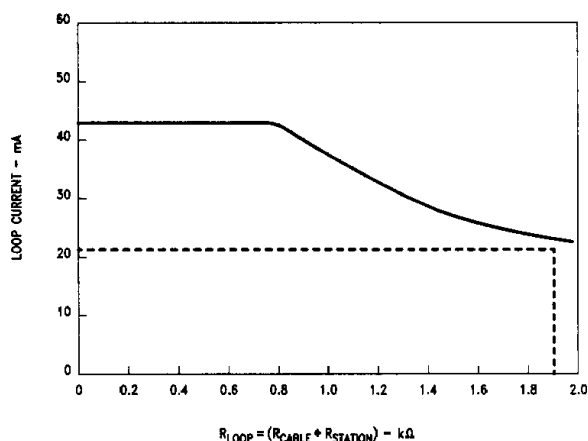


FIGURE 4. DC Feed Characteristics

### 2-Wire Impedance

The nominal 2-wire input impedance is  $900\Omega + 2.16 \mu F$ . This is shunted by a feed inductance which is nominally 26 Henries on long loops, and approaches infinity on short loops.

### Transmission Level

The 0 TLP is referenced at the PCM interface of the four wire ports. The TP3210 has 0.1 dB loss for both transmit and receive signals. On the 2-wire analog interface, the transmit is  $+0.1$  TLP and the receive is  $-0.1$  TLP. 0 TLP is defined as 0 dBm into  $900\Omega$ .

### Hybrid Balance

The Hybrid Balance Control circuit contains four selectable balance networks which are selected by programming State Control Word bits D0 and D1. The balance networks are intended to be used with the corresponding reference test networks for hybrid balance as shown in Table III.

### Longitudinal Balance and Longitudinal Current Capability

The 2-wire input of the device exhibits a longitudinal impedance of  $150\Omega$  from TIP to ground and from RING to ground. These impedances are extremely well matched and are not strongly dependent on impedance matching in the external protection network. The longitudinal voltage is sensed on the loop side of the protection network and fed back to the Line Driver, thus any component variations external to the device can be corrected by the feedback loop. The Line Driver is capable of handling  $20 mA_{RMS}$  of longitudinal current in each of the TIP and RING leads.

### Loop Supervision

The Loop Supervision circuit operates in the normal (non-ringing) state. At normal battery polarity, off-hook is indicated when loop current exceeds nominally 8.5 mA and on-hook indicated when the current falls below nominally 6.5 mA, providing a 2 mA hysteresis. The Loop Supervision has been designed to maintain the dial pulse make interval greater than 25 ms regardless of the distortion introduced by the loop characteristics. At reversed battery polarity, off-hook is detected when loop current exceeds nominally 12 mA and on-hook indicated when current falls below nominally 10 mA. A logic "1" at status bit S7 indicates on-hook, while a logic "0" indicates off-hook. For Ground Start Signalling, TIP is opened with an external relay. Off-hook is indicated when the current from RING to ground exceeds nominally 17 mA and on-hook when the current falls below nominally 13 mA.

A typical example of hook switch timing is illustrated in Figure 5. While in the standby mode, all unnecessary circuitry is powered down. When Loop Supervision detects off-hook, the module is powered up,  $\overline{INTR}$  goes low and status bit S7 is cleared (A). The  $\overline{INTR}$  remains active until  $\overline{CS}$  goes low and status is read, at which time the status of the switch hook is latched, clearing  $\overline{INTR}$  (B). When the Loop Supervision detects on-hook, all unnecessary circuitry is again powered down, status bit S7 is set and  $\overline{INTR}$  is again set low (C). When the status information is read, the present switch hook status is latched, clearing the interrupt, and  $\overline{INTR}$  goes high (D). In the case of either on-hook or off-hook, if the system fails to read the status before the switch hook reverts to its previous state, the interrupt will clear itself (E). If the device's control interface is being accessed when off-hook occurs, i.e.,  $\overline{CS}$  is low,  $\overline{INTR}$  is set low immediately (F) but S7 is cleared only after  $\overline{CS}$  returns high (G). On the next Read/Write access, S7 is latched.

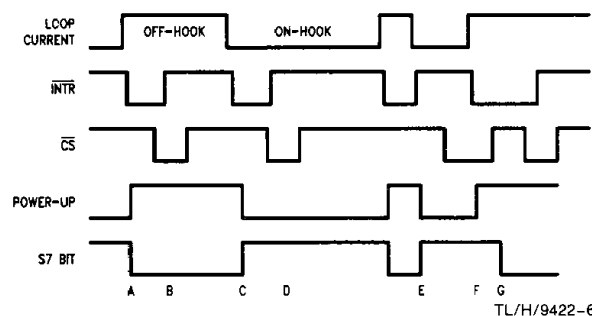


FIGURE 5. Typical Hook Switch Detect Timing

### Ring Supervision

The Ring Supervision circuit measures the loop current across two  $360\Omega$  ring sensing resistors with a  $1 M\Omega$  internal resistive bridge (see Figure 10). The voltage at the output of the bridge is filtered, then algebraically added and subtracted from a voltage corresponding to a loop current of about 11 mAdc. Each of the resulting voltages are integrated over one period of the ring frequency and compared to zero. If either of the resulting voltages is less than zero for two consecutive cycles, ring-trip is detected.  $\overline{RRLY}$  is de-activated, status bit S7 is cleared to "0" indicating ring trip, and an interrupt is also generated. Control bit D4 is not automatically reset to "0", it has to be cleared to "0" by a write/read operation after a ring trip is detected. If the MCLK is interrupted and stays continuously high or low for more than  $200 \mu s$ , the ring relay driver will be turned off.

## Functional Description (Continued)

The ring supervision circuit works with zero to five bridged ringers (1 ringer = 7 k $\Omega$  at 20 Hz), with ring frequencies from 16 Hz to 67 Hz, with ring voltages from 90 Vrms to 155 Vrms applied to either TIP or RING, superimposed on positive or negative battery voltages of from 42V to 56V on loops up to 1700 $\Omega$ . Furthermore, it operates with up to five ringers connected from TIP or RING to ground or with up to three superimposed ringers connected from TIP to ground and three from RING to ground with a battery voltage of  $\pm 38 \pm 2$ V. The ring sensing inputs at TIPS, RINGS, RBUS+ and RBUS- when connected as shown in Figure 10, will present an effective load of about 500 k $\Omega$  across the ring bus.

A typical example of ring trip timing is illustrated in Figure 6. When the Ring Supervision circuit detects a ring trip, the device immediately turns off  $\overline{\text{RRLY}}$ , clears S7 and sets  $\overline{\text{INTR}}$  low (A). The interrupt remains active until  $\overline{\text{CS}}$  goes low and the status is read, at which time the status of the switch hook is latched, clearing  $\overline{\text{INTR}}$  (B). Status bit S7 will remain a zero until the D4 bit is written to a zero, removing the device from the Ring mode (C). At this time, the S7 bit will indicate the switch hook status. Even though the station equipment is normally off-hook at this time, S7 will generally return to a "1" for several milliseconds (C) after D4 is cleared. This is because the Loop Supervision circuit was disconnected from the loop during ringing mode (D4 = 1), and it takes several milliseconds to detect the off-hook at which time S7 will be cleared and  $\overline{\text{INTR}}$  will be set low (D). At this point the device is in the normal (non-ringing) mode, all necessary circuitry is powered up.

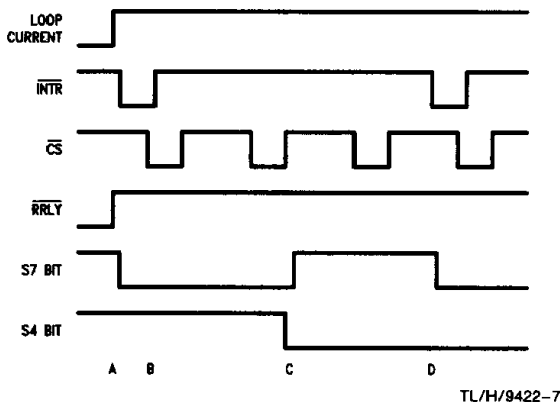


FIGURE 6. Typical Ring Trip Detect Timing

### Thermal Overload

The Line Driver incorporates a built-in thermal overload detection circuitry. In the event of a fault on the subscriber line which causes the Line Driver to reach an internal junction temperature of approximately 170°C, the Line Driver will protect itself by forcing the device into the power-denial mode (S2 is forced to "0" and S3 is forced to "1"). The device will remain in power-denial mode even though the thermal overload ceases to exist. After the line fault has been cleared, the device can be put back into service under system control (see Table IV).

