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Application Note **MSAN-151**

Implementation Details for the MH88615 SLIC

Contents

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1. Overview

The MH88615 is a subscriber line interface circuit (SLIC) which provides the interface between a telephone and a codec. The functions provided by the MH88615 include 2-4 Wire conversion, constant current line feed, on board ringing amplifier, power denial, signalling and control. Different variants are provided to meet different line impedances.

This application note is intended to assist the user in implementing an analogue line interface circuit. Please refer to the MH88615 datasheet for parametric details.

Typical applications include Pair-Gain systems, Internet Surfboards, Terminal Adapters and Multiplexers. A basic application is shown in Figure 1.

2. Power Up Sequence

When powering up the MH88615 the user should ensure that the VEE supply rail is connected before, or at the same time as, the VDD supply rail. If the user were to power up the VDD supply rail first it is possible to cause one of the operational amplifiers on the hybrid to latch up. This is a non-destructive condition. If it were to happen simply powering down the hybrid and re-applying the power correctly will overcome the latch-up condition.

If the user cannot guarantee that the correct power up sequence will be followed then by adding two Schottky diodes in their application, as shown in Figure 2, the circuit will not latch-up.

3. Signalling

The MH88615 provides control signals for Ringing and Power Denial and provides indication of Switch Hook status.

3.1 Ringing

Ringing is enabled by setting RC (pin 11) to logic 1. When the subscriber set goes off-hook, the DC loop current will be detected within a maximum of 200 ms and the $\overline{\text{SHK}}$ output will go to a logic 1. Ringing is not automatically disabled on ring trip. A suitable circuit which automatically disables ringing is shown in Figure 3. This circuit will ensure that the Ringing Control signal is taken low within 200ms of receiving a Switch Hook signal. It will also fulfill the criterion that the RC signal must not be taken high again within 400ms of receiving the SHK signal to allow DC loop current to stabalize.

3.2 Power Denial

The battery voltage may be effectively isolated from the loop driver circuit under the control of the Power Denial (PD) pin (pin 12). This pin should be set to a logic 1 to enable Power Denial. The resulting loop current is negligible and power consumption is minimized. This function is useful for disabling a loop which may have a ground fault. Note that the off-hook state cannot be detected with power denial applied.

