MOTOROLA

MC1376

Advance Information

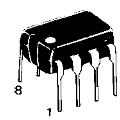
FM MODULATOR CIRCUIT

. . . a voltage-controlled oscillator/modulator ideally suited to cordless telephone and television intercarrier applications.

- Wide Supply Range (5.0–12 Vdc)
- Useful Frequency Range (1.4–14 MHz)
- Low Distortion (<1%)
- Excellent Oscillator Stability
- Output RF Driver Transistor Included
- Low Cost, Low Component Count Circuit
- Wide Deviation Capability

FM MODULATOR CIRCUIT

SILICON MONOLITHIC INTEGRATED CIRCUIT



CASE 626-04

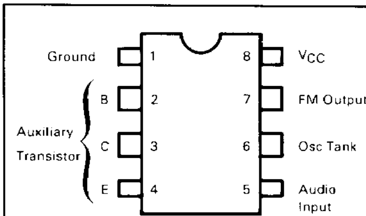
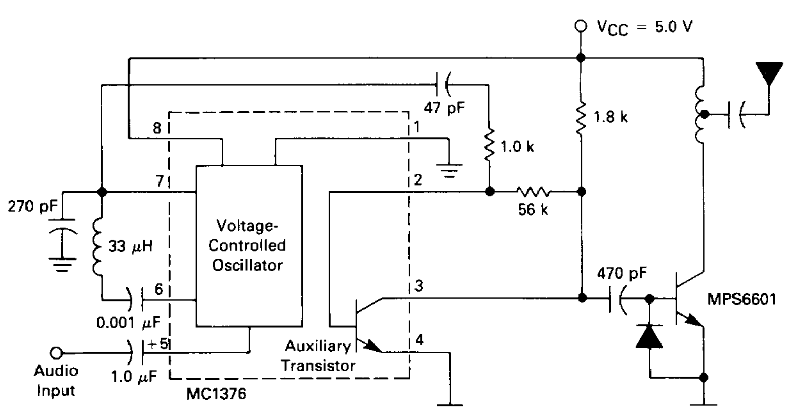


FIGURE 1 — CORDLESS TELEPHONE BASE STATION TRANSMITTER (1.76 MHz)



This document contains information on a new product. Specifications and information herein are subject to change without notice.

MAXIMUM RATINGS (T_A 25°C unless otherwise noted)

Rating	Value	Unit
Modulator Supply Voltage	13	Vdc
Transistor Collector-Emitter Voltage	10	Vdc
Transistor Collector-Base Voltage	15	Vdc
Operating Ambient Temperature Range	0 to +75	°C
Storage Temperature Range	-65 to +150	°C
Junction Temperature	150	°C
Power Dissipation, Package Derate above 25°C	1.2 10	Watts mW/°C

MODULATOR ELECTRICAL CHARACTERISTICS (T_A = 25°C, V_{CC} = 12 Vdc, Test Circuit of Figure 2 unless otherwise noted)

Characteristic	Min	Typ	Max	Unit
Operating Supply Voltage Supply Current, V_{CC} = 12 Vdc (excluding transistor)	5.0 —	— 5.0	12 8.0	Vdc mAdc
Frequency Range of Modulator Frequency Shift versus Temperature (R1 = ∞) Frequency Shift versus V_{CC} (R1 = ∞) Output Amplitude Output Harmonics, Unmodulated	— — — 80 —	1.4–14 — 3.3 150 −43	— 0.3 — — —	MHz kHz/°C kHz/V mVp-p dB
Modulation Sensitivity 1.7 MHz 4.5 MHz 10.7 MHz	— — —	0.20 0.24 0.80	— — —	MHz/V MHz/V MHz/V
Audio Distortion (±25 kHz, Deviation, R1 = 27 k, f_o = 4.5 MHz) Incidental AM (±25 kHz FM, 4.5 MHz)	— —	0.55 2.0	— —	% %
Audio Input Resistance (Pin 5 to ground) Audio Input Capacitance (Pin 5 to ground)	— —	6.0 5.0	— —	kΩ pF
Stray Tuning Capacitance (Pin 7 to ground) Effective Oscillator Source Impedance (Pin 7)	— —	6.0 2.0	— —	pF kΩ

