National Semiconductor

PRELIMINARY

TP5700/TP5700-1/TP5710 Telephone Speech Circuits

General Description

The TP5700 is a linear bipolar device which includes all the functions required to build the speech circuit of a telephone. It replaces the hybrid transformer, compensation circuit and sidetone network used in traditional designs. When used with an electret microphone (with integral FET buffer) and dynamic receiver, superior audio linearity, distortion and noise performance are obtained. Loop attenuation compensation is also included.

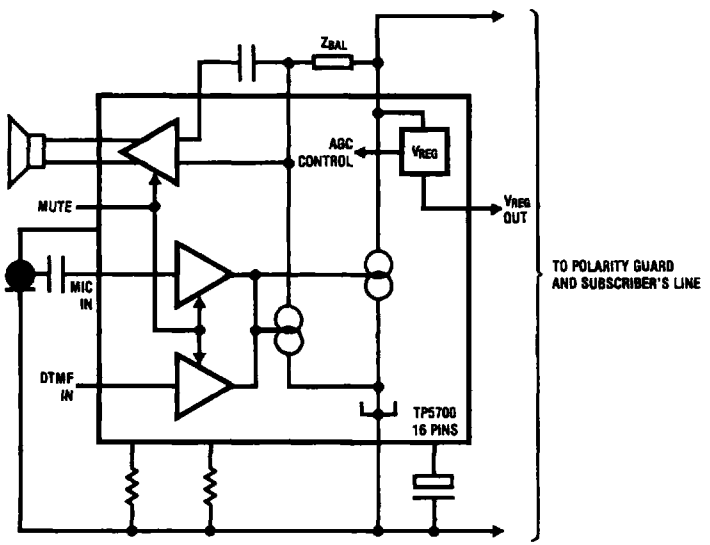
The TP5710 provides additional gain and differential inputs for use with a dynamic microphone.

The low voltage design enables the circuit to work over a wide range of operating conditions, including long loops, extension telephones and subscriber carrier applications. Operating power is derived from the telephone line.

Features

- 5 mA–120 mA loop operation
- Voltage swing down to 1.0V
- Transmit amplifier for electret microphone — TP5700, -1
- Transmit amplifier for dynamic microphone — TP5710
- Receive amplifier with push-pull outputs
- Automatic gain compensation for loop length
- Sidetone impedance independent of input impedance
- DTMF interface with muting
- Voltage regulator outputs for DTMF generator etc.
- Works in parallel with a standard phone on 20 mA loop

Simplified Block Diagram



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Absolute Maximum Ratings

V^+ with Respect to V^-	20V	Storage Temperature, T_S	−65°C to +150°C
Voltage at Any Other Pin	$V^+ + 0.3V$ to $V^- - 0.3V$	Junction Temperature	150°C
Operating Temperature, T_A	−25°C to +70°C	Lead Temperature (Soldering, 10 seconds)	300°C
Power Dissipation	1W		