A typical example of thermal overload detection timing is illustrated in Figure 7. When a thermal overload is detected, S2 is set low and S3 is set high (A), forcing the device into the Power-Denial mode, and  $\overline{\text{INTR}}$  is set low. The interrupt remains active until  $\overline{\text{CS}}$  goes low, clearing  $\overline{\text{INTR}}$  (B). As long as the thermal overload condition exists, the power denial mode cannot be reset by a write operation (B). When the thermal overload condition clears, the  $\overline{\text{INTR}}$  will again be set

low, but the device continues to remain at power denial mode (C). Thus the device does not automatically reapply power to the line since the fault that originally caused the failure may still exist and would simply cause the overload to reoccur. In this example, the Power-Denial mode is cleared by a control write to normal mode, clearing S2 and S3 to "0" (D). If the device is being accessed at the instant the thermal shutdown indication occurs,  $\overline{\text{INTR}}$  is set low immediately, but S2 will be set low and S3 will be set high only after  $\overline{\text{CS}}$  returns high (E).

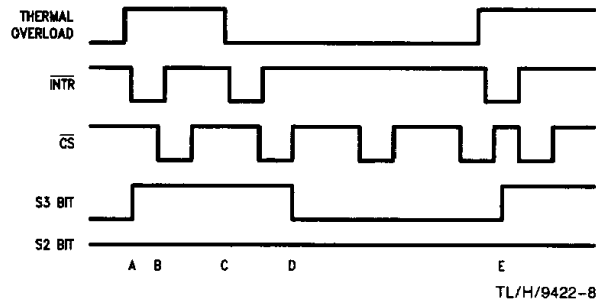


FIGURE 7. Typical Thermal Overload Detection Timing

### On-Hook Transmission Mode

The device is in the on-hook transmission mode when bit D3 and D2 of the State Control Data Word is set to the logic "1" and the loop is under "on-hook". In this mode, the line drivers operate in a reduced power state but all circuitry is active. This enables the system to communicate with a subscriber terminal or the subscriber in the central office to provide alarm and telemetry services. When the loop goes off-hook, the loop supervision circuitry behaves normally and causes the line drivers to power up. Bit S7 of the Status Information Word is cleared and an interrupt is initiated. This enables the system to terminate any transmissions and handle the call initiation in the normal manner.

### PCM Interface

The PCM interface consists of inputs MCLK, BCLK, FSx, FS $\overline{\text{R}}$  and D $\overline{\text{R}}$ , and outputs Dx and TSx. MCLK controls the internal operation of the COMBO Codec/Filter's encoder and decoder, and must be 1.536 MHz or 1.544 MHz if CLKSEL is connected high and 2.048 MHz if CLKSEL is connected low. BCLK shifts the PCM data out of Dx on its rising edge and latches the PCM data into D $\overline{\text{R}}$  on its falling edge. It must be synchronous with MCLK and may be any integer multiple of 8 kHz from 64 kHz to 2.048 MHz. FSx and FS $\overline{\text{R}}$  are 8 kHz pulse waveforms which determine the beginning of the PCM data transfer out of Dx and into D $\overline{\text{R}}$  respectively. Both must be synchronous with MCLK but may have any phase relationship with each other. TSx is an open drain output which pulses low for the duration of the data transfer out of Dx. It is intended to be wire-ORed with the TSx outputs of other subscriber line interface modules to provide an enable signal for external TRI-STATE drivers buffering the PCM transmit data from a line card onto the backplane.

### Short Frame Sync Operation

The TP3210 Subscribe Line Interface Module can utilize either a short frame sync pulse or a long frame sync pulse. Upon power initialization, the device assumes a short frame mode. In this mode, the frame sync pulses applied to both FSx and FS $\overline{\text{R}}$  must be one BCLK period long and with timing relationships as specified in Figure 8. With FSx high during a

## Functional Description (Continued)

falling edge of BCLK, the next rising edge of BCLK enables the Dx TRI-STATE output buffer, which will output the PCM sign bit. The following seven rising edges of the bit clock shifts out the remaining seven bits of PCM data, MSB first. The next falling edge disables the Dx output. With  $FS_R$  high during a falling edge of BCLK, the next falling edge latches the PCM sign bit into  $D_R$ . The next seven falling edges latch the remaining seven bits, MSB first.

### Long Frame Sync Operation

To use the long frame sync mode, the frame sync pulses applied to both  $FS_x$  and  $FS_R$  must be three or more bit periods long, with timing relationships as specified in Figure 9.

Based on the transmit frame sync pulse, the device 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, whichever comes later, and the first bit clocked out is the PCM sign bit. The following seven rising edges of BCLK shift out the remaining seven bits, MSB first. The  $D_x$  output is disabled by the falling edge of BCLK following the eighth rising edge or by  $FS_x$  going low, whichever comes later. A rising edge of the receive frame sync will cause PCM data at  $D_R$  to be latched in on the next eight falling edges of BCLK.

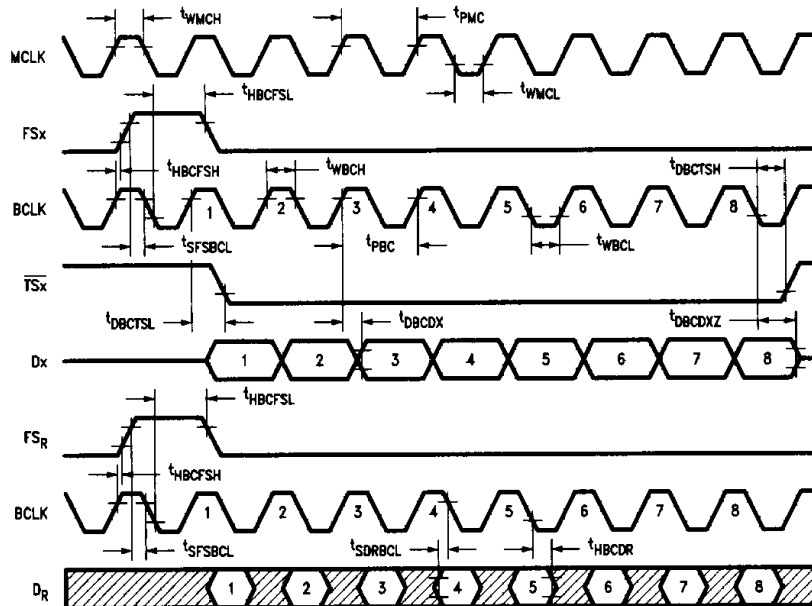


FIGURE 8. Timing Diagram for Short Frame Mode

TL/H/9422-9

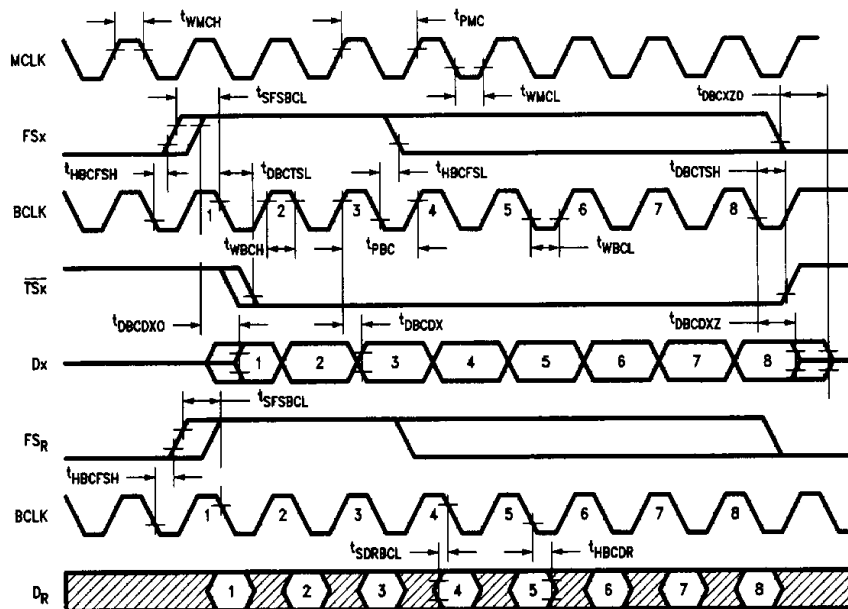


FIGURE 9. Timing Diagram for Long Frame Mode

TL/H/9422-10

## 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 GND                        | −0.5V to +7V                       |
| $V_{BB}$ to GND                        | +0.5V to −7V                       |
| $V_{BAT}$ to RTN                       | +0.5V to −70V                      |
| RTN to GND                             | ±500V, 10 $\mu$ s/50 $\mu$ s Pulse |
| Voltage at Any Digital Input or Output | $V_{CC} + 0.3V$ to GND − 0.3V      |