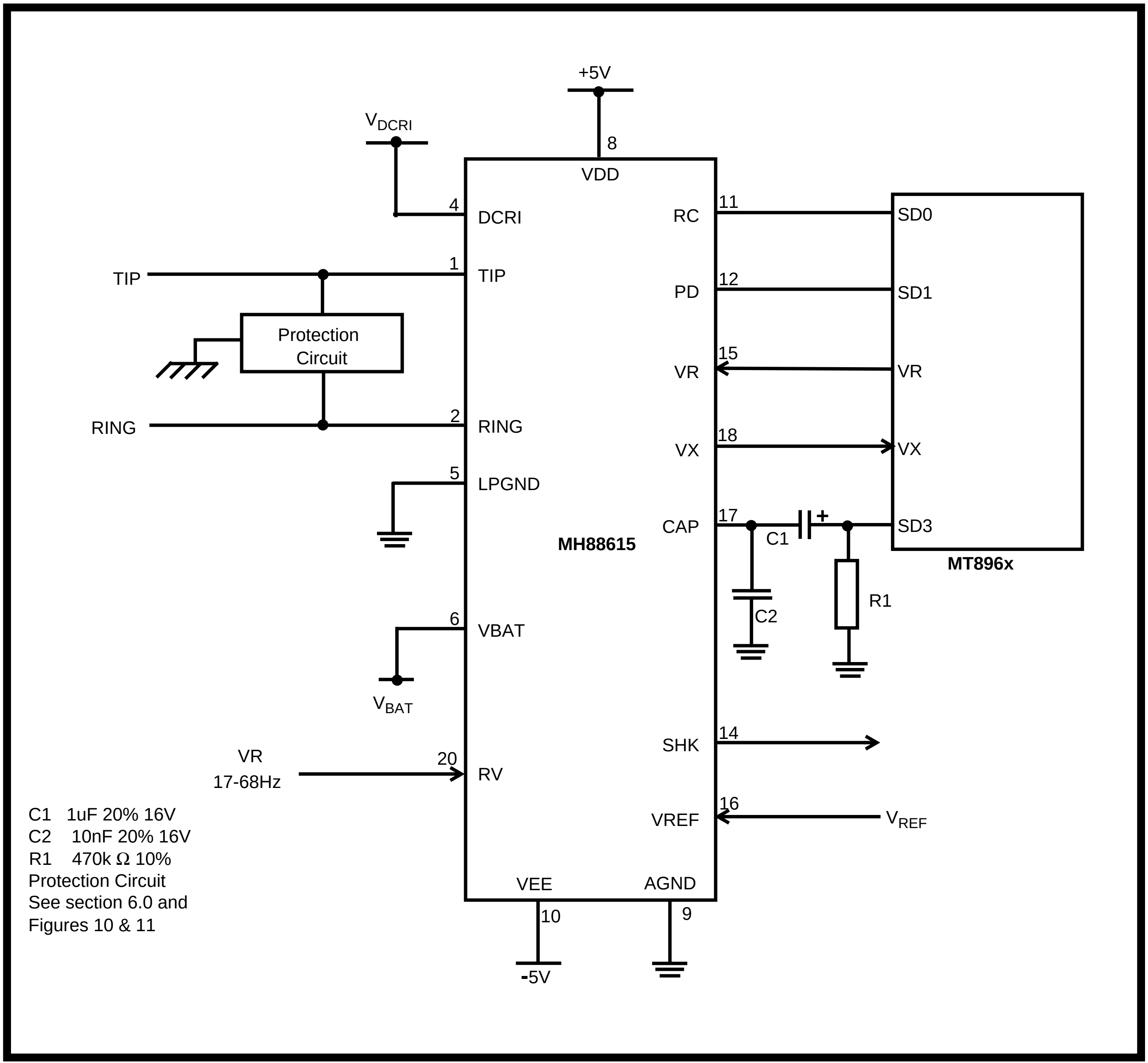

Figure 1 - Basic Application Circuit

3.3 Switch Hook Detection

The SHK output (pin 14) is set to logic 1 when the DC loop current exceeds the internally set threshold of typically 10mA indicating that the subscriber set has gone off-hook.

Dial pulses can be detected by monitoring the interruption rate at the SHK pin. These pulses may need to be debounced by the system software.

For switch hook detection during ringing a 1µF capacitor will provide adequate attenuation of ringing frequencies. This capacitor must be switched in during ringing and must be switched out during pulse dialling if dial pulse detection is required. This may be achieved using either a transistor (see Figure 4), relay or sense drive output of a CODEC (see Figure 1). If only DTMF signaling is required, the capacitor may be left permanently connected.

Once SHK goes high Ring Control should be kept low for a minimum of 400ms to allow the DC control loop sufficient time to stabilize.

