# MH88600
## Global SLIC
Preliminary Information

ISSUE 7 April 1995

## Features

- Programmable line impedance matching
- Internal complex impedance networks
- Transformerless 2-4 wire conversion
- Programmable transmit/receive gain
- Accommodates worldwide transmission standards
- Operates with a wide range of battery voltages
- Adjustable constant current battery feed
- Overvoltage and short circuit protection
- Switch hook and ground button detection
- Ring trip filter and relay driver
- Low power consumption
- High power dissipation capability during fault conditions

## Applications

Line interface for:
- PABXs
- Control Systems
- Key Telephone Systems
- Central Office Equipment

**Ordering Information**

| | |
|---|---|
| MH88600 | 40 Pin DIL Hybrid |

**0°C to 70°C**

## Description

The MH88600 is a SLIC (Subscriber Line Interface Circuit) which provides all of the BORSCH functions of Battery Feed, Overvoltage Protection, Ringing Feed, Line Supervision and 2-4 Wire Hybrid conversion. In addition, the device matches the many different line impedances specified by regulatory authorities of around the world.

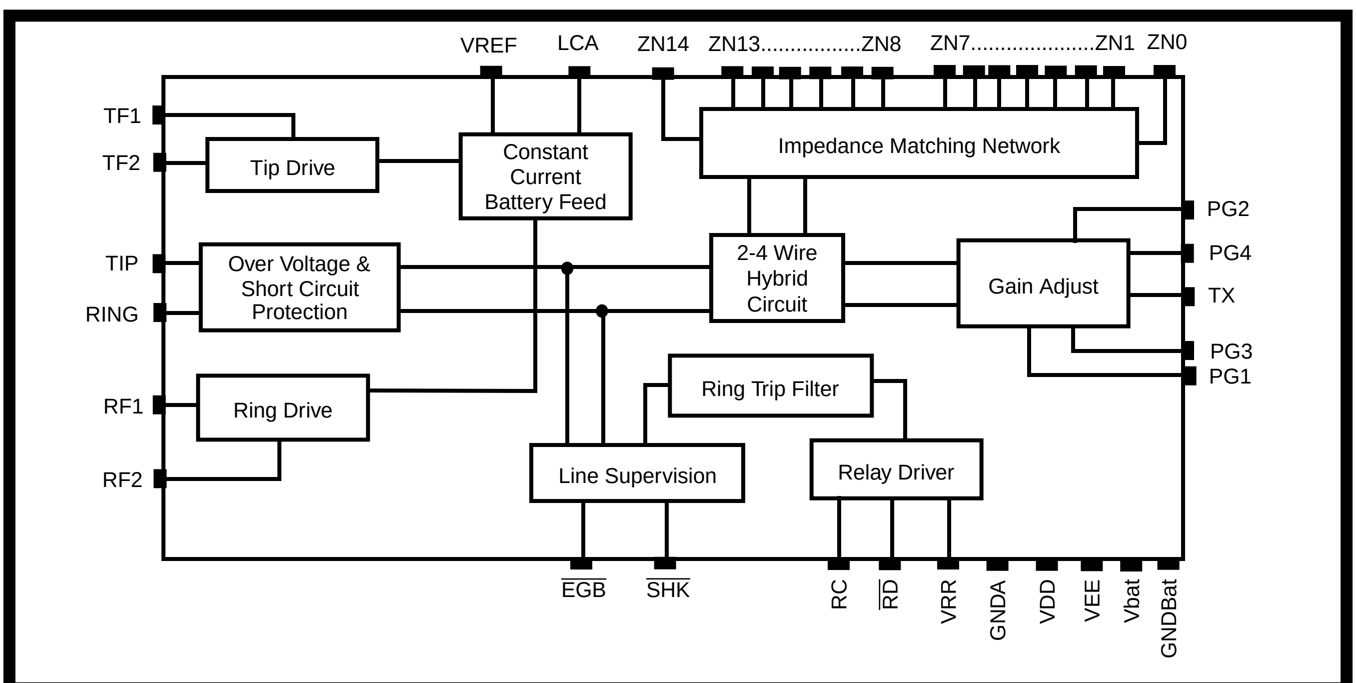



**Figure 1 - Functional Block Diagram**

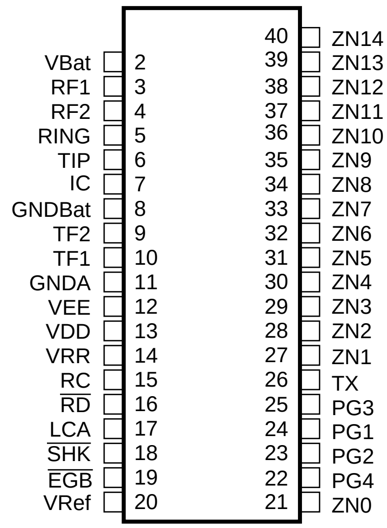



**Figure 2 - Pin Connections**

## Pin Description

| Pin # | Name | Description |
|---|---|---|
| 1 | | No pin at this location. |
| 2 | $V_{Bat}$ | **Battery Supply Voltage (Negative).** |
| 3 | RF1 | **Ring Feed (1):** Connect to relay contact. See Figures 6 & 7. |
| 4 | RF2 | **Ring Feed (2)**. Connect to relay contact. See Figures 6 & 7. |
| 5 | RING | Connects to the “Ring” or “B” lead of the telephone line. |
| 6 | TIP | Connects to the “Tip” or “A” lead of the telephone line. |
| 7 | I/C | **Internal Connection.** |
| 8 | $GND_{Bat}$ | **Battery Supply Ground (Positive):** Connect to System Ground |
| 9 | TF2 | **Tip Feed (2).** Connect to TF1 for unbalanced ringing, see Figure 6. Connect to relay contact for balanced ringing, see Figure 7. |
| 10 | TF1 | **Tip Feed (1).** Connect to TF2 for unbalanced ringing, see Figure 6. Connect to relay contact for balanced ringing, see Figure 7. |
| 11 | GNDA | **Analog Ground:** Normally connected to System Ground. |
| 12 | $V_{EE}$ | **Negative Power Supply Voltage:** Normally -5V. |
| 13 | $V_{DD}$ | **Positive Power Supply Voltage:** Normally +5V. |
| 14 | $V_{RR}$ | **Ringing Relay Clamp Diode:** Connect to relay coil and to relay supply voltage (Positive). For +5V relay, connect to VDD. |
| 15 | RC | **Ring Control (Input):** A logic high will activate the Ring Relay Drive if $\overline{SHK}$ is high. |
| 16 | $\overline{RD}$ | **Ring Relay Drive (Output).** Connect to relay coil. A logic low will activate the relay by sinking current from VRR through the relay coil. |
| 17 | LCA | **Loop Current Adjust (Input):** Loop current is proportional to the voltage at this input. Normally connected to VRef |
| 18 | $\overline{SHK}$ | **Switch Hook Detect (Output):** A logic low indicates an off-hook condition. |
| 19 | $\overline{EGB}$ | **Earth Ground Button (Output):** A logic low indicates a grounded Ring lead condition. |
| 20 | $V_{Ref}$ | **Voltage Reference (Output):** Normally connected to LCA for default loop current. |

