
Abstract

The Zarlink Le77D21 device is a highly integrated two-channel Subscriber Line Interface Circuit (SLIC) device designed to work with the Le78D11 Subscriber Line Audio-Processing Circuit codec/filter. This application note details a solution that allows the codec/filter to detect and inform the system of a ground start event, while the SLIC device is in a simulated Tip Open mode (Disconnect state), using a voltage sense input in conjunction with an external circuit.

1.0 GROUND START SIGNALING OVERVIEW

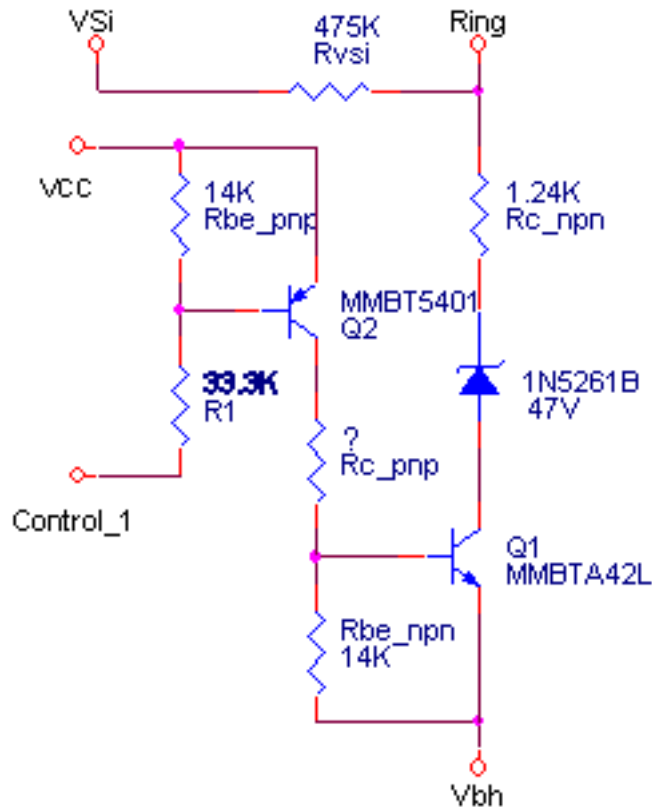
Ground start signaling is a method of access line signaling which requires the customer interface (CI) to provide a ground on the ring conductor at the network interface (NI) to initiate service requests. The service request is usually done by a Private Branch Exchange (PBX). A Central Office (CO) connected to a ground start PBX is usually in a tip open state and acknowledges the service request by grounding the tip lead (a description of the steps required for an outgoing / incoming call are detailed in a later section of this document). The Le77D21 device is capable of using its standby or active states to bring the tip lead as close to ground as possible but does not have a tip open state to select when there is no activity on the line.

In order to use the Le77D21 device in a ground start application, the Tip Open mode has to be mimicked by putting the SLIC device into Disconnect. In the Disconnect state, the tip and ring leads are changed to high impedance causing the tip to look like an open circuit to the PBX. However, in the Disconnect state, the codec/filter is unable to monitor the ring lead through the SLIC device for a ground start event. Therefore, the codec/filter will have to inform the system of a ground start event by using one of its two voltage sense inputs to monitor the ring lead through an external circuit (see [Figure 1](#)).

The ground start detection circuit is made up of transistors, resistors, and a Zener diode so the cost added to a design is minimal. When the circuit is enabled, the codec/filter will monitor the ring lead using a voltage sense input (one per channel). An interrupt will occur if the PBX grounds the ring lead causing the voltage on ring to fall below a predetermined programmable threshold of the codec/filter. When disabled, the circuit is high impedance and will have minimal affect on longitudinal balance or operation in other states. The circuit has to be controlled from an I/O of the host processor.

2.0 EXTERNAL CIRCUIT

Figure 1. Ground Start Detection Circuit



3.0 EQUATIONS

Three equations are required for using the external circuit — two for choosing the appropriate component based on the high battery of the system and one for choosing an appropriate threshold for the voltage source input of the codec/filter.

