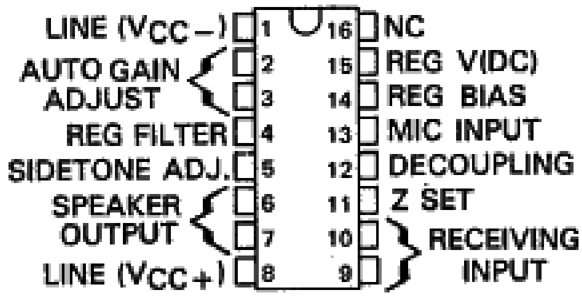
TCM1705A
INTEGRATED SPEECH CIRCUIT FOR TELEPHONE SET

APRIL 1983

- **Monolithic replacement for hybrid coil for the 2/4 wire conversion**
- **Low power requirement**
- **Automatic gain variation with DC line**
- **Externally adjustable transmitting and receiving gains**
- **Flat electrical response**
- **Externally adjustable sidetone**
- **Externally adjustable regulation function**

N PACKAGE
DUAL-IN-LINE PACKAGE
(TOP VIEW)



description

The TCM1705A is a monolithic integrated circuit which performs 2/4 wire conversion in an analog telephone set plus the functions of the receiving and transmitting amplifiers and sidetone operations. The device replaces the bulky hybrid coil and gain regulation components, allowing the replacement of the carbon granule microphone with a passive, higher performance transducer.

The TCM1705A provides low DC voltage operation, high peak-to-peak signal on the line, and low DC current operation programmable by external resistor. Transmitting and receiving gains are adjustable by external resistors, within a wide range, without affecting other parameters. Sidetone gain is also externally adjustable without affecting other parameters. Automatic gain regulation with DC line current may be adjusted and inhibited. Amplifier muting is available by grounding pin 14 of the device, and an input is available for an external tone source such as a DTMF tone generator.

The TCM1705A is designed for use with an electromagnetic-type headphone speaker and an electromagnetic or FET buffered electret microphone element. Because the characteristics required of the telephone set vary considerably from country to country worldwide, the TCM1705A is designed so that all the variables required are determined by external passive components and a circuit can be designed which satisfies a wide range of applications.

absolute maximum ratings over operating free-air temperature range

I_L Forward line current	120 mA
I_L Reverse line current	−150 mA
V_L Line voltage (3-ms pulse duration)	22 V
T_{stg} Storage temperature range	−65°C to 150°C
T_{op} Operating free-air temperature range	−25°C to 70°C
Continuous power dissipation at 25°C free-air temperature	1150 mW
Thermal resistance junction ambient	102°C/W

ADVANCE INFORMATION

TEXAS INSTRUMENTS

(T-75-07-15)

