Bt8960

Interconnection Information
Application Note

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CONEXANT™

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Interconnection Information

This application note recommends interconnections for the Bt8960. These configurations are currently being tested by Conexant and may not be optimal or final. Bt8960 applications with data rates of 160, 288, and 416 kbps are included.

The five main areas of the Bt8960 interconnections are:

1. Transmission Line Interface, including the Compromise Hybrid
2. Line Driver Gain Control
3. External Pulse Shaping Filter
4. Voltage Reference and Compensation Circuitry
5. Oscillator/Clock Interface

Transmission Line Interface

The transmission line interface comprises the compromise hybrid, two impedance matching resistors, the line transformer and two antialiasing filters. Figure 1 illustrates the interconnections. Table 1 and Table 2 list the component values recommended for data rates of 160, 288, and 416 kbps.

The purpose of the compromise hybrid is to model the impedance of the transmission line. This model generates an approximation of the transmitted signal's echo. The echo replica is then subtracted from the signal on the line transformer to generate a first order approximation of the received signal. The Bt8960 includes a dual differential analog input to accommodate a wide range of hybrid topologies using only passive components.

Hybrid component values have been determined via calculations and simulations that optimize the echo cancellation functions at the frequencies of interest for the loops specified. For 160 and 288 kbps operation, the hybrid components were optimized for the loops specified in the ANSI T1.601-1992 specification (ISDN loops). For 416 kbps operation, the ISDN loops were shortened by a factor of 0.8 in the signal flow taps (bridge taps were not changed).

In order to maximize digital echo cancellation within the Bt8960, it is important that the compromise hybrid transfer function be highly linear. Therefore, we recommend that all capacitors used in the hybrid be film or NPO ceramic capacitors because of their highly linear characteristics.

Although the Bt8960 contains a digital Echo Canceller (EC), the hybrid is needed to reduce the signal level input to the Analog-to-Digital Converter (ADC). This eliminates ADC overflow for short loops and increases the resolution of the digitized receive signal for better digital signal processing performance.

Impedance matching resistors are placed in the transmit path so that the output impedance of the line interface more closely matches the impedance of the transmission line and load. This maximizes the power transferred to the receiver on the other end of the line. The load is assumed to be 135 Ω

The line transformer provides DC isolation from the transmission line by creating a high-pass filter. The winding ratio of the transformer must be 2:1 (line side:circuit side) to generate the appropriate voltage level on the line. The primary inductance (L) of the transformer (line side) is a very critical parameter. If the inductance is too high, the cutoff frequency of the filter will be too low and the Bt8960 Echo Canceller and Equalizer will not be able to cancel out the low frequency components of the echo and Inter-Symbol Interference (ISI). If L is too low, part of the information in the signal will be filtered out, thereby decreasing the Signal-to-Noise (SNR) ratio. In addition, the line transformer must meet certain return loss requirements to maximize system performance. See Table 3 through Table 6 for the line transformer requirements. Table 7 lists suppliers and part numbers for transformers that have been designed to meet these requirements.

Antialiasing filters are needed to filter out high frequencies that would be aliased back into the passband as noise. These filters can be made of all passive components. The cutoff frequency (f_c) should be as low as possible to achieve maximum attenuation of aliasing frequencies without filtering out the desired signal. The highest frequency in the desired signal is equal to one-half of the symbol rate; therefore, there should be no more than 1 dB of attenuation at this frequency. Table 2 lists the component values recommended for the antialiasing filters. Note that the other components in the hybrid affect the frequency response of the antialiasing filters.