AUXILIARY TRANSISTOR STATIC CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Collector-Base Breakdown Voltage (I_C = 10 μAdc)	$V_{(BR)CBO}$	15	40	—	Vdc
Collector-Emitter Breakdown Voltage (I_C = 1.0 μAdc)	$V_{(BR)CEO}$	10	—	—	Vdc
Collector-Substrate Breakdown Voltage (I_C = 10 μAdc)	$V_{(BR)CIO}$	15	40	—	Vdc
Emitter-Base Breakdown Voltage (I_E = 10 μAdc)	$V_{(BR)EBO}$	4.0	—	—	Vdc
Collector-Base Cutoff Current (I_{BE} = 10 Vdc, I_E = 0)	I_{CBO}	—	—	200	nAdc
DC Current Gain (I_C = 10 mAdc, V_{CE} = 3.0 Vdc)	h_{FE}	40	90	—	—

AUXILIARY TRANSISTOR DYNAMIC CHARACTERISTICS

Characteristic	Symbol	Min	Typ	Max	Unit
Current-Gain-Bandwidth Product (V_{CE} = 3.0 Vdc, I_C = 3.0 mAdc)	f_T	250	500	—	MHz
Collector-Base Capacitance (V_{CB} = 3.0 Vdc, I_C = 0)	C_{cb}	—	1.0	—	pF
Collector-Substrate Capacitance (V_{CS} = 3.0 Vdc, I_C = 0)	C_{CI}	—	3.0	—	pF

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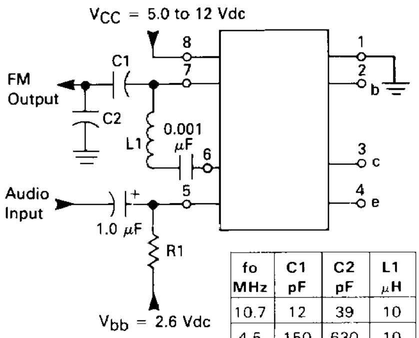
FIGURE 2 — TEST CIRCUIT



fo MHz	C1 pF	C2 pF	L1 µH
10.7	12	39	10
4.5	150	630	10
1.76	250	1000	40

MC1376 GENERAL INFORMATION

This device was initially designed for the base station transmitter of a cordless telephone, the 1.76 MHz FM modulator shown in Figure 1. It also contains a "separate" transistor suitable for service as an output buffer or amplifier for up to 50 mA. Though the oscillator contains internal phase shift components which are not accessible, the MC1376 still has an operating frequency range of 1.4 to 14 MHz, making it a good companion to MC1372 or MC1373 as a 4.5 or 5.5 MHz intercarrier sound modulator for television signal generation. Also, the device can be used as a low cost FM IF (10.7 MHz) signal source for the production line or lab. Although not suitable for true high fidelity distortion measurements, it can handle quite wide deviation with very modest distortion, compared to other oscillator configurations. The modulator section is identical to the FM portion of the MC1374, TV modulator.

FIGURE 3 — MODULATOR TRANSFER FUNCTION (1.76 MHz)

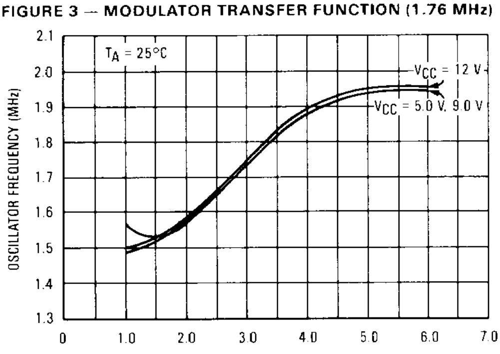


FIGURE 5 — MODULATOR TRANSFER FUNCTION (10.7 MHz)

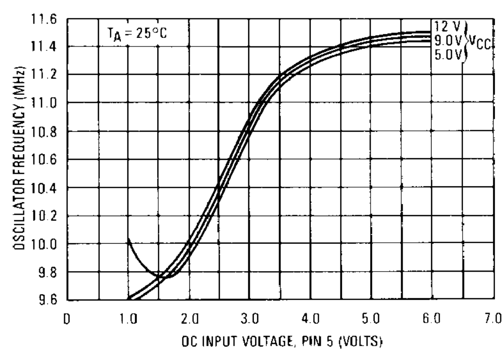


FIGURE 4 — MODULATOR TRANSFER FUNCTION (4.5 MHz)