Fig. 1 - TCM 1705A - BLOCK DIAGRAM

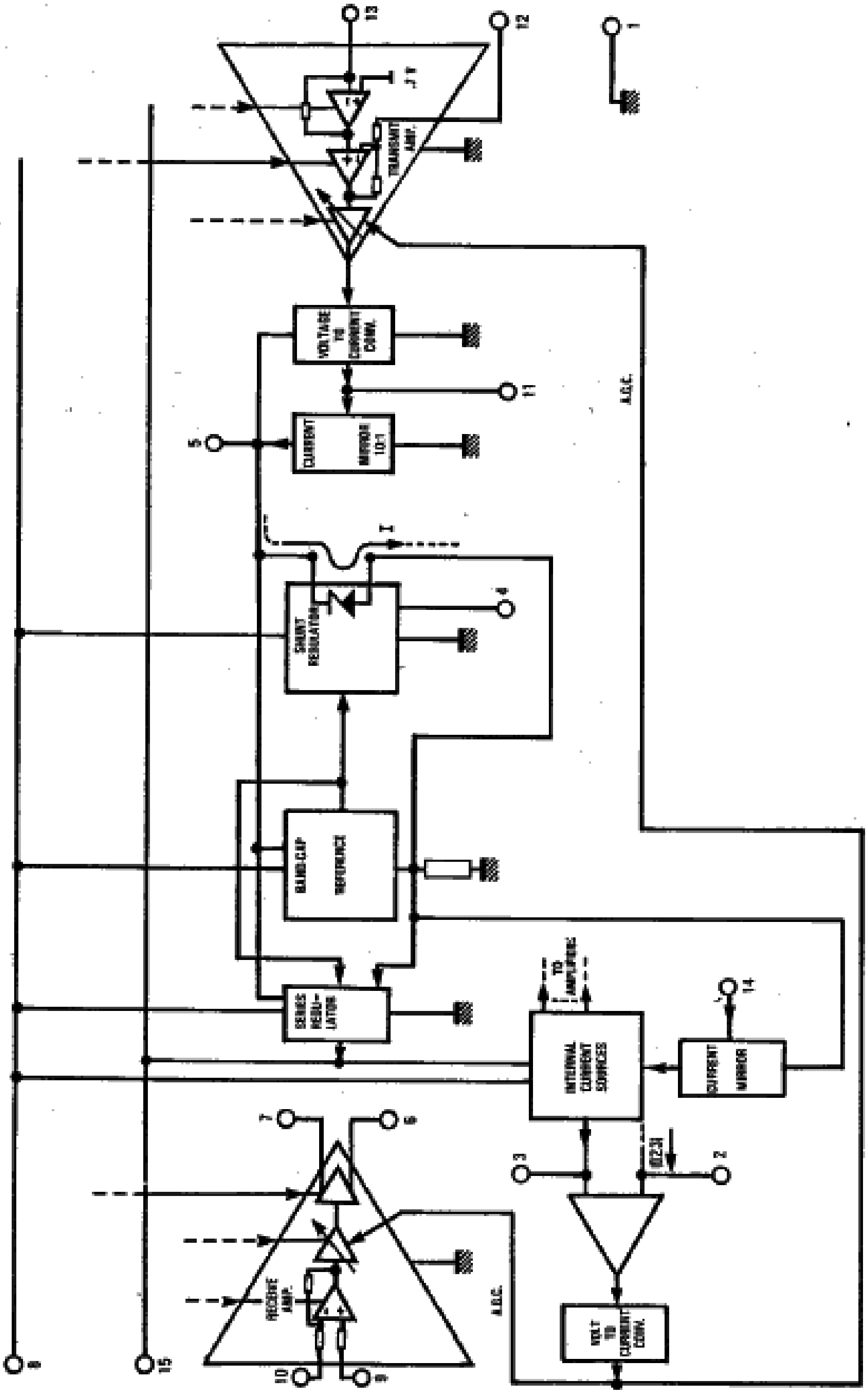
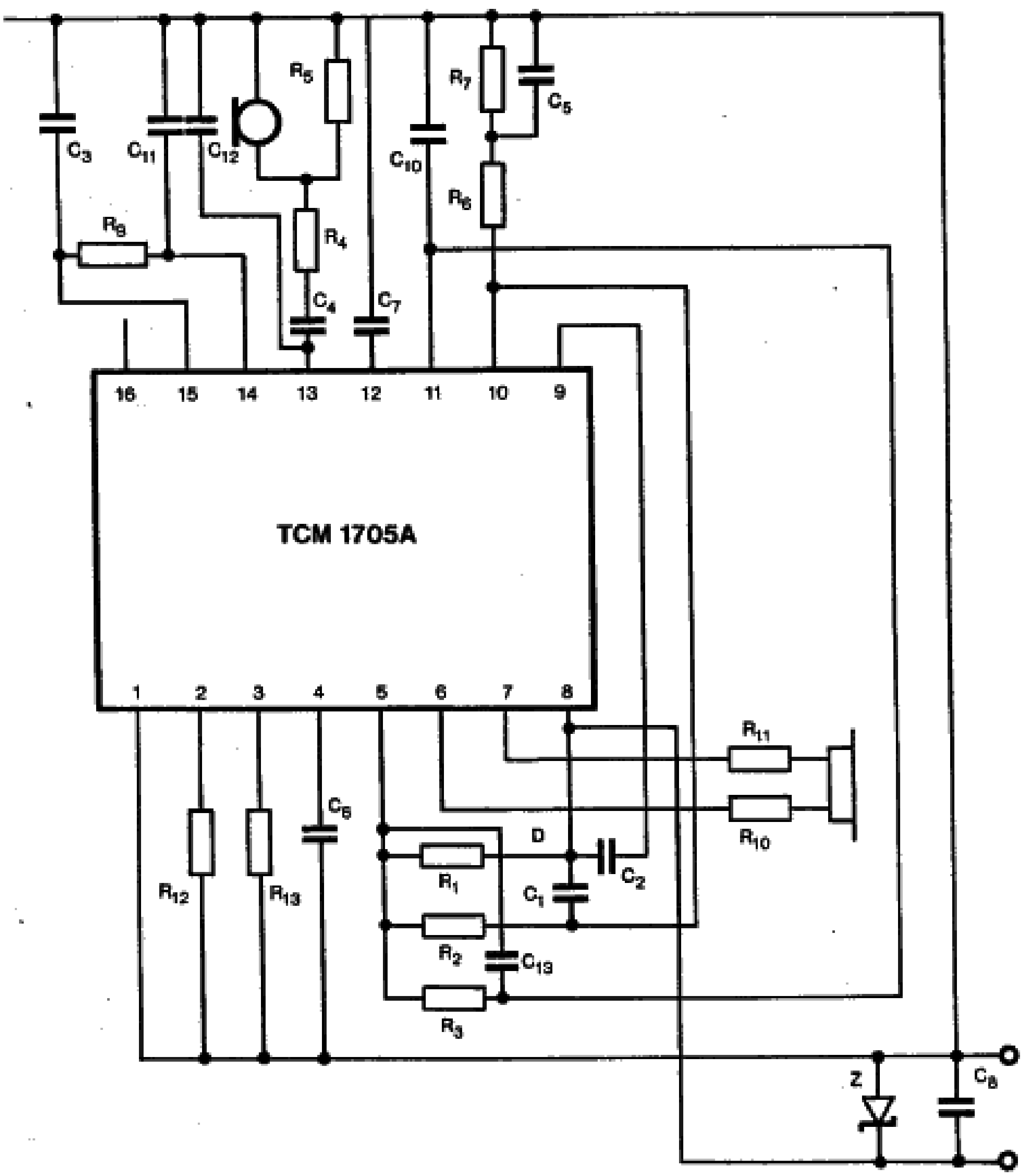


Fig. 2 - TCM 1705A - TYPICAL CIRCUIT FOR MAGNETIC TRANSDUCERS WITH 350 OHMS EQUIVALENT IMPEDANCE

TCM 1705A EXTERNAL COMPONENTS VALUES:

R_1 = 26.7 Ω
R_2 = 187 Ω
R_3 = 12K
R_4 = 1K
R_5 = 1K
R_6 = 1.62K
R_7 = 8.66K
R_9 = 24.3K
R_{10} = 130 Ω
R_{11} = 130 Ω
R_{12} = 487 Ω
R_{13} = 3.83K
C_1 = 220 nf
C_2 = 470 nf
C_3 = 1 µf
C_4 = 3.3µf
C_5 = 22nf
C_6 = 3.3µf
C_7 = 1 µf
C_8 = 10nf
C_{10} = 22nf
C_{11} = 10nf
C_{12} = 10nf
C_{13} = 4.7nf
Z = 12V



Note : See Application note 3 for external components function.