Figure 1. Bt8960 Line Interface Interconnection Diagram

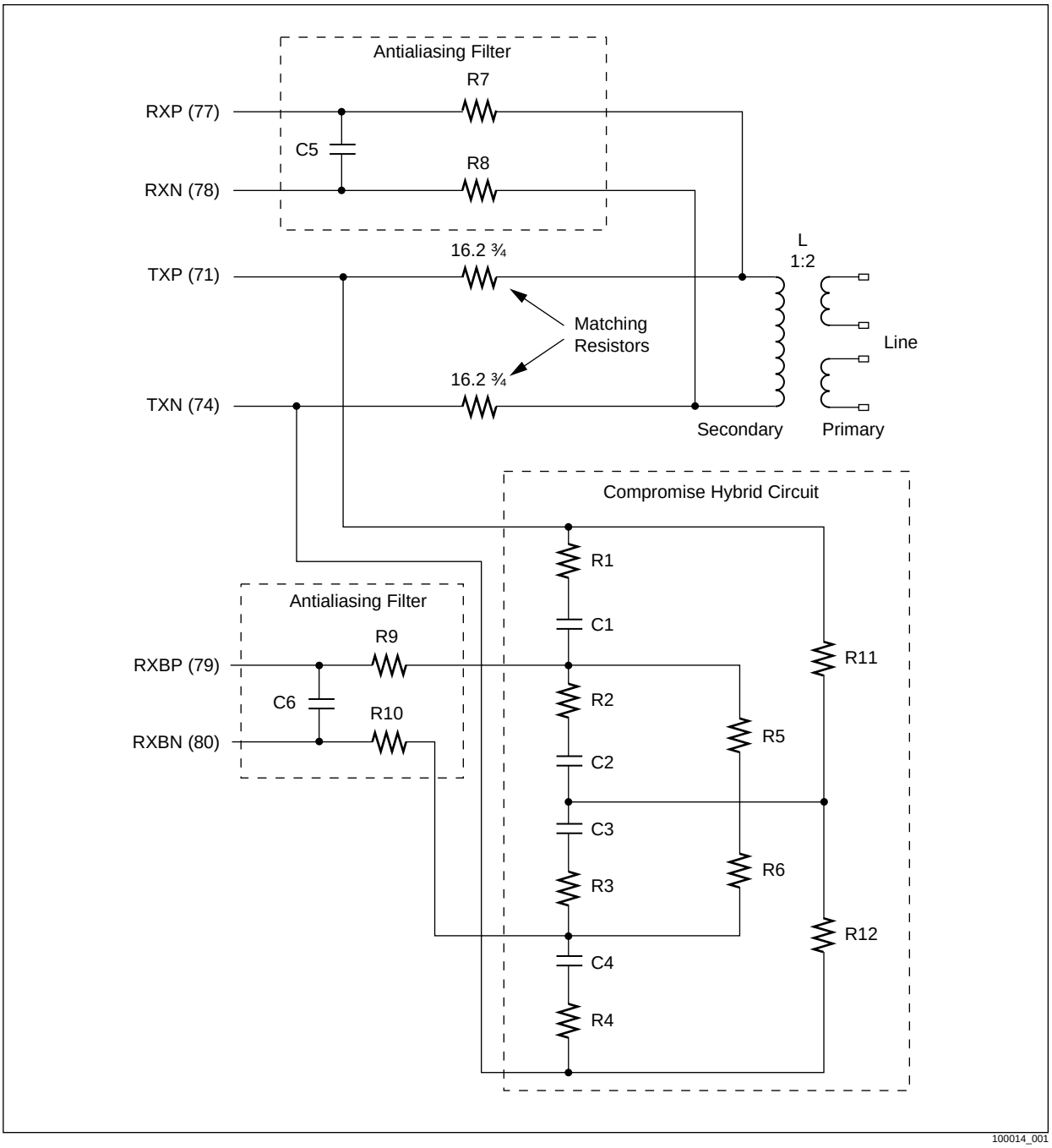

Table 1. Compromise Hybrid Component Values

Hybrid Components	Data Rate		
	160 kbps	**288 kbps**	**416 kbps**
R1, R4	2.0 kΩ	2 kΩ	2.4 kΩ
C1, C4	8.2 nF	5.6 nF	3.3 nF
R2, R3	1.5 kΩ	1kΩ	2.4 kΩ
C2, C3	820 pF	1.8 nF	680 pF
R5, R6	8.2 k¾	6.04 k¾	5.76 k¾
R11, R12	5.1 k¾	5.1 k¾	5.1 k¾
NOTE(S): All capacitors in the signal path should be film or NPO ceramic capacitors.			