|                                      |                               |
|--------------------------------------|-------------------------------|
| TPR, RPR to RTN                      | +2V to −85V (50 ms)           |
| TIP, RING, TIPS, RINGS               | ±1000V,                       |
| RBUS+, RBUS− to RTN                  | 10 $\mu$ s/1000 $\mu$ s Pulse |
| Operating Temperature Range          | −25°C to +125°C               |
| Storage Temperature Range            | −65°C to +150°C               |
| Lead Temperature (Soldering, 10 Sec) | 300°C                         |
| Maximum Junction Temperature         | 150°C                         |

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN.

| Symbol                                                           | Parameter                                              | Conditions                                                                      | Min                  | Typ  | Max                      | Units   |
|------------------------------------------------------------------|--------------------------------------------------------|---------------------------------------------------------------------------------|----------------------|------|--------------------------|---------|
| <b>POWER DISSIPATION</b> (Normal Mode: D2=0, D3=0)               |                                                        |                                                                                 |                      |      |                          |         |
| $I_{BAT0}$                                                       | $V_{BAT}$ Idle Current                                 | $I_{Loop} = 0$ mA, $V_{BAT} = -57V$                                             |                      | 2.1  | <b>3.2</b>               | mA      |
| $I_{BB0}$                                                        | $V_{BB}$ Idle Current                                  | $I_{Loop} = 0$ mA                                                               |                      | 1.9  | <b>3.5</b>               | mA      |
| $I_{CC0}$                                                        | $V_{CC}$ Idle Current                                  | $I_{Loop} = 0$ mA                                                               |                      | 2.9  | <b>4.5</b>               | mA      |
| $I_{BAT1}$                                                       | $V_{BAT}$ Active Current                               | $I_{Loop} = 20$ mA, $V_{BAT} = -57V$                                            |                      | 23   | <b>25</b>                | mA      |
| $I_{BB1}$                                                        | $V_{BB}$ Active Current                                | $I_{Loop} = 20$ mA                                                              |                      | 8.9  | <b>15.2</b>              | mA      |
| $I_{CC1}$                                                        | $V_{CC}$ Active Current                                | $I_{Loop} = 20$ mA                                                              |                      | 11.8 | <b>15.2</b>              | mA      |
| <b>POWER DISSIPATION</b> (On-Hook Transmission Mode: D2=1, D3=1) |                                                        |                                                                                 |                      |      |                          |         |
| $I_{BAT0H}$                                                      | $V_{BAT}$ Idle Current                                 | $I_{Loop} = 0$ mA, $V_{BAT} = -57V$                                             |                      | 2.1  | <b>3.2</b>               | mA      |
| $I_{BB0H}$                                                       | $V_{BB}$ Idle Current                                  | $I_{Loop} = 0$ mA                                                               |                      | 8.9  | <b>15.2</b>              | mA      |
| $I_{CC0H}$                                                       | $V_{CC}$ Idle Current                                  | $I_{Loop} = 0$ mA                                                               |                      | 11.8 | <b>15.2</b>              | mA      |
| <b>DIGITAL INTERFACE</b> (Note 1)                                |                                                        |                                                                                 |                      |      |                          |         |
| $V_{IL}$                                                         | Input Low Level                                        |                                                                                 |                      |      | <b>0.7</b>               | V       |
| $V_{IH}$                                                         | Input High Level                                       | All Digital Inputs except CLKSEL<br>CLKSEL                                      | <b>2</b><br><b>4</b> |      |                          | V<br>V  |
| $V_{OL}$                                                         | Output Low Level                                       | Dx, $\overline{TSx}$ , CO, $I_L = 3.2$ mA<br>$\overline{INTR}$ , $I_L = 2.0$ mA |                      |      | <b>0.4</b><br><b>0.4</b> | V<br>V  |
| $V_{OH}$                                                         | Output High Level                                      | Dx, CO, $I_H = -3.2$ mA                                                         | <b>2.4</b>           |      |                          | V       |
| $I_{IL}$                                                         | Input Low Current                                      | $GND < V_{IN} < V_{IL}$ ,<br>All Digital Inputs                                 | − <b>100</b>         |      | <b>100</b>               | $\mu$ A |
| $I_{IH}$                                                         | Input High Current                                     | $V_{IH} < V_{IN} < V_{CC}$ ,<br>All Digital Inputs                              | − <b>100</b>         |      | <b>100</b>               | $\mu$ A |
| $I_{OH}$                                                         | Output High Current                                    | $\overline{TSx}$ and $\overline{INTR}$ ,<br>$V_{OH} < V_{OUT} < V_{CC}$         | − <b>100</b>         |      | <b>100</b>               | $\mu$ A |
| $I_{OZ}$                                                         | Output Current in the High Impedance State (TRI-STATE) | CO, Dx                                                                          | − <b>100</b>         |      | <b>100</b>               | $\mu$ A |

**Note 1:** See Appendix I for the definition of digital interface parameters.

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                  | Parameter                                                         | Conditions                                                                                                                                                                                                                                                     | Min                                 | Typ   | Max                                 | Units          |
|-------------------------|-------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------|-------------------------------------|----------------|
| <b>BATTERY FEED</b>     |                                                                   |                                                                                                                                                                                                                                                                |                                     |       |                                     |                |
| $I_{Loop+}$             | Loop Current                                                      | $R_{Loop} = 1900\Omega$ , $V_{BAT} = -55V$<br>$R_{Loop} = 1300\Omega$ , $V_{BAT} = -57V$<br>$R_{Loop} = 200\Omega$ , $V_{BAT} = -59V$<br>$V_{BB} = -5V \pm 5\%$                                                                                                | <b>21</b><br><b>27</b><br><b>40</b> | 43    | <b>24</b><br><b>33</b><br><b>46</b> | mA<br>mA<br>mA |
| $I_{Loop-}$             | Reverse Loop Current                                              | $R_{Loop} = 1900\Omega$ , $V_{BAT} = -55V$<br>$R_{Loop} = 1300\Omega$ , $V_{BAT} = -57V$<br>$R_{Loop} = 200\Omega$ , $V_{BAT} = -59V$<br>$V_{BB} = -5V \pm 5\%$                                                                                                | <b>20</b><br><b>26</b><br><b>38</b> | 43    | <b>25</b><br><b>34</b><br><b>46</b> | mA<br>mA<br>mA |
| $I_{PD}$                | Power Denial Loop Current                                         | $R_{Loop} = 200\Omega$                                                                                                                                                                                                                                         |                                     | 0.1   | <b>2</b>                            | mA             |
| $V_{Loop}$              | Loop Voltage                                                      | $R_{Loop} = 10\text{ k}\Omega$                                                                                                                                                                                                                                 |                                     | -46.8 |                                     | V              |
| <b>LOOP SUPERVISION</b> |                                                                   |                                                                                                                                                                                                                                                                |                                     |       |                                     |                |
| Roffhk0                 | Loop Resistance to Produce an Off-Hook Indication at Loop Start   | Roffhk0 Connected from TIP to RING, $V_{BAT} = -55V$                                                                                                                                                                                                           |                                     |       | <b>2400</b>                         | $\Omega$       |
| Ronhk0                  | Loop Resistance to Produce an On-Hook Indication at Loop Start    | Ronhk0 Connected from TIP to RING, $V_{BAT} = -59V$                                                                                                                                                                                                            | <b>9</b>                            |       |                                     | k $\Omega$     |
| Roffhk1                 | Loop Resistance to Produce an Off-Hook Indication at Ground Start | Roffhk1 Connected from RING to RTN, TIP Open<br>$V_{BAT} = -55V$                                                                                                                                                                                               |                                     |       | <b>2450</b>                         | $\Omega$       |
| Ronhk1                  | Loop Resistance to Produce an On-Hook Indication at Ground Start  | Ronhk1 Connected from RING to RTN, TIP Open<br>$V_{BAT} = -59V$                                                                                                                                                                                                | <b>9</b>                            |       |                                     | k $\Omega$     |
| DPD                     | Dial Pulse Distortion                                             | $R_{Leak} = 10\text{ k}\Omega \parallel (5\text{ k}\Omega + 2.16\text{ }\mu F)$<br>$R_{Loop} = 200\Omega$ , 12 pps, Break = 64%<br>$R_{Loop} = 1900\Omega$ , 12 pps, Break = 64%<br>$\overline{CS}$ High,<br>Measure Width of Make Period at $\overline{INTR}$ | <b>25</b><br><b>25</b>              |       | <b>58</b><br><b>58</b>              | ms<br>ms       |
| <b>RING SUPERVISION</b> |                                                                   |                                                                                                                                                                                                                                                                |                                     |       |                                     |                |
| RNGTRP1                 | Ring Trip Detect, Normal Ringing                                  | $RBUS+ = 0V$ , $RBUS- = -48V$<br>$TIPS = -4.70V$ , $RINGS = -43.3V$ ,<br>Must Detect Ring-Trip within the Specified Time                                                                                                                                       | <b>50</b>                           |       | <b>180</b>                          | ms             |
| RNGTRP2                 | Ring Trip Detect, Reverse Ringing                                 | $RBUS+ = -48V$ , $RBUS- = 0V$ ,<br>$TIPS = -43.3V$ , $RINGS = -4.7V$ ,<br>Must Detect Ring-Trip within the Specified Time                                                                                                                                      | <b>50</b>                           |       | <b>180</b>                          | ms             |