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Fig. 3 - TCM 1705A - TEST CIRCUIT FOR DC MEASUREMENTS

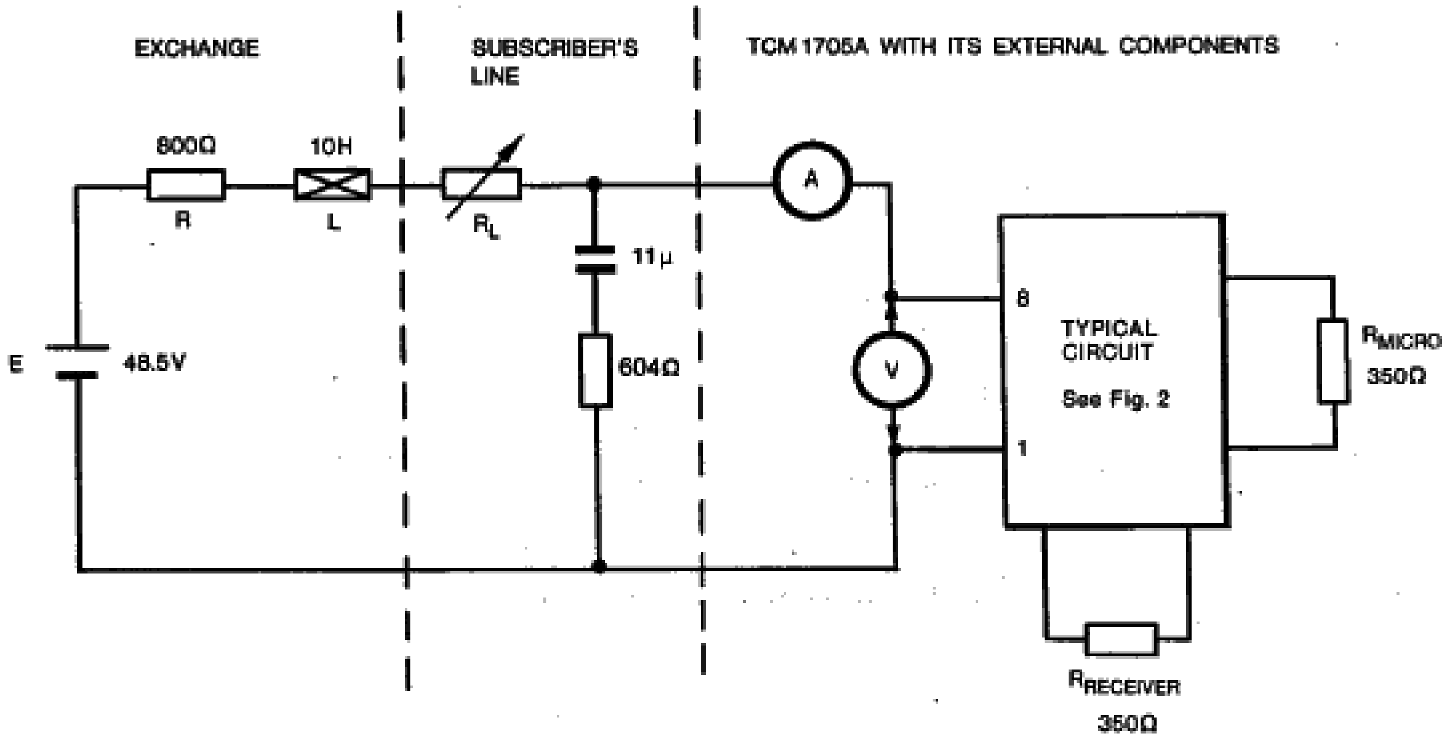

Fig. 4 - TCM 1705A - TRANSMISSION TEST CIRCUIT

TRANSMISSION GAIN G_T IS DEFINED AS :

