High-performance low-power FM IF system

605

FEATURES

- Low-Power consumption 5.7mA typical at 6V
- Mixer input to >500MHz
- Mixer conversion power gain of 13dB at 45MHz
- Mixer noise figure of 4.6dB at 45MHz
- XTAL oscillator effective to 150MHz (L.C. oscillator to 1GHz local oscillator can be injected)
- 102dB of IF Amp/Limiter gain
- 25MHz limiter small signal bandwidth
- Temperature compensated logarithmic Received Signal Strength Indicator (RSSI) with a dynamic range in excess of 90dB
- Two audio outputs - muted and unmuted
- Low external component count; suitable for crystal/ceramic/LC filters
- Excellent sensitivity: 0.22μV into 50Ω matching network for 12dB SINAD (Signal to Noise and Distortion ratio) for 1kHz tone with RF at 45MHz and IF at 455kHz
- Meets cellular radio specifications
- ESD hardened

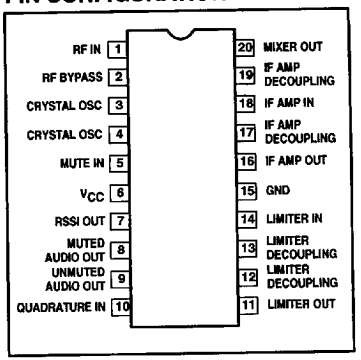
MILITARY APPLICATIONS

- Cellular Radio FM IF
- Military High Performance communications receivers
- Single conversion VHF/UHF receivers
- SCA receivers
- RF level meter
- Spectrum analyzer
- Military Instrumentation
- FSK and ASK data receivers
- Log amps
- Wideband low current amplification

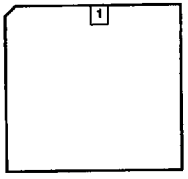
DESCRIPTION

The 605 is a high-performance monolithic low-power FM IF system incorporating a mixer/oscillator, two limiting intermediate frequency amplifiers, quadrature detector, muting, logarithmic received signal strength indicator (RSSI), and voltage regulator. The 605 combines the functions of Philips Semiconductors 602 and 604A, but features higher mixer input intercept, higher IF bandwidth (25MHz) and temperature compensated RSSI and limiters permitting higher performance application. The 605 is available in 20-lead dual-in-line 300mil-package and a 20-lead grounded 1.2 leadless chip carrier package.

PIN CONFIGURATION



LLCC PIN CONFIGURATION



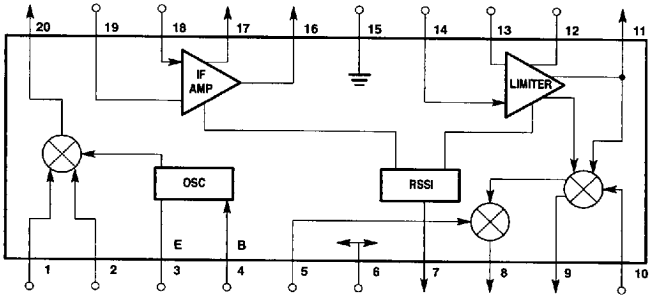
PIN	FUNCTION	PIN	FUNCTION
1	RF IN	11	LIMITER OUT
2	RF BYPASS	12	LIMITER DECOUPLING
3	CRYSTAL OSC	13	LIMITER DECOUPLING
4	CRYSTAL OSC	14	LIMITER IN
5	MUTE IN	15	GND
6	V_{CC}	16	IF AMP OUT
7	RSSI OUT	17	IF AMP DECOUPLING
8	MUTED AUDIO OUT	18	IF AMP IN
9	UNMUTED AUDIO OUT	19	IF AMP DECOUPLING
10	QUADRATURE IN	20	MIXER OUT

ORDERING INFORMATION

DESCRIPTION	ORDER CODE	PACKAGE DESIGNATOR*
20-Pin Ceramic DIP	605/BRA	GDIP1-T20
20-Pin Ceramic LLCC	605/B2A	CQCC2-N20

* MIL-STD 1835 or Appendix A of 1995 Military Data Handbook

BLOCK DIAGRAM



ABSOLUTE MAXIMUM RATINGS

SYMBOL	PARAMETER	RATING	UNIT
V_{CC}	Maximum operating voltage	9	V
T_{STG}	Storage temperature range	-65 to +150	°C

RECOMMENDED OPERATING CONDITIONS

SYMBOL	PARAMETER	LIMITS	UNIT
V_{CC}	Power supply voltage range	4.5 to 8.0	V
T_{amb}	Operating temperature range	-55 to +125	°C

DC ELECTRICAL CHARACTERISTICS

V_{CC} = +6V, T_{amb} = -55°C to +125°C; unless otherwise stated.