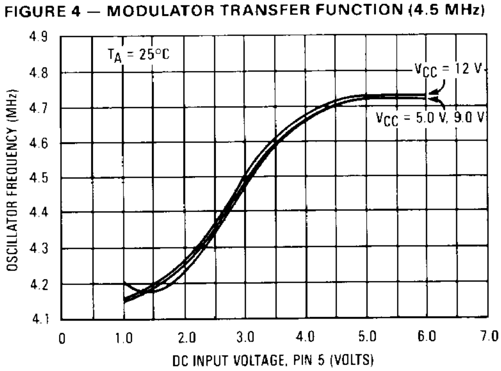
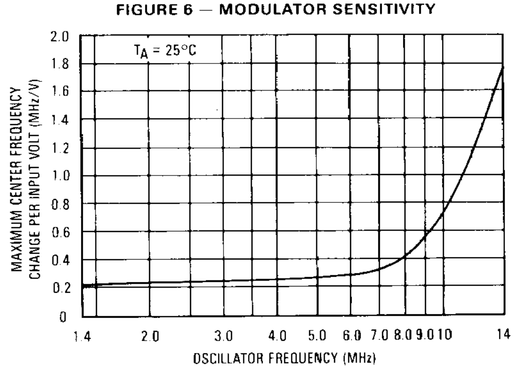


FIGURE 6 — MODULATOR SENSITIVITY



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APPLICATIONS INFORMATION

The oscillator center frequency is approximately the resonance of the inductor (Pin 6 to Pin 7) and the total capacitance from Pin 7 to ground. Include 6.0 pF (internal) and the circuit strays in the resonant frequency calculations for the higher frequency applications. For overall oscillator stability, it is best to keep the X_L and X_C in the range of 300 Ω to 1.0 kΩ.

The modulator transfer characteristics for three test frequencies are shown in Figures 3, 4 and 5. Although the horizontal axes of these curves are labelled "dc input voltage, Pin 5", they are valid transfer functions relating instantaneous Pin 5 voltage to output frequency.

Figure 6 is a plot of the maximum deviation per input volt over the usable frequency range of the part.

Most applications will require no dc connection at the audio input, Pin 5. However, some performance improvements can be achieved by addition of biasing circuitry. The unaided device will usually establish its own Pin 5 bias at 2.9 to 3.0 V. A brief study of Figures 3, 4, and 5 shows that this bias is a little high for optimum modulation linearity. This is verified by taking distortion measurments using a high quality FM detector (see Figure 7). Note that the distortion readings can be significantly reduced by externally pulling Pin 5 bias down to 2.6 to 2.7 V. Temperature and supply voltage factors must also be considered in determining bias implementation.

Figure 8 shows frequency as a function of temperature for several biasing methods (refer to the Test Circuit in Figure 2). This shows that pulling Pin 5 down to 2.6 V through 27 kΩ greatly improves the temperature stability. If V_{CC} is well regulated, then a simple 180 kΩ/30 kΩ resistor divider is a good choice for optimum distortion and frequency stability versus temperature. However, if V_{CC} is not regulated, then the divider is not a good method, as shown in Figure 9. To summarize, the biasing of Pin 5 must be done with considerations of distortion, ambient temperature, and supply stability. Temperature drift can also be compensated by means of controlled temperature coefficient capacitors, which are very common and inexpensive in this range of values. An N150 type used for C1 will nearly flatten the R1 = ∞ case in Figure 8.

The FM output at Pin 7 is usually about 600 mVp-p and has low harmonic content and high (2 kΩ) output impedance. The oscillator behavior is relatively unaffected by loading above 1.0 kΩ. If lower impedance must be driven, the capacitive divider used in the test circuit is a useful technique, or the "extra" transistor can be used as a buffer.

The transistor is a large geometry device capable of operating at over 50 mA. Figure 11 provides the base-emitter voltage characteristics and Figure 12 shows the current gain versus collector current for the device. See the Electrical Characteristics for other useful parameters.