3.1 Zener Diode

The zener diode is used to ensure a voltage of less than -56 V on the ring during the Tip Open state. There is an indirect expectation that the loop current during the ring to ground state will be greater than 17 mA (TIA 464 section 4.1.1.4.3). In order to meet this expectation the value of the Zener diode needs to be chosen so that when the SLIC device is in the High battery state, it is driving the ring lead with approximately -50 V through R_{c_nnp} . R_{c_nnp} was then chosen so that with the -50 V , a maximum of 2000 ft 26 AWG, fuse resistors, and a ring to ground, there is nominally 25 mA of loop current during the ring to ground state.

$$V_z = \sim -50\text{ V} - V_{bh}$$

Note:

A value of -50 V was chosen to keep well below the -56 V specified in 60950 during the silent period of ringing. A High battery of no less than $\sim 50\text{ V}$ is recommended for this part.

3.2 R_{c_pnp}

R_{c_pnp} is chosen based on the high battery voltage level. This resistor provides a current limit for the base drive of the npn transistor if the pnp transistor is saturated. R_{c_pnp} also sets the ring to ground current along with the series resistor.

$$R_{c_pnp} = (V_{cc} - V_{bh} - V_{be}) / (i_{b_nnp} + 50\text{ }\mu\text{A})$$

Note:

$V_{cc} = 3.3V$ I/O, V_{be} is the base to emitter voltage of the pnp in saturation $\sim 0.7V$

$ib_{npn} = I_{loop} / (\text{Beta of transistor})$

Typical V_{be} is approximately $0.7V$. ib_{npn} is directly proportional to the loop current and indirectly proportional to the beta of the npn transistor and has been setup to be approximately $625 \mu A$.

3.3 Voltage source input threshold

The voltage on the ring lead will be monitored through a $475 k\Omega$ resistor by a voltage source input (VSi) of the codec/filter. When the VSi voltages sensed by the Le78D11 device drops below a programmable threshold (TVS), the Le78D11 device signals this condition by setting the appropriate VSi bits in the Global Device Status register. The TVS need to be set in between the voltage from ring to ground during the Ring to ground event and the voltage from ring to ground during idle current draw by the PBX through leakage resistance.

$$V_{Si} \geq (-V_{bh} - V_z) * (R_{total} / (R_{total} + R_{c_nnp}))$$

Note:

R_{total} is the sum of the following three line conditions: 2000 ft of 26AWG of wire or $\sim 160 \Omega$, 50Ω of fuse resistance and 550Ω from ring to ground created by the PBX. $R_{total} = 760 \Omega$

$$V_{Si} < (-V_{bh} - V_z) * (R_{leakage} / (R_{leakage} + R_{c_nnp}))$$

Note:

$R_{leakage}$ can extend up to $10 k\Omega$ of resistance.

When setting the sense threshold using the Write Loop Supervision Parameter command, a positive value should be used while monitoring negative voltages.

4.0 EXAMPLE CALCULATIONS

Assume the following:

$$V_{bh} \text{ is } -98 V$$

There is a maximum of 2000 ft 26 AWG of wire between the CO and the PBX.

There is $10 k\Omega$ of ring feed leakage resistance from ring to ground.

To ensure that about $-50V$ is applied to the ring lead:

$$V_z = -50 V - V_{bh} = 48 V \text{ (the closest actual voltage rating of a Zener is } 47V \text{ +/- } 5\%)$$

$$ib_{npn} = 25 \text{ mA} / 40 = 625 \mu A$$

$$R_{c_pnp} = (V_{cc} - V_{bh} - V_{be}) / (ib_{npn} + 50 \mu A) = 149.0 k\Omega$$

$$V_{Si} \leq (98 V - 47 V) * (760 \text{ Ohms} / (760 \Omega + 1240 \Omega)) \leq 19.38 V$$

$$V_{Si} > (98 V - 47 V) * (10 k\text{Ohms} / (10 k\Omega + 1240 \Omega)) > 45.37 V$$

To ensure that the VSi causes an interrupt when ring to ground is applied and at no other time, select a threshold halfway between the two values.