Table 2. Antialias Filter Component Values

Antialias Filter Components	Data Rate		
	160 kbps	**288 kbps**	**416 kbps**
R7, R8	2.1 kΩ	1.3 kΩ	1.3 kΩ
C5	470 pF	470 pF	330 pF
R9, R10	2.1 kΩ	1.3 kΩ	1.3 kΩ
C6	470 pF	470 pF	330 pF

Table 3. Line Transformer Primary Inductance Specification

Parameter	Data Rate		
	160 kbps	**288 kbps**	**416 kbps**
Primary Inductance	8 mH	5 mH	3.5 mH
NOTE(S): The primary inductance is for the line side of the transformer. The winding ratio of the transformer must be 2:1 (line side:circuit side). Primary inductance tolerance equals ±10%.			

Table 4. Line Transformer Return Loss Specification (160 kbps)

Parameter	Requirement
0 Hz to 1.3 kHZ	0 dB
1.3 kHz to 9 kHz	0 to 16.5 dB (+20 dB/decade)
9 kHz to 40 kHz	20 dB
40 kHz to 270 kHz	16.5 to 0 dB (–20 dB/decade)
270 kHz +	0 dB

Table 5. Line Transformer Return Loss Specification (288 kbps)

Parameter	Requirement
0 Hz to 3 kHZ	0 dB
3 kHz to 20 kHz	0 to 16.5 dB (+20 dB/decade)
20 kHz to 80 kHz	16.5 dB
80 kHz to 530 kHz	16.5 to 0 dB (–20 dB/decade)
530 kHz +	0 dB

Table 6. Line Transformer Return Loss Specification (416 kbps)

Parameter	Requirement
0 Hz to 5 kHZ	0 dB
5 kHz to 33 kHz	0 to 16.5 dB (+20 dB/decade)
33 kHz to 110 kHz	16.5 dB
110 kHz to 740 kHz	16.5 to 0 dB (–20 dB/decade)
740 kHz +	0 dB

Table 7. Line Transformer Recommended Suppliers

Supplier Name	Phone Number	Part Number		
		160 kbps	288 kbps	416 kbps
Midcom, Inc.	(800) 643-2661	671-7871	671-7797	671-7798
Pulse Engineering	(619) 674-8130	B1004	B1002	B1001
Schott Corp.	(612) 475-1173	29872	28887	28888

Line Driver Gain Control and Pulse Shaping

External resistors must be connected to the line driver as shown in Figure 2 to set the line driver gain to 1.5. The external pulse-shaping filter is also included in Figure 2 because it affects the gain of the line driver. Note that the line driver is integrated into the Bt8960 device.

The external pulse shaping filter must be connected between the Bt8960 switched-capacitor pulse-shaping filter outputs (TXPSP and TXPSN) and the inputs to the line driver as shown in Figure 2. The purpose of this filter is to filter out spectral images around the clock frequency. This low-pass filter should be designed to pass frequencies up to one-half of the sampling rate with less than 1 dB of attenuation. See Table 8 for the recommended values of the capacitor, C8.