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                                                                           | Parameter                            | Conditions                                                                                                                                                   | Min                                                           | Typ | Max        | Units                      |
|----------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|-----|------------|----------------------------|
| <b>RING SUPERVISION</b> (Continued)                                              |                                      |                                                                                                                                                              |                                                               |     |            |                            |
| RNGTRP3                                                                          | Ring Trip Non-Detect Normal Ringing  | RBUS+ = 0V, RBUS- = -48V, TIPS = -3.25V, RINGS = -44.75V, Must Not Detect Ring-Trip within the Specified Time (Note 2)                                       | <b>0</b>                                                      |     | <b>180</b> | ms                         |
| RNGTRP4                                                                          | Ring Trip Non-Detect Reverse Ringing | RBUS+ = -48V, RBUS- = 0V, TIPS = -44.75V, RINGS = -3.25V, Must Not Detect Ring-Trip within the Specified Time (Note 2)                                       | <b>0</b>                                                      |     | <b>180</b> | ms                         |
| RNGTRP5                                                                          | Ring Trip Detect, Normal Ringing     | TIPS, RBUS- = -4.7V, RINGS, RBUS+ = 17 Vrms, f = 20 Hz, Must Detect Ring-Trip within the Specified Time                                                      | <b>100</b>                                                    |     | <b>190</b> | ms                         |
| RNGTRP6                                                                          | Ring Trip Detect Reverse Ringing     | TIPS, RBUS- = 17 Vrms, RINGS, RBUS+ = -4.7V, f = 20 Hz, Must Detect Ring-Trip within the Specified Time                                                      | <b>100</b>                                                    |     | <b>190</b> | ms                         |
| RNGTRP7                                                                          | Ring Trip Non-Detect Normal Ringing  | TIPS, RBUS- = -3.25V, RINGS, RBUS+ = 17 Vrms, f = 20 Hz, Must Not Detect Ring-Trip within the Specified Time (Note 2)                                        | <b>0</b>                                                      |     | <b>190</b> | ms                         |
| RNGTRP8                                                                          | Ring Trip Non-Detect Reverse Ringing | TIPS, RBUS- = 17 Vrms, RINGS, RBUS+ = -3.25V, f = 20 Hz, Must not Detect Ring-Trip within the Specified Time (Note 2)                                        | <b>0</b>                                                      |     | <b>190</b> | ms                         |
| <b>HYBRID BALANCE</b> Unless otherwise specified, $I_{Loop} = 20$ mA, D2=0, D3=0 |                                      |                                                                                                                                                              |                                                               |     |            |                            |
| ECHO1                                                                            | 4-Wire Return Loss                   | $Z_{REF} = 900\Omega$ across Tip-Ring<br>D1 = 0, D0 = 0<br>f = 203.125 Hz<br>= 484.375 Hz<br>= 1015.625 Hz<br>= 2500 Hz<br>= 3406.25 Hz                      | <b>21</b><br><b>26</b><br><b>26</b><br><b>26</b><br><b>21</b> | 40  |            | dB<br>dB<br>dB<br>dB<br>dB |
| ECHO2                                                                            | 4-Wire Return Loss                   | $Z_{REF} = 1650\Omega \parallel (100\Omega + 0.005 \mu F)$<br>D1 = 0, D0 = 1<br>f = 203.125 Hz<br>= 484.375 Hz<br>= 1015.625 Hz<br>= 2500 Hz<br>= 3406.25 Hz | <b>21</b><br><b>26</b><br><b>26</b><br><b>26</b><br><b>21</b> | 40  |            | dB<br>dB<br>dB<br>dB<br>dB |
| ECHO3                                                                            | 4-Wire Return Loss                   | $Z_{REF} = 800\Omega \parallel (100\Omega + 0.05 \mu F)$<br>D1 = 1, D0 = 0<br>f = 203.125 Hz<br>= 484.375 Hz<br>= 1015.625 Hz<br>= 2500 Hz<br>= 3406.25 Hz   | <b>21</b><br><b>26</b><br><b>26</b><br><b>26</b><br><b>21</b> | 40  |            | dB<br>dB<br>dB<br>dB<br>dB |

**Note 2:** The intent of Ring Trip Non-Detect tests are to ensure that ring does not occur under the specified conditions even after an essentially infinite period of time. For practical purposes of cost effectively testing the SLIM Subscriber Line Interface Module, the wait time to determine that a false ring trip has not occurred has necessarily been limited to a value which has been determined through characterization to ensure that false ring trip never occurs.