DC Electrical Characteristics

Unless otherwise specified, all tests based on the test circuits shown in *Figure 1*, all limits apply for T_A = 0°C to 60°C, typical values apply at T_A = 25°C.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{T-R}	Tip-Ring Voltage including nominal 1.4V polarity guard (See *Figure 1*)	I_{LOOP} = 5 mA		2.8		V
		= 20 mA, TP5700			4	
		= 20 mA, TP5700-1			5	V
		= 20 mA, TP5710		4.7		V
		= 50 mA		7		V
		= 80 mA		10.5		V
		= 120 mA		15		V
V_I	Minimum Instantaneous Voltage Swing	V^+ to V^-, I_{LOOP} = 5mA		1.0		V
TRANSMIT AMPLIFIER TP5700, TP5700-1						
R_{XIN}	Input Resistance	From Pin 7 to V^-	15	30	50	kΩ
G_{XA}	Gain at 1 kHz, T_A = 25°C	R_{AGC} = 0Ω to V^-, I_{LOOP} = 20 mA, TP5700	33	35	37	dB
		TP5700-1	32		38	dB
G_{XT}	Gain Variation v. T_A	T_A = 0°C to 60°C		±1		dB
G_{XI}	Gain Variation v. I_{LOOP}	I_{LOOP} = 20 to 100 mA		−6		dB
N_X	Transmit Noise	MIC IN_1 = 0V		12	18	dBrnC
TP5710						
R_{XIN}	Differential Input Resistance	From Pin 7 to Pin 11		1.2		kΩ
G_{XA}	Gain at 1 kHz, T_A = 25°C	R_{AGC} = 0Ω to V^-, I_{LOOP} = 20 mA, T_A = 25°C		57		dB
G_{XT}	Gain Variation v. T_A	T_A = 0°C to 60°C		±1		dB
G_{XI}	Gain Variation v. I_{LOOP}	I_{LOOP} = 20 to 100 mA		−6		dB
N_X	Transmit Noise	MIC IN_1 = MIC IN_2 = 0V		18		dBrnC
ALL DEVICES						
S/D_X	Signal/Total Harmonic Distortion	$I_{LOOP} \geq$ 20 mA, V_L = 800 mVrms		2	10	%
G_{XM}	Gain Change when MUTED	MUTE IN ≥ V_{MON}		−55		dB
DTMF AMPLIFIER						
R_{DIN}	Input Resistance	From Pin 8 to V^-		20		kΩ
G_{XD}	Gain at 1 kHz	R_{AGC} = 0Ω to V^-, I_{LOOP} = 20 mA, T_A = 25°C		6		dB
G_{XDT}	Gain Variation v. T_A	T_A = 0°C to 60°C		±1		dB
G_{XDI}	Gain Variation v. I_{LOOP}	I_{LOOP} = 20 to 100 mA		−6		dB
MUTE INPUT						
I_{MIN}	Input Current	Pin 9 = 1.5V		40		μA
V_{MOFF}	MUTE OFF Input Voltage				0.5	V
V_{MON}	MUTE ON Input Voltage		1.5			V

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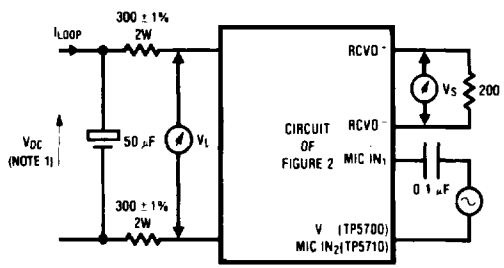
DC Electrical Characteristics (Continued)

Unless otherwise specified, all tests based on the test circuits shown in *Figure 1*, all limits apply for T_A = 0°C to 60°C, typical values apply at T_A = 25°C.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
RECEIVE AMPLIFIER						
R_{RIN}	Input Resistance	From Pin 12 to V⁻	20	35	55	kΩ
G_{RA}	Gain at 1 kHz, T_A = 25°C	R_{AGC} = 0Ω, MUTE IN ≤ V_{MOFF} I_{LOOP} = 20 mA	−5.5	−4	−2.5	dB
G_{RT}	Gain Variation v. T_A	T_A = 0°C to 60°C		±0.5		dB
G_{RI}	Gain Variation v. I_{LOOP}	I_{LOOP} = 20 to 100 mA		−6		dB
G_{RM}	Gain Change when MUTED	MUTE IN ≥ V_{MON}	−15	−20	−23	dB
N_R	Receive Noise	V_{RCVIN} = 0V		0	10	dBrnC
S/D_R	Signal/Total Harmonic Distortion	V_R = 400 mVrms I_{LOOP} ≥ 20 mA		2	10	%
V_RC	Output Clipping Level		1.2	2		Vp-p
V_{ROS}	Output Offset Voltage				100	mV
SIDETONE CHARACTERISTICS						
STC	Sidetone Cancellation at 1kHz	20 mA ≤ I_{LOOP} ≤ 100 mA, Note 2		15		dB
VOLTAGE REGULATOR OUTPUTS						
V_{REG1}	Output Voltage, Pin 10	I_{LOOP} ≥ 20 mA MUTE IN ≤ V_{MOFF} MUTE IN ≥ V_{MON}	2	 3		V V
I_{REG1}	*Maximum Output Current*, Pin 10	MUTE IN ≤ V_{MOFF} MUTE IN ≥ V_{MON}		200 2.7		μA mA
V_{REG2}	Output Voltage, Pin 11	I_{LOOP} ≥ 20 mA	1.1	1.2		V
I_{REG2}	Maximum Output Current, Pin 11	I_{LOOP} ≥ 20 mA	300	500		μA