$$G_T = 20 \log \frac{V_L}{V_M} \text{ (dB)}$$

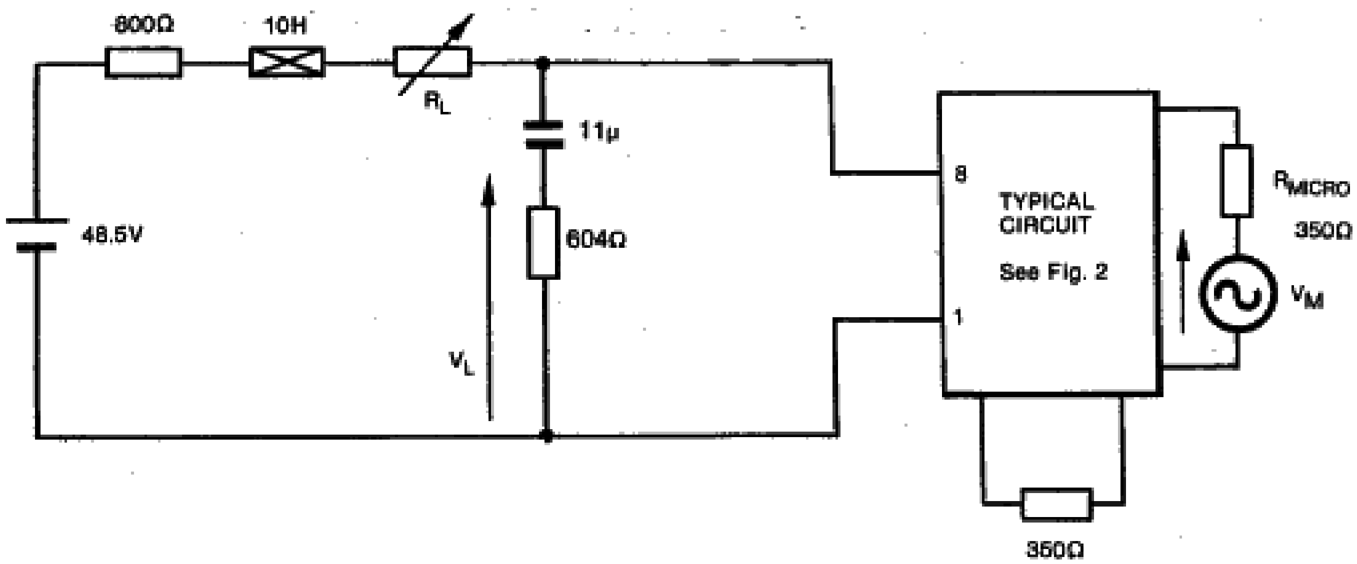

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Fig. 5 - TCM 1705A - RECEIVING TEST CIRCUIT

RECEIVING GAIN G_R IS DEFINED AS :

$$G_R = 20 \log \frac{V_R}{V_L} \text{ (dB)}$$

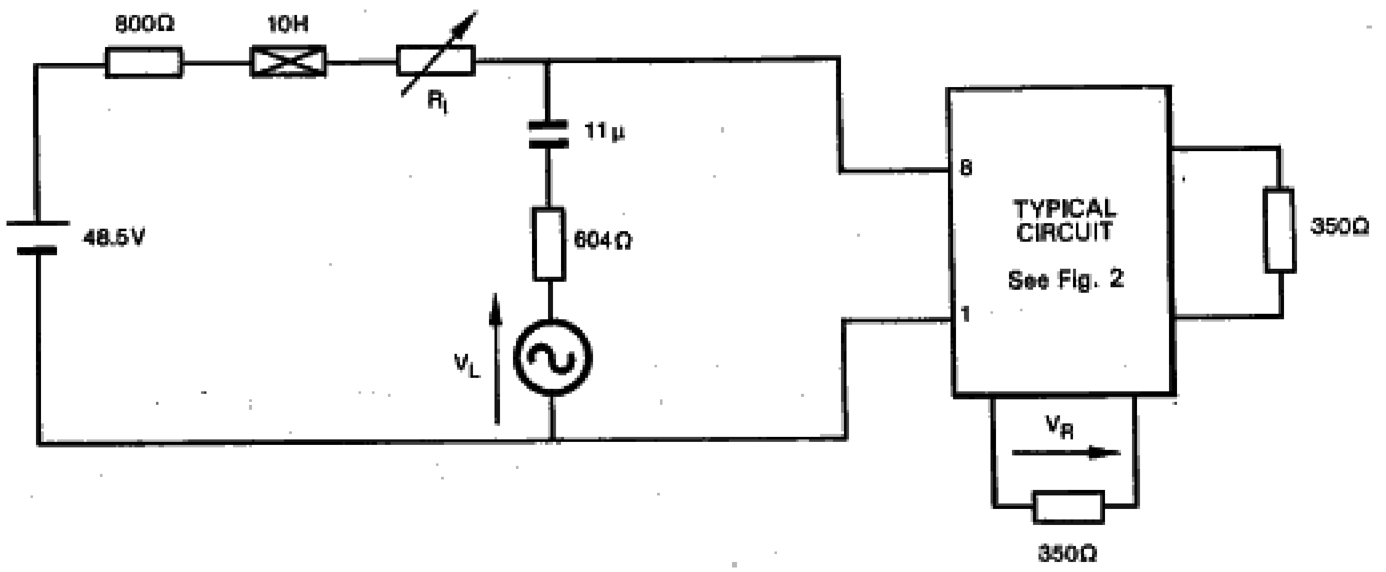
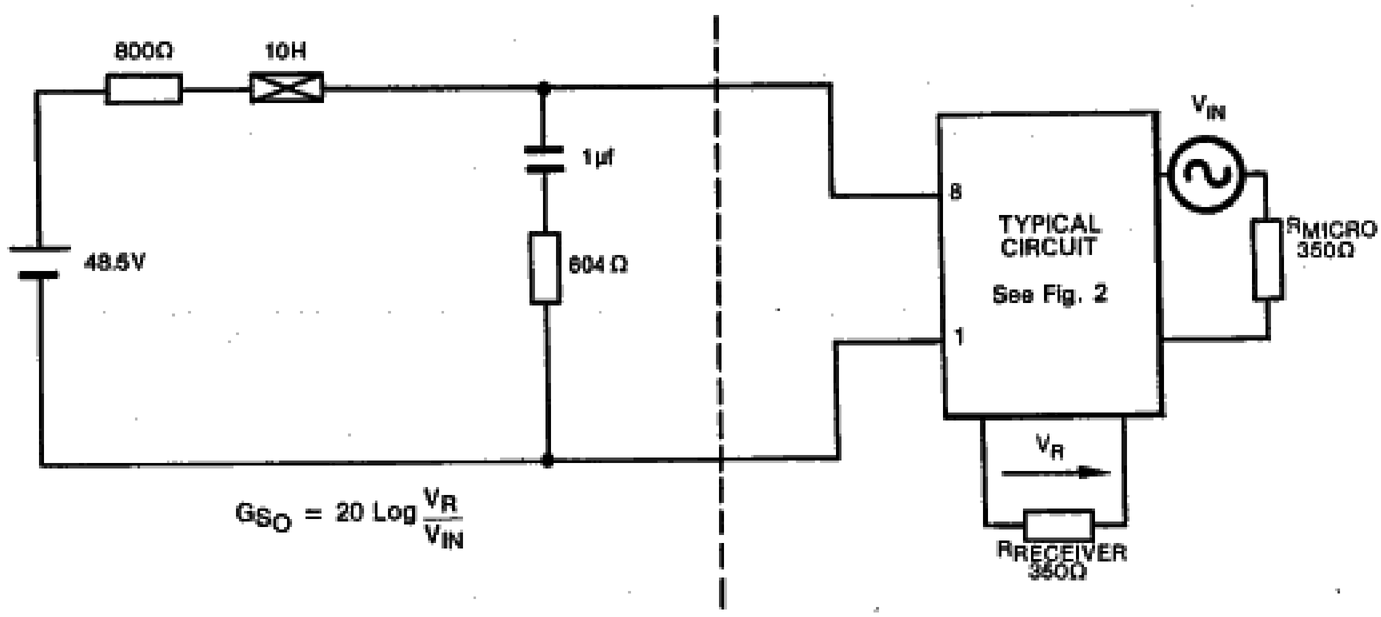