## Pin Description (Continued)

| Pin # | Name | Description |
|---|---|---|
| 21 | ZN0 | **Impedance Node 0.** Connect to external network for impedance ($Z_{in}$) setting. See Table 2 and Figure 8. |
| 22 | PG4 | **Programming 4 (Input).** Used for programmable gain and for default gain. Used as 4-Wire Receive Input for default gain. See Table 3 and Figure 4 and 5. |
| 23 | PG2 | **Programming 2 (Input).** Used for programmable gain. Used with resistor for 4-Wire Receive Input. See Table 3 and Figure 4. |
| 24 | PG1 | **Programming 1 (Input).** Used for programmable gain. See Table 3 and Figure 4. |
| 25 | PG3 | **Programming 3 (Input).** Used for programmable gain and for default gain. See Table 3 and Figure 4 and 5. |
| 26 | TX | **4-Wire Transmit Output:** |
| 27 | ZN1 | **Impedance Node 1:** Connect to other Impedance Nodes for impedance ($Z_{in}$) setting, see Table 1. Or, connect to external network for impedance ($Z_{in}$) setting, see Table 2 and Figure 8. |
| 28 | ZN2 | **Impedance Node 2**: Connect to other impedances Nodes for impedance ($Z_{in}$) setting. See Table 1. |
| 29 | ZN3 | **Impedance Node 3:** As per ZN2. See Table 1. |
| 30 | ZN4 | **Impedance Node 4:** As per ZN2. See Table 1 |
| 31 | ZN5 | **Impedance Node 5:** As per ZN2. See Table 1 |
| 32 | ZN6 | **Impedance Node 6:** As per ZN2. See Table 1 |
| 33 | ZN7 | **Impedance Node 7:** As per ZN2. See Table 1 |
| 34 | ZN8 | **Impedance Node 8:** As per ZN2. See Table 1 |
| 35 | ZN9 | **Impedance Node 9:** As per ZN2. See Table 1 |
| 36 | ZN10 | **Impedance Node 10:** As per ZN2. See Table 1 |
| 37 | ZN11 | **Impedance Node 11:** As per ZN2. See Table 1 |
| 38 | ZN12 | **Impedance Node 12:** As per ZN2. See Table 1 |
| 39 | ZN13 | **Impedance Node 13:** As per ZN2. See Table 1 |
| 40 | ZN14 | **Impedance Node 14:** Connect to external network for impedance ($Z_{in}$) setting. See Table 2 and Figure 8. |

## Functional Description

### The BORSH Functions

The MH88600 performs all of the BORSH functions; Battery Feed, Overvoltage Protection, Ringing, Supervision and Hybrid.

### Battery Feed

The MH88600 provides the loop with constant DC current to power the telephone set. The voltage (negative) applied at the LCA pin determines the magnitude of the lop current.

$$I_{Loop} = 3.731 \times VLCA\ mA\ (\pm 2mA)$$

Either the internal ($V_{Ref}$) or an external negative voltage reference may be used to set the loop current.

### Overvoltage Protection

The MH88600 is protected from short term (20ms) transients (+250V) between Tip and Ring, Tip and ground, and Ring and Ground. However, additional protection circuitry may be needed depending on the regulatory requirements which must be met. Normally, simple external shunt protection as shown in Figures 6,7 and 8 is all that is required.

### Ringing

The MH88600 has the capability to accommodate both balanced and unbalanced ringing sources. Refer to Figure 7 for the Balanced Ringing Circuit and Figure 6 for the Unbalanced Ringing Circuit.

### Supervision

The MH88600 is capable of detecting both Ground Button and Switch Hook conditions. The Ground Button detection (a logic low at the $\overline{EGB}$ output) operates when an imbalance in Tip and Ring DC current exceeds an internal threshold level caused by a grounded Ring Lead. Use of the $\overline{EGB}$ output is restricted to the off-hook condition of the telephone. The Switch Hook detection operates (a logic low at the $\overline{SHK}$ output) when the DC loop current exceeds an internal threshold level.

The Ring Trip Detection Circuit prevents false off-hook detection due to the current associated with the AC ringing voltage and also due to the large current transients when the ring voltage is switched in and out. In addition, the circuit prevents connection of the ringing source during off-hook conditions.

### Hybrid

The 2-4 Wire Hybrid circuit separates the balanced full duplex signal at Tip and Ring of the telephone line into receive and transmit ground referenced signals at RX (receive) and TX (transmit) of the SLIC. The Hybrid also prevents the input signal at RX from appearing at TX. The degree to which the Hybrid prevents the RX signal from appearing at TX is specified at transhybrid loss.

## Tip-Ring Drive Circuit

The audio input ground referenced signal at RX is converted to a balanced output signal at Tip and Ring. The output signal consists of the audio signal superimposed on the DC Battery Feed Constant Current. The Tip-Ring Drive Circuit is optimised for good 2-Wire longitudinal balance.

## Short Circuit Protection

The MH88600 is protected from long term (infinite) short circuit conditions occurring between Tip and Ring, Tip and Ground, Ring and Ground, and Ring and Battery. The current is limited to the same value as the Constant Current Battery Feed.

## Programmable Line Impedance

The MH88600's Tip-Ring ($Z_{in}$) impedance can be matched to the different impedances specified by different telephone administrations worldwide. This is accomplished by either linking specific pins as specified in Table 1, or by adding external components as shown in Figure 8 and Table 2.

## Programmable Transmit & Receive Gain

Transmit gain (TX to Tip-Ring) and Receive Gain (Tip-Ring to RX) can be programmed by connecting external resistors as indicated in Figure 4 and Table 3. Alternatively, the default Receive Gain of -4d Band Transmit Gain of +4dB can be obtained by connecting pins as shown in figure 5 and Table3.

Note that RX is not a pin on the SLIC. The RX terminal will be either PG4 or the connection to the receive gain programming resistor RRX shown in Figure 4 and Figure 5.