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FIGURE 7 — DISTORTION versus MODULATION DEPTH

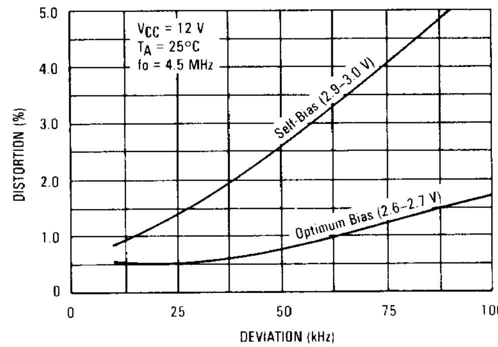

FIGURE 8 — FREQUENCY STABILITY versus TEMPERATURE

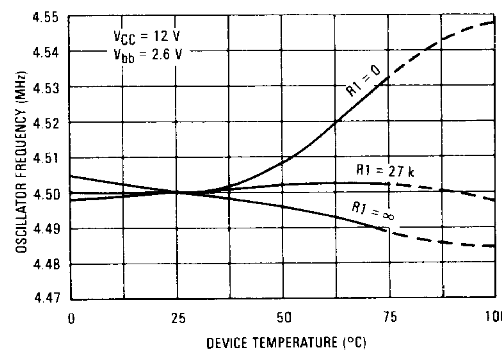

FIGURE 9 — FREQUENCY STABILITY versus SUPPLY VOLTAGE

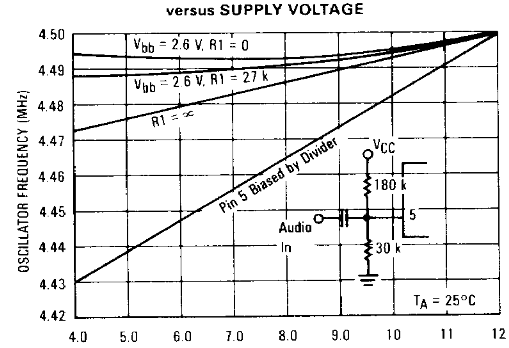

FIGURE 10 — INTERNAL SCHEMATIC

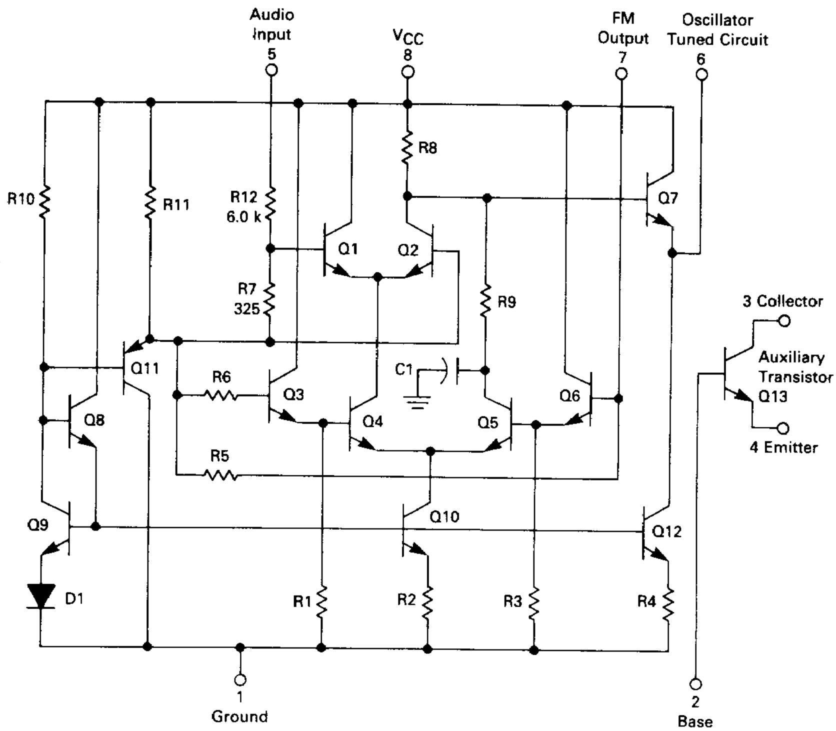

FIGURE 11 — BASE-EMITTER VOLTAGE

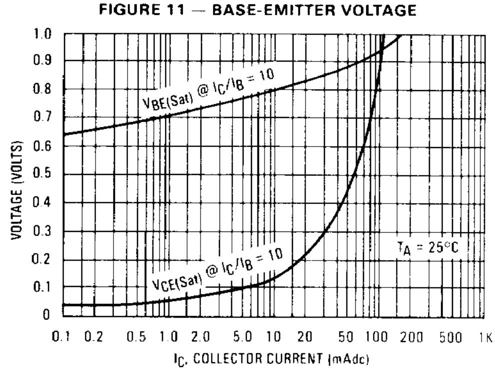

FIGURE 12 — NORMALIZED DC CURRENT GAIN