4.1 Example Calculation BOM

Part Type	SM Size / TH Spacing	Vol/Tol.	SM / TH	Qty.	Designation	Vendor/ Part Number
Resistors						
475K 1%	0603	1/16W	SM	1	Rvsi	Panasonic -ECG / ERJ-3EKF4753V
1.24K 1%	1206	1/4W	SM	1	Rc_npn	Yageo America - 9C12063A1241FKHFT
182K 1%	0603	1/16W	SM	1	Rc_pnp	Panasonic -ECG / ERJ-3EKF1823V
14K	0603	1/16W	SM	2	Rbe_npn, Rbe_pnp	Panasonic -ECG / ERJ-3EKF1402V
33.2K	0603	1/16W	SM	1	R1	Panasonic -ECG / ERJ-3EKF3322VV
Transistors						
	SOT-23	300V	SM	1	Q1	Diodes Inc. / MMBTA42-7
	SOT-23	150V	SM	1	Q2	Diodes Inc / MMBT5401
Zeners						
	D0-35	47V/ .5W	SM	1	D1N750	Diodes Inc / 1N5261B-T

5.0 GROUND START SIGNALING SCENARIOS

5.1 Steps of Outgoing Ground Start Call

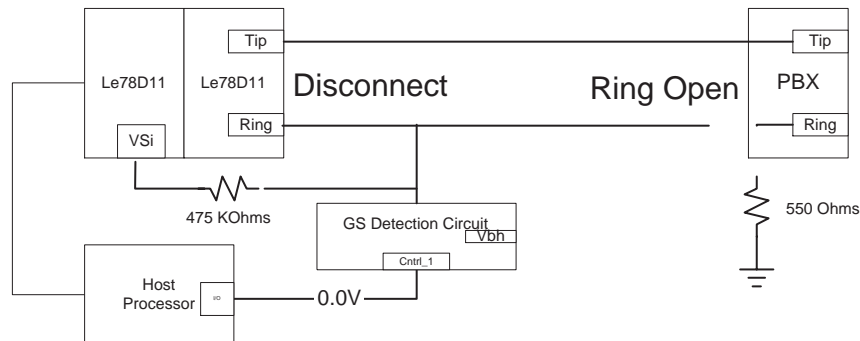
PBX Calling/Seizing C.O. (Le77D212 Device):

Step 1: Idle, The C.O. (Le77D21) is in the Disconnect state and the PBX is in the Ring Open state.

Note:

To allow the VSi pin to detect a voltage change on ring, the codec path must be activated after the SLIC device is put into the Disconnect state.

Figure 2. SLIC Device in Disconnect/PBX with Ring Open

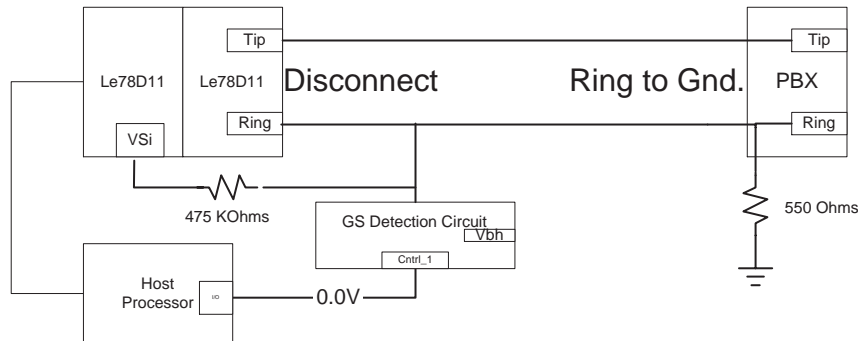


Step 2: The PBX grounds the Ring lead through 550 Ω to initiate the call. The voltage sense pin of the Le78D11 device will fall below a predefined threshold indicating a fault in the form of a power interrupt in the Global Device Status Register.

Note:

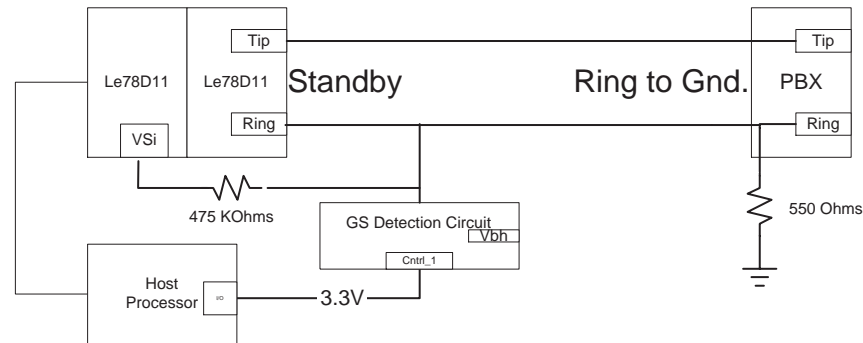
Note an off hook indication may occur at this point but is a don't care.