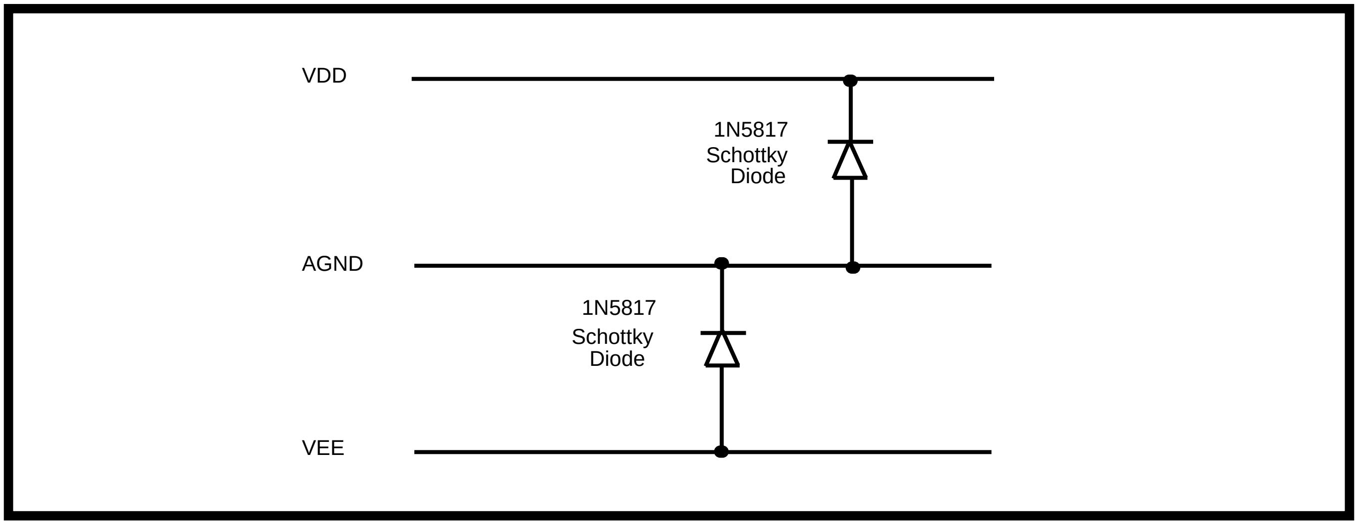

Figure 2 - Latch-up Protection

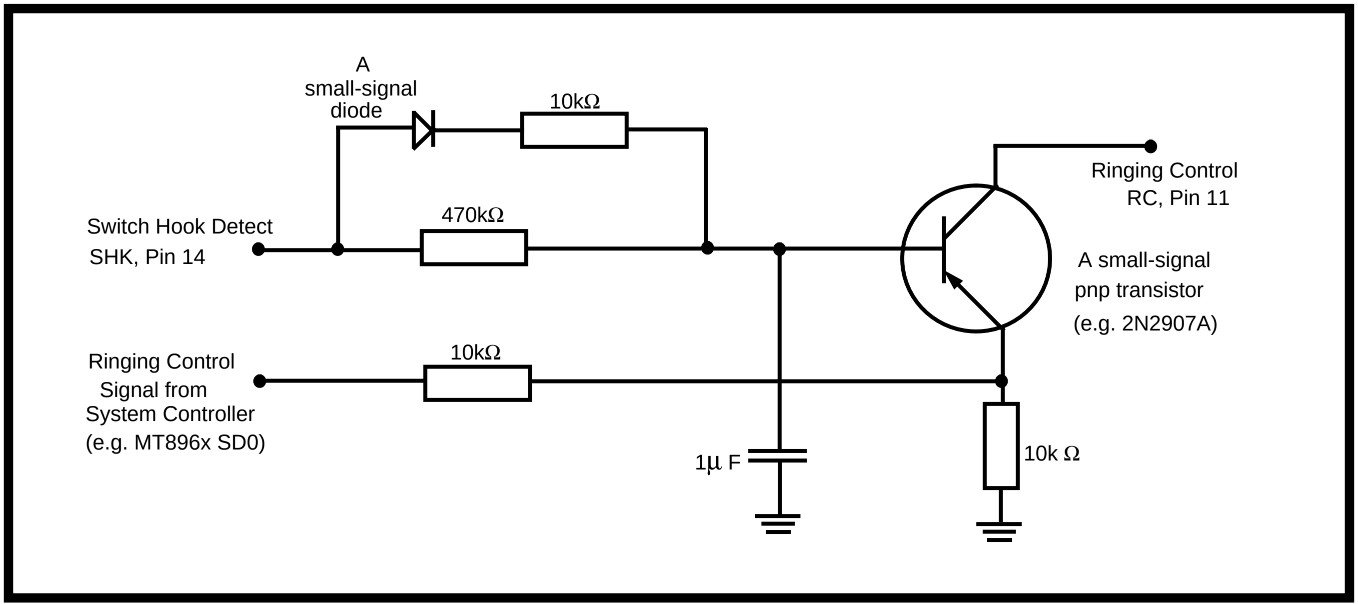

Figure 3 - Ring Trip Circuit

4. Line Current Feed and Battery Voltage

The MH88615 employs a complex feedback circuit to supply a constant current feed to the line. The loop current may be programmed by applying a DC reference voltage to V_{REF} (pin 16). The loop current can be found using the following equation:

$$I_{LOOP} = -(0.52\ V_{BAT} + 4.24\ V_{REF})\ \text{mA}$$

For example if V_{REF} is connected to ground and Vbat is -48V,

$$I_{LOOP} = -(0.52 \times -48 + 4.24 \times 0)\ \text{mA}$$

$$I_{LOOP} = -(-24.96) \approx 25\ \text{mA}$$

V_{REF} should be supplied from a low impedance source.

V_{REF} may be adjusted to supply loop currents outside the recommended 18-30mA range, although performance is not guaranteed.

It should be noted that above 35mA excessive heat dissipation and clipping of the audio signal may occur. The loop current control fails below loop currents of 12mA.

If the loop length is too long, the voltage drop across the combination of line and telephone can prevent the Tip and Ring drivers from supplying the maximum desired loop current. Under these conditions the Tip and Ring drivers become saturated and the audio transmission performance deteriorates.

If a value for V_{REF} other than 0V is required then a solution is shown in Figure 5. R1 and R2 are chosen to produce the correct voltage and this is buffered by the op-amp. The op-amp provides the low impedance source. So, for example, to generate V_{REF} = -2.5V the values R1 = 300kΩ and R2 = 100kΩ could be used.