Fig. 6 - TCM 1705A - SIDETONE TEST CIRCUIT (0 Km line length)



$$G_{SO} = 20 \text{ Log} \frac{V_R}{V_{IN}}$$

V_{IN} is a signal containing the following frequencies, with the relative levels:

300 Hz	−71.4 dBm	1900 Hz	−64.7 dBm
700 Hz	−60 dBm	2300 Hz	−66.6 dBm
1100 Hz	−61.4 dBm	2700 Hz	−66.6 dBm
1500 Hz	−64 dBm		

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ELECTRICAL CHARACTERISTIC
(T_{AMB} = 25°C, f = 300 to 3400Hz UNLESS OTHERWISE SPECIFIED)

PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	REMARKS
V_L DC LINE VOLTAGE	I_L = 9MA		3.5		V	Fig. 2,3
	I_L = 12MA		3.6	4.4	V	
	I_L = 18MA		4.0	4.8	V	
	I_L = 30MA	3.7	4.5	5.5	V	
	I_L = 50MA		5.6	6.5	V	
	I_L = 80MA		7.0	8.0	V	
V_5 SHUNT REGULATOR	I_L = 30MA	3.3	4.0	4.8	V	Fig. 2,3
V_{15} SERIES REGULATOR		1.7	1.9	2.1	V	
G_T TRANSMITTING GAIN GTO	T_{AMB} = +25°C, I_L = 9MA		47			Fig. 2,6 Externally adjustable (See enclosed Appl. Notes 6)
	f = 1KHz, I_L = 12MA	45.9	47.4	48.9		
	V_M = 3m$V_{p\text{-}p}$, I_L = 18MA	45.8	47.3	48.8	dB	
	I_L = 30MA	43.9	45.4	46.9	dB	
	I_L = 50MA	40.3	41.8	43.3	dB	
	I_L = 80MA	40.2	41.7	43.2	dB	
TRANSMITTING DISTORTION	T_{AMB} = 25°C f = 1KHz VOLTAGE PEAK FOR 3% DISTORTION					Fig. 2,4
	I_L = 9MA		0.9		V_{peak}	
	I_L = 12MA	0.5	1.10		V_{peak}	
	I_L = 18MA	1.20			V_{peak}	
	I_L = 30MA	1.85			V_{peak}	
	I_L = 50MA	1.85			V_{peak}	
	I_L = 80MA	1.85			V_{peak}	
TRANSMITTING FREQUENCY RESPONSE	V_M = 3m$V_{p\text{-}p}$ I_L = 12 to 80MA f_{REF} = 1KHz			+1 -2	dB	Fig. 2,4
TRANSMITTING NOISE	V_M = 0V I_L = 12 to 80MA		−70		dBV_p	Fig. 2,4

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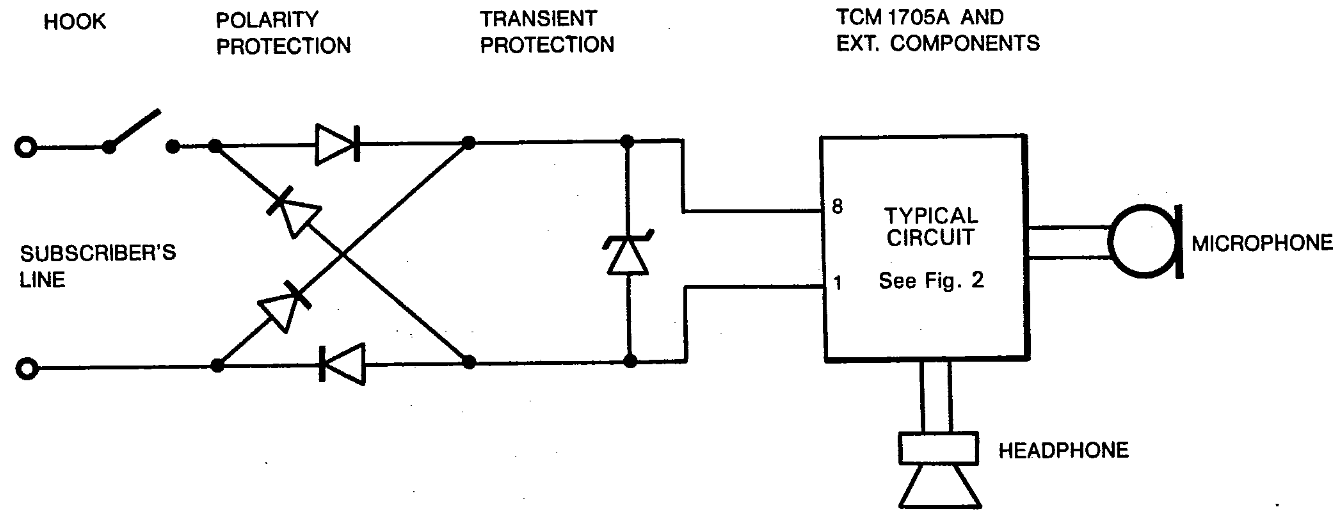
ELECTRICAL CHARACTERISTICS (Continued)