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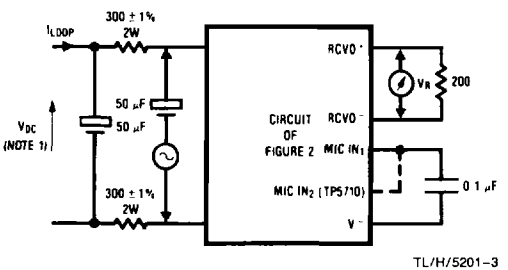
1a. Test Circuit for Transmit and Sidetone



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1b. Test Circuit for Receive

FIGURE 1. Test Circuits for Electrical Characteristics

Note 1. Adjust V_{DC} to set specified I_{LOOP} current.

Note 2. *To measure Sidetone Cancellation, set oscillator in Fig. 1a for V_L = 100 mVrms; measure V_S. Then in Fig. 1b set oscillator = 100 mVrms; measure V_R.* STC = 20log V_R/V_S.

Functional Description

The TP5700, TP5710 Telephone Speech Circuits are powered from the telephone Tip and Ring terminals via a full-wave rectifier bridge to protect against loop polarity reversals. The devices provide the following functions:

LINE REGULATOR

A DC regulator sinks current from the loop in order to maintain a DC slope resistance similar to that of a standard phone.

R_{DC} provides an adjustment for the slope resistance.

MICROPHONE AMPLIFIER

A single-ended input amplifier on the TP5700 enables a low cost electret microphone to be used. This provides superior distortion, linearity and noise performance compared to a traditional carbon microphone. The electret should be capacitively coupled to the amplifier input. The acoustic sensitivity of the microphone is intended to be in the range of −60 to −70 dBV/μBar.

Loss can be inserted if required by adding a resistive potentiometer either at MIC IN_1 or the connection between the pre-amp output and driver stage input. The driver stage provides automatic gain compensation to reduce the gain as loop length decreases. The AGC range can be adjusted by means of R_{AGC} to limit the maximum loss on a short loop from 0 to 6 dB.

Functional Description (Continued)

The TP5710 provides additional gain and balanced differential inputs for use with a dynamic microphone.

RECEIVE AMPLIFIER

This buffer amplifier provides the necessary gain or loss for the receive signal. RCV IN should be AC coupled to SIDETONE (pin 4). Automatic gain control is built into the amplifier to reduce the gain as loop length decreases. The AGC range is adjusted in common with the transmit AGC range with a range of adjustment for maximum loss from 0 to 6 dB. Push-pull complementary outputs provide balanced direct drive to a dynamic transducer, which may have an impedance as low as 100Ω. The effective receive gain can be reduced by adding a resistor in series with the transducer. The receive gain is automatically reduced by 20 dB when the MUTE input is pulled high.

SIDETONE CIRCUIT

The level of Sidetone cancellation may be adjusted by connecting an external balance impedance to SIDETONE (pin 4) and coupling this point to V^+. For good sidetone cancellation the balance impedance should be approximately 10 times the subscriber line input impedance. Some typical component values to match a precise 600Ω termination for test purposes are shown in *Figure 2*. Use the component values shown in the Applications Section for better results over a wide range of telephone line impedances.