Figure 3. The PBX grounds Ring through 550 Ω



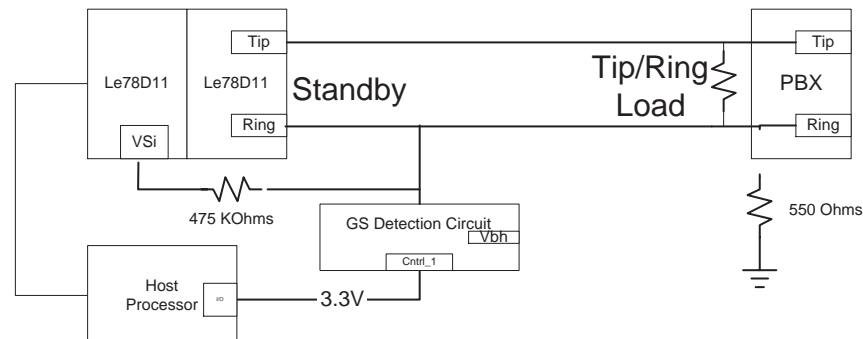
Step 3: To acknowledge the call, the Le77D21 device is put into the Standby state to bring Tip as close to Ground as possible and the sense circuit is disabled by changing the I/O from low to high.

Figure 4. Sense Circuit Causes an Interrupt and Places the SLIC Device into the Standby State



Step 4: When Tip approaches 0 V, the PBX will remove the ground from the Ring lead and connect a load across tip and ring. Once the ground is removed from the ring lead the power interrupt (fault) condition will be removed. When the PBX places a load across Tip and Ring, an off hook indication will occur.

Figure 5. PBX Detects Tip to Ground and Applies a Load Across Tip and Ring



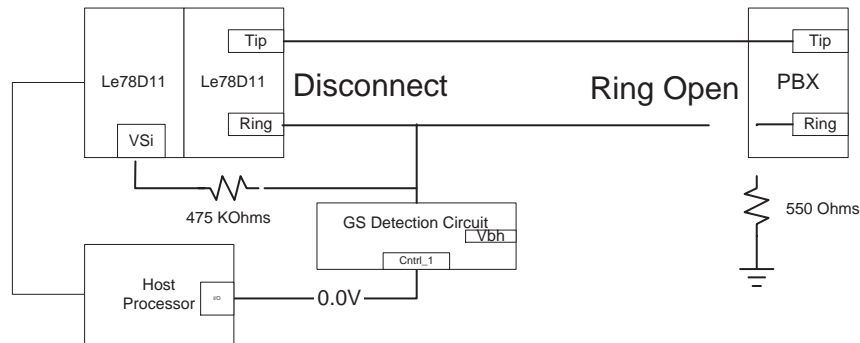
Step 5: The C.O. detects the off-hook and places the Le77D212 device into the Active state.

5.2

Steps of incoming Ground Start Call

C.O. (Le77D21 device) Calling/Seizing PBX:

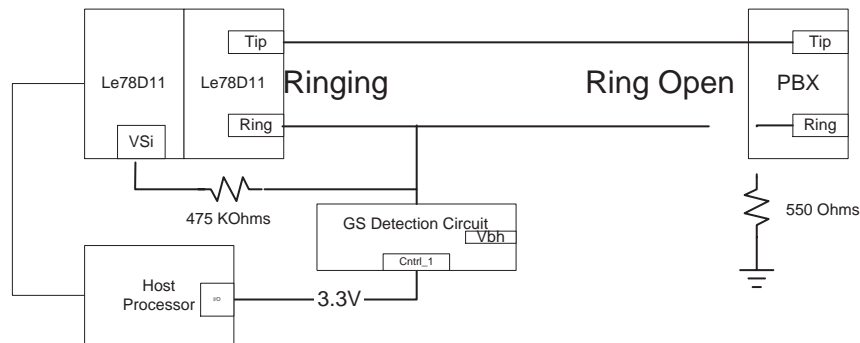
Step 1: Idle: The C.O. (Le77D21 device) is in the Disconnect State and the PBX is in the Ring open state. When the CO initiates a call the external circuit is disabled.