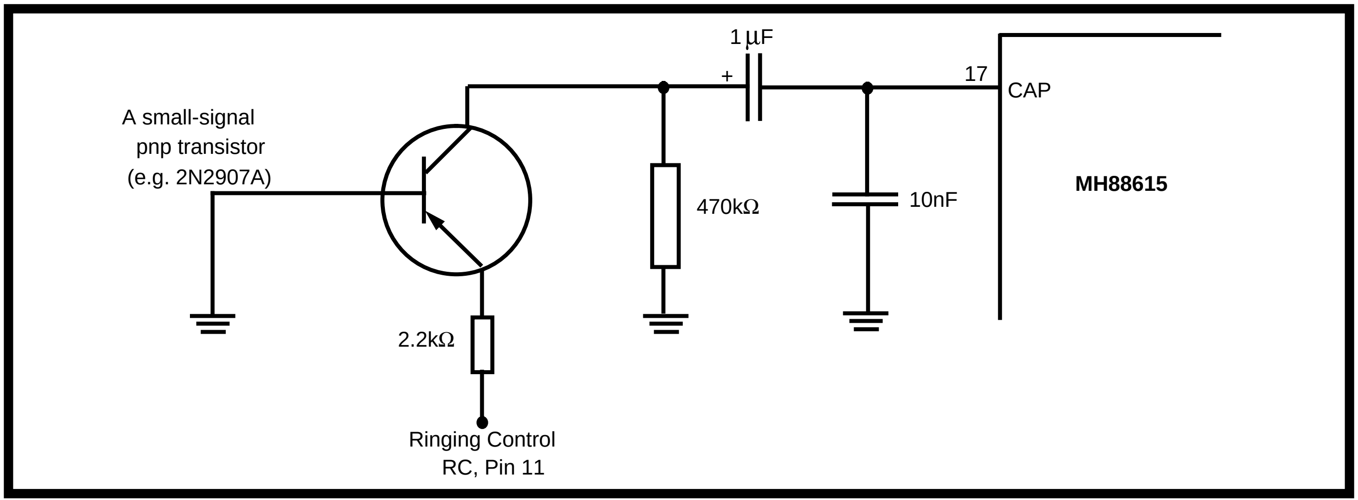

Figure 4 - Ringing Filter Circuit

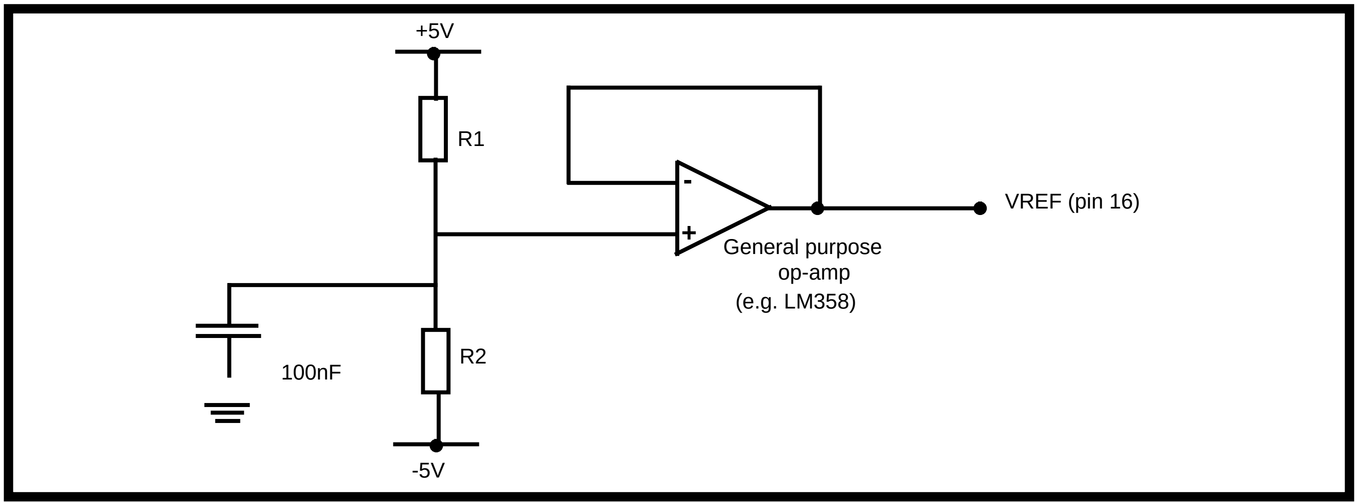

Figure 5 - V_{ref} Generation

5. Ringing Voltage Amplifier

The open circuit output Ringing Voltage is controlled by varying the input voltage at RV,

$$Vtf\text{-}rf = (V_R \times 60)\ Vrms$$

$$V_{ren} = \frac{Vtf\text{-}rf \times Z_{ren}}{Z_{ren} + 200}$$

(assuming zero line length)

Thus if a 75Vrms signal is required at Vtf-rf then the input level should be 1.25Vrms. See Figure 9.

Do not use excessive ringing input signals which cause clipping and saturation in the ringing voltage amplifier as this interferes with correct ring trip detection and may cause excessive heat dissipation.

Do not use square waves for ringing input signals as this causes incorrect ring trip detection. Sine wave drive is strongly recommended. However, if necessary, a TTL square wave can be suitably conditioned using the filter shown in Figure 6.

The input to the ringing section, RV (pin 20), must be ground referenced with a low resistance DC path to ground. Any DC offset in the input signal will result in a corresponding shift in the output voltage (multiplied by 60). This may result in clipping of the ringing signal. The input voltage RV must be chosen so that the ringing output is not driven into saturation. The input impedance at this pin is typically 5.5kΩ. The input to RV can be AC coupled using a series 1µF capacitor followed by a 1kΩ resistor to ground.

5.1 Ringing Oscillator

Figure 7 shows a simple Wien Bridge oscillator circuit which may be evaluated for use as a ringing oscillator. The oscillator frequency for this circuit is given by:

$$Fosc = \frac{1}{2\pi \times 68 \times 10^3 \times Cring}$$

Frequency (Hz)	Cring (nF)
19.5	120
23.4	100
34.4	68
49.8	47

Table 1 - Possible values for Cring

Capacitor values are all from the E24 range.

The output amplitude is controlled by Ra such that

$$Ra \approx \frac{V_o \times 500 \times 10^3}{2.5}$$

Where V_o is the required input voltage to RV (pin 20).

This circuit will not be suitable for all applications especially if low total harmonic distortion of the ringing signal is essential to the application. There are other oscillator circuits, including variations on the one given here, which may also be considered.