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                                                                                                                                                        | Parameter                                           | Conditions                                                                                                                                                                               | Min                                                           | Typ   | Max         | Units                      |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|-------|-------------|----------------------------|
| <b>HYBRID BALANCE</b> (Continued)                                                                                                                             |                                                     |                                                                                                                                                                                          |                                                               |       |             |                            |
| ECHO4                                                                                                                                                         | 4-Wire Return Loss                                  | $Z_{REF} = 900\Omega + 2.16 \mu F$<br>$D1 = 1, D0 = 1$<br>$f = 203.125 \text{ Hz}$<br>$= 484.375 \text{ Hz}$<br>$= 1015.625 \text{ Hz}$<br>$= 2500 \text{ Hz}$<br>$= 3406.25 \text{ Hz}$ | <b>21</b><br><b>26</b><br><b>26</b><br><b>26</b><br><b>21</b> | 40    |             | dB<br>dB<br>dB<br>dB<br>dB |
| <b>TRANSMISSION</b> Unless Otherwise Noted, $Z_{REF} = 900\Omega + 2.16 \mu F$ , $f = 1015.625 \text{ Hz}$ , $I_{Loop} = 20 \text{ mA}$ , $D2 = 0$ , $D3 = 0$ |                                                     |                                                                                                                                                                                          |                                                               |       |             |                            |
| RTNLOSS                                                                                                                                                       | 2-Wire Return Loss                                  | $f = 203.125 \text{ Hz}$<br>$= 484.375 \text{ Hz}$<br>$= 1015.625 \text{ Hz}$<br>$= 2500 \text{ Hz}$<br>$= 3406.25 \text{ Hz}$                                                           | <b>21</b><br><b>27</b><br><b>27</b><br><b>27</b><br><b>27</b> | 40    |             | dB<br>dB<br>dB<br>dB<br>dB |
| 0 dBmO                                                                                                                                                        | The Absolute 2-Wire Reference Level                 | The Absolute Reference Level at at the 2-Wire Interface is Defined as 0 dBm into $900\Omega$ .                                                                                           |                                                               | 0.949 |             | Vrms                       |
| GRA                                                                                                                                                           | Absolute Receive Gain                               | $V_{CC} = 5V$ , $V_{BB} = -5V$ ,<br>$V_{BAT} = -56V$ , $f = 1015.625 \text{ Hz}$ ,<br>$T_A = +25^\circ C$ , Input = Digital Code for 0 dBm0 at $D_R$ , Measure Voltage across TIP-RING.  | <b>-0.35</b>                                                  | -0.1  | <b>0.15</b> | dB                         |
| GXA                                                                                                                                                           | Absolute Transmit Gain                              | $V_{CC} = 5V$ , $V_{BB} = -5V$<br>$V_{BAT} = -56V$ , $f = 1015.625 \text{ Hz}$ ,<br>$T_A = +25^\circ C$ , Input = 0 dBm0 at 2-Wire Port, Measure Digital Code at $D_x$ .                 | <b>-0.35</b>                                                  | -0.1  | <b>0.15</b> | dB                         |
| GRA0H                                                                                                                                                         | Absolute Receive Gain at On-Hook Transmission Mode  | $V_{CC} = 5V$ , $V_{BB} = -5V$<br>$V_{BAT} = -56V$ , $T_A = +25^\circ C$ ,<br>$Z_{REF} = 900\Omega + 2.16 \mu F$<br>$I_{Loop} = 0 \text{ mA}$ , $D2 = 1$ , $D3 = 1$                      | <b>-1.1</b>                                                   | -0.1  | <b>0.9</b>  | dB                         |
| GXA0H                                                                                                                                                         | Absolute Transmit Gain at On-Hook Transmission Mode | $V_{CC} = 5V$ , $V_{BB} = -5V$<br>$V_{BAT} = -56V$ , $T_A = +25^\circ C$ ,<br>$I_{Loop} = 0 \text{ mA}$ , $D2 = 1$ , $D3 = 1$                                                            | <b>-1.1</b>                                                   | -0.1  | <b>0.9</b>  | dB                         |
| GRAV                                                                                                                                                          | Absolute Receive Gain over Supply Range             | $V_{CC} = 5V \pm 5\%$ , $V_{BB} = -5V \pm 5\%$<br>$V_{BAT} = -55V$ to $-59V$ ,<br>$f = 1015.625 \text{ Hz}$                                                                              | <b>-0.4</b>                                                   | -0.1  | <b>0.2</b>  | dB                         |
| GXAV                                                                                                                                                          | Absolute Transmit Gain over Supply Range            | $V_{CC} = 5V \pm 5\%$ , $V_{BB} = -5V \pm 5\%$<br>$V_{BAT} = -55V$ to $-59V$ ,<br>$f = 1015.625 \text{ Hz}$                                                                              | <b>-0.4</b>                                                   | -0.1  | <b>0.2</b>  | dB                         |
| GRT                                                                                                                                                           | Receive Gain Variation over Temperature             | $V_{CC} = 5V$ , $V_{BB} = -5V$ ,<br>$V_{BAT} = -56V$ , $f = 1015.625 \text{ Hz}$<br>Reference to GRA                                                                                     | -0.1                                                          |       | 0.1         | dB                         |
| GXT                                                                                                                                                           | Transmit Gain Variation over Temperature            | $V_{CC} = 5V$ , $V_{BB} = -5V$ ,<br>$V_{BAT} = -56V$ , $f = 1015.625 \text{ Hz}$<br>Reference to GXA                                                                                     | -0.1                                                          |       | 0.1         | dB                         |

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                                                                                                                                                                    | Parameter                                  | Conditions                                           | Min          | Typ | Max         | Units |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------------------------------------------------|--------------|-----|-------------|-------|
| <b>TRANSMISSION</b> Unless Otherwise Noted, $Z_{REF} = 900\Omega + 2.16 \mu F$ , $f = 1015.625 \text{ Hz}$ , $I_{Loop} = 20 \text{ mA}$ , $D2 = 0$ , $D3 = 0$ (Continued) |                                            |                                                      |              |     |             |       |
| GRF                                                                                                                                                                       | Receive Frequency Response                 | Measure Relative to GRA,<br>$f = 203.125 \text{ Hz}$ | <b>-1.9</b>  |     | <b>0</b>    | dB    |
|                                                                                                                                                                           |                                            | $= 296.875 \text{ Hz}$                               | <b>-0.4</b>  |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 484.375 \text{ Hz}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 2015.625 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 2703.125 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 3015.625 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 3203.125 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 3390.625 \text{ Hz}$                              | <b>-1.2</b>  |     | <b>0</b>    | dB    |
|                                                                                                                                                                           |                                            | $= 3984.375 \text{ Hz}$                              |              |     | <b>-14</b>  | dB    |
|                                                                                                                                                                           |                                            |                                                      |              |     |             |       |
| SOS                                                                                                                                                                       | Spurious Out of Band Signals (Alias Tones) | Measure Relative to GRA,<br>$f = 4796.75 \text{ Hz}$ |              |     | <b>-30</b>  | dB    |
|                                                                                                                                                                           |                                            | $= 6703.125 \text{ Hz}$                              |              |     | <b>-30</b>  | dB    |
|                                                                                                                                                                           |                                            | $= 11390.625 \text{ Hz}$                             |              |     | <b>-30</b>  | dB    |
| GXF                                                                                                                                                                       | Transmit Frequency Response                | Measure Relative to GXA,<br>$f = 62.500 \text{ Hz}$  |              |     | <b>-21</b>  | dB    |
|                                                                                                                                                                           |                                            | $= 203.125 \text{ Hz}$                               | <b>-2.5</b>  |     | <b>0</b>    | dB    |
|                                                                                                                                                                           |                                            | $= 296.875 \text{ Hz}$                               | <b>-0.4</b>  |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 484.375 \text{ Hz}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 2015.625 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 2703.125 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 3015.625 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 3203.125 \text{ Hz}$                              | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= 3390.625 \text{ Hz}$                              | <b>-1.2</b>  |     | <b>0</b>    | dB    |
|                                                                                                                                                                           |                                            | $= 3984.375 \text{ Hz}$                              |              |     | <b>-14</b>  | dB    |
|                                                                                                                                                                           |                                            | $= 5046.875 \text{ Hz}$                              |              |     | <b>-32</b>  | dB    |
|                                                                                                                                                                           |                                            | $= 11890.625 \text{ Hz}$                             |              |     | <b>-32</b>  | dB    |
| GRL                                                                                                                                                                       | Receive Gain Variation with Signal Level   | Measure Relative to GRA<br>PCM Level                 |              |     |             |       |
|                                                                                                                                                                           |                                            | $= 3.1 \text{ dBmO}$                                 | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -2.3 \text{ dBmO}$                                | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -11.4 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -17.6 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -23.9 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -29.9 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -37.8 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -47.1 \text{ dBmO}$                               | <b>-0.45</b> |     | <b>0.45</b> | dB    |
|                                                                                                                                                                           |                                            | $= -55.7 \text{ dBmO}$                               | <b>-1.3</b>  |     | <b>1.3</b>  | dB    |
| GXL                                                                                                                                                                       | Transmit Gain Variation with Signal Level  | Measure Relative to GXA<br>PCM Level                 |              |     |             |       |
|                                                                                                                                                                           |                                            | $= 3.1 \text{ dBmO}$                                 | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -2.3 \text{ dBmO}$                                | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -11.4 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -17.6 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -23.9 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -29.9 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -37.8 \text{ dBmO}$                               | <b>-0.25</b> |     | <b>0.25</b> | dB    |
|                                                                                                                                                                           |                                            | $= -47.1 \text{ dBmO}$                               | <b>-0.45</b> |     | <b>0.45</b> | dB    |
|                                                                                                                                                                           |                                            | $= -55.7 \text{ dBmO}$                               | <b>-1.3</b>  |     | <b>1.3</b>  | dB    |