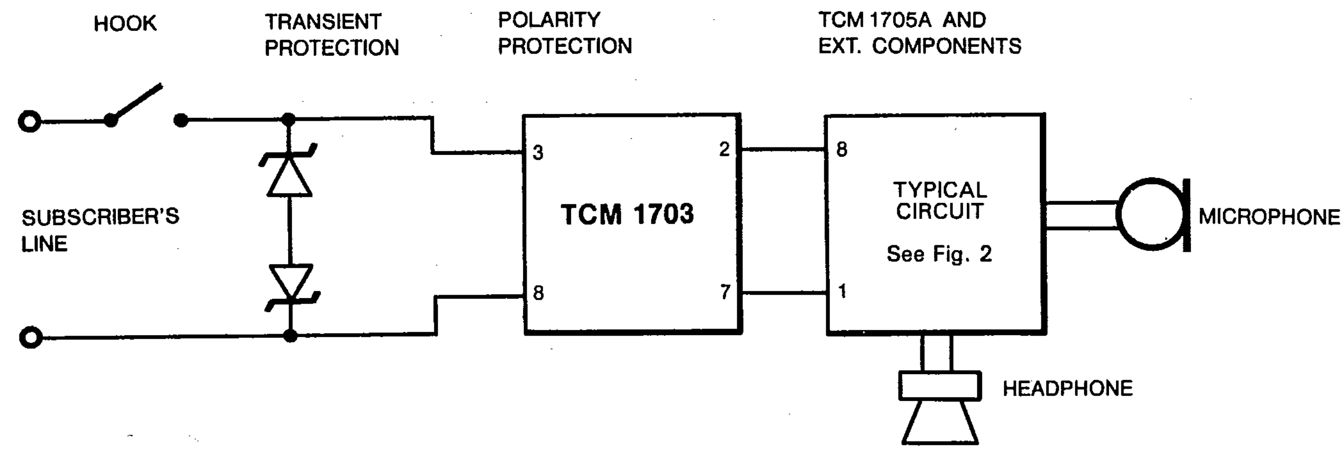
PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT	REMARKS
RECEIVING AMPLIFIER						
G_R RECEIVING GAIN GRO	T_{AMB} = 25°C, f = 1KHz, V_L = 0.3V_{p-p}, I_L = 9MA		-13			Fig. 2,5 Externally adjustable (See enclosed Appl. Note 7)
	I_L = 12MA	-12.5	-11	- 9.5	dB	
	I_L = 18MA	-12.3	-10.8	- 9.3	dB	
	I_L = 30MA	-14.4	-12.9	-11.4	dB	
	I_L = 50MA	-17.9	-16.4	-14.9	dB	
	I_L = 80MA	-18.0	-16.5	-15.0	dB	
RECEIVING DISTORTION	T_{AMB} = 25°C, f = 1KHz, I_L = 9MA		200			Fig. 2,5
	I_L = 12MA	280				
	I_L = 18MA	300				
	I_L = 30MA	320			mV	
	I_L = 50 to 80MA	350				
	PEAK FOR 3% DISTORTION					
RECEIVING FREQUENCY RESPONSE	V_L = 0.3V_{p-p}, I_L = 12 to 80MA, f_{REF} = 1KHz			±1.5	dB	Fig. 2,5
RECEIVING NOISE	V_L = 0V, I_L = 12 to 80MA		-75		dBVP	Fig. 2,5
LINE IMPEDANCE TO THE LINE	V_L = 0.3V_{p-p}, f = 1KHz, I_L = 12 to 80MA		600		Ω	Externally adjustable by means of resistor R_3
SIDETONE GAIN $G'_{SO} = G_{SO} - G_{RO} - G_{TO}$	V_{IN} AS PER FIG. 6; G_{TO}, G_{RO} are the transmitting and Receiving gains for 0KM CABLE		- 1.5		dB	Externally adjustable (See application Note 5)