Figure 2. External Pulse-Shaping Filter and Line Driver Gain Circuit

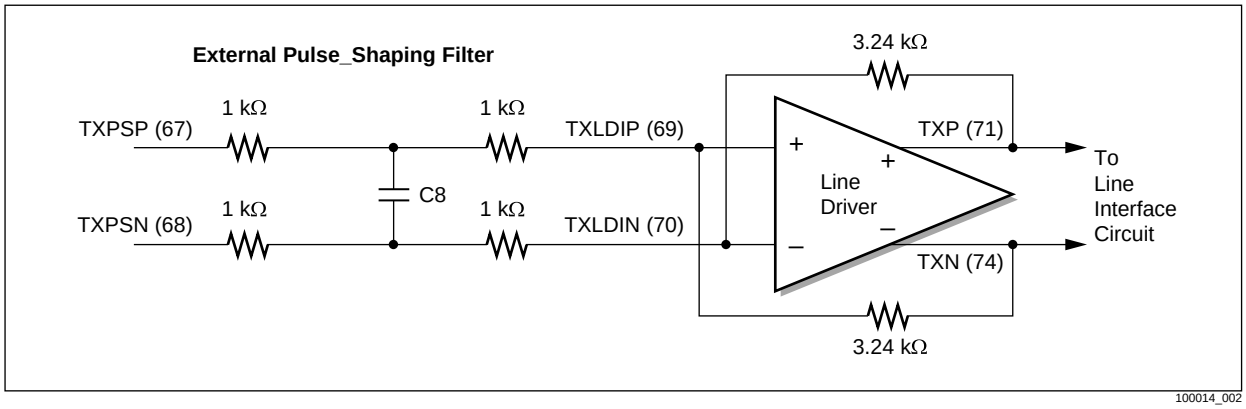

Table 8. External Pulse-Shaping Filter Capacitor Value

Component	Data Rate		
	160 kbps	**288 kbps**	**416 kbps**
C8	3.3 nF	1.8 nF	1.2 nF

Voltage Reference and Compensation Circuitry

Compensation capacitors must be connected between all of the Bt8960 voltage reference pins and analog ground. The voltage reference signals, their associated pin numbers, and the recommended compensation capacitor values are listed in Table 9.

Table 9. Compensation Capacitor Values

Signal Name	Pin Number	Capacitor Value
VCOMO	58	0.22 µF
VCOMI	57	0.22 µF
VCCAP	59	0.22 µF
VRXP	51	0.22 µF
VRXN	52	0.22 µF
VTXP	60	0.22 µF
VTXN	61	0.22 µF

In addition to the compensation capacitors, an external resistor is needed to set the bias current used in the Bt8960. This resistor must be connected between the RBIAS pin (pin 56) and analog ground. The recommended value of the resistor is given in Table 10.

Table 10. Bias Current Resistor Value

Signal Name	Pin Number	Resistor Value
RBIAS	56	9.53 kΩ

Crystal/Clock Interface

A crystal or an external clock is needed to provide clocking for the Bt8960. If a crystal is used, it should be connected to the XTALI/MCLK and XTALO pins along with two external capacitors as shown in Figure 3. The recommended specification for the crystal is given in Table 11.

If an external clock is used, it should be connected to the XTALI/MCLK pin (pin 40) and the XTALO pin (pin 39) should be left floating. The clock frequency should be equal to 32 times the data rate.

Figure 3. Crystal Oscillator Connection Diagram

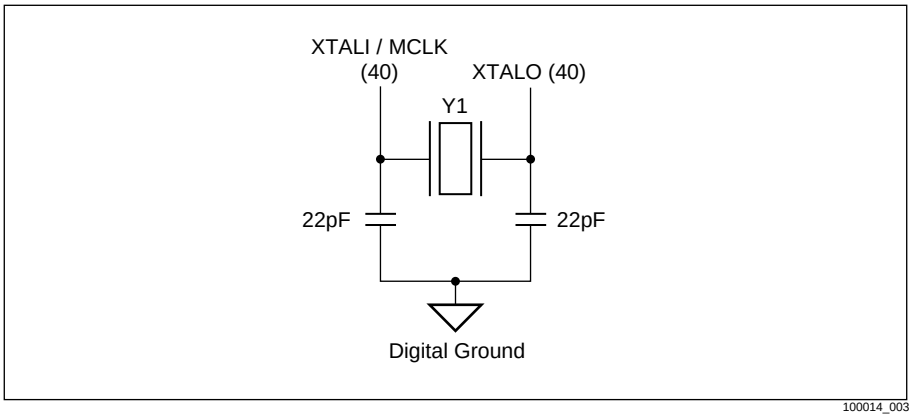

Table 11. Crystal Specification

Parameter	Data Rates		
	160 kbps	**288 kbps**	**416 kbps**
Frequency	5.120 MHz	9.216 MHz	13.312 MHz
Tolerance	20 ppm		
Load Capacitance	16 pF		

Revision History

Rev.	Changes
A	Initial release
B	Provided Pulse Engineering and Schott Corp. part numbers for 160 kbps. Figure 2 changed from 3.01 kΩ to 3.24 kΩ.
C	Allow NPO ceramic capacitors. New 160 kbps hybrid. New 416 kbps hybrid. New 160 kbps transformer. Return loss specification. 10% tolerance on primary inductance.

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