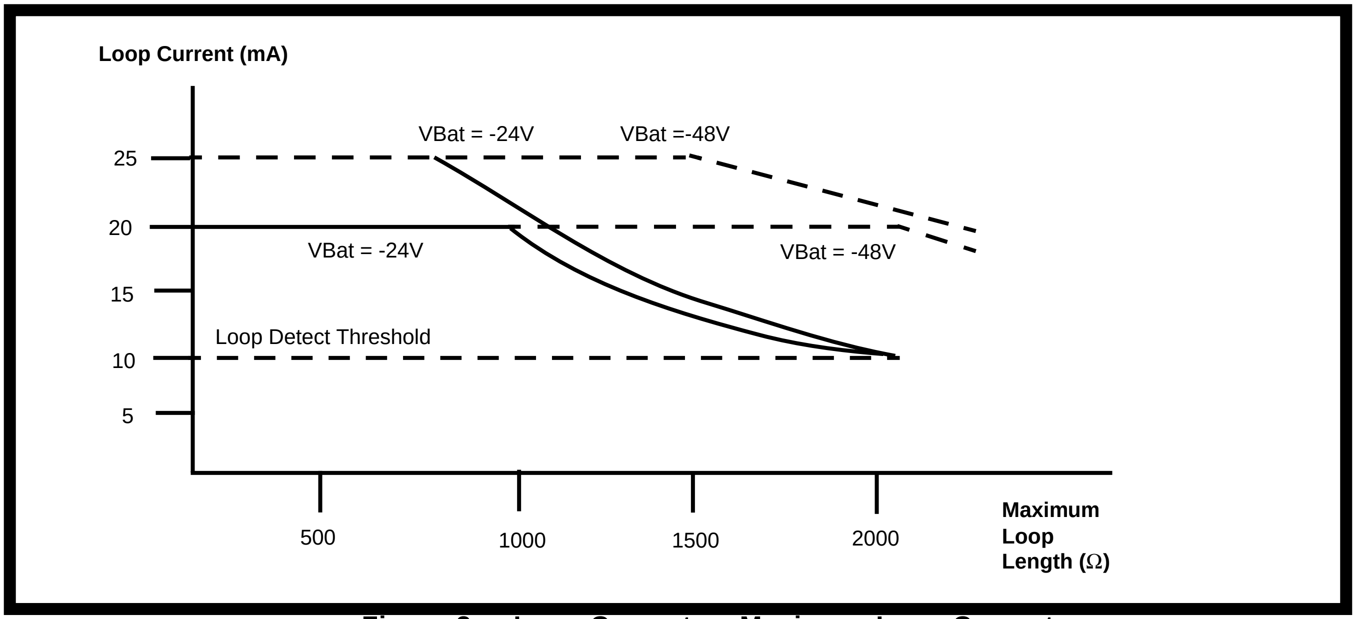



**Figure 3a - Loop Current vs.Maximum Loop Current**

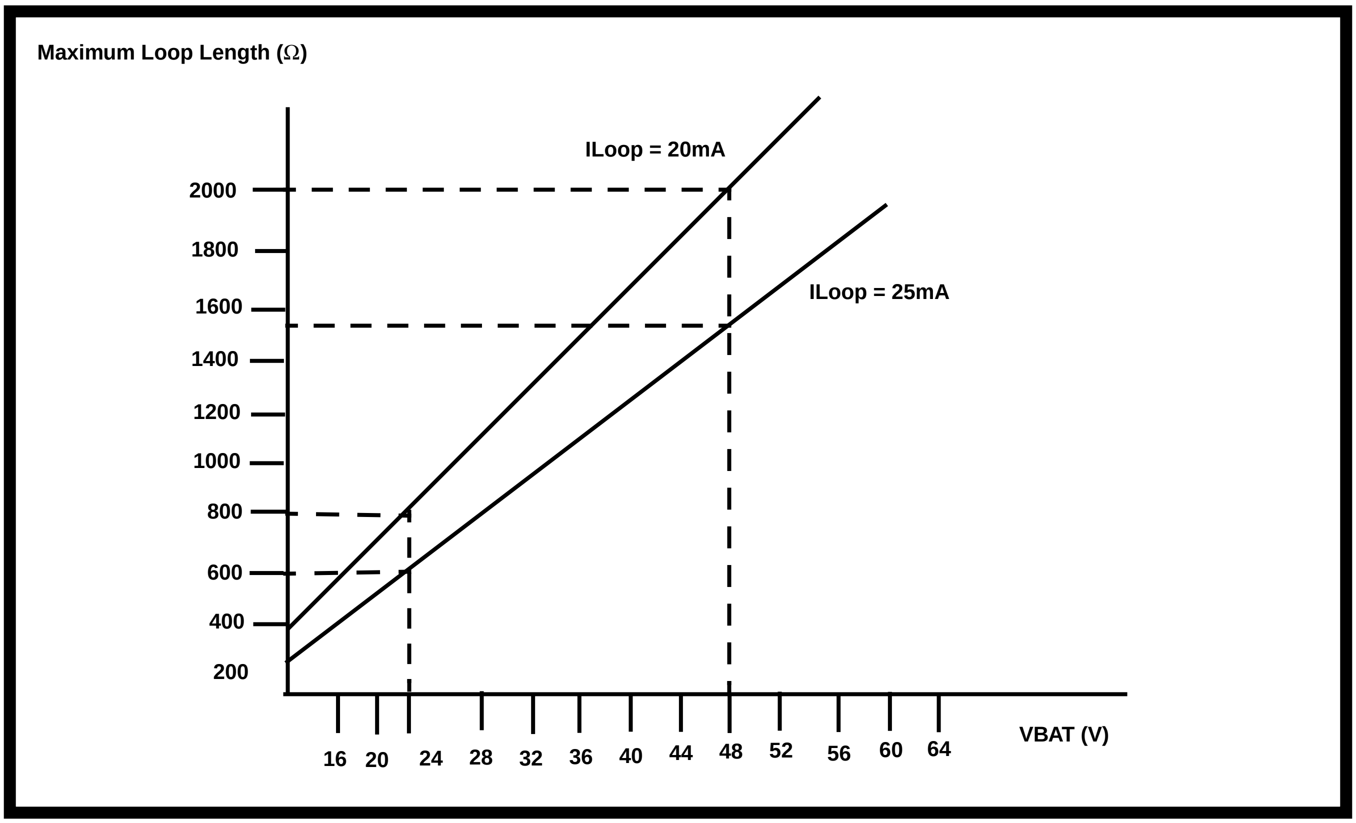



**Figure 3b - Maximum Loop Length vs Battery voltage**

## Absolute Maximum Ratings* - Voltages are with respect to AGND.

| | Parameters | Sym | Min. | Max | Units |
|---|---|---|---|---|---|
| 1 | DC Supply Voltages | $V_{DD}$ | -0.3 | 15 | V |
| | | $V_{EE}$ | +0.3 | -15 | V |
| | (GNDA = $GND_{Bat}$) | $V_{Bat}$ | +0.3 | -80 | V |
| | | $V_{RR}$ | -0.3 | 40 | V |
| 2 | Storage Temperature | $T_S$ | -55 | 125 | °C |
| 3 | Power Dissipation | $P_D$ | | 4 | W |

* Exceeding these values may cause permanent damage. Functional operation under these conditions is not implied.