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                                                                                                                                                                | Parameter                           | Conditions                                                                              | Min       | Typ | Max | Units   |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-----------------------------------------------------------------------------------------|-----------|-----|-----|---------|
| <b>TRANSMISSION</b> Unless Otherwise Noted, $Z_{REF} = 900\Omega + 2.16 \mu F$ , $f = 1015.625 \text{ Hz}$ , $I_{Loop} = 20 \text{ mA}$ , $D2=0$ , $D3=0$ (Continued) |                                     |                                                                                         |           |     |     |         |
| STDR                                                                                                                                                                  | Receive Signal to Total Distortion  | Measure through C Message Filter<br>$f = 1015.625 \text{ Hz}$ , PCM Level<br>= 3.1 dBmO | <b>33</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = 0.0 dBmO                                                                              | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -2.3 dBmO                                                                             | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -11.4 dBmO                                                                            | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -17.6 dBmO                                                                            | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -23.9 dBmO                                                                            | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -29.9 dBmO                                                                            | <b>35</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -37.8 dBmO                                                                            | <b>31</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -40.0 dBmO                                                                            | <b>29</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -45.0 dBmO                                                                            | <b>25</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -47.1 dBmO                                                                            | <b>23</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -55.7 dBmO                                                                            | <b>14</b> |     |     | dBc     |
| STDx                                                                                                                                                                  | Transmit Signal to Total Distortion | Measure through C Message Filter<br>$f = 1015.625 \text{ Hz}$ , PCM Level<br>= 3.1 dBmO | <b>33</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = 0.0 dBmO                                                                              | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -2.3 dBmO                                                                             | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -11.4 dBmO                                                                            | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -17.6 dBmO                                                                            | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -23.9 dBmO                                                                            | <b>36</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -29.9 dBmO                                                                            | <b>35</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -37.8 dBmO                                                                            | <b>31</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -40.0 dBmO                                                                            | <b>29</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -45.0 dBmO                                                                            | <b>25</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -47.1 dBmO                                                                            | <b>22</b> |     |     | dBc     |
|                                                                                                                                                                       |                                     | = -55.7 dBmO                                                                            | <b>13</b> |     |     | dBc     |
| DRA                                                                                                                                                                   | Absolute Receive Delay              | $f = 1600 \text{ Hz}$                                                                   |           | 190 |     | $\mu s$ |
| DRR                                                                                                                                                                   | Receive Delay Distortion            | Measure Relative to DRA,<br>$f = 500 \text{ Hz}$                                        |           | -2  |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 1000 Hz                                                                               |           | -10 |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 2600 Hz                                                                               |           | 70  |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 2800 Hz                                                                               |           | 100 |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 3000 Hz                                                                               |           | 150 |     | $\mu s$ |
| DXA                                                                                                                                                                   | Absolute Transmit Delay             | $f = 1600 \text{ Hz}$                                                                   |           | 300 |     | $\mu s$ |
| DXR                                                                                                                                                                   | Transmit Delay Distortion           | Measure Relative to DXA,<br>$f = 500 \text{ Hz}$                                        |           | 250 |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 600 Hz                                                                                |           | 150 |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 800 Hz                                                                                |           | 65  |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 1000 Hz                                                                               |           | 30  |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 2600 Hz                                                                               |           | 60  |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 2800 Hz                                                                               |           | 80  |     | $\mu s$ |
|                                                                                                                                                                       |                                     | = 3000 Hz                                                                               |           | 140 |     | $\mu s$ |

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                                                                                                                                     | Parameter                                         | Conditions                                                                                                                                                                                                                                              | Min                                    | Typ      | Max | Units                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------|----------|-----|----------------------------------------|
| NOISE $Z_{REF} = 900\Omega + 2.16 \mu F$ , $I_{Loop} = 20 \text{ mA}$ , $D2=0$ , $D3=0$                                                    |                                                   |                                                                                                                                                                                                                                                         |                                        |          |     |                                        |
| NRC                                                                                                                                        | Receive C Message Weighted Idle Channel Noise     | PCM Code is Alternating Positive and Negative Zeroes                                                                                                                                                                                                    |                                        | 9        | 13  | dBrnC0                                 |
| NXC                                                                                                                                        | Transmit C Message Weighted Idle Channel Noise    | Measured by Extrapolation from Signal to Distortion Measurements at $-50 \text{ dBmO}$                                                                                                                                                                  |                                        | 13       | 16  | dBrnC0                                 |
| POWER SUPPLY REJECTION RATIO Unless Otherwise Specified, $Z_{REF} = 900\Omega + 2.16 \mu F$ , $I_{Loop} = 20 \text{ mA}$ , $D2=0$ , $D3=0$ |                                                   |                                                                                                                                                                                                                                                         |                                        |          |     |                                        |
| PPSR <sub>R</sub>                                                                                                                          | V <sub>CC</sub> Power Supply Rejection, Receive   | f = 328.125 Hz<br>f = 1078.125 Hz<br>f = 3328.125 Hz                                                                                                                                                                                                    | 30<br>30<br>30                         |          |     | dB<br>dB<br>dB                         |
| VPSR <sub>R</sub>                                                                                                                          | V <sub>BAT</sub> Power Supply Rejection, Receive  | f = 328.125 Hz<br>f = 1078.125 Hz<br>f = 3328.125 Hz                                                                                                                                                                                                    | 30<br>40<br>40                         |          |     | dB<br>dB<br>dB                         |
| PPSR <sub>x</sub>                                                                                                                          | V <sub>CC</sub> Power Supply Rejection, Transmit  | f = 328.125 Hz<br>f = 1078.125 Hz<br>f = 3328.125 Hz                                                                                                                                                                                                    | 30<br>30<br>30                         |          |     | dB<br>dB<br>dB                         |
| VPSR <sub>x</sub>                                                                                                                          | V <sub>BAT</sub> Power Supply Rejection, Transmit | f = 328.125 Hz<br>f = 1078.125 Hz<br>f = 3328.125 Hz                                                                                                                                                                                                    | 30<br>40<br>40                         |          |     | dB<br>dB<br>dB                         |
| LONGITUDINAL BALANCE AND CAPABILITY                                                                                                        |                                                   |                                                                                                                                                                                                                                                         |                                        |          |     |                                        |
| I <sub>LLS1</sub>                                                                                                                          | Longitudinal Current Capability, Loop Start       | I <sub>Loop</sub> = 5 mA, f = 60 Hz, Inject I <sub>LLS1</sub> into TIP and RING. Device Must Not Detect Off-Hook. Triangular Waveform                                                                                                                   | 21                                     |          |     | mArms                                  |
| I <sub>LLS2</sub>                                                                                                                          | Longitudinal Current Capability, Loop Start       | I <sub>Loop</sub> = 21 mA, f = 60 Hz, Inject I <sub>LLS2</sub> into TIP and RING. Device Must Not Detect On-Hook. Triangular Waveform                                                                                                                   | 21                                     |          |     | mArms                                  |
| I <sub>LGS1</sub>                                                                                                                          | Longitudinal Current Capability, Ground Start     | f = 60 Hz, I <sub>Ground</sub> = 0 mA Triangular Waveform. Inject I <sub>LGS1</sub> into RING, TIP Open. Device Must Not Detect Off-Hook                                                                                                                | 8.5                                    |          |     | mArms                                  |
| I <sub>LGS2</sub>                                                                                                                          | Longitudinal Current Capability, Ground Start     | I <sub>Ground</sub> = 50 mA, f = 60 Hz. Inject I <sub>LGS2</sub> into RING, TIP Open. Device Must Not Detect On-Hook. Triangular Waveform                                                                                                               | 50                                     |          |     | mArms                                  |
| BAL2W                                                                                                                                      | 2-Wire Longitudinal Balance                       | IEEE Method 455-1976, I <sub>Loop</sub> = 20 mA, I <sub>Longitudinal</sub> = 20 mArms/leg, Measure V <sub>metallic</sub> across TIP-RING<br>f = 62.5 Hz<br>= 203.125 Hz<br>= 1015.625 Hz<br>= 2015.625 Hz<br>= 2703.125 Hz<br>= 3000 Hz<br>= 3406.25 Hz | 61<br>61<br>61<br>61<br>56<br>54<br>51 | 64<br>64 |     | dB<br>dB<br>dB<br>dB<br>dB<br>dB<br>dB |

