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System Application Note

AN-5 *Telco interface design for echo elimination*

L9002VX / VX2 Code Division Spread Spectrum Telephone Chip

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Audio Echo Design Analysis

In digital cordless phone designs, buffering delay in between the base and the handset base band processors will amplify telephone interface (telco) audio echo.

In United States the local telephone loop was built up over 100 years with telco impedance measured at the RJ-11 phone jack following a statistical distribution targeted at the 600ohm mean value. Therefore telephone base station design to match this 600ohm target will result in a varying amount of reflections depending on the particular local telephone line. It is therefore important to design the analog network configuration to minimize on the reflection effect from any impedance mismatch that is going to exist in the real world.

This signal reflection is less noticeable in old analog phone design because the feedback is instantaneous to the handset earpiece similar to the experience of side tone. In digital cordless phones employing time-division duplex (TDD) designs such feedback will result in audio echo whose delay is a function of the buffering delay in the base band processor.

Active circuit matching for typical base station designs

Please see figure 1 for a general implementation of a telco interface design employing 2 Op Amps. Detail component circuits are included in the appendix.

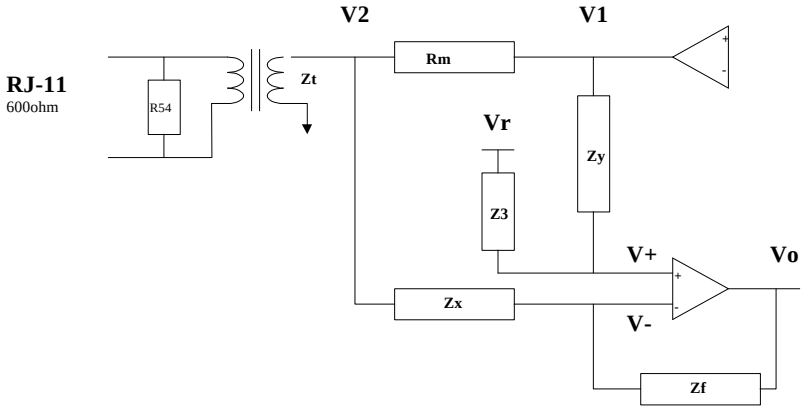

Figure 1: General representation of Telco interface network.

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Analyze the above circuit with the following abbreviations:

Zx: R64 in series with C67, denoted by == , R64^C67

Zf: R65 in parallel with C70 == R65 // C70

Zt: impedance of the line transformer looking in from node V2, when the telco connection is made.

Zy: [(R55 // C61) ^ (R59 ^ C65)]

Z3: R60 // C64

Rm == R52

Further use the following network labels:

V1: Junction of R55 and R52.

V2: Junction of R52 and transformer T1.

V+: Voltage at pin 10 of Op Amp U4C

V-: Voltage at pin 9 of Op Amp U4C, which equals to V+ when active.

Vr: Voltage at junction of R60 and C56.

Vo: Voltage at pin 8 of Op Amp U4C

Then the following voltage and current equations have to exist according to circuit laws:

$V+ = (V1 - Vr) * (Z3 / (Z3 + Zy)) + Vr$ (1): voltage divider.

$(V2 - V+) / Zx = (V+ - Vo) / Zf$ (2): current sum.

$V2 = V1 * (Zt / (Rm + Zt))$ (3): voltage divider.

Use equations (1) to (3) to express Vo as a function of V1 and Vr:

$Vo = V1 * [(Z3 / (Z3 + Zy)) * ((Zx + Zy) / Zx) - (Zt * Zf)/(Zx * (Rm + Zt))]$

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$$+ \ Vr * (Zy/Zx) * (Zx + Zf) / (Z3 + Zy) \qquad (4)$$

For ideal echo cancellation condition to exist, Vo is independent of V1, which implies:

$$[Z3 / (Z3 + Zy)] * [(Zx + Zf) / Zx] = (Zt * Zf) / [Zx * (Rm + Zt)]$$

After re arrangement:

$$\mathbf{Zy = Zx * [1 + (Rm / Zt)] * (Z3 / Zf) + Z3 * (Rm / Zt)} \qquad (5)$$

Equation (5) is the condition for complete echo cancellation of the base unit telco circuit. However, due to the statistical variance of Zt (as a result of the telco impedance variance), the best matching can be found by targeting the matching resistor (Rm) to produce a 600ohm mean for the RJ-11 interface.

Therefore, if the following conditions are chosen:

Rm = Zt — In this case, placing R54 (1.2K) at the opposite side reduces the variance on Zt. Further assumes the imaginary component of Zt is negligible.

Z3 = Zf — To eliminate the effect of Op Amp offset current from its input pins (pins 9 and 10 of U4C.)

It follows, from equation (5), the condition for echo minimization is:

$$Zy = 2 * Zx + Z3 \qquad (6)$$

The values stated on circuit diagram 1 reflect compromises due to the choice of transformer T1 (hence Ztś matching component with Rm).

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