5.2 Ringing Supply Voltages

During ringing (Ringing Control pin 11 is set to logic 1), the MH88615 uses both the V_{BAT} and the V_{DCRI}

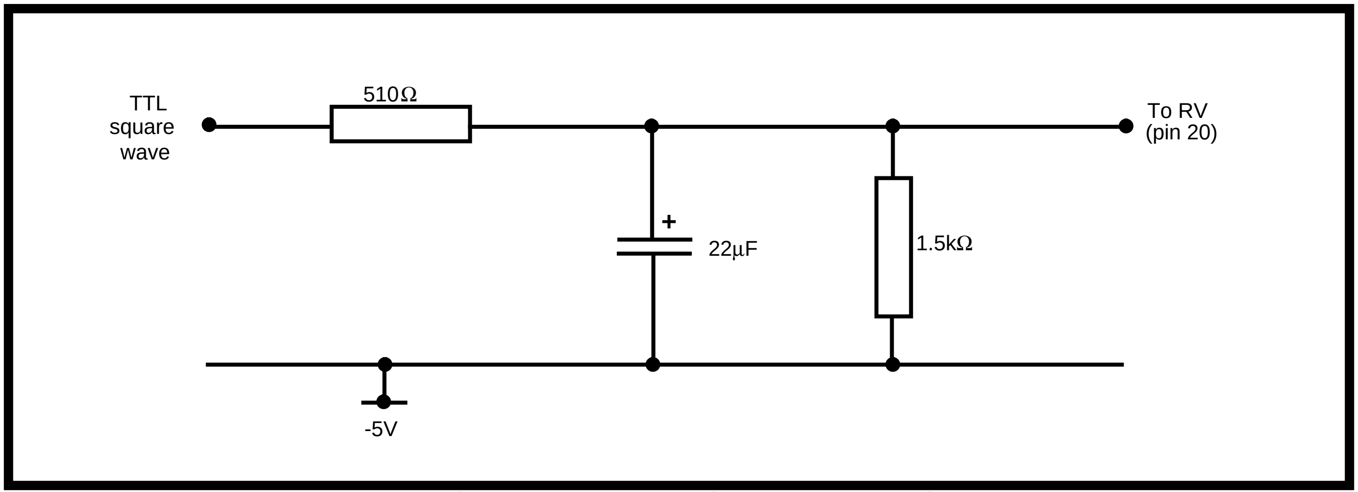

Figure 6 - Suggested Square Wave Filter

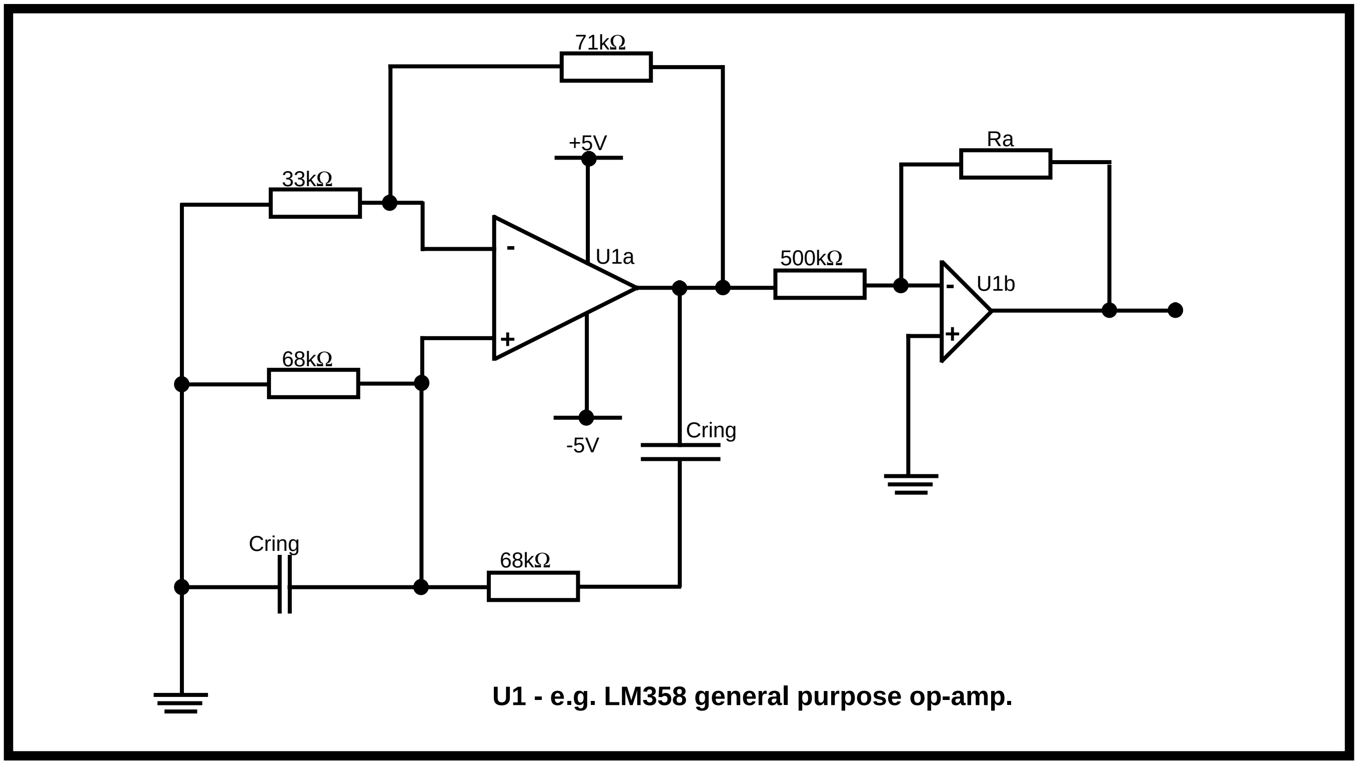

Figure 7 - Suggested Ringing Oscillator

supplies to power the output stage. The maximum open circuit voltage swing that can be accommodated is given by:

$V_{tf-rf} = (0.602\ V_{DCRI} - 0.6\ V_{BAT} - 2.0)$ Vrms.
See Figure 8.

V_{tf-rf} is the voltage across the Tip and Ring feed stages and is not accessible externally (see Figure 9). This voltage is fed to line via 2 x 100Ω resistors. To determine the actual Tip-Ring voltage available under worst case load, the maximum line length and maximum Ringer Equivalent Number (R.E.N) must also be taken into account.

Rloop is the resistance of the telephone loop. Typical loops have a resistance of 168Ω per km (154Ω. per 3000ft). The typical loop capacitance is 50nF per km (46nF per 3000ft) and so at ringing frequencies (17Hz-68Hz) the capacitive reactance of the line may be ignored.

Z_{LOAD} is the ringing load presented by however many instruments are connected to the line. This value is country dependent but a REN of 1 is typically between 7kΩ and 8kΩ. See Figure 9.

6. Protection Circuit

If the SLIC is to be used in an exposed or "off-premise" application it will usually be required to withstand certain levels of voltage surge and AC power line contact test conditions, which are specified by the PTT in each country (examples of these are CCITT K20 and Bellcore GR-1089).

In practice these conditions originate from lightning strikes or fractured overhead power cables collapsing across telephone lines.

It is the customers responsibility to determine these requirements and implement protection in their system.

Typically a system will require Primary Protection such as a gas discharge tube at the Main Distribution Frame (MDF) and secondary Protection which usually consists of a series element for overcurrent protection and a shunt element for overvoltage suppression. See Figure 10.