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                                                                               | Parameter                                                                       | Conditions                         | Min        | Typ | Max          | Units   |
|--------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|------------------------------------|------------|-----|--------------|---------|
| <b>LONG FRAME SYNC MODE</b> (Figure 9)                                               |                                                                                 |                                    |            |     |              |         |
| $t_{HBCFSH}$                                                                         | Hold Time from BCLK Low to FS                                                   |                                    | <b>0</b>   |     |              | ns      |
| $t_{SFSBC0}$                                                                         | Setup Time from FS to BCLK Low                                                  |                                    | <b>80</b>  |     |              | ns      |
| $t_{WFSL}$                                                                           | Width of FS Low                                                                 |                                    | <b>160</b> |     |              | ns      |
| $t_{DBCDX0}$                                                                         | Delay Time from BCLK or FS, Whichever Comes Later to Dx Valid                   | $C_L = 150$ pF Plus 2 LSTTL Loads  | <b>20</b>  |     | <b>165</b>   | ns      |
| $t_{DBCDX}$                                                                          | Delay Time from BCLK to Dx Valid                                                | $C_L = 150$ pF Plus 2 LSTTL Loads  | <b>0</b>   |     | <b>140</b>   | ns      |
| $t_{DBCDXz}$                                                                         | Delay Time from BCLK to Dx Disabled                                             | $C_L = 50$ pF                      | <b>50</b>  |     | <b>165</b>   | ns      |
| $t_{DBCDXz0}$                                                                        | Delay Time from BCLK or FS, Whichever Comes Later, to Dx Disabled               | $C_L = 50$ pF                      | <b>20</b>  |     | <b>165</b>   | ns      |
| $t_{SDRBC}$                                                                          | Setup Time from $D_R$ to BCLK Low                                               |                                    | <b>50</b>  |     |              | ns      |
| $t_{HBCDR}$                                                                          | Hold Time from BCLK Low to $D_R$ Valid                                          |                                    | <b>50</b>  |     |              | ns      |
| <b>DIGITAL TIMING, SERIAL CONTROL INTERFACE</b> (See Figures 2 and 3, Notes 4 and 5) |                                                                                 |                                    |            |     |              |         |
| $1/t_{PCC}$                                                                          | CCLK Frequency                                                                  | Frequency Accuracy $< \pm 100$ ppm | 0.08       |     | <b>2.048</b> | MHz     |
| $t_{WCCH}$                                                                           | Width of CCLK High                                                              |                                    | <b>200</b> |     |              | ns      |
| $t_{WCCL}$                                                                           | Width of CCLK Low                                                               |                                    | <b>200</b> |     |              | ns      |
| $t_{WCSL}$                                                                           | Width of $\overline{CS}$ Low                                                    |                                    |            |     | <b>100</b>   | $\mu s$ |
| <b>READ/WRITE, WRITE READ MODES</b> (Figure 2)                                       |                                                                                 |                                    |            |     |              |         |
| $t_{HCCCS}$                                                                          | Hold Time from CCLK to $\overline{CS}$                                          |                                    | <b>100</b> |     |              | ns      |
| $t_{SCSCC}$                                                                          | Setup Time from $\overline{CS}$ to CCLK                                         |                                    | <b>100</b> |     |              | ns      |
| $t_{DCCCO}$                                                                          | Delay Time from CCLK or $\overline{CS}$ , Whichever Comes Later, to CO Valid    | $C_L = 150$ pF Plus 2 LSTTL Loads  |            |     | <b>150</b>   | ns      |
| $t_{DCCCOZ}$                                                                         | Delay Time from CCLK or $\overline{CS}$ , Whichever Comes Later, to CO Disabled |                                    |            |     | <b>150</b>   | ns      |

## Electrical Characteristics

Unless otherwise noted, limits printed in **bold** characters are guaranteed for  $V_{CC} = 5.0V \pm 5\%$ ,  $V_{BB} = -5.0V \pm 5\%$ ,  $V_{BAT} = -55V$  to  $-59V$ ,  $T_A = 0^\circ C$  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. Typical characteristics are specified at  $V_{CC} = 5.0V$ ,  $V_{BB} = -5.0V$ ,  $V_{BAT} = -56V$ ,  $T_A = 25^\circ C$ . All digital signals are referenced to GND, all analog signals are referenced to RTN. (Continued)

| Symbol                                                     | Parameter                                                     | Conditions                                                  | Min        | Typ | Max        | Units |
|------------------------------------------------------------|---------------------------------------------------------------|-------------------------------------------------------------|------------|-----|------------|-------|
| <b>READ/WRITE, WRITE READ MODES</b> (Figure 2) (Continued) |                                                               |                                                             |            |     |            |       |
| $t_{SCCI}$                                                 | Setup Time from CI to CCLK                                    |                                                             | <b>100</b> |     |            | ns    |
| $t_{HCICC}$                                                | Hold Time from CCLK to CI                                     |                                                             | <b>100</b> |     |            | ns    |
| $t_{DCSIN}$                                                | Delay Time from $\overline{CS}$ Low to $\overline{INTR}$ High | $R_L = 1\text{ k}\Omega$ from $\overline{INTR}$ to $V_{CC}$ |            |     | <b>200</b> | ns    |
| <b>QUICK STATUS READ MODE</b> (Figure 3)                   |                                                               |                                                             |            |     |            |       |
| $t_{HCCSL}$                                                | Hold Time from CCLK to $\overline{CS}$ Low                    |                                                             | <b>100</b> |     |            | ns    |
| $t_{SCSCCL}$                                               | Setup Time from $\overline{CS}$ to CCLK Low                   |                                                             | <b>100</b> |     |            | ns    |
| $t_{DCSCO}$                                                | Delay Time from $\overline{CS}$ to CO Valid                   | $C_L = 150\text{ pF}$ Plus 2 LSTLL Loads                    |            |     | <b>150</b> | ns    |
| $t_{DCSCOZ}$                                               | Delay Time from $\overline{CS}$ to CO Disabled                |                                                             |            |     | <b>150</b> | ns    |

**Note 4:** See Appendix I for the definition and naming conventions used for digital timing parameters.

**Note 5:** See Table V for the definition of the mnemonics used for the digital timing parameters.

**TABLE V. Timing Parameter Mnemonics**

| Pin Name          | Mnemonic |
|-------------------|----------|
| $\overline{INTR}$ | IN       |
| $\overline{CS}$   | CS       |
| CO                | CO       |
| CI                | CI       |
| CCLK              | CC       |
| MCLK              | MC       |
| BCLK              | BC       |
| $D_R$             | DR       |
| $D_x$             | DX       |
| $\overline{TS_x}$ | TS       |
| $FS_R$            | FS       |
| $FS_x$            | FS       |

## Applications Information

### Typical Line Circuit

Relatively few external components are required to implement a full featured central office line circuit. As shown in *Figure 10*, a complete line circuit is implemented using TP3210 with an external protection network consisting of fuse resistors  $R_{TIP}$  and  $R_{RING}$ , and a voltage clamp device, two  $360\Omega$  ring sensing resistors, a ring relay and two test relays. It should be noted that no supply decoupling capacitors are required for each line circuit at  $\pm 5V$  supplies, although the use of one larger electrolytic capacitor may be advisable for each power supply near the point at which it enters the line card.

Protection resistors  $R_{TIP}$  and  $R_{RING}$  should be nominally  $100\Omega$  matched to within  $\pm 1\%$ . The selection of these protection resistors is important because they are fundamental to the ability of the line circuit to meet lightning and power cross requirements.  $R_{TIP}$  and  $R_{RING}$  should be designed such that they can withstand level one lightning and power cross requirements, while fusing open when over-stressed by level two lightning and power cross. TPR and RPR are protected by an external voltage clamp device to limit the voltage at these two pins to within  $+2$  to  $-85V$ . The ring sensing resistors,  $R_S$  are  $360\Omega$  which sets the ring trip threshold to about 11 mAdC. The heavy relay current will be returned to GND3 at pin 26.