Figure 6. SLIC Device in Disconnect/PBX with Ring Open

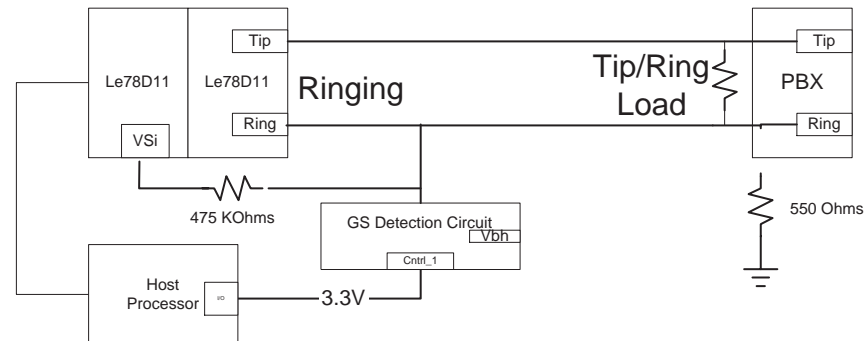
Step 2: The C.O. is switched into a ring cadence.

Note:

Considerations about the ring signal have been made below.

Figure 7. Ground Start Detection Circuit is Disabled and Ring Cadence is Started

Step 3: The PBX will detect the ringing signal on the ring lead or a ground on the tip lead and apply a load across Tip and Ring.

Figure 8. Le77D212 Device Detects Load Across Tip and Ring and Switches to Active State

Step 4: Le77D212 device will detect the load across tip and ring and switch to the Active state.

5.3 Ring Signal Considerations

The ring signal of the Le77D212 device is based on always having one amplifier near ground. Therefore, by applying the correct amount of DC offset to the SLIC device an unbalanced ringing signal can be generated.

To keep the tip lead as close to ground as possible during the silent intervals of the ring cadence, the SLIC device needs to be switched into the Standby state or the Active state if CID is needed.

One example of an unbalanced ringing signal can be produced using the following parameters: a Vbh of -98 V, a trapezoidal waveform with a crest factor of 1.2, and a -48 V of offset will produce a 40 Vrms ringing signal on the ring lead.

6.0 CONCERNS

6.1 Tip-to-Ground

EIA TIA 464-B and ANSI T1.401 specify a V-I template that defines a valid tip ground. At low currents on the tip lead of the Le77D21 device (Standby, Active or offset ringing) tip is close to -5 V which is the upper edge of the template. Some PBXs do not interpret this as a tip ground.

6.2 Component Concerns

Due to the amount of current that may be sunk through R_{c_nnp} and V_z , component failures may occur if underrated components are used in the ground start detection circuit. Depending on the amount of time that elapses between the PBX grounding ring, the host processor servicing the interrupt and disabling the ground start circuit, high wattage components may be required. The R_{c_nnp} could see as much as 1 Watt, if the process of servicing the ground start event and disabling the circuit takes more than 10 to 50 ms. Likewise, if V_{bh} was -98 V as it was in the previous example, the Zener diode could dissipate as much as 1.25 W if the ground start circuit is not disabled quick enough.