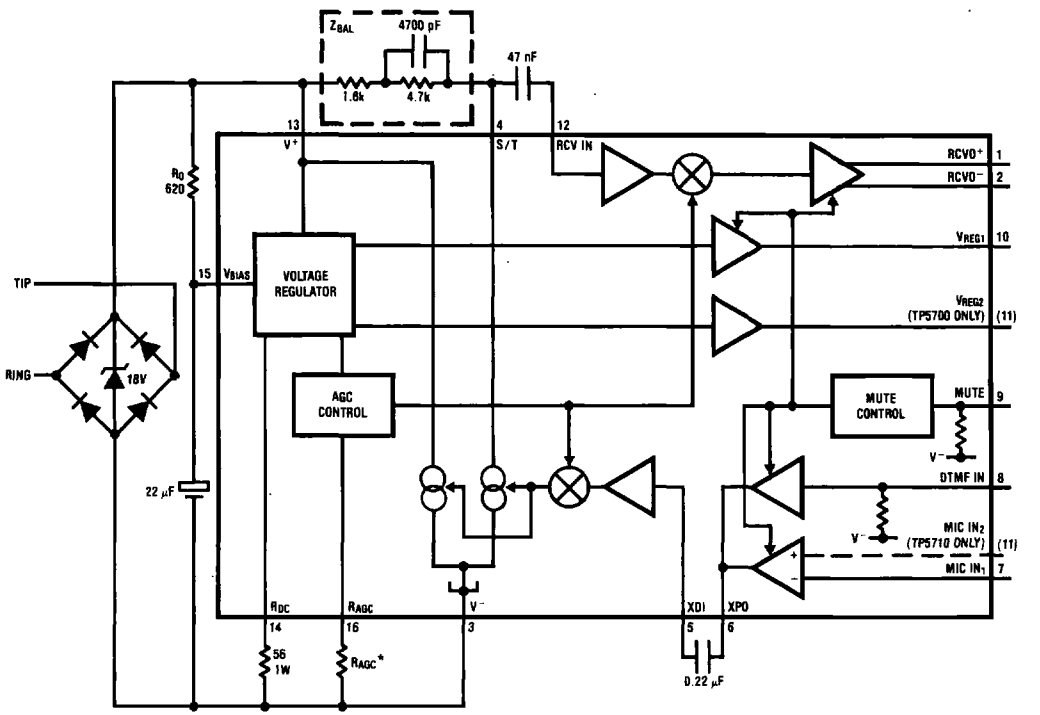
DTMF AMPLIFIER

An additional transmit amplifier is included to enable the open-emitter output of a conventional DTMF generator to be connected to the line via the transmit output stage. This path includes the transmit AGC section. When the MUTE input is pulled high, the DTMF input is enabled and the MIC input disabled. When MUTE IN is open-circuit or pulled to V^- the DTMF input is switched off and the MIC input is enabled.

VOLTAGE REGULATOR OUTPUTS

A precision band-gap voltage reference on the TP5700 and TP5710 controls a regulator to provide bias for internal circuits. Two auxiliary outputs are also available (one on the TP5710). V_{REG1} is provided specifically for powering a low voltage pulse dialer or DTMF generator. In order to protect this output in low voltage situations where the instantaneous voltage across the Speech Circuit may swing below the V_{REG1} output voltage, an internal switch controls the maximum available output current. In speech mode, MUTE IN is low, V_{REG1} output will track approximately ½ the Tip-Ring voltage and the available output current is limited to 200 μA. This is adequate to power a DTMF generator in standby mode. When MUTE IN is pulled high to switch the Speech Circuit to the DTMF dialing mode, V_{REG1} is switched to a 3V regulated output and up to 2 mA may be drawn from it to power the active DTMF generator.

On the TP5700 only, a 1.2V regulated output is also provided at V_{REG2} to power a low voltage 2-wire electret microphone such as the Primo EM80-PMI$_2$.



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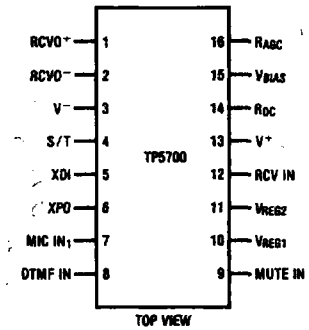
* See Figure 3

Note: Z_{BAL} circuit shown is for test purposes with a resistive line termination. See Applications Information for suggested component values for normal reactive line applications.