## Recommended Operating Conditions

| | Characteristics | Sym | Min. | Typ* | Max | Units | Comments |
|---|---|---|---|---|---|---|---|
| 1 | Operating Supply Voltage | $V_{DD}$ | 4.75 | 5.0 | 5.25 | V | |
| | | $V_{EE}$ | -5.25 | -5.0 | -4.75 | V | |
| | | $V_{Bat}$ | -72 | -48 | -24 | V | |
| | | $V_{RR}$ | | 5 | 24 | V | |
| 2 | Operating Temperature | $T_{OP}$ | 0 | | 70 | °C | |

* Typical figures are at 25°C and are for design aid only: not guaranteed and not subject to production testing.

## DC Electrical Characteristics †

| | | Parameters | Sym | Min. | Typ* | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|---|---|
| 1 | | Supply Current | $I_{DD}$<br>$I_{EE}$<br>$I_{Bat}$ | | 8.5<br>5.0 | 12.0<br>10.0<br>4.8 | mA<br>mA<br>mA | $R_{Loop}$=Open Cct,<br>$V_{Bat}$ = -48V |
| 2 | | Power Consumption | PC | | | 330<br>755<br>1556 | mW<br>mW<br>mW | Standby<br>$R_{Loop}$=1200Ω<br>$R_{Loop}$=0Ω<br>$V_{Bat}$=-48V |
| 3 | | Constant Current Battery Feed ‡ | $I_{Loop}$<br>$I_{Loop}$ | 18<br>21 | 20<br>25 | 22<br>30 | mA<br>mA | LCA=-5.4V when $R_{Loop}$-0Ω<br>LCA=linked to $V_{Ref}$ when $R_{Loop}$=0Ω |
| 4 | | Operating Loop Resistance‡ | $R_{Loop}$ | 2000<br>800<br>1560<br>600 | | | Ω<br>Ω<br>Ω<br>Ω | $V_{Bat}$ =-48V, $I_{Loop}$=20mA<br>$V_{Bat}$ =-48V, $I_{Loop}$=20mA<br>$V_{Bat}$ =-48V, $I_{LLoop}$=25mA<br>$V_{Bat}$ =-48V, $I_{Loop}$=25mA |
| 5 | | Off-Hook Detect Threshold | $SHK_{th}$ | | 10 | | mA | |
| 6 | | GND Button Detect Threshold | $EGB_{th}$ | | 10 | | mA | |
| 7 | | Ring GND Over-Current Protection | | | 32 | 41 | mA | |
| 8 | $\overline{SHK}$ & | Low Level Output Voltage<br>High Level Output Voltage | $V_{OL}$<br>$V_{OH}$ | <br>2.4 | | 0.4 | V<br>V | No Load |
| 9 | $\overline{EGB}$ | Sink Current<br>Source Current | $I_{OL}$<br>$I_{OH}$ | 160<br>390 | | | µA<br>µA | $V_{OL}$ =0.8V<br>$V_{OH}$ =-0.2V |
| 10 | RC | Low Level Input Voltage<br>High Level Input Voltage | $V_{IL}$<br>$V_{IH}$ | <br>4.0 | | 0.4 | V<br>V | |
| 11 | | High Level Input Current | $I_{IH}$ | | | 1.5 | mA | $V_{IH}$ = $V_{DD}$ |
| 12 | $\overline{RD}$ | Sink Current | $I_{RLY}$ | 65 | | | mA | |
| 13 | | Clamp Diode Current | $I_{CD}$ | | | 65 | mA | |
| 14 | $V_{Ref}$ | Internal Reference | | -7.4 | -6.7 | -6.0 | V | LCA linked to $V_{Ref}$ |

* Typical figures are at 25˚C and are for design aid only: not guaranteed and not subject to production testing.
† DC Electrical Characteristics are over recommended operating conditions unless otherwise stated.
‡ See Figures 3a and 3b.

## AC Electrical Characteristics† - Voltages are with respect to GNDA unless otherwise stated.

| | Characteristics | Sym | Min. | Typ* | Max | Units | Test Conditions |
|---|---|---|---|---|---|---|---|
| 1 | Ringer Voltage | VR | | | 105 | $V_{rms}$ | See Fig 6 |
| 2 | Ringer Equivalence No. | REN | | | 5 | | |
| 3 | Ring Trip Detect Time | | | | 200 | ms | |
| 4 | Input Impedance at PG4<br>at VRX | $Z_{RX}$ | | 112<br>RRX | | kΩ | See Fig 5<br>See Fig 4 |
| 5 | Output Impedance at TX | $Z_{TX}$ | | 3 | | Ω | |
| 6 | Gain 2-Wire to TX: Fixed Gain | A TX | +3.5 | +4 | +4.5 | dB | Input 1.0V at 1kHz See Fig 5 |
| | Programmable Range | RTX | -12 | | +6 | dB | See Figure 4 |
| | Frequency Response Gain relative to Gain @ 1kHz<br>300Hz<br>600Hz and 2400Hz<br>3000Hz<br>3400Hz | $A_R$ TX | <br>-0.75<br>-0.1<br>-0.3<br>-0.75 | | <br>0.1<br>0.1<br>0.1<br>0.1 | <br>dB<br>dB<br>dB<br>dB | Input 1.0V<br>600Ω 2-Wire Impedance |
| 7 | Gain RX to 2-Wire: Fixed Gain | ARX | -4.5 | -4 | -3.5 | dB | Input 1.0V at 1kHz See Fig 5 |
| | Programmable Range | RRX | -12 | | +6 | dB | See Figure 4 |
| | Frequency Response Gain relative to Gain @ 1kHz<br>300Hz<br>600Hz and 2400Hz<br>3000Hz<br>3400Hz | $A_R$RX | <br>-0.75<br>-0.1<br>-0.3<br>-0.75 | | <br>0.1<br>0.1<br>0.1<br>0.1 | <br>dB<br>dB<br>dB<br>dB | Input 1.0V<br>600Ω 2-Wire Impedance |
| 8 | 2-Wire Return Loss | RL | 20<br>18 | 26 | | dB<br>dB | Input 1.0V, 200Hz to 3.4kHz<br>Input 1.0V, 3.4kHz to 4kHz |
| 9 | 2-Wire Input Impedance | $Z_{IN}$ | | | | | See Table 1 |
| 10 | Transhybrid Loss | THL | 20 | 40 | | dB | Input 1.0V at 300Hz to 3400Hz at PG4 |
| 11 | Longitudinal Balance | | 52<br>41 | | | dB<br>dB | 40 - 3400Hz<br>3400-4000Hz |
| 12 | Total Harmonic Distortion<br>at TX<br>at 2-Wire | THD | | <br>0.1<br>0.1 | <br>1.0<br>1.0 | <br>%<br>% | <br>Input 1.0V at 1kHz at 2-Wire<br>Input 1.0V at 1kHz at PG4 |
| 13 | Common Mode Reject Ratio | CMRR | 40 | | | | CCITT 0.121 |
| 14 | Idle Channel Noise at TX<br>(0dB gain)<br>Idle Channel Noise at 2-Wire<br>(0dB gain) | Nc<br>Np<br>Nc<br>Np | | 13<br>-78<br>11<br>-80 | 18<br>-73<br>16<br>-75 | dBrnC<br>dBrnp<br>dBrnC<br>dBrnp | |
| 15 | Power Supply Reject Ratio $V_{DD}$<br>$V_{EE}$<br>$V_{BAT}$ | PSRR | 25<br>20<br>30 | | | dB<br>dB<br>dB | Ripple 1Vpp 1kHz<br>Measure 2-Wire or TX |
| 16 | Dial Pulse Distortion<br>(SHK High to Low Time) | $t_d$ | | 0.4 | 1 | ms | 2-Wire loop at 1.2kΩ |