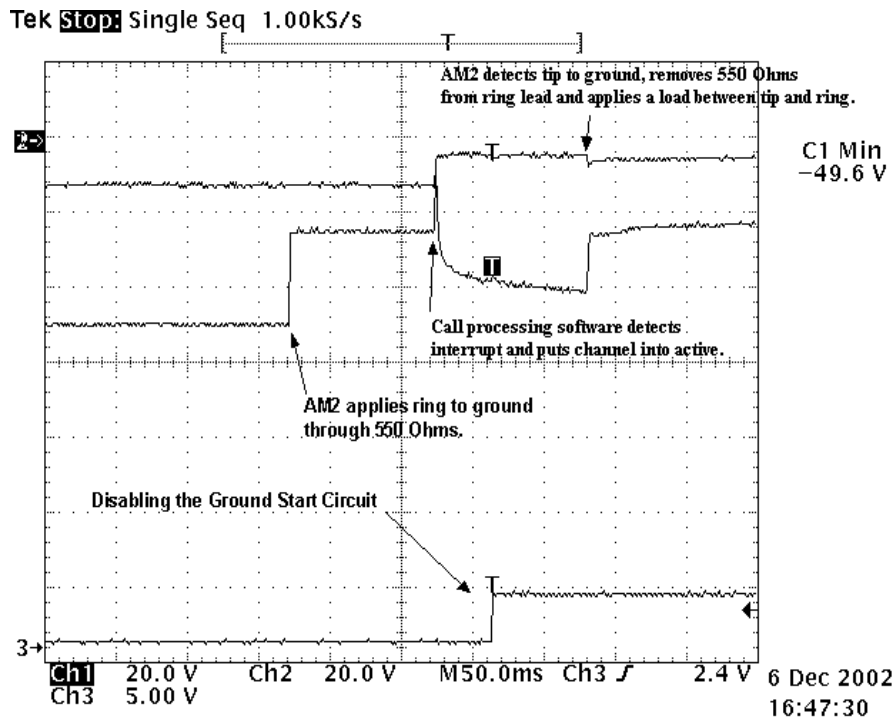
7.0 TEST RESULTS

To ensure that the ground start circuit is properly functioning an Ameritec AM2S Squirt® call processing box was used to test the ground start circuit during out going and incoming calls. A Wandel & Goltermann PCM4 was then used to take a longitudinal balance measurement.

7.1 Outgoing Call

An outgoing call was made to test the ability of the circuit to detect a ground start. The design was able to detect a ground start, put the tested channel into active and disable the ground start circuit in less than 200 ms (See Figure 9). Note that the time between the ring to ground and the part going to Active is dependent upon the speed of the call processing software.

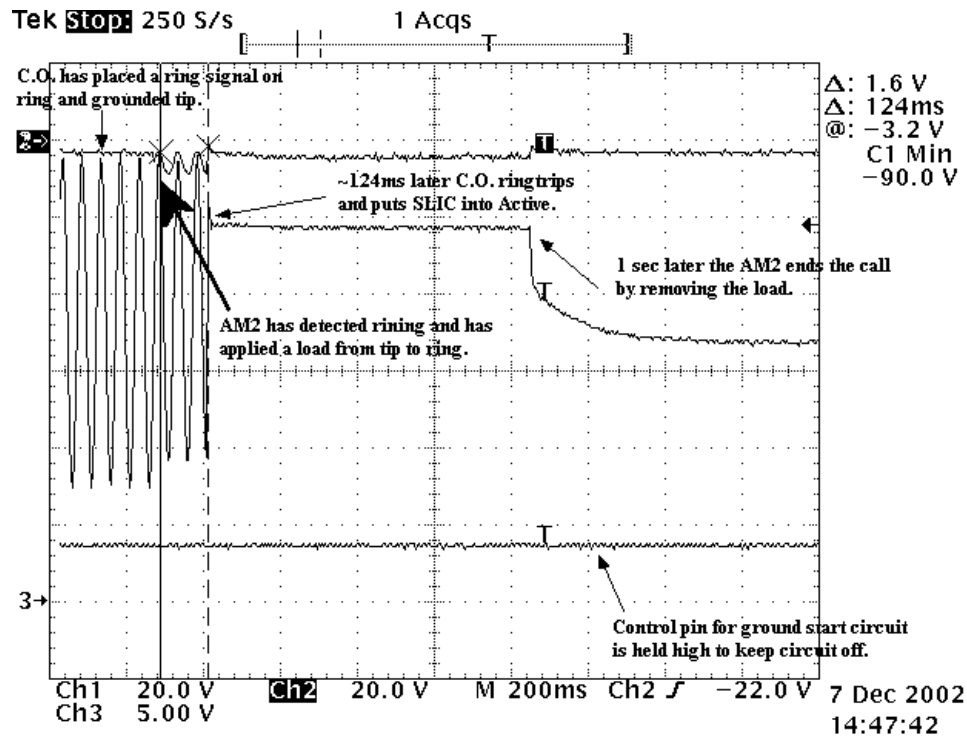
Figure 9. Outgoing Call from AM2 to C.O.



7.2 Incoming Call

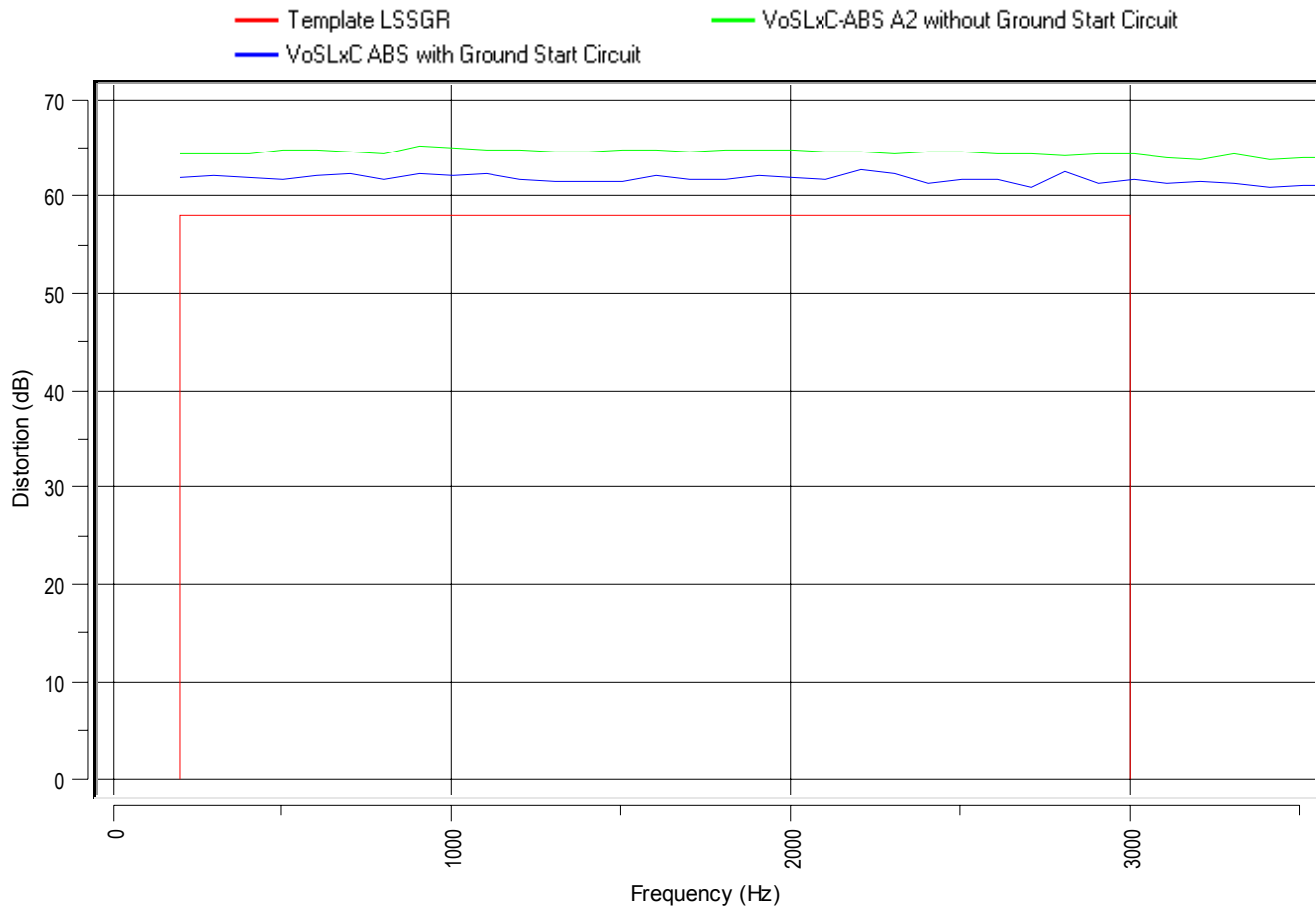
An incoming call was made to ensure the circuit components were able to withstand the high voltages during ringing. The test also determines if the Le77D21 device provided a sufficient ringing signal to the AM2 to initiate a call. Note the AM2 detects an out going call by monitoring the ring lead for a ring signal. Some PBXs monitor the tip lead for a ground

Figure 10. Incoming Call from C.O. to AM2



7.3 Longitudinal Balance

In order to keep the cost of the circuit low, less than ideal components were used. Therefore, longitudinal balance measurements were taken with the PCM4 both before and after the circuit was added to the line to ensure that the leakage currents of the transistors cause little to no degradation in performance (see [Figure 11](#)).

Figure 11. Longitudinal Balance results**Longitudinal Balance (B21) 600 (Li: ---, Lo: ---, Input Level -10, a-law)**



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