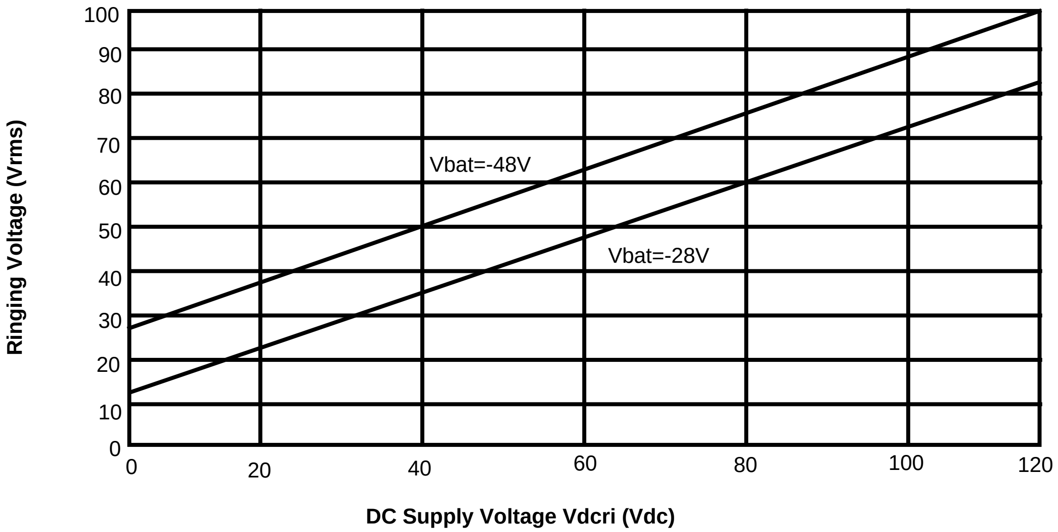

Figure 8 - Maximum Ringing Voltage $V_{tf\text{-}rf}$

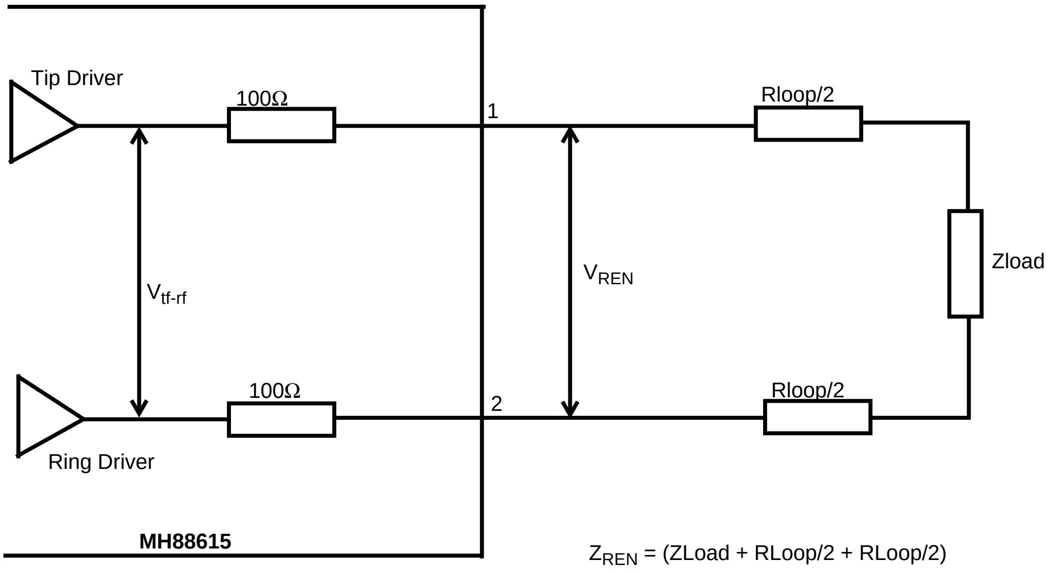

Figure 9 - Maximum Ringing Voltage Vtf-rf

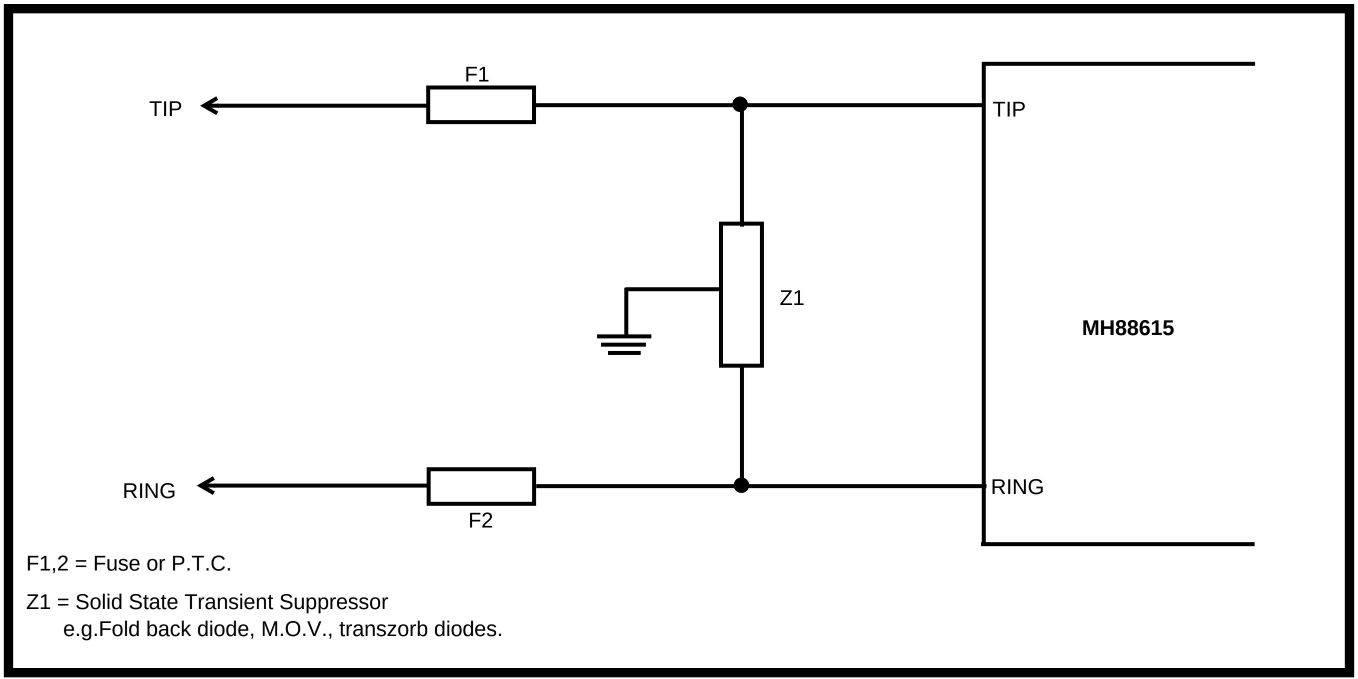

Figure 10 - Typical Secondary Protection Circuit

7. Audio Interface

The receive direction originates on the 4-wire side (VR), is converted to 2-wire and sent to be received by the telephone.

In the transmit direction, the signal is sent from the telephone (2-wire) to the MH88615 where it is converted to 4-wire and transmitted over the TX line.

7.1 Receive Signal

The input to this section, VR (pin 15), must be AC coupled (use 220nF capacitors) or DC coupled and ground referenced with a 0V offset. Any DC offsets will result in an error in the loop current. If the AC signal is not ground referenced there will be an error in the loop current. Under these circumstances the signal must not be DC coupled.