† AC Electrical Characteristics are over recommended operating unless otherwise stated.
* Typical figures are at 25 C and are for design aid only: not guaranteed and not subject to production testing.

**Table 1: Impedance Matching with Jumpers**

| | Zin Code | Zin 2-Wire Input Impedance | Administration | ZN1 Link to: | ZN8 Link to: |
|---|---|---|---|---|---|
| 1 | 600 | 600Ω | --- | ZN7 | --- |
| 2 | UK | 370Ω + 620Ω // 310nF | United Kingdom | ZN6 | ZN13 |
| 3 | D | 220Ω + 820Ω // 310nF | Germany, Austria | ZN5 | ZN12 |
| 4 | NA | 350Ω + 1000Ω // 310nF | Canada, USA | ZN4 | ZN11 |
| 5 | F | 210Ω +880Ω // 310nF | France | ZN3 | ZN10 |
| 6 | N | 120Ω + 820Ω // 310nF | Norway | ZN2 | ZN9 |
| 7 | A | 220Ω + 820Ω // 310nF | Australia | Use D Code | Use D Code |

Note 1: The above impedances are as suggested by references: BS6305 (UK), REG3 (Australia), Proposed NET4, FCC Part 68 and recommendations by the various Administrations. Confirm your impedance requirements before proceeding.
Note 2: All links to ZN1 should be as short as possible.

**Table 2: Impedance Matching with External Components**

| | Zin Code | Zin 2-Wire Input Impedance | Administration | Rs | Rp | Cp |
|---|---|---|---|---|---|---|
| 1 | --- | 600Ω + 2.16µF | --- | 6kΩ | 1MΩ | 216nF |
| 2 | ATT | 900Ω + 2.16µF | AT&T | 9kΩ | 1MΩ | 216nF |
| 3 | NTT | 600Ω + 1.0µF | NTT | 6kΩ | 1MΩ | 100nF |
| 4 | NZ | 370Ω + (620Ω // 220nF) | New Zealand | 3.7kΩ | 6.2kΩ | 22nF |

Note 1: The above impedances are as suggested by reference CCITT Q.522. Confirm your impedance requirements before proceeding.
Note 2: For Rs, Rp & C calculations, G is set to 10, R is set to 5656.8Ω, refer to figure 8 for additional information.

**Table 3: Transmit and Receive Gain Programming**

| Transmit Gain (dB) | RTX Resistor Value (Ω) | Notes |
|---|---|---|
| +5.62 | 270k | |
| +4.0 | No Resistor | Results in 0dB overall gain when used with Mitel A-law codec (ie MT8965) |
| +3.69 | 216k | Results in 0dB overall gain when used with Mitel µ-law codec (ie MT8964) |
| +2.1 | 180k | |
| 0.0 | 141k | |
| -3.0 | 100k | |
| **Transmit Gain (dB)** | **RTX Resistor Value (Ω)** | **Notes** |
| +6.6 | 33.1k | |
| +0.0 | 70.7k | |
| -3.0 | 100k | |
| -3.69 | 108k | Results in 0dB overall gain when used with Mitel A-law codec (ie. MT8964) |
| 4.0 | No Resistor | Results in 0dB overall gain when used with Mitel µ-law codec (ie MT8965) |
| -6.5 | 150k | |

Note 1: See Figures 4 and 5 for additional details.
Note 2: Overall gain refers to the receive path of PCM to 2-Wire, and to transmit path of 2-Wire to PCM.

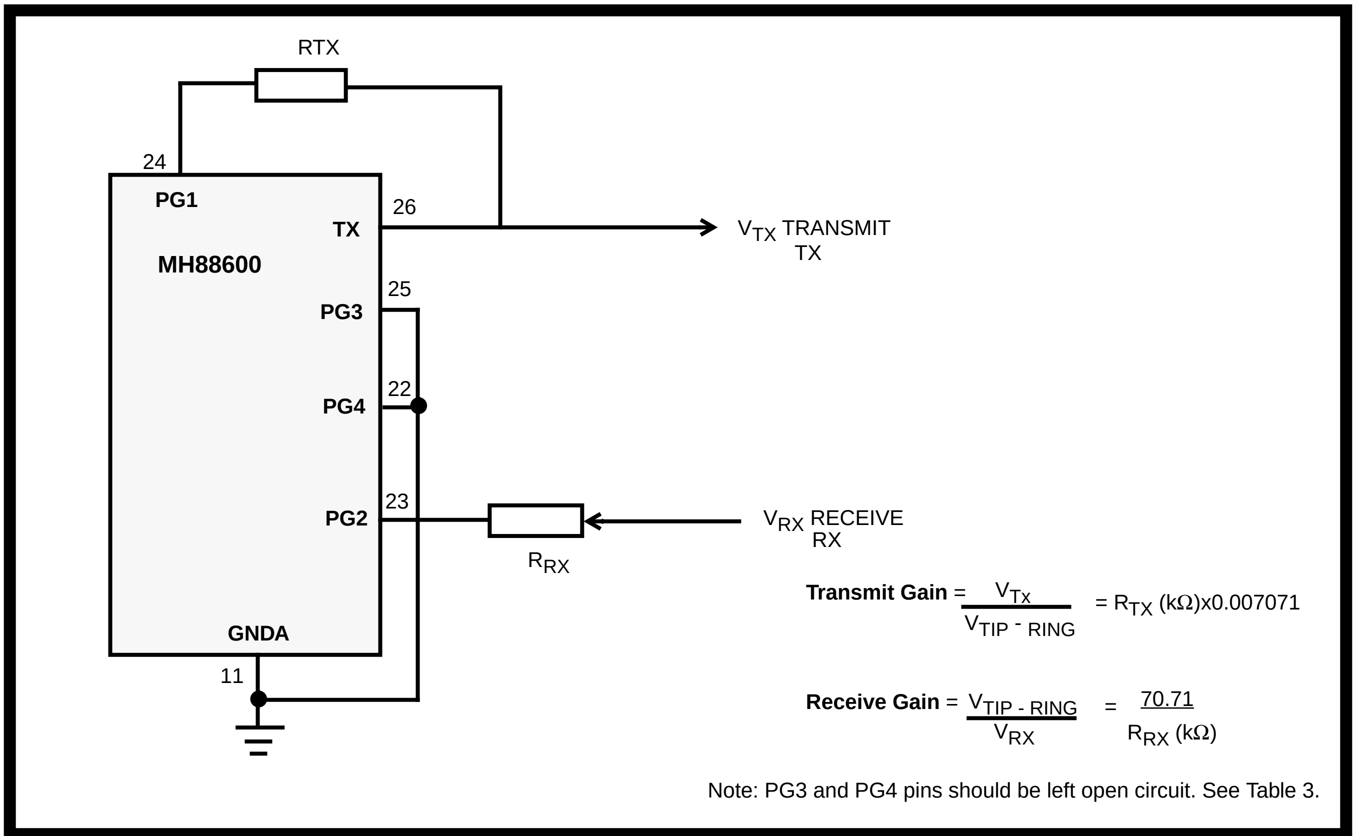



**Figure 4 - Configuration of MH88600 for Gain Programming**

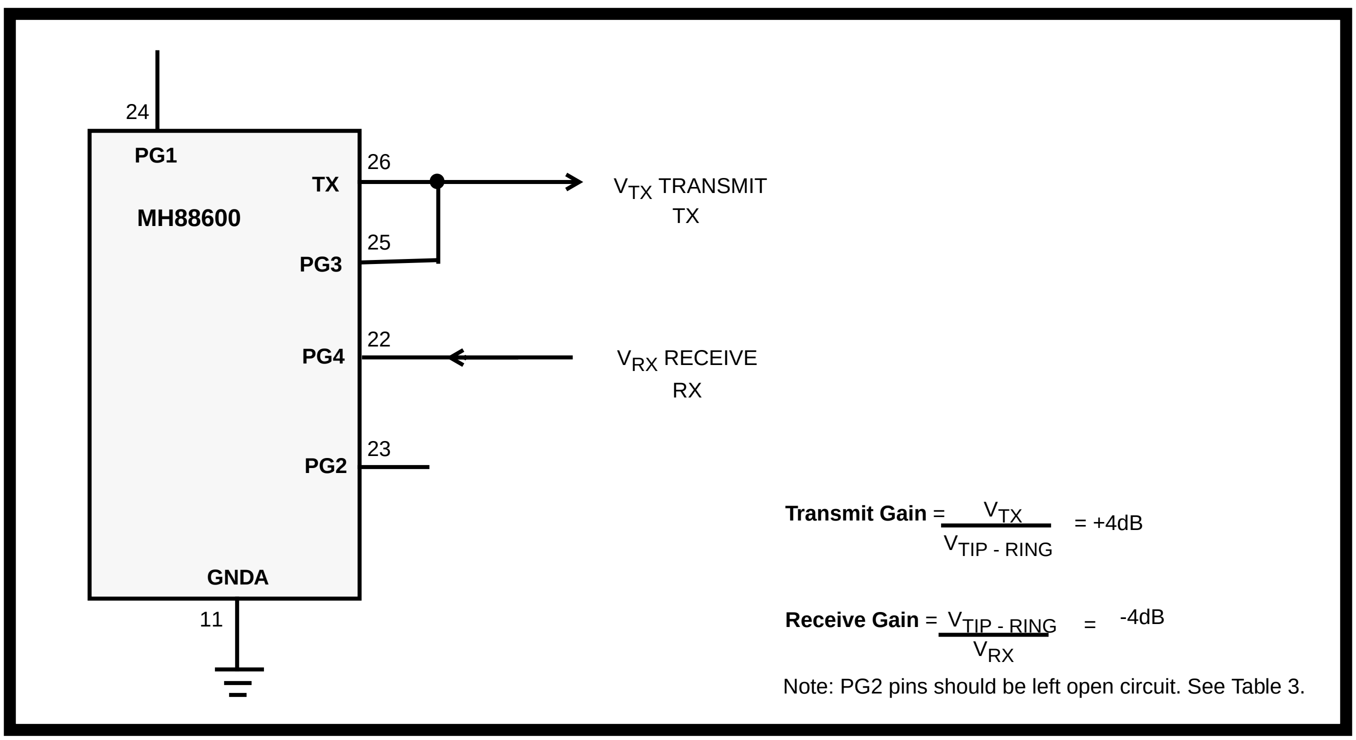



**Figure 5 - Configuration of MH88600 for Default Gains**

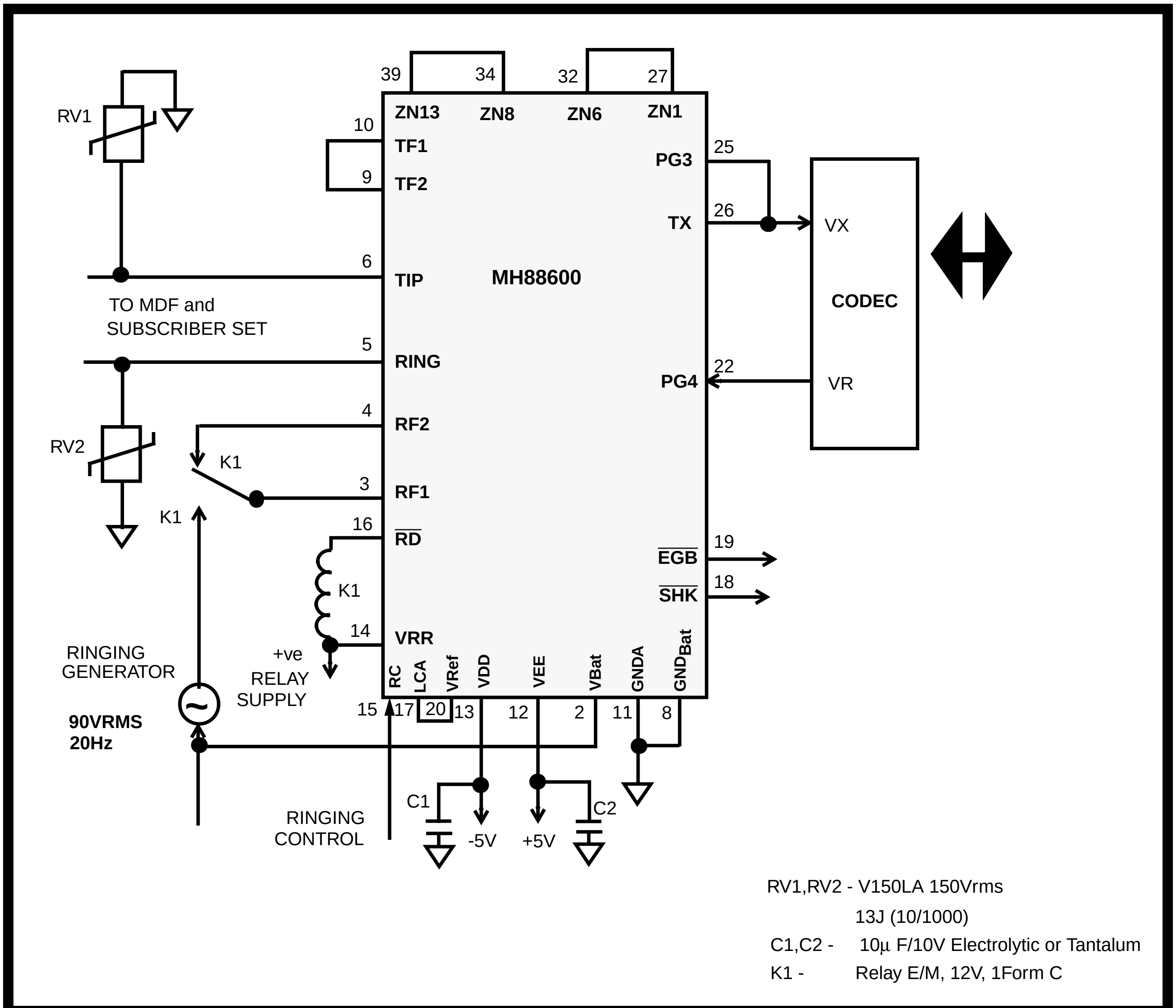



**Figure 6- Typical Application Circuit**

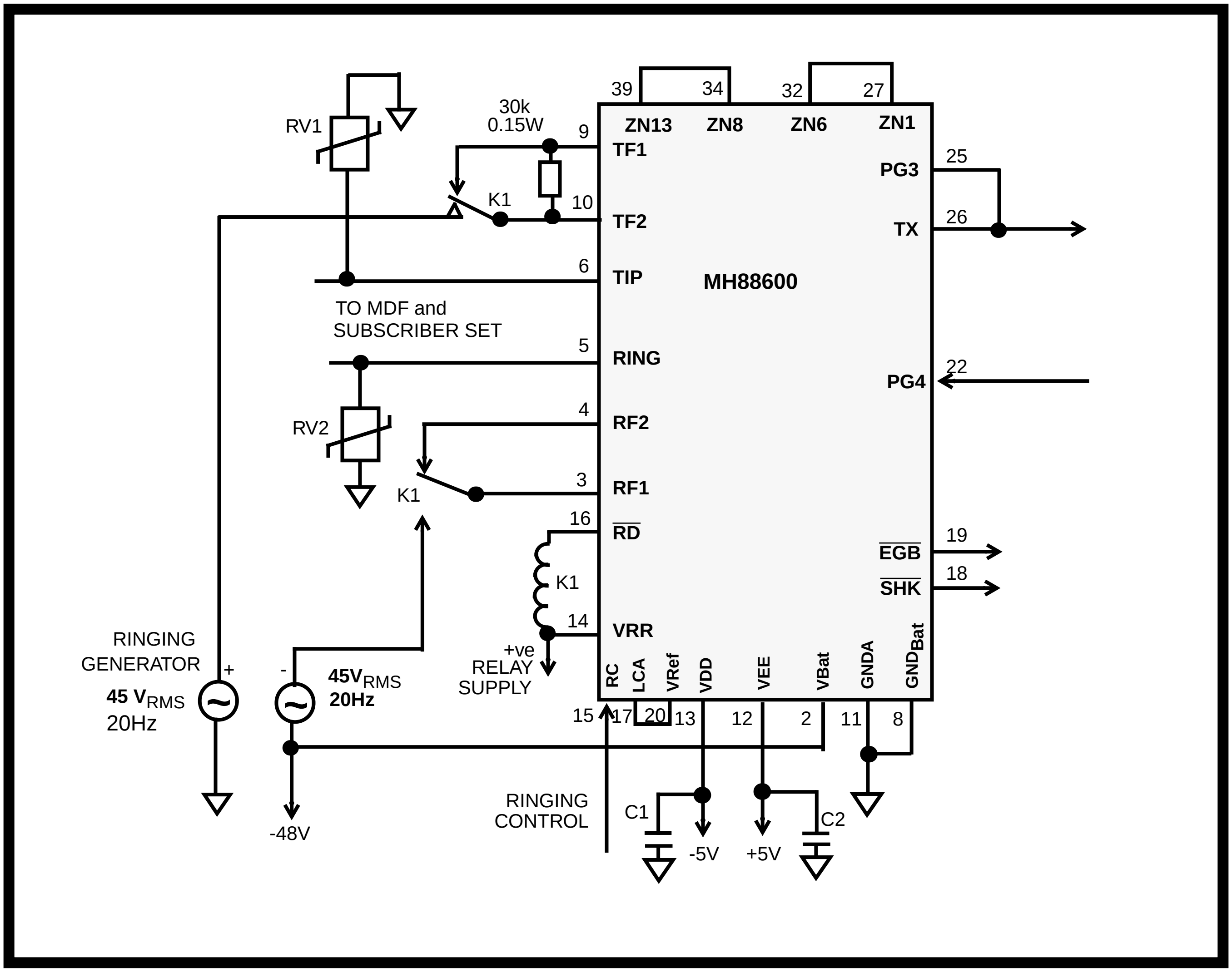



**Figure 7 - Application Circuit for Balanced Ringing**

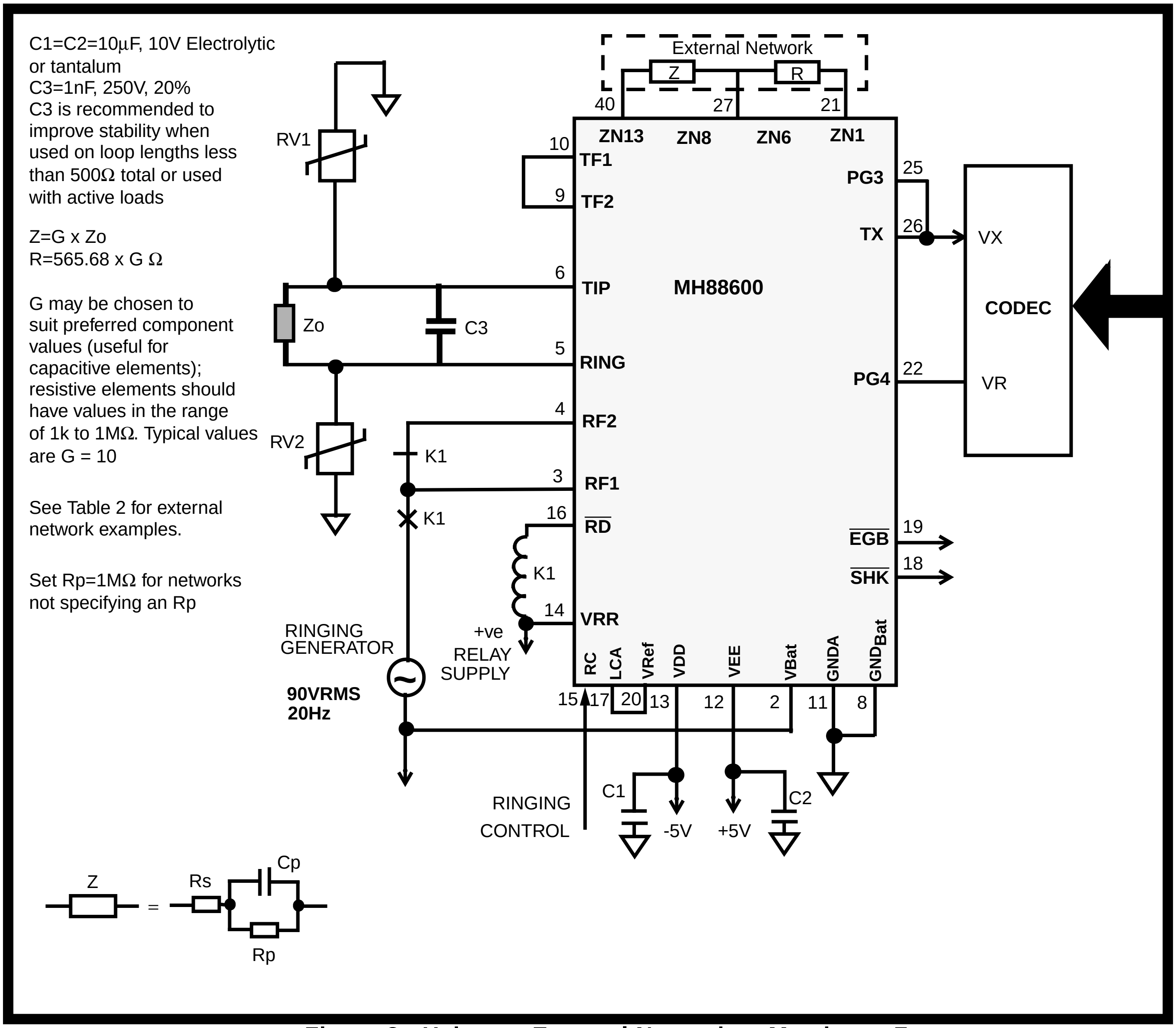
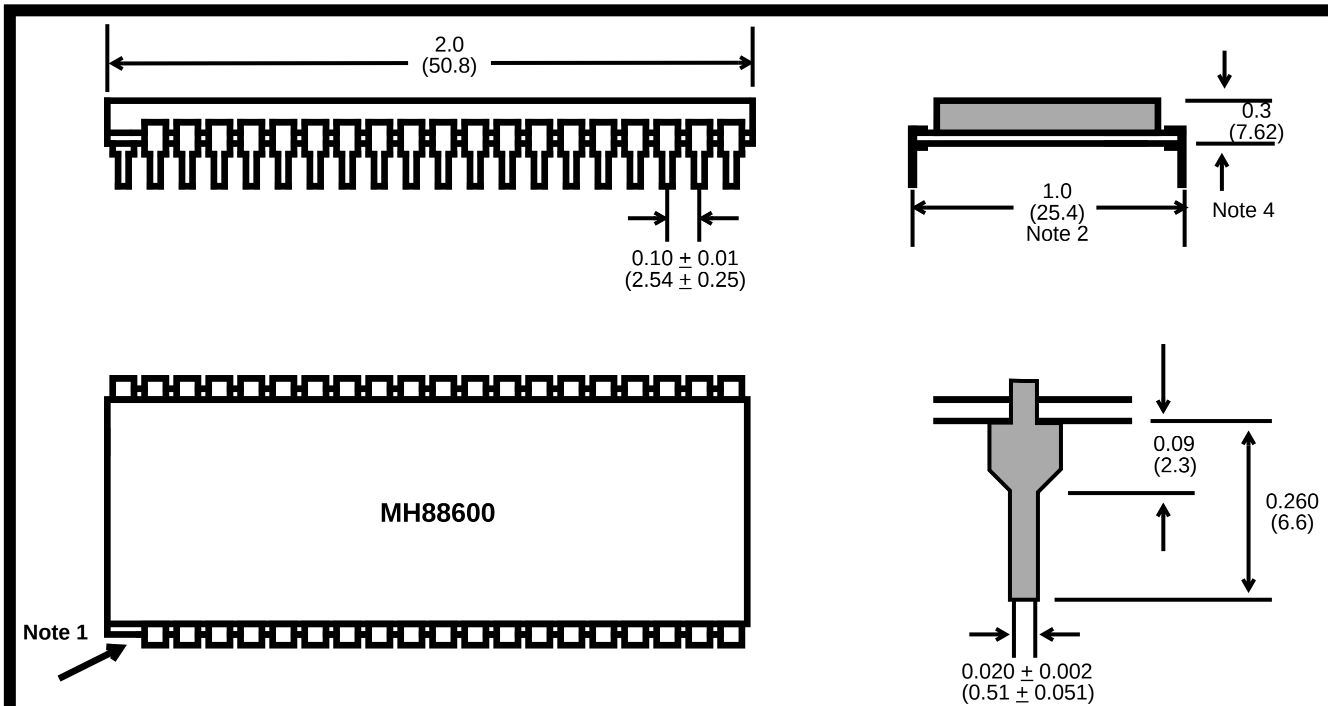



**Figure 8 - Using an External Network to Match any Zo**




**Notes:**
1) Pin 1 not fitted.
2) Row pitch is to the centre of the pins.
3) All dimensions are typical and in inches (mm).
4) Seated Height
5) Not to scale

**Figure 9 - Mechanical Data**