TCM 1705A APPLICATION NOTES

1 - LOW VOLTAGE TELEPHONE SET - Fig 7 -



2 - VERY LOW VOLTAGE TELEPHONE SET - Fig 8 -



TCM 1705A - APPLICATION NOTES

3 - EXTERNAL COMPONENTS FUNCTION

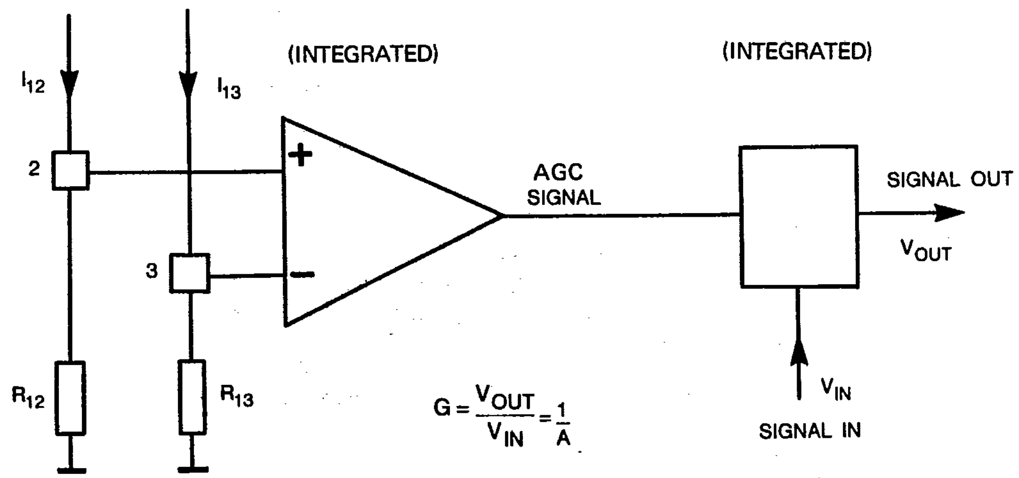
COMPONENT	FUNCTION	REMARKS
R_1, R_2	Form 2 sides of the wheatstone bridge. The receiving gain is proportional to their value.	See page 12
R_6, R_7, C_5	Form the balancing network, i.e. the third side of the wheatstone bridge.	See page 12
R_4, R_5	Adjust both the transmitting gain and the matching impedance for the microphone.	See page 13
R_9	Controls the bias current for the circuit. With R_9 = 24.3K the minimum operating current for the circuit is 9MA. By decreasing R_9, the minimum operating current increases and receiving and transmitting dynamic ranges are improved.	
R_{10}, R_{11}	Adjust the receiving gain and the matching impedance for the headphone.	See page 13
R_{12}, R_{13}	Adjust the gain regulation function	See page 11
R_3	Controls the resistive part of the line impedance.	
C_1	Capacitor to give a flat receiving frequency response.	
C_2	DC blocking capacitor for receiving amplifier input.	
C_3	Filter capacitor of the internal series voltage regulator.	
C_4	DC blocking capacitor on the transmitting amplifier input.	
C_6	Insures a high A.C. dynamic impedance to the internal shunt regulator.	
C_7	Decouples the second stage of the transmitting amplifier.	
C_8	Controls the capacitive part of the line impedance, and improves radiofrequency rejection.	
$C_{10}, C_{11}, C_{12}, C_{13}$	Radiofrequency interference rejection capacitors (with C_8).	
Z	Overvoltage protection zener.	

TCM 1705A - APPLICATION NOTES

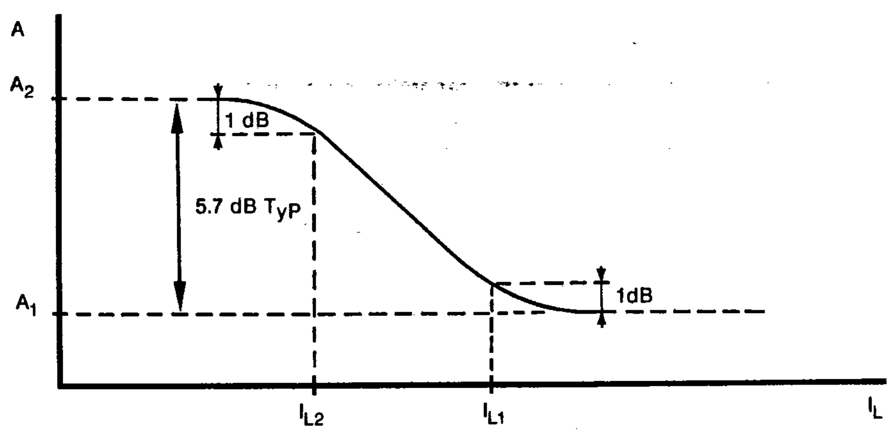
4 - REGULATION FUNCTION - FIG. 9, 10

The regulation characteristic can be altered to suit the system requirements with R_{12} and R_{13}.

Principle of operation :



I_{12} and I_{13} are currents supplied by integrated current sources of the device.
Current I_{12} is proportional to the DC line current.
Current I_{13} is constant and internally fixed.
So, by varying the length of the line, I_{12} varies and A varies consequently according to the curve shown below:



Note: With R_9 = 24.3K, R_{12} = 487 Ω and R_{13} = 3.83K I_{L1} are I_{L2} are around 40 mA and 25 mA respectively.

TCM 1705A · APPLICATION NOTES

The ratio $\frac{A_2}{A_1}$ is internally fixed (5.7 dB ± 0.4).

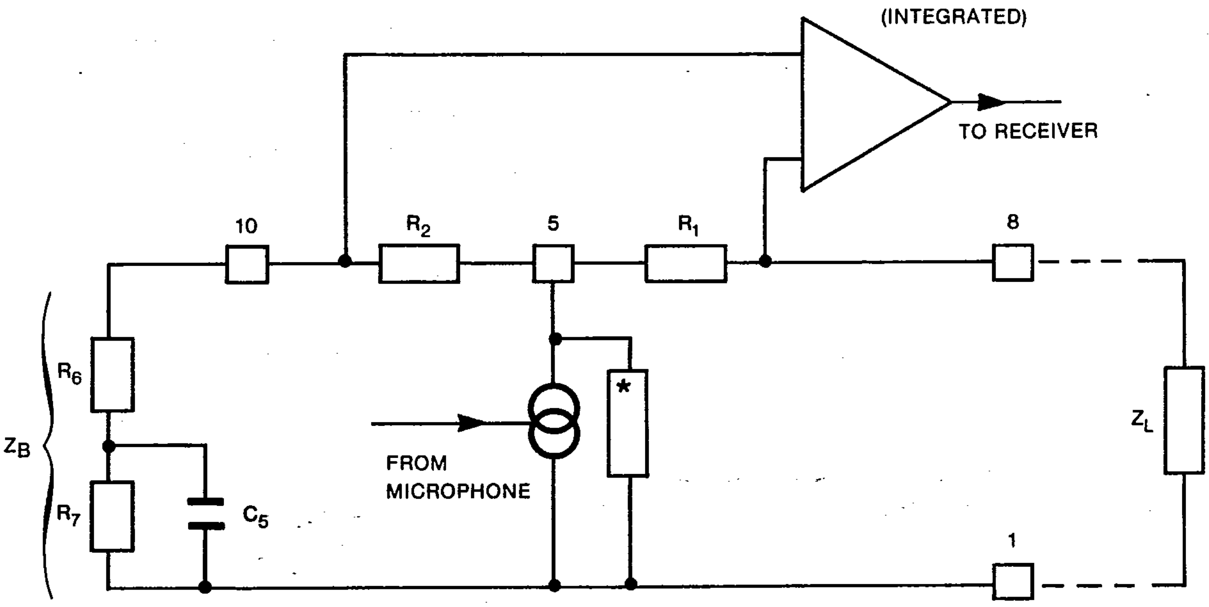
As the relationship between I_L and Line Length depends on the feeding system used in the exchange it is necessary to shift points I_{12} and I_{L1} by a proper choice of resistors R_{12} and R_{13} which gives the required regulation response gain versus line length.