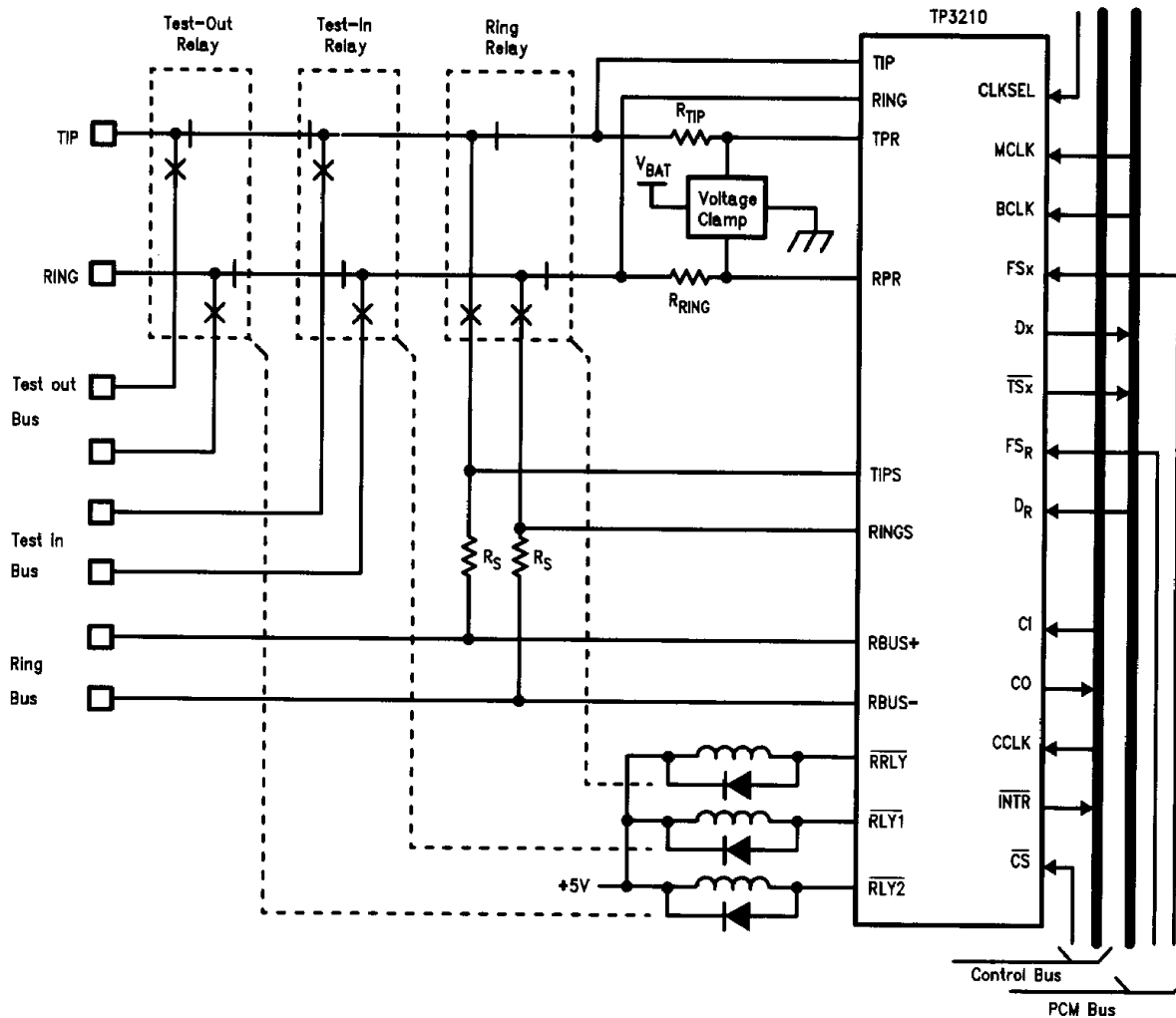


FIGURE 10. Complete Central Office Line Circuit

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## Applications Information (Continued)

### Secondary Protection

The surge protection network in *Figure 10* consists of resistors  $R_{TIP}$ ,  $R_{RING}$  and a voltage limiting circuit which limits the voltage at TPR and RPR. A number of low cost possibilities for this voltage limit are shown in *Figure 11*. The lowest cost solution is a simple full wave rectifier diode bridge used to clamp the voltage to no more than one or two volts above RTN or below  $V_{BAT}$ , provided that the  $V_{BAT}$  supply is capable to absorb the power surges. The TIP and RING input

terminals of the TP3210 are internally connected in series to two 300 k $\Omega$  thick film resistors, which are capable to withstand power cross and surges.

### Typical Line Card

A complete N-channel line card is illustrated in *Figure 12*. The backplane control interfaces vary greatly in different applications, and this example illustrates a possible arrangement.

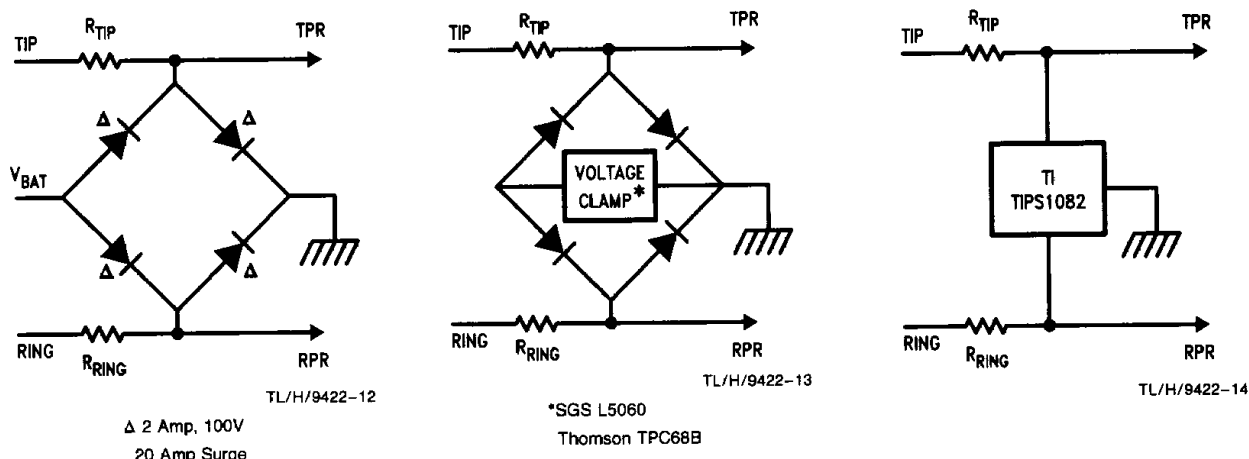


FIGURE 11. Some Secondary Protection Networks

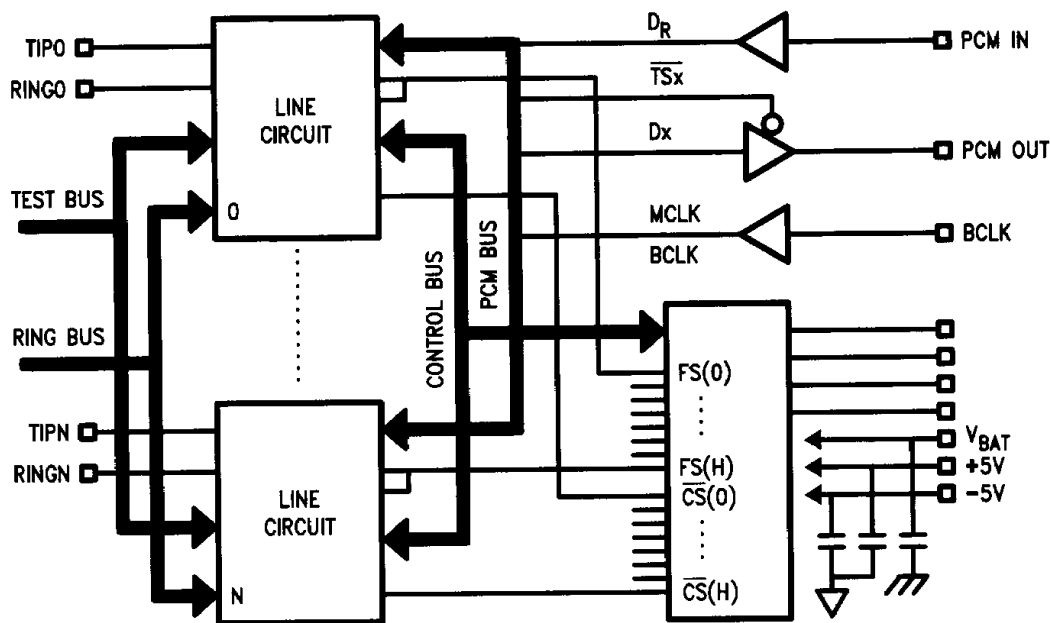


FIGURE 12. Typical N-Channel Linecard