SYMBOL	PARAMETER	TEST CONDITIONS	LIMITS			UNIT
			MIN	TYP[2]	MAX	
I_{CC}	DC current drain		3.8	5.7	7.0	mA
	Mute switch input threshold (ON)		1.7			V
	Mute switch input threshold (OFF)				1.0	V

AC ELECTRICAL CHARACTERISTICS

At -55°C to +125°C; V_{CC} = +6V, unless otherwise stated. RF frequency = 45MHz + 14.5dBV RF input step-up; IF frequency = 455kHz; R17 = 5.1k; RF level = -45dBm; FM modulation = 1kHz with ±8kHz peak deviation. Audio output with C-message weighted filter and deemphasis capacitor. Test Circuit Figure 1. The Parameters listed below are tested using automatic test equipment to assure consistent electrical characteristics. The limits do not represent the ultimate performance limits of the device. Use of an optimized RF layout will improve many of the listed parameters.

SYMBOL	PARAMETER	TEST CONDITION	LIMITS			UNIT
			MIN	TYP[2]	MAX	
Mixer/Osc section (ext LO = 300mV)						
f_{IN}	Input signal frequency			500		MHz
f_{OSC}	Crystal oscillator frequency			150		MHz
	Noise figure at 45MHz[3]			5.0	7.0	dB
	Third-order intercept point	f1 = 45.0; f2 = 45.06MHz		-10		dBm
	Conversion power gain	Matched 14.5dBV step-up	7	13	17	dB
		50Ω source		-1.7		dB
	RF input resistance[3]	Single-ended input	3.0	4.7		kΩ
	RF input capacitance[3]			3.5	4.0	pF
	Mixer output resistance[3]	(Pin 20)	1.25	1.5		kΩ
IF section						
	IF amp gain			39.7		dB
	Limiter gain			62.5		dB
	Input limiting -3dB, r_{17} = 5.1k	Test at Pin 18		-113		dBm
	AM rejection	80% AM 1kHz	24	34	43	dB
	Audio level, R_{10} = 100K	15nF de-emphasis	60	150	280	mV_{RMS}
	Unmuted audio level, R_{11} = 100k	150pF de-emphasis		480		mV_{RMS}
	SINAD sensitivity	RF level -118dB		16		dB
THD	Total harmonic distortion		-31	-42		dB
S/N	Signal-to-noise ratio	No modulation for noise		73		dB
	IF RSSI output, R_9 = 100k[1]	IF level = -118dBm	0	160	850	mV
	1.5k input	IF level = -68dBm	1.7	2.5	3.2	V
		IF level = -18dBm	3.5	4.8	5.6	V
	RSSI range	R_9 = 100kΩ Pin 16		90		dB
	RSSI accuracy	R_9 = 100kΩ Pin 16		±1.5		dB
	IF input impedance[3]		1.40	1.6		kΩ
	IF output impedance[3]		0.85	1.0		kΩ
	Limiter input impedance[3]		1.40	1.6		kΩ
	Unmuted audio output resistance			58		kΩ
	Muted audio output resistance			58		kΩ
RF/IF section (int LO)						
	Unmuted audio level	4.5V = V_{CC}, RF level = -27dBm		450		mV_{RMS}
	System RSSI output	4.5V = V_{CC}, RF level = -27dBm		4.3		V

NOTES:

1. The generator source impedance is 50Ω, but the 605 input impedance at Pin 18 is 1500Ω. As a result, IF levels refers to the actual signal that enters the 605 input (Pin 8) which is about 21dB less than the "available power" at the generator.
2. T_{amb} = 25°C, all typical values are for design aid only and not guaranteed or subject to testing.
3. This parameter is guaranteed by design, but not tested.

CIRCUIT DESCRIPTION

The 605 is an IF signal processing system suitable for second IF or single conversion systems with input frequency as high as 1GHz. The bandwidth of the IF amplifier is about 40MHz, with 39.7dBV of gain from a 50Ω source. The bandwidth of the limiter is about 28MHz with about 62.5dBV of gain from a 50Ω source. However, the gain/bandwidth distribution is optimized for 455kHz, 1.5kΩ source applications. The overall system is well-suited to battery operation as well as high performance and high quality products of all types.

The input stage is a Gilbert cell mixer with oscillator. Typical mixer characteristics include a noise figure of 5dB, conversion gain of 13dB, and input third order intercept of 10dBm. The oscillator will operate in excess of 1GHz in L/C tank configurations. Harley or Colpitts circuits can be used up to 100MHz for xtal configurations. Butler oscillators are recommended for xtal configurations up to 150MHz.

The output of the mixer is internally loaded with a 1.5kΩ resistor permitting direct connection to a 455kHz ceramic filter. The input resistance of the limiting IF amplifiers is also 1.5kΩ. With most 455KHz ceramic filters and many crystal filters, no impedance matching network is necessary. To achieve optimum linearity of the log signal strength indicator, there must be a 12dB(v) insertion loss between the first and second IF stages. If the IF filter or interstage network does not cause 12dB(v) insertion loss, a fixed or variable resistor can be added between the first IF output (Pin 16) and the interstage network.

The signal from the second limiting amplifier goes to a Gilbert cell quadrature detector. One port of the Gilbert cell is internally driven by the IF. The other output of the IF is AC-coupled to a tuned quadrature network. This signal, which now has a 90% phase relationship to the internal signal, drives the other port of the multiplier cell.

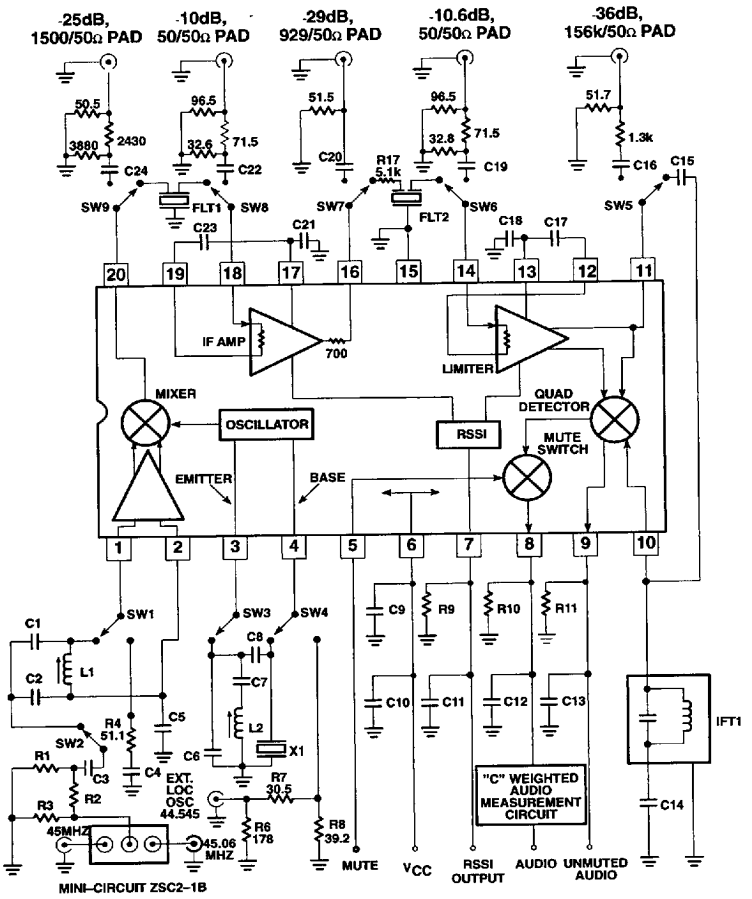
Overall, the IF section has a gain of 90dB. For operation at intermediate frequencies greater than 455kHz, special care must be given to layout, termination, and interstage loss to avoid instability.

The demodulated output of the quadrature detector is available at two pins, one continuous and one with a mute switch. Signal attenuation with the mute activated is greater than 60dB. The mute input is very high impedance and is compatible with CMOS or TTL levels.

A log signal strength completes the circuitry. The output range is greater than 90dB and is temperature compensated. This log signal strength indicator exceeds the criteria for AMPs or TACs cellular telephone.

NOTE: dB(v) = 20 log V_{OUT}/V_{IN}.

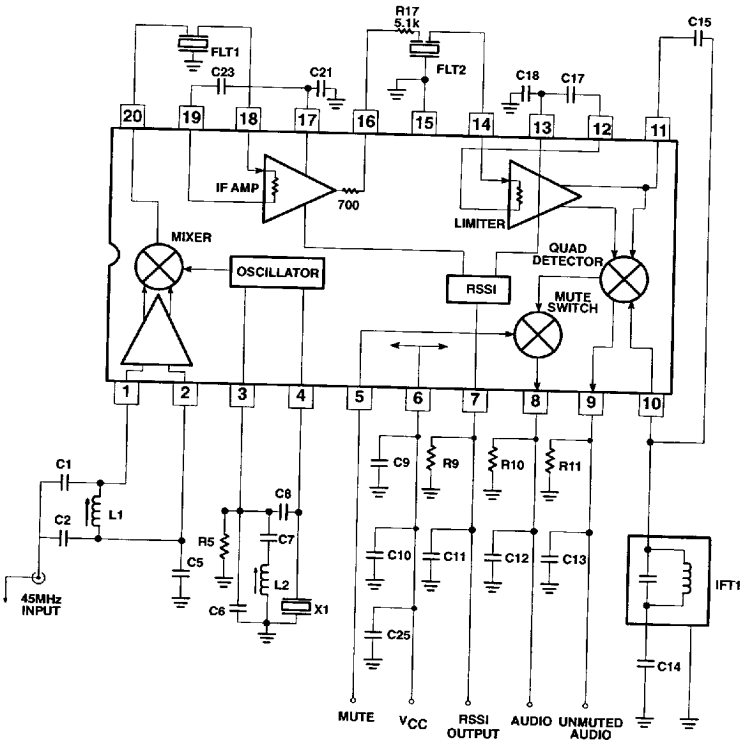
For additional application information please refer to AN1994 *Reviewing Key Areas When Designing with the NE605*, stock number 98-2006-070.



Automatic Test Circuit Component List

C1	100pF NPO Ceramic
C2	390pF NPO Ceramic
C5	100nF ±10% Monolithic Ceramic
C6	22pF NPO Ceramic
C7	1nF Ceramic
C8	10.0pF NPO Ceramic
C9	100nF ±10% Monolithic Ceramic
C10	15μF Tantalum (minimum)
C11	100nF ±10% Monolithic Ceramic
C12	15nF ±10% Ceramic
C13	150pF ±2% N1500 Ceramic
C14	100nF ±10% Monolithic Ceramic
C15	10pF NPO Ceramic
C17	100nF ±10% Monolithic Ceramic
C18	100nF ±10% Monolithic Ceramic
C21	100nF ±10% Monolithic Ceramic
C23	100nF ±10% Monolithic Ceramic
C25	100nF ±10% Monolithic Ceramic
Flt 1	Ceramic Filter Murata SFG455A3 or equiv
Flt 2	Ceramic Filter Murata SFG455A3 or equiv
IFT 1	455kHz (Ce = 180pF) Toko RMC–2A6597H
L1	147–160nH Coilcraft UNI–10/142–04J08S
L2	3.3μH nominal Toko 292CNS–T1046Z
X1	44.545MHz Crystal ICM4712701
R9	100k ±1% 1/4W Metal Film
R17	5.1k ±5% 1/4W Carbon Composition
R10	100k ±1% 1/4W Metal Film (optional)
R11	100k ±1% 1/4W Metal Film (optional)

Figure 1. NE/SA605 45MHz Test Circuit (Relays as shown)



Application Component List

C1	100pF NPO Ceramic
C2	390pF NPO Ceramic
C5	100nF ±10% Monolithic Ceramic
C6	22pF NPO Ceramic
C7	1nF Ceramic
C8	10.0pF NPO Ceramic
C9	100nF ±10% Monolithic Ceramic
C10	15μF Tantalum (minimum)
C11	100nF ±10% Monolithic Ceramic
C12	15nF ±10% Ceramic
C13	150pF ±2% N1500 Ceramic
C14	100nF ±10% Monolithic Ceramic
C15	10pF NPO Ceramic
C17	100nF ±10% Monolithic Ceramic
C18	100nF ±10% Monolithic Ceramic
C21	100nF ±10% Monolithic Ceramic
C23	100nF ±10% Monolithic Ceramic
C25	100nF ±10% Monolithic Ceramic
Flt 1	Ceramic Filter Murata SFG455A3 or equiv
Flt 2	Ceramic Filter Murata SFG455A3 or equiv
IFT 1	455kHz (Ce = 180pF) Toko RMC–2A6597H
L1	147–160nH Coilcraft UNI–10/142–04J08S
L2	3.3μH nominal Toko 292CNS–T1046Z
X1	44.545MHz Crystal ICM4712701
R9	100k ±1% 1/4W Metal Film
R17	5.1k ±5% 1/4W Carbon Composition
R5	Not Used in Application Board (see Note 8)
R10	100k ±1% 1/4W Metal Film (optional)
R11	100k ±1% 1/4W Metal Film (optional)

Figure 2. NE/SA605 45MHz Application Circuit

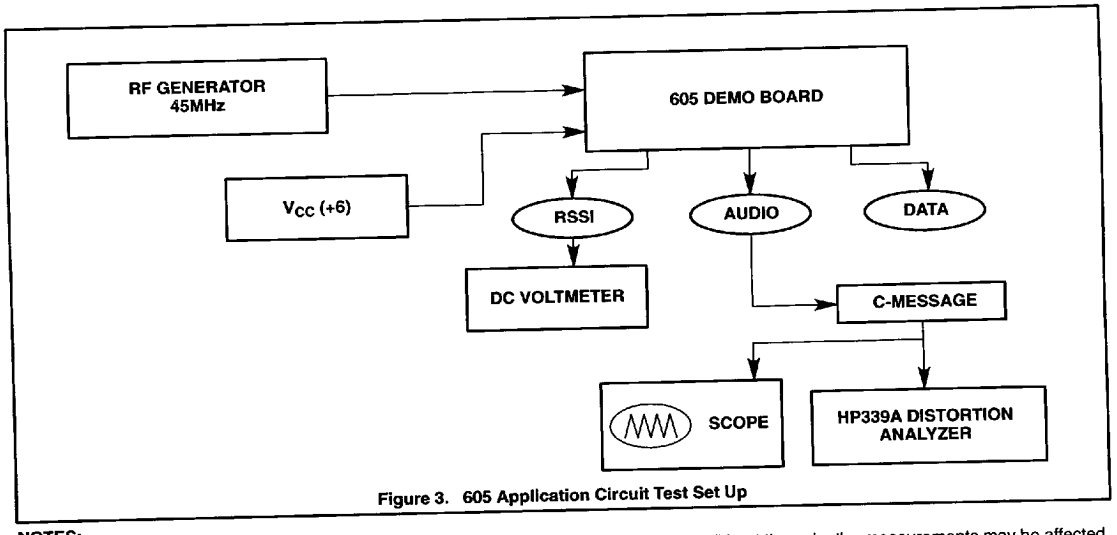


Figure 3. 605 Application Circuit Test Set Up

NOTES:

1. C-message: The C-message filter has a peak gain of 100 for accurate measurements. Without the gain, the measurements may be affected by the noise of the scope and HP339 analyzer.
2. Ceramic filters: The ceramic filters can be 30kHz SFG455A3s made by Murata which have 30kHz IF bandwidth (they come in blue), or 16kHz CFU455Ds, also made by Murata (they come in black). All of our specifications and testing are done with the more wideband filter.
3. RF generator: Set your RF generator at 45.000MHz, use a 1kHz modulation frequency and a 6kHz frequency deviation if you use 16kHz filters, or 8kHz if you use 30kHz filters.
4. Sensitivity: The measured typical sensitivity for 12dB SINAD should be 0.22µV or -120dBm at the RF input.
5. Layout: The layout is very critical in the performance of the receiver. We highly recommend our demo board layout.
6. RSSI: The smallest RSSI voltage (i.e., when no RF input is present and the input is terminated) is a measure of the quality of the layout and design. If the lowest RSSI voltage is 250mV or higher, it means the receiver is in regenerative mode. In that case the receiver sensitivity will be worse than expected.
7. Supply bypass and shielding: All of the inductors, the quad tank, and their shield must be grounded. A 10-15uF or higher value tantalum capacitor on the supply line is essential. A low frequency ESR screening test on this capacitor will ensure consistent good sensitivity in production. A 0.1µF bypass capacitor on the supply pin and grounded near the 44.545 MHz oscillator improves sensitivity by 2-3dB.
8. R5 can be used to bias the oscillator at a higher current for operation above 45MHz. Recommended value is 22kΩ, but should not be below 10kΩ.

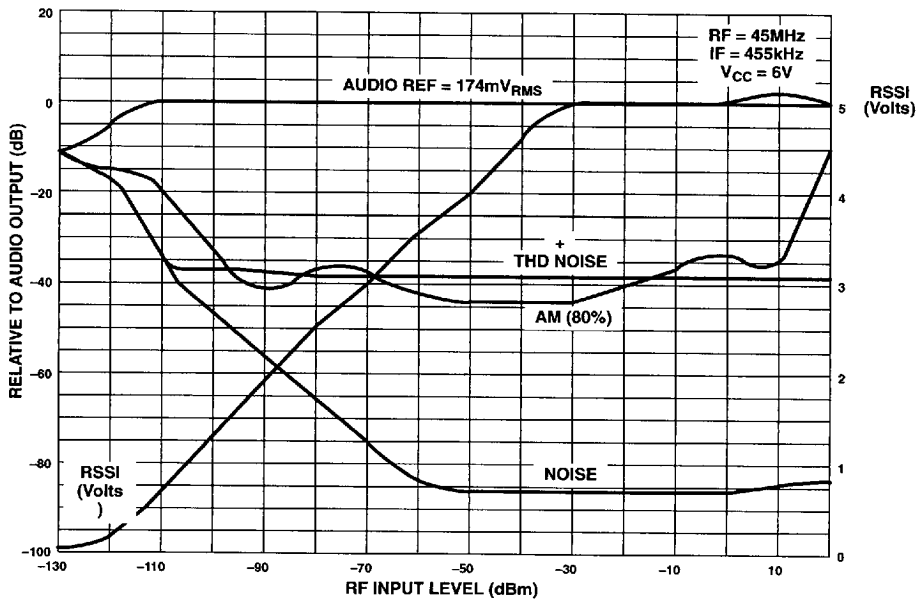


Figure 4. 605 Application Board at 25°C

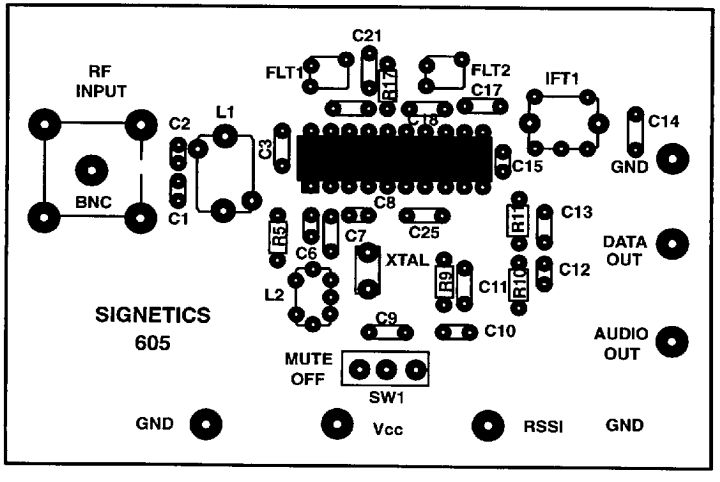
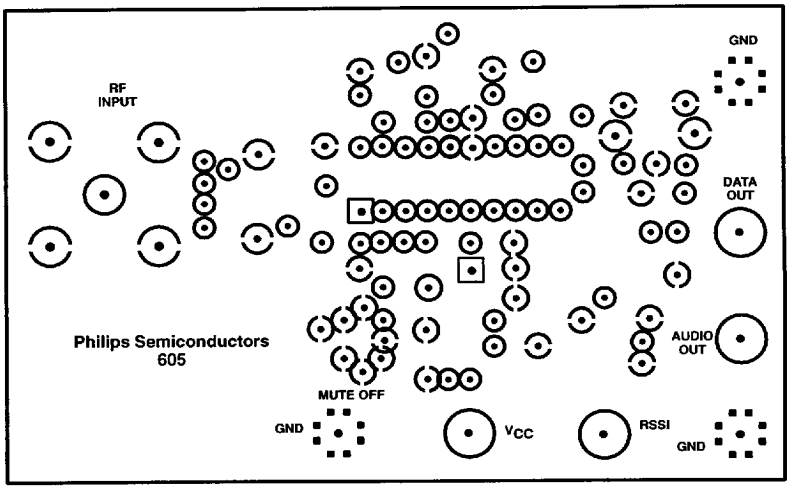
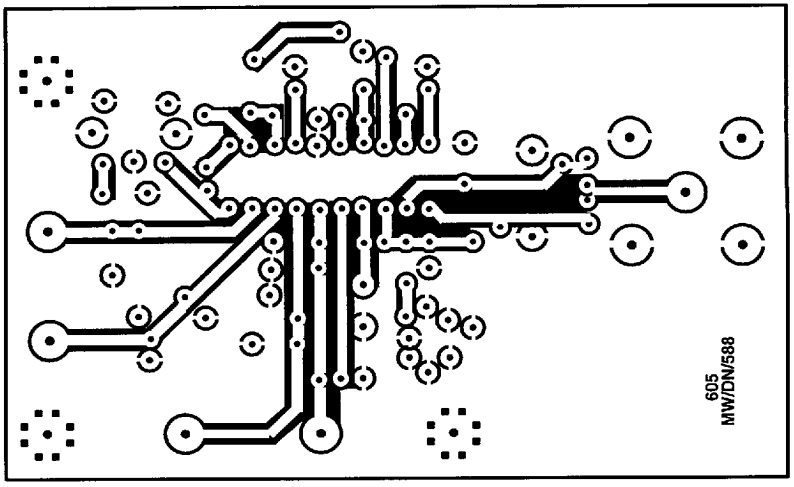


Figure 5. Component Placement for 605 Application Circuit



TOP VIEW



BOTTOM VIEW

Figure 6. Layout for 605 Test and Application Board

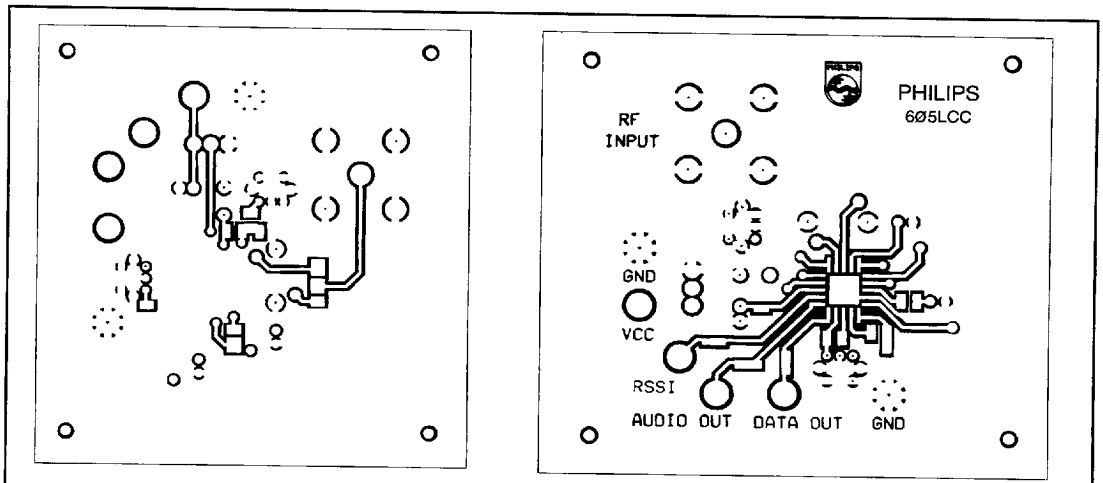


Figure 7. Layout of Test and Application Board for the LLCC Package