As an example :
if R_{12} = 487 Ohm and R_{13} = 3.83KOhm, measurements give a regulation function, optimized for the feeding system 48V, 2×400 Ohm.

As a special case, when $R_{12} = 0$, the gain 15 constant at the high value (A_2).

5 · SIDETONE FUNCTION · FIG 11

This function is performed with the following bridge structure :



where R_6, R_7, C_5 set the balancing impedance Z_B.

The sidetone balance is perfect when $Z_B = \frac{R_2}{R_1} Z_L$.

This sidetone performance can be adjusted with R2, R6, R7, C5 without affecting other parts or parameters of the circuit.
As an example:
if R_2 = 187 Ohm, R_6 = 1.62 KOhm, R_7 = 8.66 KOhm, C_5 = 22 nF give good side tone performances with .4 and .5 cables.

* Equivalent shunt impedance on pin 5 (function of R_3).

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TCM 1705A - APPLICATION NOTES

6 - TRANSMITTING GAIN - FIG 12

Transmitting gain and impedance seen by the microphone can be adjusted with resistors R_4 and R_5.

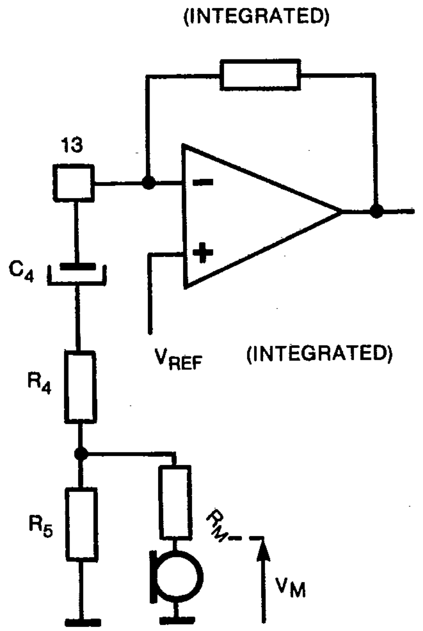


Figure 12 gives more details than fig. 2 about the microphone input. The overall transmitting gain can be vritten as:

$$G_T = \frac{V_L}{V_M} = \frac{KT}{RM} \bullet \frac{1}{\frac{R4}{RM} + \frac{R4}{ZM}}$$

Where Z_M is the impedence seen by the microphone is:

$$ZM = \frac{R4 \bullet R5}{R4 + R5}$$

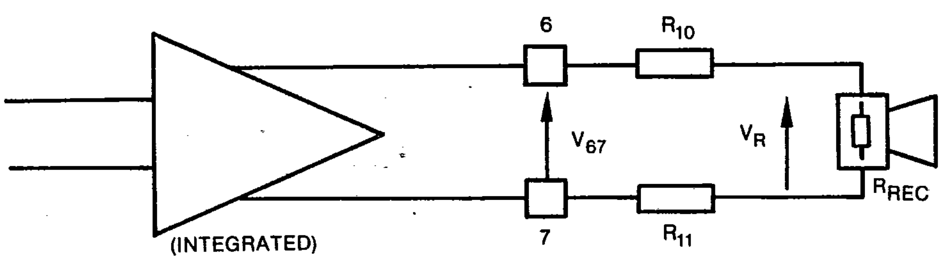
For 80MA and for the value of external components shown in Fig. 2 and 4 K_T = 207 (KΩ.Typ.)

Thus knowing the wanted gain $G_T(80)$, R_M and Z_M, we can calculate R_4 and R_5.

As an example if the wanted gain $G_T(80)$ = 41.7 dB, R_M = .35KΩ, Z_M = .5KΩ, then, $R_4 = R_5$ = 1KΩ

7 - RECEIVING GAIN - FIG 13

Receiving gain be adjusted with resistors R_{10} and R_{11}. Figure 13 gives more details about the receiver outputs.



The overall receiving gain can be written as:

$$G_R = \frac{V_R}{V_L} = K_R \frac{V_R}{V_{67}}$$

With $$\frac{V_R}{V_{67}} = \frac{R_{REC}}{(R_{10} + R_{11}) + R_{REC}}$$

and K_R = .256 (Typ.) for A DC line current = 80MA and for the value of external components shown in Fig. 2 and 5.

Thus R_{10} and R_{11} can be chosen, given the required gain and receiver internal impedance R_{REC}.