FIGURE 2. TP5700, TP5710 Telephone Speech Circuits

Connection Diagrams

Dual-In-Line Package



Order Number TP5700, TP5710
See NS Package N16A

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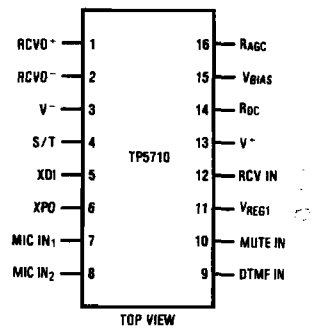
Dual-In-Line Package



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Pin Descriptions

Pins 1, 2 RCV0+ and RCV0−

The push-pull complementary outputs of the receive amplifier. Dynamic transducers with a minimum impedance of 100 Ω can be directly driven by these outputs.

Pin 3 V−

This is the negative supply input to the device and should be connected to the negative output of the polarity guard. All other voltages on the device are referred to this pin.

Pin 4 S/T

This is the output of the Sidetone cancellation signal, which requires a balance impedance of approximately 10 times the subscriber's line impedance to be connected from this pin to V+ (pin 13).

Pin 5 XDI

The input to the line output driver amplifier. Transmit AGC is applied in this stage.

Pin 6 XPO

This is the transmit pre-amp output which is normally capacitively coupled to pin 5.

Pin 7 MIC IN_1

This is the inverting input to the transmit pre-amplifier and is intended to be capacitively coupled to an FET-buffered electret microphone (TP5700).

Pin 8 DTMF IN

The DTMF input which has an internal resistor to V− to provide the emitter load resistor for a CMOS DTMF generator. This input is only active when MUTE IN (pin 9) is pulled high.

Pin 9 MUTE IN

The MUTE Input, which must be pulled at least 1.5V higher than V− to mute MIC IN and enable DTMF IN.

Pin 10 V_{REG1}

The regulated output for biasing a pulse dialer or DTMF generator. A 4.7 μF decoupling capacitor to V− should be fitted if this output is used.

Pin 11 V_{REG2} (TP5700, TP5700-1 only)

A 1.2V regulated output suitable for powering a low-voltage electret microphone. A 1μF decoupling capacitor to V− should be fitted if this output is used.

Pin 11 MIC IN_2 (TP5710 only).

The non-inverting input to the transmit pre-amplifier for dynamic microphones.

Pin 12 RCV IN

The receive AGC amplifier input.

Pin 13 V+

This is the positive supply input to the device and should be connected to the positive output of the polarity guard. The current through this pin is modulated by the transmit signal.

Pin 14 R_{DC}

An external 1W resistor is required from this pin to V− to control the DC input impedance of the circuit. The nominal value is 56Ω for low voltage operation. Values up to 82Ω may be used to increase the available transmit output voltage swing at the expense of low voltage operation.

Pin 15 V_{BIAS}

This internal voltage bias line must be connected to V− via an external resistor, R_0, and decoupled to V− with a 22 μF capacitor. R_0 dominates the AC input impedance of the circuit and should be 620Ω for a 600Ω input impedance or 910Ω for a 900Ω input impedance.

Pin 16 R_{AGC}

The range of transmit and receive gain variations between short and long loops may be adjusted by connecting a resistor from this pin to V− (pin 3). *Figure 3* shows the relationship between the resistor value and the AGC range. This pin may be left open-circuit to defeat AGC action.

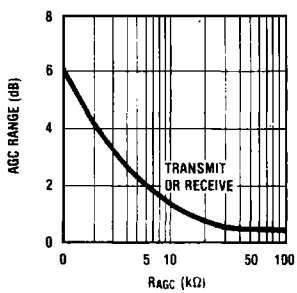

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FIGURE 3.

Applications Information

The TP5700 and TP5710 are flexible circuits designed with several user adjustments to enable the performance to be optimized for different applications. The choice of transducer types and the cavities in which they are mounted will also greatly influence the acoustic performance of the telephone. Some of the consequences of circuit adjustments are as follows:

R_{DC} ADJUSTMENT

56Ω is the recommended value for R_{DC} if it is required to meet a maximum Tip-Ring voltage of 4V on a 20 mA loop (assuming no more than 1.4V is dropped across the polarity guard). If a higher Tip-Ring voltage is acceptable, R_{DC} may be increased, which will provide a small increase in the available transmit output voltage swing before clipping occurs. R_{DC} should be less than 82Ω to avoid exceeding the maximum rated voltage on a short loop.

R_{AGC} ADJUSTMENT

The available AGC range is more than adequate to compensate for the loss of most loops. R_{AGC} should be chosen only to partly compensate for the anticipated maximum loop loss, as over-compensation may tend to exaggerate the variations of sidetone with loop length.

SIDETONE ADJUSTMENT

The component values used for Z_{BAL} should be selected to provide a clear sidetone sound without excessive "hollowness." The capacitor value and ratio of the two resistors will fix the pole location. To avoid reducing the low voltage performance of the circuit the sum of the two resistors should not exceed 10 kΩ.

POWERING ELECTRET MICROPHONES (TP5700 only)

Electret microphones with integral FET buffers are available in both two-wire and three-wire versions and a range of operating voltage ranges. There are four methods of powering the microphone.

1. The 1.2V V_{REG2} output provides the lowest voltage method for microphones rated down to 1V. V_{REG2} must be decoupled with a 1 μF capacitor to ground.
2. If V_{REG1} is not required for DTMF generator operation, it may be used to provide up to 200 μA for microphone power.
3. V_{BIAS} (pin 15) may be used as a decoupled, but unregulated, supply for electrets requiring a higher operating voltage than V_{REG1} or V_{REG2}. The additional current drawn through R_0 will, however, raise the minimum operating voltage of the Speech Circuit. If this method is used the decoupling capacitor must be increased to at least 100 μF to maintain good low frequency return loss.
4. An electret type with a good power supply rejection ratio can be powered from V+, or a regulated and decoupled supply dropped from V+.

TONE DIALING TELEPHONE

Figure 4 shows the TP5700 directly interfacing to a low voltage DTMF generator. V_{REG1} supplies the necessary 2V minimum bias to enable the TP5380 to sense key closures and pull its MUTE output high. V_{REG1} then switches to a 3V regulated output to sustain the Tone Dialer during tone generation. The TP5700 DTMF input incorporates the necessary load resistor to V− and provides gain plus AGC action to compensate for loop length. A muted tone level is heard in the receiver. For DTMF generators with a higher output level than the TP5380, a resistive potentiometer should be added to reduce the level at the speech circuit DTMF input.

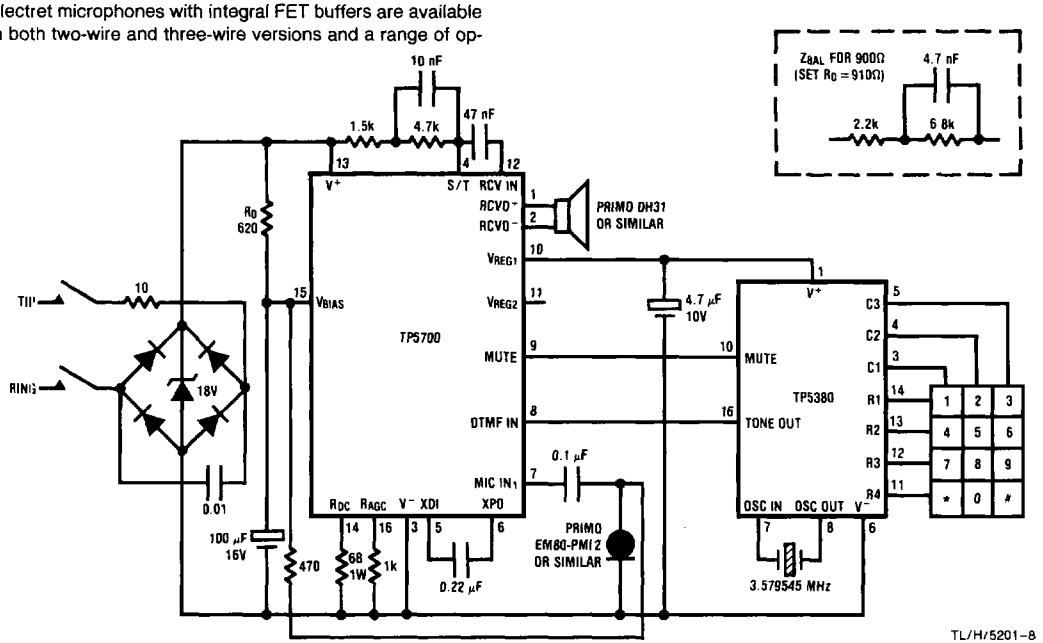

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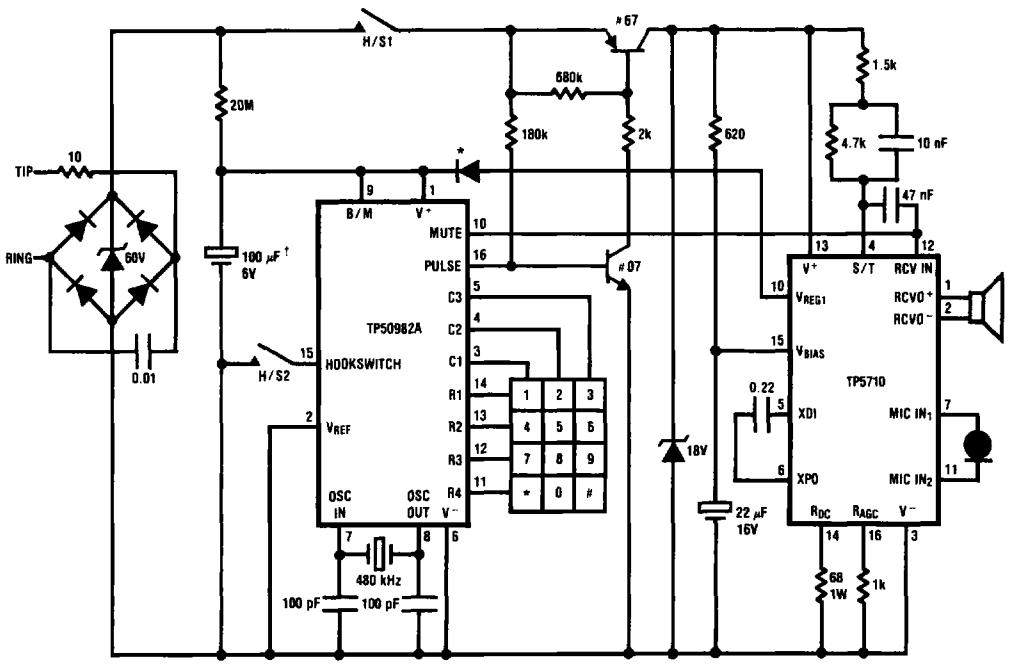
FIGURE 4. Typical Tone Dialing Telephone

Applications Information (Continued)

PULSE DIALING TELEPHONE

The TP5700 or TP5710 can reduce the number of components required to build a pulse dialing telephone, as shown in *Figure 5*. The usual current source can be eliminated by using the V_{REG1} output to power a TP50982A low-voltage (1.7V) pulse dialer via a blocking diode. A low forward-voltage drop diode such as a Schottky type is necessary because V_{REG1} is used in its non-regulated mode and its output voltage may fall to 2V on a 20 mA loop. A 100 µF decoupling capacitor is required to hold up the pulse dialer supply voltage during dialing. This capacitor will take about one second to charge up when the telephone is first connected to the line, but thereafter the 20 MΩ resistor required to retain the last-number dialed memory will keep this capacitor charged. Partial muting is obtained by directly connecting the N-channel open-drain MUTE output of the pulse dialer to the RCV IN pin on the Speech Circuit.

A fully muted pulse dialer design requires the use of a shunt-mode dialer such as the TP50981A or TP50985A. Suitable interface circuits are shown in the TP50981A data sheet.



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* Select as necessary to suit mic sensitivity

† Low leakage type

FIGURE 5. Typical Pulse Dialing Telephone