The input impedance is typically 100kΩ.

7.2 Transmit Signal

The output of this section, VX (pin 18), is DC coupled.

The output impedance is typically 10Ω.

8. Design Example

This is an example of how to design a SLIC interface using the MH88615.

The SLIC interface must be capable of driving a REN of 5 (1 REN = 7kΩ) up to 7km. The loop current must be set to 25mA.

Design Procedure

1. Determine the Battery Voltage:

Assuming standard 0.5mm telephony cabling the loop resistance is 7 x 168Ω = 1200Ω approximately.

Tip-Ring Voltage is 1500 x 0.025 = 37.5V. The voltage drop in the feed resistors is 2 x 100 x 0.025 = 5V. This gives Vtf-rf = 42.5V. The transistors in the driver need approximately 2.5V collector-emitter bias, so choosing a battery voltage of -48V is appropriate.

2. Determine the Reference Voltage setting.

The desired loop current is 25mA. With a battery Voltage of -48V V_{REF} should be connected directly to ground.

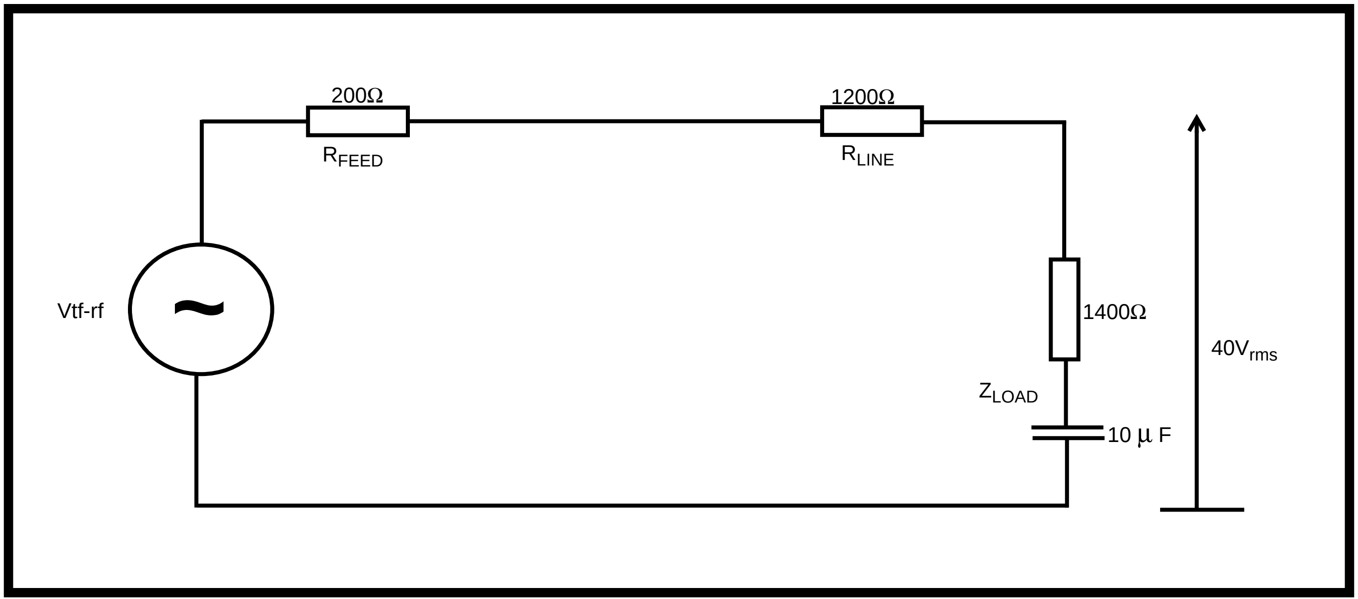

Figure 11 - Ringing Equivalent Circuit

3. Determine the Ringing Voltage output requirement.

Assuming that each telephone requires 40V to energize the bell, then V_{LOAD} = 40V. As the load is 5 telephones, each with an impedance of 7kΩ in parallel, then the total R_{LOAD} is 1400Ω. The equivalent circuit is shown in Figure 11.

Vtf-rf = 2800 x 40/1400 = 80Vrms

4. Determine the Ringing Power Supply requirement.

As a ringing voltage of 80Vrms is required, with a battery voltage of -48V, from Figure 8 the minimum V_{DCRI} is 90V approximately. Choosing 96V DC for V_{DCRI} ensures additional headroom and may be generated from -48V by using a voltage triple circuit.

5. Determine the Ringing Voltage input.

$RV=V_{tf-rf}/60$
RV = 80/60 = 1.33 Vrms

6. This design can be implemented using the schematic of a Basic Application Circuit shown in Figure 1.

Use V_{BAT} = -48V
V_{REF} = 0V
V_{DCRI} = 90V
V_R = 1.33V

9. Additional Reference Material

MH88615 Data Sheet.

MSAN-131 Subscriber Line Interface for Digital Switching Systems.

Glossary of Telecommunications Terms (see section G1 of Mitel Telecom Components Data Book issue 10).

Notes: