

# MOTOROLA SEMICONDUCTOR TECHNICAL DATA

## Specifications and Applications Information

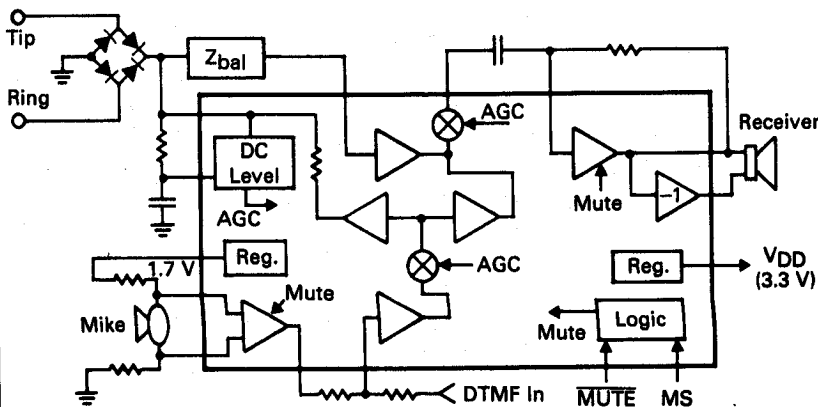
### TELEPHONE SPEECH NETWORK WITH DIALER INTERFACE

The MC34114 is a monolithic integrated telephone speech network designed to replace the bulky magnetic hybrid circuit of a telephone set. The MC34114 incorporates the necessary functions of transmit amplification, receive amplification, and sidetone control, each with externally adjustable gain. Loop length equalization varies the gains based on loop current. The microphone amplifier has a balanced, differential input stage designed to reduce RFI problems. A MUTE input mutes the microphone and receive amplifiers during dialing. A regulated output voltage is provided for biasing of the microphone, and a separate output voltage powers an external dialer, microprocessor, or other circuitry. The MC34114 is designed to operate at a minimum of 1.2 volts, making party line operation possible.

A circuit using the MC34114 can be made to comply with Bell Telephone, British Telecom (BT), and NTT (Nippon Telegraph & Telephone) standards. It is available in a standard 18-pin DIP, and a 20-pin SOIC (surface mount) package.

- Operation Down to 1.2 Volts
- Externally Adjustable Transmit, Receive, and Sidetone Gains
- Differential Microphone Amplifier Input Minimizes RFI Susceptibility
- Transmit, Receive, and Sidetone Equalization on Both Voice and DTMF Signals
- Regulated 1.7 Volts Output for Biasing Microphone
- Regulated 3.3 Volts Output for Powering External Dialer or MPU
- Microphone and Receive Amplifiers Muted During Dialing
- Differential Receive Amplifier Output Eliminates Coupling Capacitor
- Operates with Receiver Impedances of 50 Ohms and Higher
- Complies with NTT, Bell Telephone and BT Standards

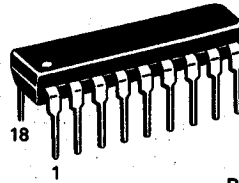
### SIMPLIFIED BLOCK DIAGRAM



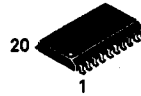
## MC34114

### TELEPHONE SPEECH NETWORK WITH DIALER INTERFACE

SILICON MONOLITHIC  
INTEGRATED CIRCUIT

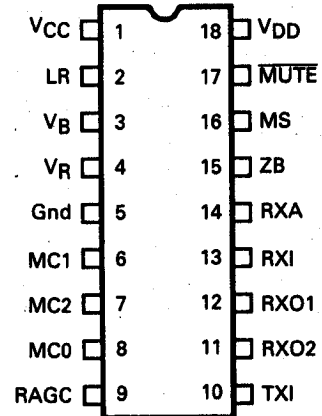


P SUFFIX  
PLASTIC PACKAGE  
CASE 707



DW SUFFIX  
PLASTIC PACKAGE  
CASE 751D

### PIN CONNECTIONS (Top View) (DIP Package)



### ORDERING INFORMATION

Package	Part No.
18-Pin Plastic DIP	MC34114P
20-Pin Surface Mount	MC34114DW

**ABSOLUTE MAXIMUM RATINGS**

Parameter	Value	Units
V <sub>CC</sub> Supply Voltage	-1.0, +12	Vdc
Voltage at V <sub>DD</sub> (Externally Applied, V <sub>CC</sub> = 0)	-1.0, +6.0	Vdc
Voltage at $\overline{\text{MUTE}}$ , MS (V <sub>CC</sub> > 1.5 Volts)	-1.0, V <sub>DD</sub> +0.5	Vdc
Voltage at $\overline{\text{MUTE}}$ , MS (V <sub>CC</sub> = 0)	-1.0, +6.0	Vdc
Voltage at RAGC (0 < V <sub>CC</sub> < 12 Volts)	-1.0, +6.0	Vdc
Current through V <sub>CC</sub> , LR	130	mA
Current into Z <sub>B</sub> (Pin 15)	3.0	mA
Storage Temperature	-65, +150	°C

"Maximum Ratings" are those values beyond which the safety of the device cannot be guaranteed. They are not meant to imply that the devices can be operated at these limits. The "Recommended Operating Conditions" provides conditions for actual device operation.

**RECOMMENDED OPERATING LIMITS**

Parameter	Min	Typ	Max	Units
V <sub>CC</sub> Voltage (Speech, Pulse Mode) (Tone Dialing Mode)	+1.2 +3.3	—	+10.5 +10.5	Vdc
Loop Current (into V <sub>CC</sub> ) (Speech, Pulse Mode) (Tone Dialing Mode)	4.0 15	—	120 120	mA
Receiver Impedance	50	—	—	Ω
Voltage at $\overline{\text{MUTE}}$ , MS (V <sub>CC</sub> > 1.5 Volts)	0	—	V <sub>DD</sub>	Vdc
R1 (Resistor from V <sub>CC</sub> to V <sub>B</sub> )	100	—	1800	Ω
Ambient Temperature	-20	—	+70	°C

All limits are not necessarily functional concurrently.

**ELECTRICAL CHARACTERISTICS (T<sub>A</sub> = 25°C, See Figure 1)**

Parameter	Symbol	Min	Typ	Max	Units
<b>SUPPLY CURRENT</b>					
Supply Current into V <sub>CC</sub> (Pin 2 open, R <sub>12</sub> = 25 k, V <sub>DD</sub> unloaded)					mA
Speech Mode (Figure 2)	I <sub>ccsp</sub>	4.0	5.0	5.5	
V <sub>CC</sub> = 1.2 Volts		9.0	11	12	
V <sub>CC</sub> = 3.5 Volts		10	12	14	
Tone Mode (Figure 4)	I <sub>ct</sub>	—	13	—	
V <sub>CC</sub> = 8.0 Volts		—	14	—	
V <sub>CC</sub> = 10.5 Volts		—	16	—	
V <sub>CC</sub> = 3.3 Volts		—	18	—	
V <sub>CC</sub> = 8.0 Volts		—	—	—	
V <sub>CC</sub> = 10 Volts		—	—	—	

**VOLTAGE REGULATORS**

V <sub>R</sub> Voltage (I <sub>R</sub> = 65 μA, V <sub>CC</sub> = 2.5 V, Figure 5)	V <sub>R</sub>	1.6	1.7	1.85	Vdc
Load Regulation (0 < I <sub>R</sub> < 300 μA, V <sub>CC</sub> = 2.5 V)		—	0.2	0.5	Vdc
Line Regulation (I <sub>R</sub> = 65 μA, 2.5 < V <sub>CC</sub> < 10.5 V)		-70	±20	+70	mVdc
V <sub>DD</sub> Voltage (V <sub>CC</sub> ≥ 3.8 V, I <sub>DD</sub> = 0, Figure 6)	V <sub>DD</sub>	3.1	3.3	3.7	Vdc
Line Regulation (I <sub>DD</sub> = 0, 5.0 V < V <sub>CC</sub> < 10.5 V)		-70	±30	+70	mVdc
Maximum Output Current (V <sub>CC</sub> = 3.8 V, V <sub>DD</sub> ≥ 3.0 V)	I <sub>DDMAX</sub>	0.8	1.0	—	mA
Speech Mode		2.2	2.5	—	μA
Pulse, Tone Mode		—	—	—	
Input Leakage Current (V <sub>CC</sub> = 0, 3.3 Volts applied to V <sub>DD</sub> )	I <sub>lkg</sub>	—	0.02	0.5	μA
$\overline{\text{Mute}}$ open or at V <sub>DD</sub>		—	180	—	
$\overline{\text{Mute}}$ = 0 Volts		—	—	—	

**ELECTRICAL CHARACTERISTICS — continued** ( $T_A = 25^\circ\text{C}$ , See Figure 1)

Parameter	Symbol	Min	Typ	Max	Units
<b>MICROPHONE AMPLIFIER</b>					
Gain ( $\overline{\text{Mute}} = V_{DD}$ )	GMIC	28	30	32	dB
Input Common Mode Rejection Ratio (1.0 kHz)	CMRR	20	26	—	dB
Input Impedance (Each Input)	RINMIC	14	20	27	k $\Omega$
MCO DC Bias Voltage ( $V_{CC} > 3.4\text{ V}$ , $\overline{\text{Mute}} = \text{Hi}$ ) ( $V_{CC} = 1.2\text{ V}$ , $\overline{\text{Mute}} = \text{Hi}$ ) ( $\overline{\text{Mute}} = 0\text{ V}$ )	VMCODC	0.85 0.6 —	1.1 0.71 0.08	1.25 0.93 —	Vdc
MCO Max Voltage Swing (THD = 5%, $V_{CC} > 2.7\text{ V}$ ) (THD = 5%, $V_{CC} = 1.2\text{ V}$ )	VMCOAC	— —	2.0 500	— —	Vp-p mVp-p
MCO Output Impedance	ZMCO	—	270	—	$\Omega$
MCO Output Current Capability (THD = 5%)	IMCO	—	160	—	$\mu\text{A}$
Gain Reduction when Muted ( $\overline{\text{Mute}} = 0\text{ Volts}$ , $f = 1.0\text{ kHz}$ )	GMUT	55	70	—	dB
<b>RECEIVE AMPLIFIER</b>					
RXI Bias Current ( $\overline{\text{Mute}} = \text{Hi}$ )	I <sub>IBR</sub>	—	50	—	nA
RXO1, RXO2 Bias Voltage ( $V_{CC} = 1.2\text{ V}$ ) ( $V_{CC} > 3.0\text{ V}$ )	RXDC	580 585	630 650	695 720	mVdc
RXO1–RXO2 Offset Voltage ( $V_{CC} > 3.0\text{ V}$ )	R <sub>XVOS</sub>	–35	0	+35	mVdc
RXO1–RXO2 Max Voltage Swing (Figure 9) (THD = 5%, Receiver = $\infty$ ) (THD = 5%, Receiver = 150 $\Omega$ )	V <sub>RXAC</sub>	— —	2.2 800	— —	Vp-p mVp-p
Internal Feedback Resistor (for muting)	R <sub>FIN</sub>	—	1.0	—	k $\Omega$
RXO1 & RXO2 Source Current	I <sub>RX</sub>	2.6	3.2	3.5	mA
<b>INTERNAL CURRENT AMPLIFIERS</b>					
TXI Input Impedance	R <sub>TXI</sub>	0.85	1.0	1.15	k $\Omega$
ZB Input Impedance	R <sub>ZB</sub>	—	500	—	$\Omega$
RXA Output Impedance	R <sub>RXA</sub>	—	10	—	k $\Omega$
AC Current Gain TXI to VCC ( $V_{RAGC} = 0\text{ V}$ ) TXI to VCC ( $V_{RAGC} = 1.3\text{ V}$ ) ZB to RXA ( $V_{RAGC} = 0\text{ V}$ , RXA = AC Gnd) ZB to RXA ( $V_{RAGC} = 1.3\text{ V}$ , RXA = AC Gnd) TXI to RXA ( $V_{RAGC} = 0\text{ V}$ , RXA = AC Gnd) TXI to RXA ( $V_{RAGC} = 1.3\text{ V}$ , RXA = AC Gnd)	G <sub>TX</sub> G <sub>ZB</sub> G <sub>STA</sub>	— — — — — —	100 50 0.5 0.25 1.22 0.61	— — — — — —	A/A
<b>DC INTERFACE</b>					
LR Level Shift ( $V_{CC} - V_{LR}$ ) ( $I_{LOOP} = 20\text{ mA}$ , $\overline{\text{Mute}} = V_{DD}$ ) ( $I_{LOOP} = 80\text{ mA}$ , $\overline{\text{Mute}} = V_{DD}$ ) ( $I_{LOOP} = 20\text{ mA}$ , $\overline{\text{Mute}} \& \overline{\text{MS}} = 0\text{ V}$ ) ( $I_{LOOP} = 80\text{ mA}$ , $\overline{\text{Mute}} \& \overline{\text{MS}} = 0\text{ V}$ )	$\Delta V_{LRS}$ $\Delta V_{LRT}$	— — — —	2.8 3.5 3.8 5.0	— — — —	Vdc
VCC Boost ( $I_{LOOP} = 20\text{ mA}$ , $\overline{\text{Mute}} \& \overline{\text{MS}}$ switched from Hi to Lo, $R_1 = 620\ \Omega$ )	$\Delta V_{LRB}$	0.7	1.0	1.2	Vdc
RAGC Current ( $V_{RAGC} = 0\text{ V}$ ) ( $V_{RAGC} = 1.0\text{ V}$ )	I <sub>RAGC</sub>	— —	–40 –12	— —	$\mu\text{A}$

**ELECTRICAL CHARACTERISTICS — continued** ( $T_A = 25^\circ\text{C}$ , See Figure 1)

Parameter	Symbol	Min	Typ	Max	Units
<b>LOGIC INPUTS</b>					
MUTE Input Impedance ( $V_{CC} > 1.2\text{ V}$ ) ( $V_{CC} = 0\text{ V}$ , $0 < \overline{\text{Mute}} < 6.0\text{ V}$ )	R <sub>MUT</sub>	—	60	—	k $\Omega$
Input Low Voltage	V <sub>ILMT</sub>	0	>60	—	M $\Omega$
Input High Voltage	V <sub>IHMT</sub>	$V_{DD} - 0.5$	—	1.0	V <sub>dc</sub>
Holdover (Delay for Receive amplifier to return to full gain after Pin 17 switches from 0 to $V_{DD}$ )	T <sub>MUT</sub>	8.0	11	25	mSec
MS Input Impedance ( $V_{CC} > 1.2\text{ V}$ ) ( $V_{CC} = 0\text{ V}$ , $\overline{\text{Mute}} = \text{open or } V_{DD}$ ) ( $V_{CC} = 0$ , $\overline{\text{Mute}} = 0$ )	R <sub>MS</sub>	—	—	—	k $\Omega$
Input Low Voltage	V <sub>ILMS</sub>	0	>50	—	M $\Omega$
Input High Voltage	V <sub>IHMS</sub>	2.0	4.0	—	k $\Omega$
				0.3	V <sub>dc</sub>
				$V_{DD}$	V <sub>dc</sub>

**SYSTEM SPECIFICATIONS** ( $f = 1.0\text{ kHz}$  unless noted,  $T_A = 25^\circ\text{C}$ , Refer to Figure 1)

Parameter	Symbol	Min	Typ	Max	Units
<b>LINE INTERFACE</b>					
V <sub>CC</sub> DC Voltage (Pin 1) Bell Telephone Standard and NTT Specs. ( $R_2 = 43\ \Omega$ , $R_3 = 13\ \Omega$ )	V <sub>CC</sub>				V <sub>dc</sub>
Speech Mode I <sub>LOOP</sub> = 10 mA		1.7	2.0	2.3	
I <sub>LOOP</sub> = 20 mA		3.0	3.4	3.7	
I <sub>LOOP</sub> = 30 mA		3.5	4.1	4.5	
Tone Mode I <sub>LOOP</sub> = 120 mA		8.5	9.9	10.5	
I <sub>LOOP</sub> = 20 mA		3.9	4.1	4.3	
I <sub>LOOP</sub> = 30 mA		4.5	5.1	5.5	
British Telecom Standard ( $R_2 = 43\ \Omega + 2.5\text{ V Zener}$ , $R_3 = 13\ \Omega$ )					
Speech Mode I <sub>LOOP</sub> = 10 mA		—	4.3	—	
I <sub>LOOP</sub> = 20 mA		—	5.9	—	
I <sub>LOOP</sub> = 30 mA		—	6.9	—	
I <sub>LOOP</sub> = 70 mA		—	10	—	
AC Terminating Impedance (I <sub>LOOP</sub> = 20 mA, Figure 11)	Z <sub>AC</sub>	500	600	700	$\Omega$
<b>RECEIVE PATH</b>					
Gain ( $V_{CC}$ to RXO1–RXO2, Figures 14, 15) I <sub>LOOP</sub> = 20 mA I <sub>LOOP</sub> = 100 mA	G <sub>RX</sub>	-7.2 -13.5	-6.1 -11	-5.0 -9.5	dB
$\Delta$ Gain (G <sub>RX</sub> @ 100 mA versus 20 mA)	$\Delta$ G <sub>RX</sub>	-7.5	-6.0	-4.5	dB
Muted Gain ( $\overline{\text{Mute}} = \text{Logic 0}$ , I <sub>LOOP</sub> = 20 mA)	G <sub>RXM</sub>	—	-22	-20	dB
Distortion (at RXO1–RXO2, $V_{CC} = 250\text{ mVrms}$ ) f = 300 Hz f = 1.0 kHz f = 3.4 kHz	TH <sub>DR</sub>	—	0.3 0.2 0.02	— 2.0 —	%
Output Noise Across RXO1–RXO2 (@ 1.0 kHz)	N <sub>RXO</sub>	—	4.0	—	$\mu\text{Vrms}$
<b>TRANSMIT PATH</b>					
Gain (MC1–MC2 to $V_{CC}$ , Figures 12, 13) I <sub>LOOP</sub> = 20 mA I <sub>LOOP</sub> = 100 mA	G <sub>TX</sub>	36 29	38.5 32.5	40.5 35.5	dB
$\Delta$ Gain (G <sub>TX</sub> @ 100 mA versus 20 mA)	$\Delta$ G <sub>TX</sub>	-7.5	-6.0	-4.5	dB
Max $V_{CC}$ Voltage Swing (THD = 5%, Figure 8) I <sub>LOOP</sub> = 20 mA I <sub>LOOP</sub> = 100 mA	V <sub>TXMAX</sub>	—	3.0 2.3	—	V <sub>p-p</sub>
Gain Reduction when muted (MC1–MC2 to $V_{CC}$ , $\overline{\text{Mute}} = 0\text{ V}$ )	G <sub>TXM</sub>	—	68	—	dB
Distortion (0 dBm @ $V_{CC}$ ) f = 300 Hz f = 1.0 kHz f = 3.4 kHz	TH <sub>DT</sub>	—	0.5 1.5 1.3	— 3.0 —	%
Output Noise at $V_{CC}$ (@ 1.0 kHz)	N <sub>TXO</sub>	—	17	—	$\mu\text{Vrms}$
<b>SIDETONE</b>					
Sidetone Gain (Gain from $V_{CC}$ to RXO1–RXO2 with signal applied to MC1/MC2, I <sub>LOOP</sub> = 20 mA)	G <sub>ST</sub>	—	-27	-22	dB

## PIN DESCRIPTIONS

Symbol	Pin Number		Description
	(SOIC)	(DIP)	
VCC	1	1	Power supply pin for the IC. Supply voltage is derived from loop current. Transmit amp output operates on this pin.
LR	2	2	Resistors R2 + R3 at this pin set the DC characteristics of the circuit. The majority of the loop current flows through these resistors. Other components may be used to produce required DC characteristics for individual regulatory agencies.
VB	3	3	A resistor or appropriate network (R1) connected from this pin to VCC sets the AC terminating impedance (return loss spec).
VR	4	4	A 1.7 volt regulated output which can be used to bias the microphone. Additionally, this voltage powers a portion of the internal circuitry. Can nominally supply 300–500 $\mu$ A.
GND	5	5	Ground pin for the entire IC. Normally this is not connected to, nor to be confused with earth ground.
MC1	6	6	Inverting differential input to the microphone amplifier. Input impedance is typically 20 k $\Omega$ .
MC2	7	7	Non-inverting differential input to the microphone amplifier. Input impedance is typically 20 k $\Omega$ .
MC0	8	8	Microphone amplifier output. Amplifier's gain is fixed at 30 dB.
RAGC	10	9	Loop current sensing input. The voltage at this pin, determined by the loop current and R3, operates the loop length equalization circuit.
TXI	11	10	Input to the transmit amplifier from the microphone amplifier, DTMF source, and other sources. Input impedance $\approx$ 1.0 k $\Omega$ .
RX02	12	11	Receive amplifier non-inverting differential output. Current capability to the receiver is typically set at $\pm$ 3.0 mA peak.
RX01	14	12	Receive amplifier inverting differential output. Current capability to the receiver is typically $\pm$ 3.0 mA peak. Gain is set by R8.
RXI	15	13	Summing input to the receive amplifier. This pin is an AC virtual ground.
RXA	16	14	Summed outputs of the receive current amplifier, sidetone amplifier, and an AGC point. Normally connected to the receive amplifier input (RXI) through a coupling capacitor.
ZB	17	15	Input to the receive current amplifier. A balance network (ZB) is connected between this pin and VCC. The network affects the receive level and sidetone performance. Input impedance is $\approx$ 500 $\Omega$ in series with a diode.
MS	18	16	Mode Select Input. A logic "1" sets the IC for pulse dialing. A logic "0" sets the IC for tone (DTMF) dialing. Effective only if MUTE is at a logic "0". Input impedance is $\approx$ 60 k $\Omega$ .
MUTE	19	17	Mute input. A logic "1" sets normal speech mode. A logic "0" mutes the microphone and receive amplifiers and allows MS to be functional. Input impedance is $\approx$ 60 k $\Omega$ referenced to VDD. An internal fixed delay of 11 mSec minimizes clicks in the receiver when returning to the speech mode.
VDD	20	18	A regulated 3.3 volt output for an external dialer. Output source current capability is 1.0 mA in speech mode, 2.5 mA in tone dialing mode.

FIGURE 1 — BLOCK DIAGRAM AND TEST CIRCUIT

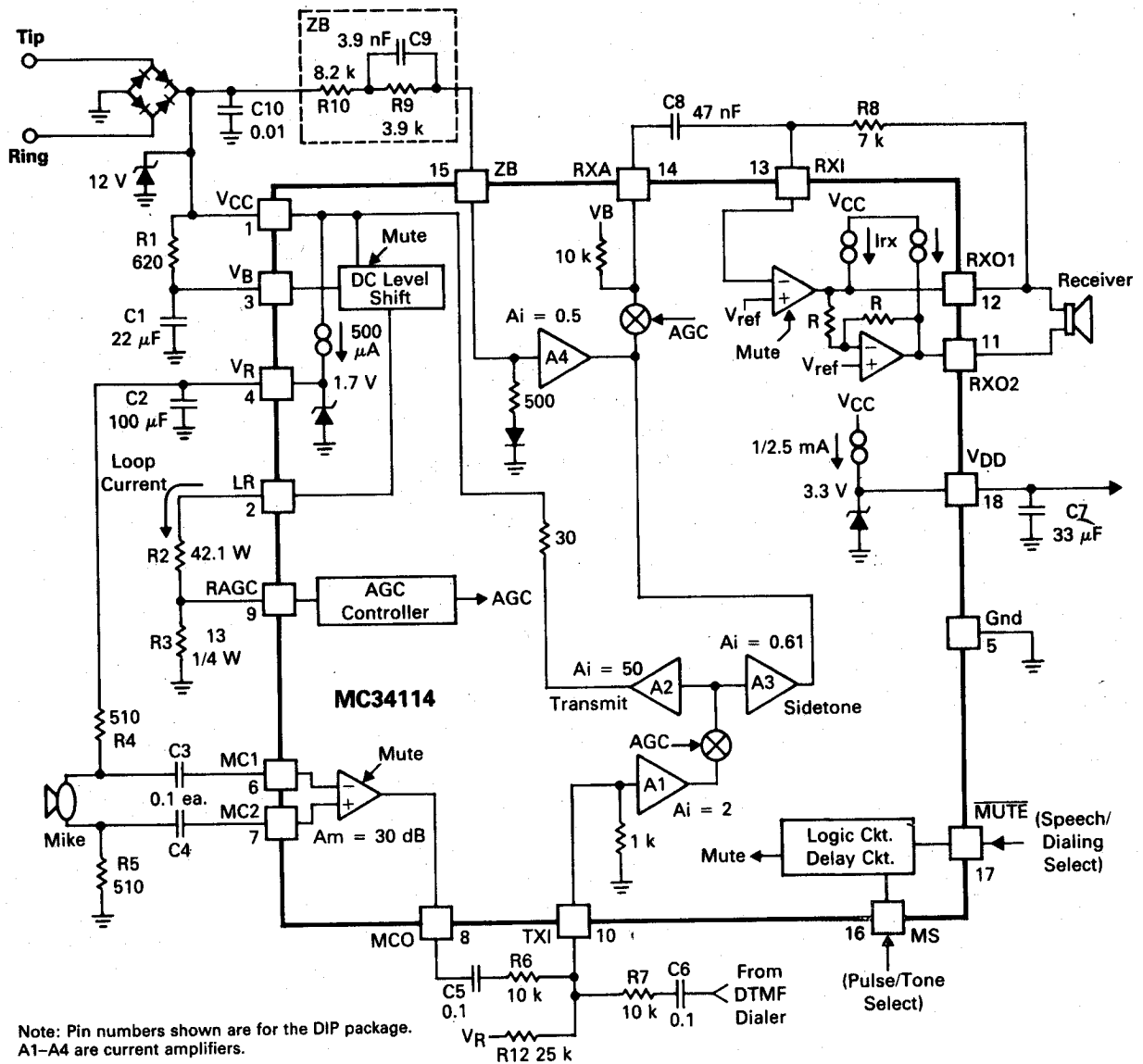


FIGURE 2 —  $I_{CC}$  versus  $V_{CC}$  (SPEECH MODE)

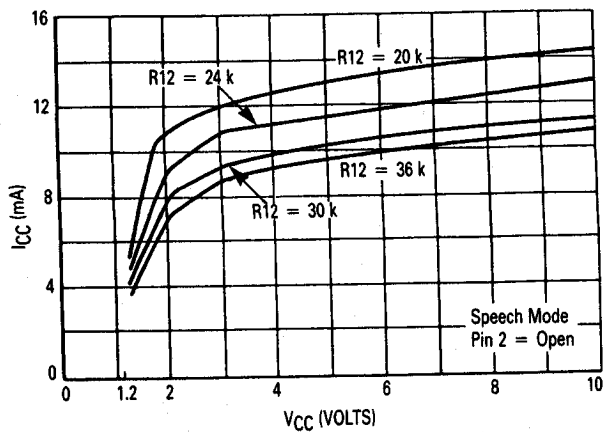


FIGURE 3 —  $I_{CC}$  versus  $V_{CC}$  (PULSE DIALING MODE)

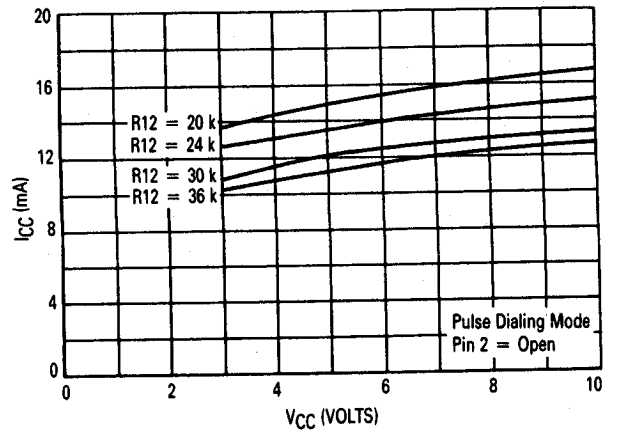


FIGURE 4 —  $I_{CC}$  versus  $V_{CC}$  (TONE DIALING MODE)

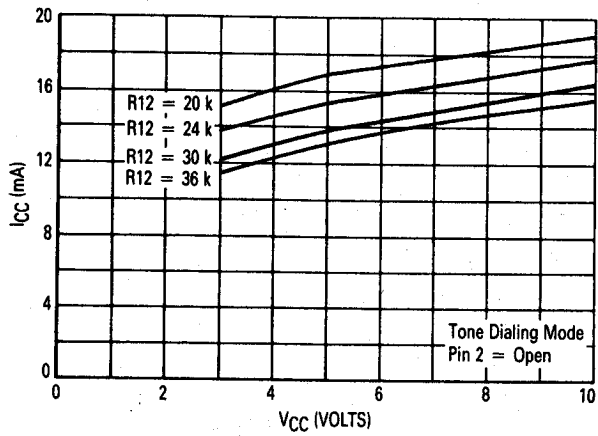


FIGURE 5 —  $V_R$  versus  $I_R$  versus  $V_{CC}$

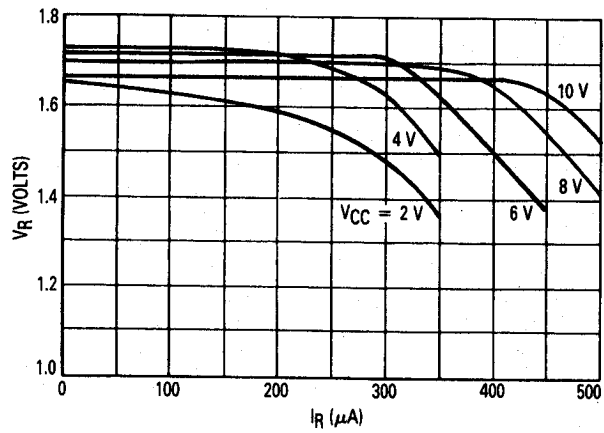


FIGURE 6 —  $V_{DD}$  versus  $I_{DD}$

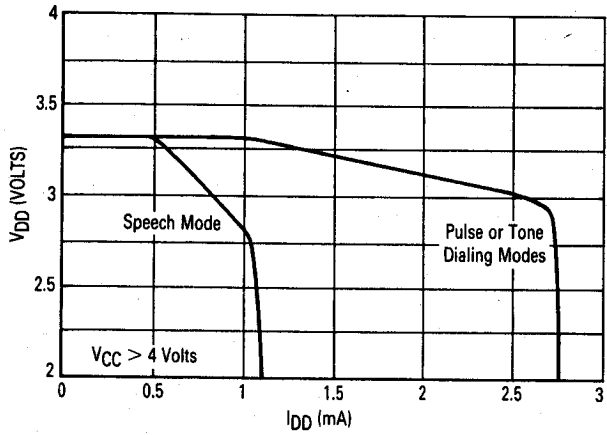


FIGURE 7 — AGC GAIN versus VOLTAGE AT PIN 9

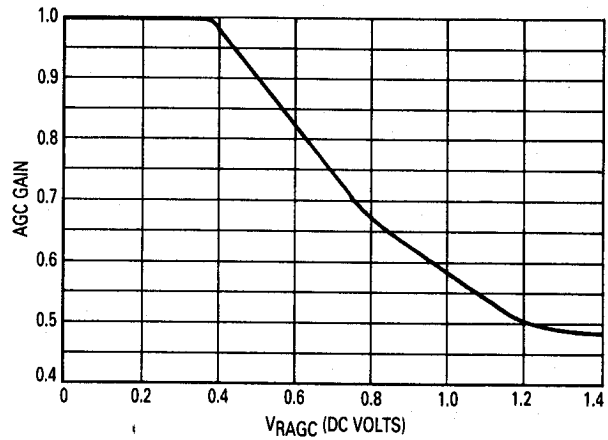


FIGURE 8 — MAXIMUM TRANSMIT SIGNAL AT  $V_{CC}$

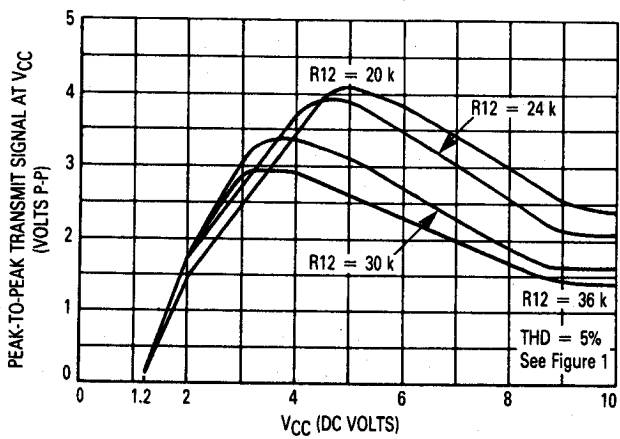
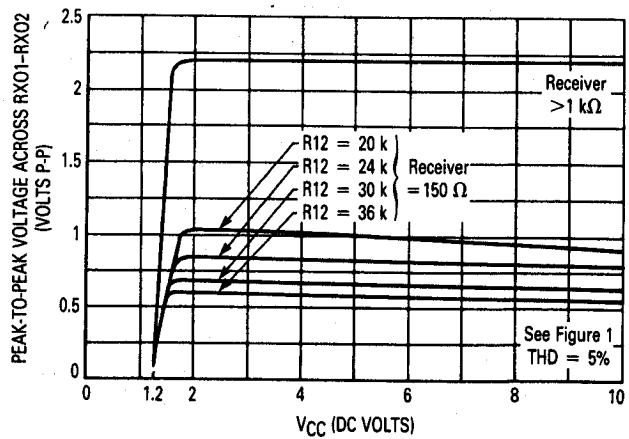


FIGURE 9 — MAXIMUM RECEIVER SIGNAL



### SYSTEM PERFORMANCE

FIGURE 10 — TIP/RING VOLTAGE versus LOOP CURRENT

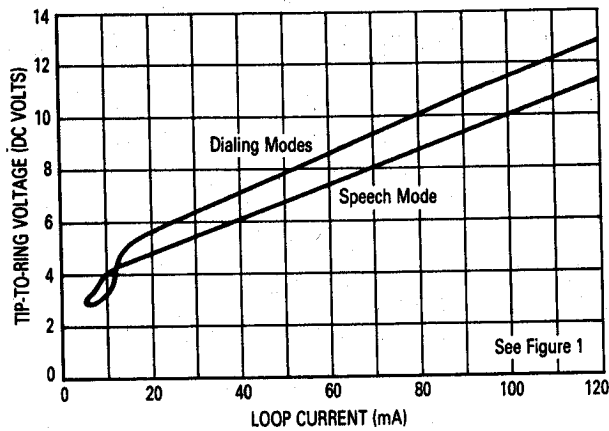


FIGURE 11 — AC TERMINATING IMPEDANCE versus LOOP CURRENT

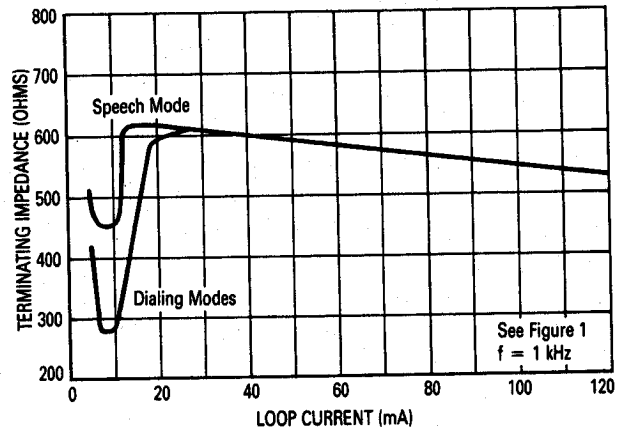


FIGURE 12 — TRANSMIT GAIN versus LOOP CURRENT

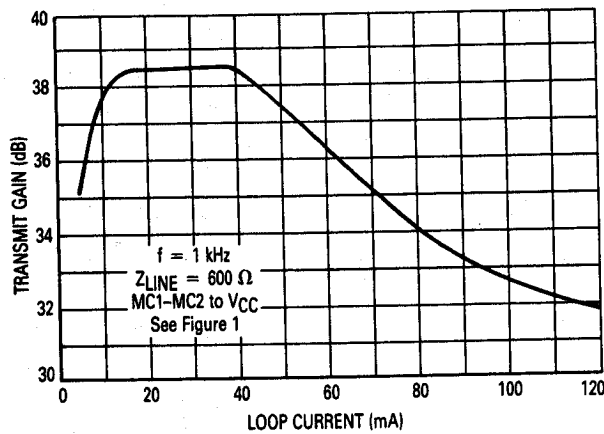


FIGURE 13 — TRANSMIT GAIN versus FREQUENCY

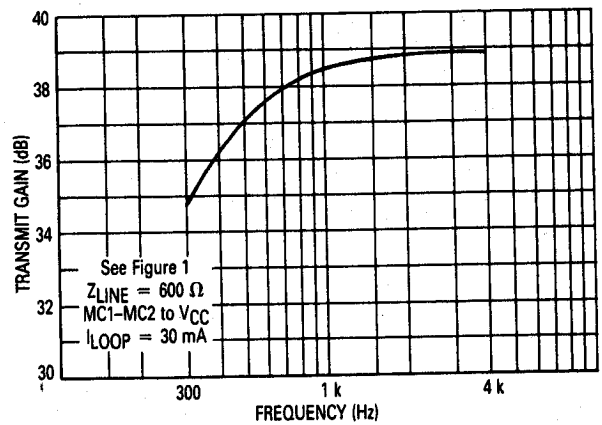


FIGURE 14 — RECEIVE GAIN versus LOOP CURRENT

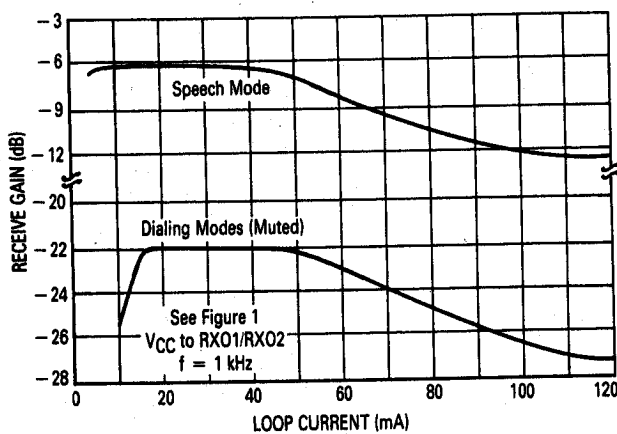
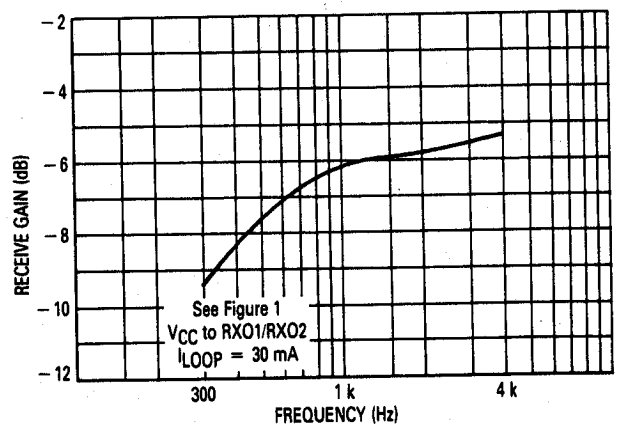


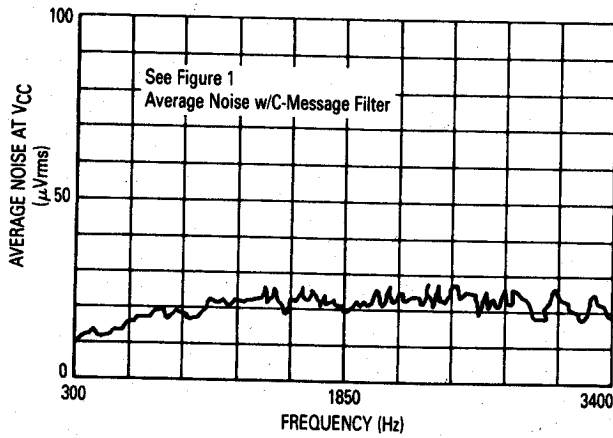
FIGURE 15 — RECEIVE GAIN versus FREQUENCY



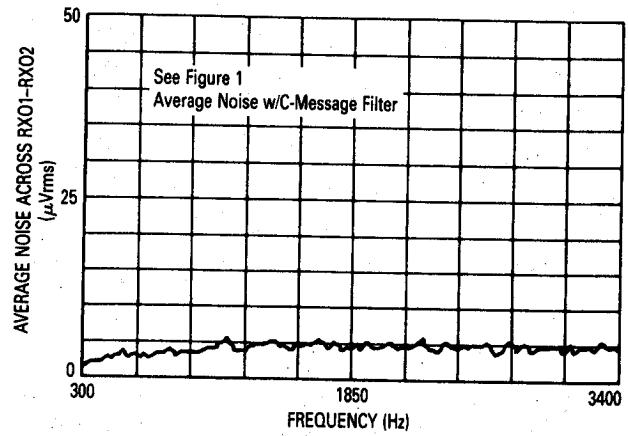


### SYSTEM PERFORMANCE

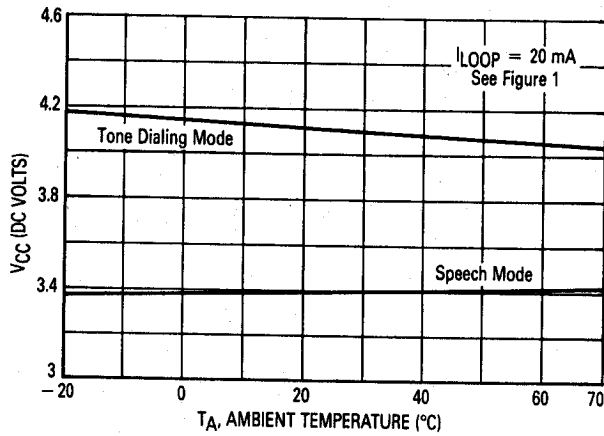
**FIGURE 16 — TRANSMIT NOISE SPECTRUM**



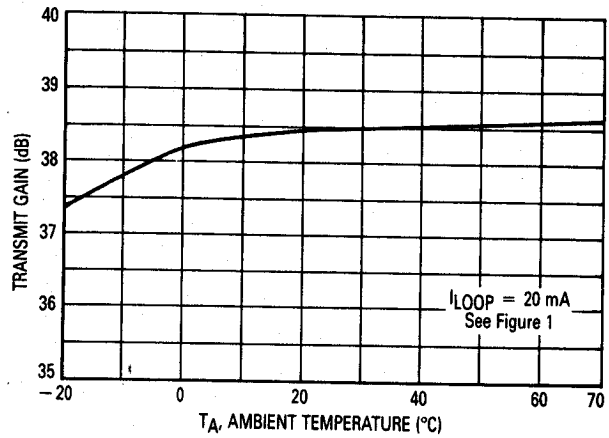
**FIGURE 17 — RECEIVE NOISE SPECTRUM**



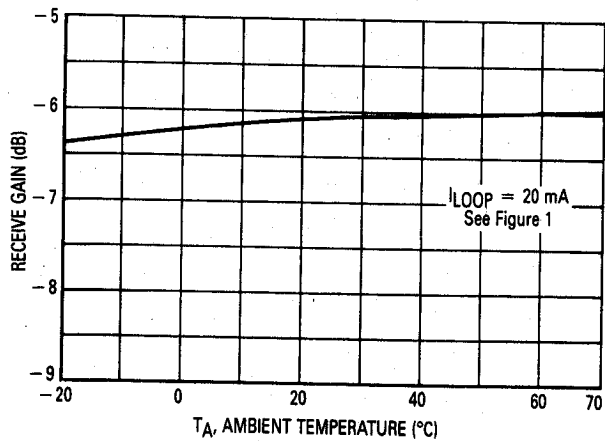
**FIGURE 18 — VCC versus TEMPERATURE**



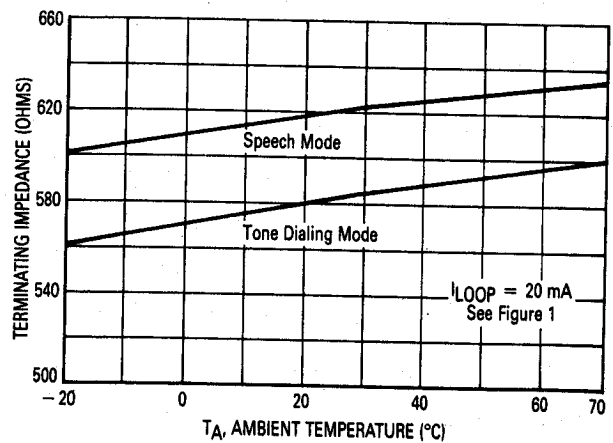
**FIGURE 19 — TRANSMIT GAIN versus TEMPERATURE**



**FIGURE 20 — RECEIVE GAIN versus TEMPERATURE**



**FIGURE 21 — AC TERMINATING IMPEDANCE versus TEMPERATURE**



## FUNCTIONAL DESCRIPTION

### INTRODUCTION

The MC34114 is a speech network which provides the hybrid function and the DC loop current interface of a telephone, and is meant to connect to Tip and Ring through a polarity guard bridge. The transmit, receive, and sidetone gains are externally adjustable, and additionally, line length compensation varies the gains with variations in loop current. The microphone amplifier employs a differential input to minimize RFI susceptibility.

The loop current interface portion determines the dc voltage versus current characteristics, and provides the required regulated voltages for internal and external use.

The dialer interface provides three modes of operation: speech (non-dialing), pulse dialing and tone (DTMF) dialing. When switching among the modes, some parameters are changed in order to optimize the circuit operation for that mode. The following table summarizes those changes:

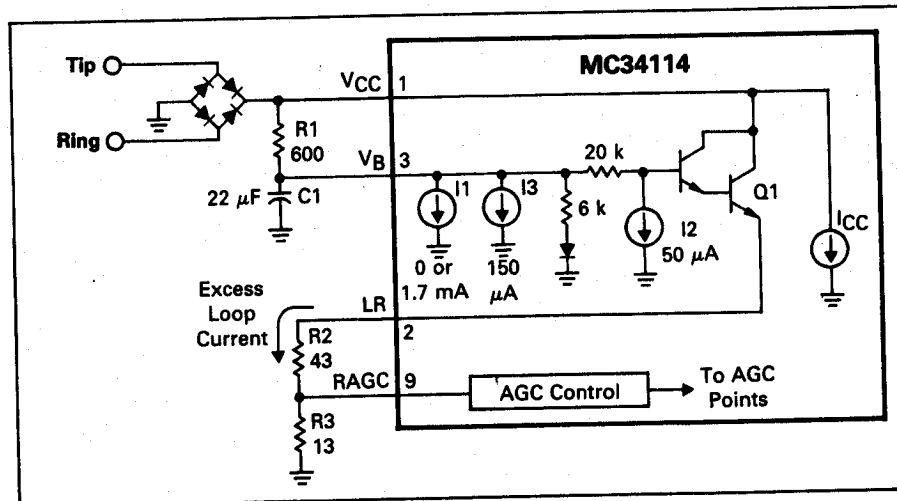
TABLE 1 — OPERATING PARAMETERS versus OPERATING MODE

Function	Speech	Pulse	Tone
LR Level Shift ( $V_{CC} - V_{LR}$ )	2.8 V	2.8 V	3.8 V
$V_{DD}$ Current Capability	1.0 mA	2.5 mA	2.5 mA
Microphone Amplifier	Functional	Muted	Muted
Receive Amp. Internal Feedback Resistor	Switched Out	Switched In	Switched In

### DC LINE INTERFACE AND LINE LENGTH COMPENSATION

The DC line interface circuit (Pins 1, 2, 3) sets the DC voltage characteristics with respect to loop current. See Figure 22.

FIGURE 22 — DC LINE INTERFACE EQUIVALENT



The DC voltage at  $V_{CC}$  is determined by the level shift from  $V_{CC}$  to  $LR$ , plus the voltage across  $R2$  and  $R3$ .  $I_{CC}$  is the internal bias current required by the MC34114, nominally in the range of 10 mA.  $I_{CC}$  can be reduced, if necessary, by increasing  $R12$ , consistent with the transmit and receive signal requirements (see the Transmit Path section). See Figures 2-4, 8 and 9.

In the speech and pulse dialing modes current source  $I1$  is off, and the level shift is due to  $Q1$ 's base-emitter drop ( $\approx 1.4$  V), 1.0 volt across the 20 k resistor, and the voltage across  $R1$ , which varies with  $V_{CC}$  from 0.15 volts to  $\approx 1.0$  volt. When the loop current coming in from Tip and Ring exceeds the  $I_{CC}$  requirement, the excess current flows through  $Q1$ ,  $R2$  and  $R3$ , to set the slope of the V-I characteristic for the circuit ( $Q1$  has an equivalent resistance of  $\approx 10 \Omega$ ). See Figure 10.

In the tone dialing mode, current source  $I1$  is on, drawing an additional 1.7 mA through  $R1$ , increasing the level shift by  $\approx 1.0$  volts (for  $R1 = 600 \Omega$ ). This feature ensures that, at low loop currents, sufficient voltage is present at  $V_{CC}$  for the DTMF signals, and that the  $V_{DD}$  regulator supplies sufficient voltage to an external dialer. The  $I_{CC}$  current increases by  $\approx 1.3$  mA in this mode.

$R1$  must be kept in the range of 100 to 1800  $\Omega$ . If it is too large, insufficient current will flow into  $V_B$  to bias up the circuit. If it is too small, insufficient filtering at  $V_B$  will result unless  $C1$  is increased accordingly. Speech signals must be well filtered from  $V_B$ .

The voltage across  $R3$  determines the operation of the AGC circuit (line length compensation). As the voltage at  $RAGC$  increases from  $\approx 0.4$  volts to  $\approx 1.2$  volts, the AGC Control varies the current gain of the two AGC

points (Figure 1) from 1.0 to 0.5, thereby reducing the gain of the transmit and receive paths by 6.0 dB. See Figure 7. Pin 9 is a high impedance input.

The values of R2 and R3 can be varied as required to comply with various regulatory agencies, to compensate for additional circuitry powered by the loop current (microprocessor, etc.), or to change the starting point of the AGC function. If the AGC is not used, Pin 9 should be connected to ground for high gains, or to  $V_R$  for low gains.

### VOLTAGE REGULATORS

The MC34114 has two internal voltage regulators which are used to power external as well as internal circuitry.

The  $V_R$  regulator provides 1.7 volts at a maximum current of  $500 \mu\text{A}$  (see Figure 5). This output is normally used to set the DC bias into TXI (Pin 10), and to bias the electret microphone.  $V_R$  will typically be  $\approx 300 \text{ mV}$  less than  $V_{CC}$  when  $V_{CC}$  is below 2.0 volts.

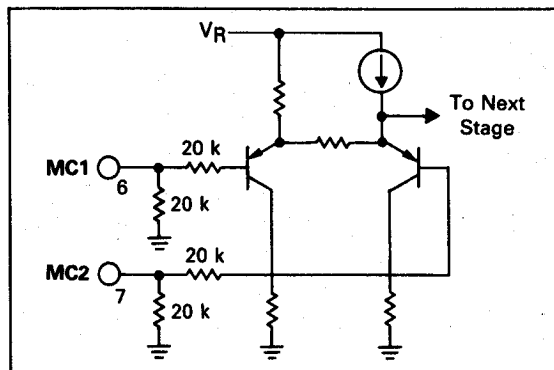
The  $V_{DD}$  regulator provides 3.3 volts at a maximum of 1.0 mA in the speech mode, and 2.5 mA in the pulse or tone dialing modes (see Figure 6). It is normally used to power an external dialer, and other associated circuitry.  $V_{DD}$  is normally  $\approx 0.5$  volts less than  $V_{CC}$  until  $V_{DD}$  regulates. It is a shunt type regulator which automatically switches to a high impedance mode when  $V_{CC}$  falls below 1.4 volts. This feature prevents excessive battery drain in the event a memory sustaining battery is used with the external dialer. Leakage current (with  $V_{CC} = 0$ ) is typically  $0.02 \mu\text{A}$  with an applied voltage of up to 6.0 volts at  $V_{DD}$ , with pin 17 open or at  $V_{DD}$ . If Pin 17 is at ground, a current of several hundred microamps will flow into  $V_{DD}$  and out of pin 17 (see paragraph on Logic Interface).

### MICROPHONE AMPLIFIER

The microphone amplifier (Pins 6, 7, 8) has a differential input, single ended output, and a fixed internal gain of +30 dB (31.1 V/V). The output is in phase with

MC2, and out of phase with MC1. The inputs (see Figure 23) have a nominal impedance of  $20 \text{ k}\Omega$ , and are matched to provide a high common mode rejection (typically 26 dB).

FIGURE 23 — INPUT STAGE



To preserve a high CMRR against unwanted signals induced in the microphone leads, the microphone should be biased with two equal value resistors as shown in Figure 1.

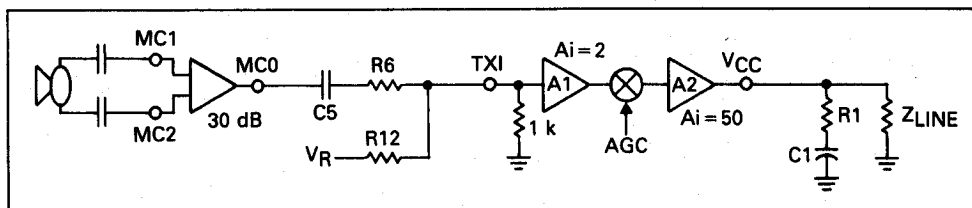
The output (MCO) has a DC bias voltage of  $\approx 1.1$  volts ( $V_{CC} > 3.0$  volts), and can nominally swing  $\approx 2.0$  volts p-p ( $500 \text{ mV p-p}$  at  $V_{CC} = 1.2$  volts). The output impedance is  $\approx 270 \Omega$ , and has a peak current capability of  $\approx 160 \mu\text{A}$  for 5% THD.

When the MC34114 is switched to either dialing mode, the microphone amplifier is muted by  $\approx 70 \text{ dB}$  (300 Hz–4 kHz), effectively disabling the microphone. The DC voltage at MCO is  $\approx 80 \text{ mV}$  when muted.

### TRANSMIT PATH

The AC 'transmit' path consists of the components shown in Figure 24 (taken from Figure 1).

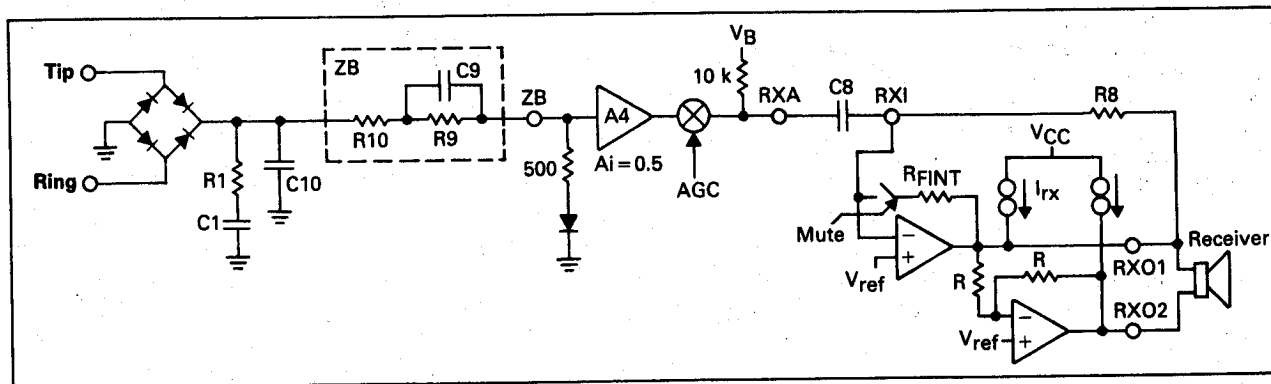
FIGURE 24 — TRANSMIT PATH



The voltage output at MCO is converted to a current into TXI by C5, R6, and TXI's 1.0 k input impedance (with a slight error due to R12). A1 and A2 are current amplifiers with a combined gain of 100. The AGC point has a current gain of 1.0 at low loop currents, and

decreases to 0.5 as loop current increases. Therefore the current gain from TXI to  $V_{CC}$  varies from 100 to 50 as loop current is increased. The resulting current output at  $V_{CC}$  acts on R1 and the line impedance (nominally  $600 \Omega$  each, C1 is an AC short) to generate a voltage

FIGURE 25 — RECEIVE PATH



signal at  $V_{CC}$ , and consequently, at Tip and Ring. The voltage gain from MC1–MC2 to Tip and Ring is therefore (first order):

$$G_{TX} = \frac{A_m \times 100 \times AGC \times R1/Z_{LINE}}{(R6 + 1.0 \text{ k})} \quad (\text{Equation 1})$$

where  $A_m$  is the gain of the microphone amplifier (31.1 V/V). At low loop currents  $G_{TX} \approx 84$  V/V (38.5 dB), and decreases to  $\approx 42$  V/V (32.5 dB) at higher loop currents, for the component values shown in Figure 1 (@ 1.0 kHz).

For more precise calculations, consideration should be given to the effects of C5 (in series with R6), R12 and R7 (each in parallel with TXI's 1.0 k impedance), and C10 and the ZB network (each in parallel with R1 and  $Z_{LINE}$ ). The cumulative effects of these additional components is  $\approx 1.5$  dB.

The voltage signal at  $V_{CC}$  is out of phase with that at TXI, and in phase with that at MC1.

The maximum available voltage swing at  $V_{CC}$  is a function of the impedance at  $V_{CC}$  ( $R1/Z_{LINE}$ ), the DC bias current at A2's output, and the  $V_{CC}$  DC voltage. A2's bias current is determined by the bias current through R12 ( $V_R/(R12 + 1.0 \text{ k})$ ) which is gained up by A1, A2 and the AGC point. Figure 8 indicates the maximum voltage swing at  $V_{CC}$  (with 5% THD).

### RECEIVE PATH

The AC receive path consists of the components shown in Figure 25 (taken from Figure 1).

R1, typically 600  $\Omega$ , provides the AC termination (return loss) for the receive signals coming in on Tip and Ring (C1 is an AC short). The receive signal creates an AC current through the ZB network and the 500  $\Omega$  resistor at the ZB pin. A4 reduces that current by 1/2, and then feeds it through the AGC point which has a gain of 1.0 at low loop currents. The AGC gain is reduced to 0.5 as loop current increases. The AC current out of the AGC point feeds through C8 to RXI, the receive amp's summing node (if C8 is large, RXA can be considered a virtual ground, and no AC current flows through the internal 10 k resistor). The voltage swing at RXO1 is then determined by the current through C8 and the R8 feedback resistor. The second op amp (at

RXO2) is internally configured for inverting unity gain. The voltage gain from Tip and Ring to RXO1–RXO2 (differential) is (first order):

$$G_{RX} = \frac{R8 \times AGC}{(ZB + 500)} \quad (\text{Equation 2})$$

where  $ZB = R10 + R9/C9 (\approx R10 + R9)$ .

For more precise calculations, the effects of C9 and C8 must be considered. C9 provides a phase shift to aid sidetone cancellation (see paragraph on Sidetone), and C8 can be selected to provide low frequency roll-off. High frequency roll-off can be obtained by adding a feedback capacitor across R8. For the component values shown in Figure 1, the receive gain measured  $\approx 0.495$  V/V (–6.1 dB) at low loop currents, and reduces to  $\approx 0.25$  V/V (–12 dB) at higher loop currents (@ 1.0 kHz).

When the MC34114 is switched to either dialing mode ( $Mute = low$ ), the receive gain is muted by the switching in of the internal feedback resistor ( $R_{FIN}$  from RXO1 to RXI) — typically 1.0 k $\Omega$ . The effective feedback resistor for the amplifier is now the parallel combination of R8 and  $R_{FIN}$ . The amount of muting (in dB) can be calculated from:

$$G_{RXM} = 20 \times \log \left( \frac{R8 + R_{FIN}}{R_{FIN}} \right) \quad (\text{Equation 3})$$

The internal resistor is switched in coincident with  $Mute$  (Pin 17) switching low. However, when  $Mute$  is switched high, a delay (nominally 11 mSec) occurs before the internal resistor is switched out. This feature prevents dialing transients (particularly during pulse dialing) from being heard as loud clicks in the receiver.

The DC bias voltages at RXI, RXO1 and RXO2 is  $\approx 0.65$  volts. The bias current at RXI is  $\approx 50$  nA into the pin. The maximum voltage swing at RXO1 and RXO2 is a function of the receiver impedance (typically 100–150  $\Omega$ ), and the value of the two  $I_{rx}$  current sources in Figure 25.  $I_{rx}$ , set by R12 (between  $V_R$  and TXI), is equal to:

$$I_{rx} = \frac{V_R \times 50 \times AGC}{(R12 + 1.0 \text{ k})} \quad (\text{Equation 4})$$

Figure 9 indicates the maximum voltage swing available to the receiver.

## SIDETONE CANCELLATION

Sidetone cancellation is provided by current amplifier A3 (see Figure 1) which generates a current representative of the transmit signal to cancel the reflected sidetone signal coming in through ZB and A4. To achieve perfect cancellation (no AC current out of RXA), it is necessary that:

$$ZB = (40 \times R1/Z_{LINE}) - 500 \Omega \quad (\text{Equation 5})$$

where ZB is the network composed of R9, R10, and C9, and  $Z_{LINE}$  is the AC impedance of the line. The reactive components of the line's impedance can be compensated for by making the ZB network comparably reactive. In Figure 1, C9 provides a phase shift to compensate for the phase shift created by the phone line.

## LOGIC INTERFACE ( $\overline{\text{Mute}}$ and MS)

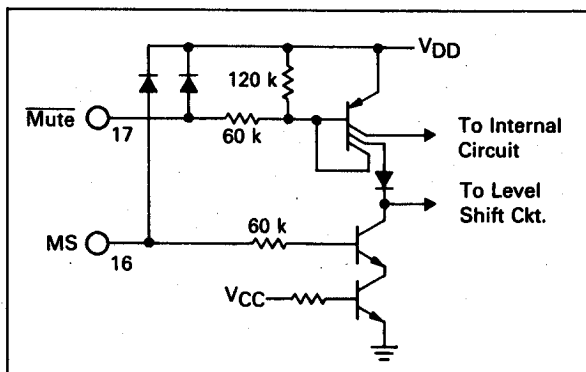
The two logic inputs ( $\overline{\text{Mute}}$  and MS) are used to switch the MC34114 between the speech and dialing modes according to the following table:

TABLE 2 — LOGIC INPUTS

$\overline{\text{Mute}}$	MS	Mode
High	X	Speech
Low	High	Pulse Dialing
Low	Low	Tone Dialing

Table 2, together with Table 1, describes the condition of the MC34114 in the various modes. Figure 26 shows the input configuration for the  $\overline{\text{Mute}}$  and MS pins.

FIGURE 26 — LOGIC INPUTS



The  $\overline{\text{Mute}}$  input has a nominal input impedance of 60 k $\Omega$ , referenced to  $V_{DD}$ . This pin may be left open for a logic "1," or connected to  $V_{DD}$ . A logic "1" is defined as between  $V_{DD}-0.5$  volts and  $V_{DD}$ . A logic "0" is defined as between ground and 1.0 volt. The switching threshold is  $\approx 2.3$  volts. When  $\overline{\text{Mute}}$  is switched low (speech to dialing), the changes listed in Table 1 will occur within 10  $\mu\text{s}$ . Upon switching high (back to speech mode), however, the receive amplifier feedback resistor will be switched out after a delay of (typically) 11 ms. This feature prevents dialing transients (particularly during pulse dialing) from being heard as loud clicks in

the receiver. The other functions listed in Table 1 transfer within 10  $\mu\text{s}$ .

The MS pin is functional only when  $\overline{\text{Mute}}$  is low and its only function is to provide an additional voltage level shift between  $V_{CC}$  and LR in the tone dialing mode (see the section on DC Interface). The input impedance is  $\approx 60$  k $\Omega$  when  $V_{CC} > 1.5$  volts. A logic "0" is between ground and 0.3 volts, and a logic "1" is between 2.0 volts and  $V_{DD}$ . The switching threshold is typically 0.75 volts. If unused, this pin must be connected to ground or  $V_{DD}$ , and not left open.

When  $V_{CC} = 0$  (on-hook condition), and a voltage in the range of 0 to 6.0 volts is applied to  $\overline{\text{Mute}}$ , a leakage current of (typically) 0.02  $\mu\text{A}$  will flow if  $\overline{\text{Mute}}$  and  $V_{DD}$  are at the same voltage. If  $\overline{\text{Mute}}$  is at a voltage different from  $V_{DD}$ , current will flow through the internal resistors and/or diode. If a memory sustaining battery is used in conjunction with an external dialer, and is configured so that its voltage appears at  $V_{DD}$ ,  $\overline{\text{Mute}}$  must be allowed to float or be connected to  $V_{DD}$  — otherwise current (in the range of 100–200  $\mu\text{A}$ ) will flow from the battery through  $V_{DD}$  and out of the  $\overline{\text{Mute}}$  pin.

When  $V_{CC} = 0$ , and a voltage in the range of 0 to 6.0 volts is applied to MS, a leakage current of (typically) 0.01  $\mu\text{A}$  will result as long as  $\overline{\text{Mute}}$  is open or at  $V_{DD}$ . If  $\overline{\text{Mute}}$  is at ground, an equivalent 3.5 k $\Omega$  parasitic resistance exists between MS and  $\overline{\text{Mute}}$ .

When  $V_{CC} < 1.5$  volts, the Mute function is non-existent and the MC34114 will be in the speech mode.

## APPLICATIONS INFORMATION

### DESIGN SEQUENCE

The design sequence for incorporating the MC34114 into most applications will be as follows (refer to Figure 1):

- 1) Decide on the AC terminating impedance (return loss), and select R1 to be that value (typically 600  $\Omega$ ). If there are other devices powered by the loop current which will be in parallel with R1 (such as a pulse dialing circuit) which lower the effective terminating impedance, R1 can be increased accordingly.
- 2) Select the maximum value of R12 which will provide the minimum required transmit and receive signals according to Figures 8 and 9.
- 3) Select the sum (R2 + R3) to provide the desired Tip and Ring DC voltage versus loop current characteristics. Then select R3 for the desired starting point of the loop length compensation. The compensation begins when the voltage across R3 is  $\approx 0.4$  volt.
- 4) Select R4 and R5 (they should be equal) to properly bias the microphone. The microphone's manufacturer should be consulted for this information.
- 5) Select R6 for proper transmit gain. See equation 1. Then select C5 to provide low frequency roll-off. Adjust R6 as required.
- 6) Select the ZB network (R9, R10, C9) to provide sidetone cancellation. See equation 5.
- 7) Select R8 for proper receive gain (depends on the specific receiver used). See equation 2. Then select C8 to provide low frequency roll-off. Adjust R8 as required.

Additional comments on Figure 1 components:

1) Capacitors C1, C2, and C7 are required to stabilize the respective regulators. In most applications it should not be necessary to change from the values shown in Figure 1.

2) C3 and C4 can be selected to provide low frequency roll-off for the microphone signals.

3) C10 filters noise generated by the MC34114, and should be close to the VCC pin. Its recommended value (0.01 μF) is such that it does not noticeably affect the system parameters. It can be increased, if desired, to provide high frequency roll-off for both transmit and receive signals. This, however, will affect the return loss specification at higher frequencies.

4) Since TXI is a (relatively) low impedance current input, it is a convenient point for injecting any signals which are to be transmitted out onto Tip and Ring. C6 and R7 are shown for transmitting the DTMF signals from a dialer. Additional RC networks can be connected to TXI for transmitting signals from speakerphones, modems, or other signal sources. The voltage gain from each signal source to Tip and Ring is:

$$G_S = \frac{Z_{LINE}/R_1 \times 100 \times AGC}{(R_x + Z_{cx})} \quad \text{(Equation 6)}$$

where  $R_x$  and  $Z_{cx}$  represent the impedances of the R and C for the particular signal source. If several signal sources are connected to TXI, the parallel combination of R6, R12, the internal 1.0 k resistor, and any other RCs at this pin must be considered when setting the gain for each signal.

5) The 12 volt zener diode shown in Figure 1 is for transient protection, and normally does not conduct. Transient and overvoltage protection **MUST** be provided externally so that the Absolute Maximum Ratings are not exceeded.

### BASIC TELEPHONE CIRCUIT

Figure 27 depicts a complete basic telephone using the MC34114 speech network, the MC145412 pulse/tone dialer, and the MC34017 tone ringer.

The MC34114 provides the speech network/hybrid functions, and its component values are calculated as described previously in this data sheet. The resistor from VCC to V<sub>B</sub> is 820 Ω (rather than 600 Ω) in this example since it is in parallel with the 2.0 kΩ resistor in the pulse dialing transistor network (providing and effective 600 Ω termination).

The MC145412 dialer is a pulse/tone dialer with 10 number memory, including last number redial. Power to the dialer is from the MC34114's V<sub>DD</sub> output, diode connected with a memory sustaining battery.

The MC34017 tone ringer (see its data sheet for details) is connected directly to Tip and Ring as it is not necessary to disconnect it when off-hook. This circuit has an REN ≈ 0.5, and meets all EIA-470 and Bell system requirements for impedance, anti-bell tapping, and turn-on/off thresholds.

### OPERATION WITH A POWER SUPPLY

Figure 28 indicates how to incorporate the MC34114 into a circuit where a power supply is used.

FIGURE 27 — BASIC PULSE/TONE TELEPHONE

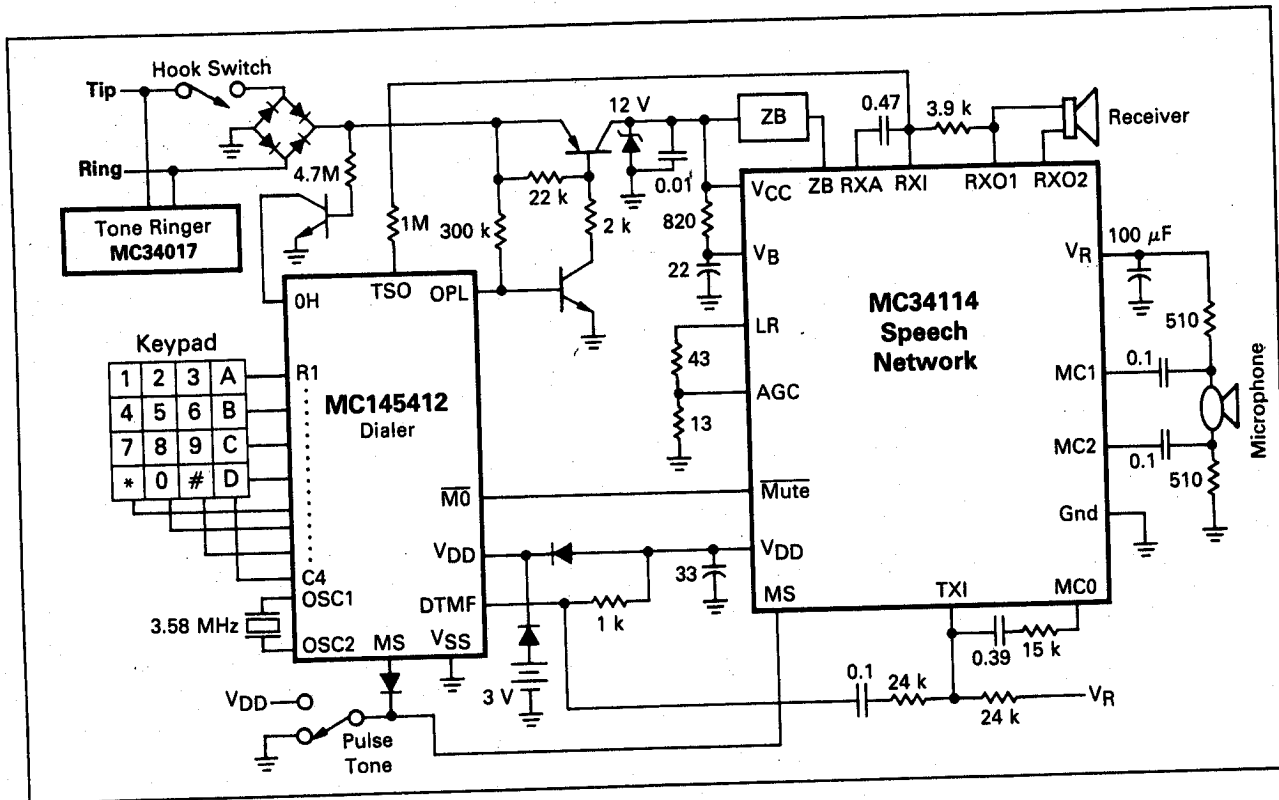
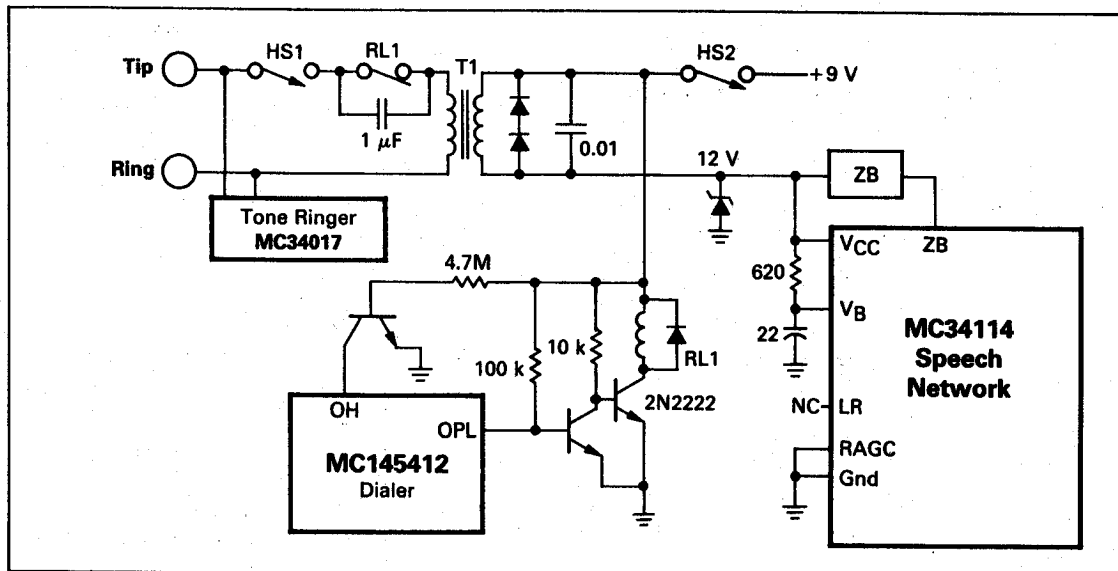


FIGURE 28 — USE WITH A POWER SUPPLY



A transformer (T1) is required at Tip and Ring to provide the isolation required between the phone line and any AC power and earth ground. (The transformer must be rated to handle the loop current.) Since the loop current does not pass through the MC34114, loop length compensation is not possible in this circuit, and pin 2 (LR) is left open. The RAGC pin is grounded, setting the transmit and receive gains to their maximum.

The transformer provides a path for the power supply to reach the MC34114, while simultaneously coupling speech signals between Tip/Ring and the MC34114. The two series diodes provide transient clamping, as does the 12 volt zener diode. Although a +9.0 volt supply is shown, other voltages can be used as long as the MC34114 receives between 4.0 and 10.5 volts at VCC.

Because of the isolation requirement, the MC145412 dialer requires a relay (RL1) to break the loop current during pulse dialing. The relay is normally off, and energized only during pulse dialing. The 1.0 μF capacitor (rated 250 volts min., NPO) across the relay contacts helps absorb transients generated during pulse dialing.

**ALTERNATE MICROPHONE CONFIGURATIONS**

The MC34114 is designed for use with electret microphones, although dynamic microphones can be used. Carbon microphones are not recommended as they generally require considerable bias current which is not available from the MC34114's regulators.

When using an electret microphone which requires more than 1.7 volts, but less than 1.0 mA for bias, it can be biased from V<sub>DD</sub> instead.

If a three terminal electret microphone (containing an internal biasing resistor or equivalent) is used, it should be connected to the MC34114 as shown in Figure 29. The common mode rejection of the balanced circuit shown in Figure 1 is not present however, and care should be taken to prevent unwanted signals (radio sta-

tions, noise, etc.) from being picked up by the microphone leads.

FIGURE 29 — 3-TERMINAL MICROPHONE

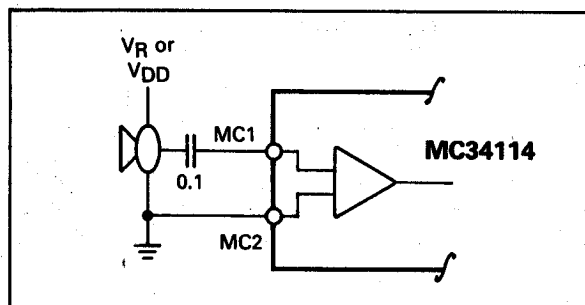
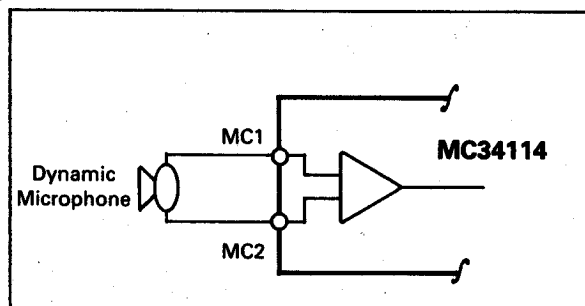


Figure 30 indicates use of the MC34114 with a dynamic microphone. The output level of dynamic microphones is generally lower than electret units, and so the gain of the transmit path will have to be adjusted accordingly.

FIGURE 30 — DYNAMIC MICROPHONE

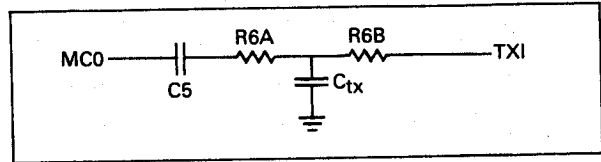


### FREQUENCY CHARACTERISTICS

Frequency characteristics for both transmit and receive signals are dependent entirely on the external components. The amplifiers within the IC have bandwidths from DC extending to in excess of 50 kHz, and therefore do not provide roll-off within the voiceband.

Low frequency roll-off for the transmit signals can be set by adjusting C3 and C4, or C5, or a combination of the three. High frequency roll-off can be provided by replacing R6 with the network shown in Figure 31.

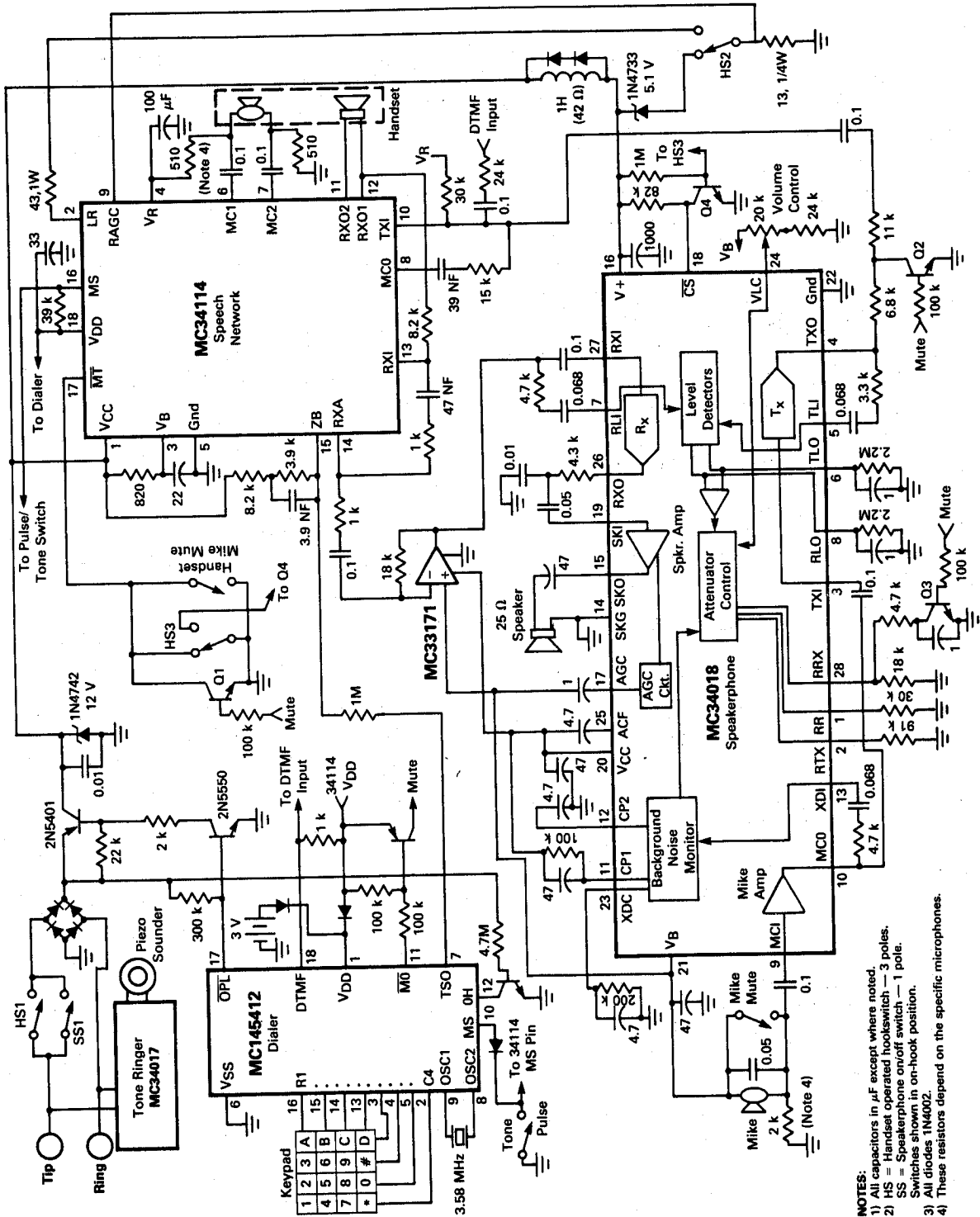
FIGURE 31 — TRANSMIT HF ROLL-OFF



The 3.0 dB upper frequency is determined by:

$$f = \frac{(R6A + R6B + 1.0 \text{ k})}{2\pi (R6A \times (R6B + 1.0 \text{ k}) \times C_{tx})} \quad (\text{Equation 7})$$

FIGURE 32 — PULSE/TONE FEATUREPHONE WITH MEMORY — LINE POWERED



- NOTES:
- 1) All capacitors in  $\mu\text{F}$  except where noted.
  - 2) HS = Handset operated hookswitch — 3 poles.
  - 3) SS = Speakerphone on/off switch — 1 pole. Switches shown in on-hook position.
  - 4) All diodes 1N4002.
- These resistors depend on the specific microphones.



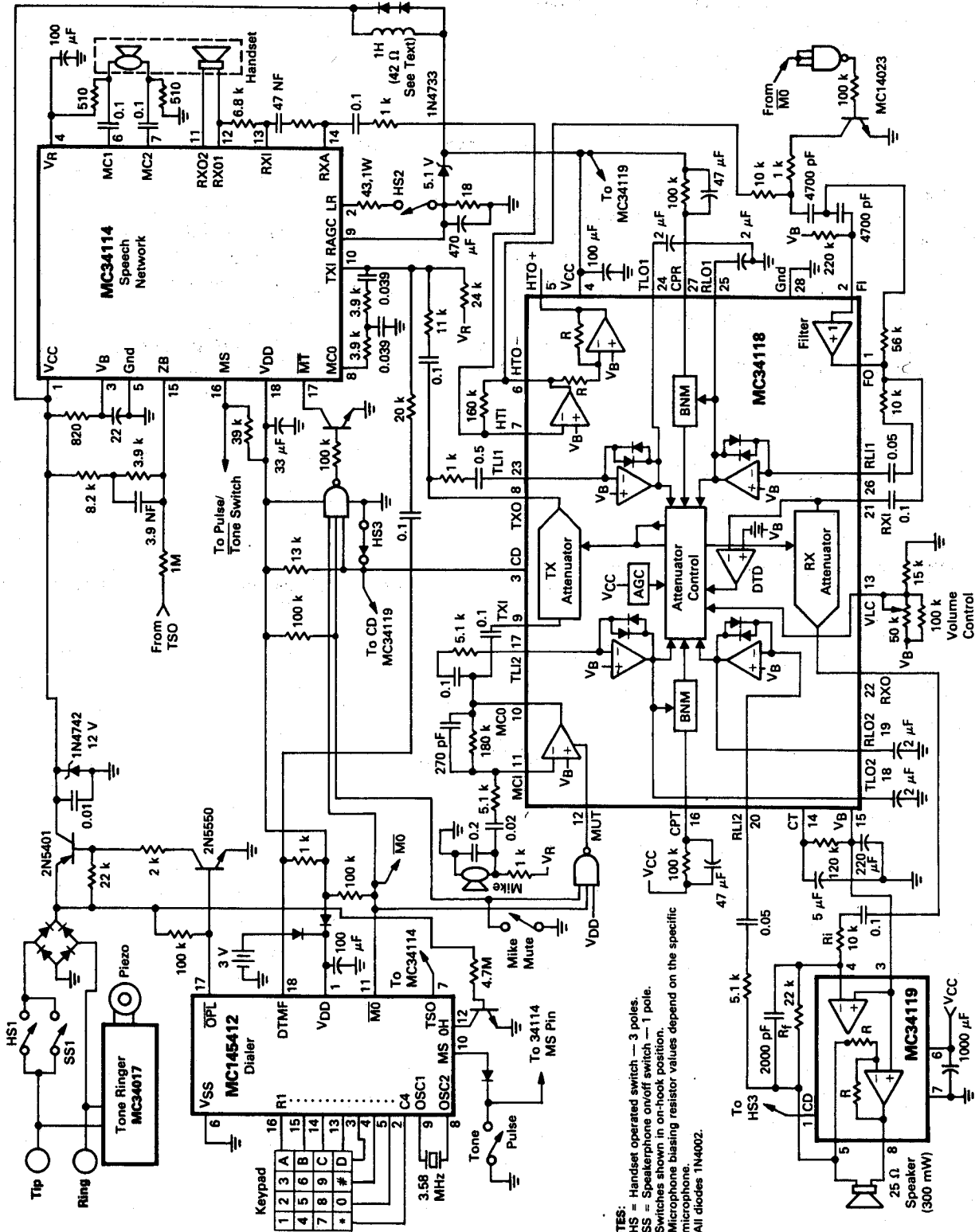
Low frequency roll-off for the receive signals can be set by adjusting C8, and high frequency roll-off can be set by placing a capacitor across R8.

**FEATUREPHONE DESIGN**

Figure 32 and Figure 33 depict two featurephone circuits which include the following functions: selectable handset and speakerphone operation, ten number memory pulse/tone dialer, tone ringer, a "Privacy"

(Mike mute) function, and line length compensation for both handset and speakerphone operation. Figure 32 uses the MC34018 speakerphone IC, while Figure 33 uses the MC34118 speakerphone IC. Application notes AN1002 and AN1004 (for Figure 32 and Figure 33 respectively) should be consulted for design and performance details, as well as variations of these two circuits.

**FIGURE 33 — PULSE/TONE FEATUREPHONE WITH MEMORY — LINE POWERED**



- NOTES:**  
 1) HS = Handset operated switch — 3 poles.  
 2) SS = Speakerphone on/off switch — 1 pole.  
 Switches shown in on-hook position.  
 3) Microphone biasing resistor values depend on the specific microphone.  
 4) All diodes 1N4002.

### EMI SUSCEPTIBILITY

Potential EMI susceptibility problems should be addressed early in the electrical and mechanical design of the telephone. EMI may enter the circuit through Tip and Ring, through the microphone wiring, or through any of the PC board traces. The most sensitive pins on the MC34114 are the microphone amplifier inputs (MC1, MC2). Board traces to these pins should be kept short, and the associated components should preferably be

physically close to the pins. TXI, RXI, and ZB should also be considered sensitive to EMI signals.

The microphone wires within the handset cord can act as an antenna, and pick up nearby radio stations. If this is a problem in the final design, adding RF filters (consisting of ferrite beads and small (0.001  $\mu$ F) ceramic capacitors) to the PC board where the wires attach to the board can generally reduce the problem.

### SUGGESTED VENDORS

#### Microphones

Primo Microphones Inc.  
Bensenville, Ill. 60106  
312-595-1022  
Model EM-60

MURA Corp.  
Westbury, N.Y. 11590  
516-935-3640  
Model EC-983-7

Hosiden America Corp.  
Elk Grove Village, Ill. 60007  
312-981-1144  
Model KUC2123

#### Telecom Transformers

Microtran Co., Inc.  
Valley Stream, N.Y. 11528  
516-561-6050  
Ask for Applications  
Bulletin F232

Stancor Products  
Logansport, IN 46947  
219-722-2244

PREM Magnetics, Inc.  
McHenry, Ill. 60050  
815-385-2700

Onan Power/Electronics  
Minneapolis, MN 55437  
612-921-5600

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