# High performance low power mixer FM IF system with high-speed RSSI

# NE/SA625

## DESCRIPTION

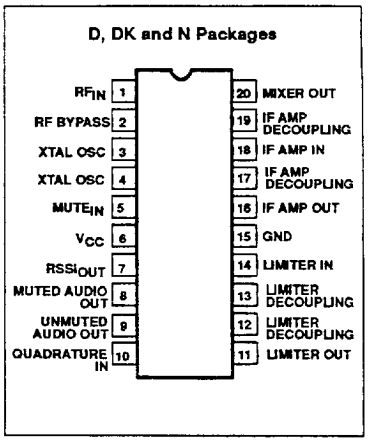
The NE/SA625 is pin-to-pin compatible with the NE/SA605, but has faster RSSI rise and fall times. The NE/SA625 is a high performance monolithic low-power FM IF system incorporating a mixer/oscillator, two limiting intermediate frequency amplifiers, quadrature detector, muting, logarithmic received signal strength indicator (RSSI) with fast rise and fall time, and voltage regulator. The NE/SA625 combines the functions of Signetics' NE602A and NE624. The NE/SA625 is available in 20-lead dual-in-line plastic and 20-lead SOL (surface-mounted miniature package) and 20-lead SSOP (shrink small outline package).

For additional technical information please refer to application notes AN1994, 1995 and 1996, which include example application diagrams, a complete overview of the product and artwork for reference.

## FEATURES

- Fast RSSI rise and fall times
- Low power consumption: 5.8mA 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
- SA625 meets cellular radio specifications
- ESD hardened

## PIN CONFIGURATION



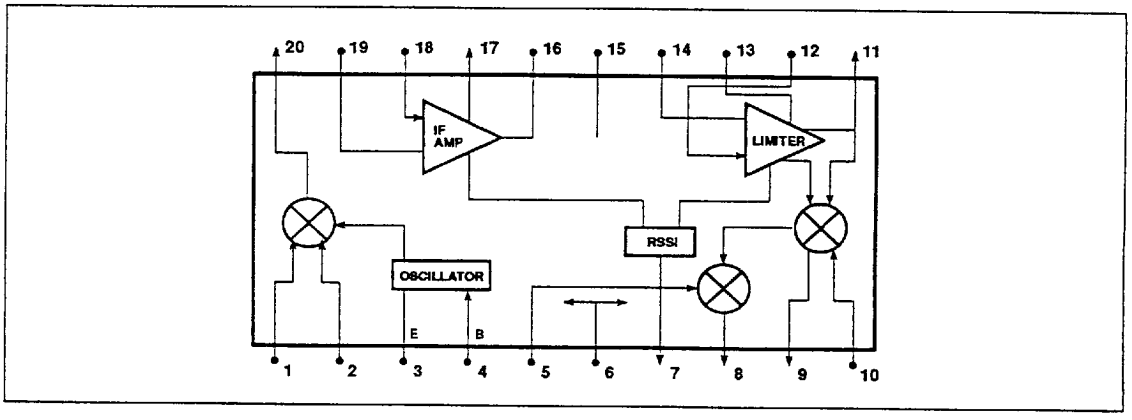

## APPLICATIONS

- Digital cellular base stations
- High performance communications receivers
- Single conversion VHF/UHF receivers
- SCA receivers
- RF level meter
- Spectrum analyzer
- Instrumentation
- FSK and ASK data receivers
- Log amps
- Wideband low current amplification
- Digital cordless telephones

## ORDERING INFORMATION

| DESCRIPTION | TEMPERATURE RANGE | ORDER CODE | DWG # |
|---|---|---|---|
| 20-Pin Plastic DIP | 0 to +70°C | NE625N | 0408B |
| 20-Pin Plastic SOL (Surface-mount) | 0 to +70°C | NE625D | 0172D |
| 20-Pin Plastic SSOP (Surface-mount) | 0 to +70°C | NE625DK | 1563 |
| 20-Pin Plastic DIP | -40 to +85°C | SA625N | 0408B |
| 20-Pin Plastic SOL (Surface-mount) | -40 to +85°C | SA625D | 0172D |
| 20-Pin Plastic SSOP (Surface-mount) | -40 to +85°C | SA625DK | 1563 |

## BLOCK DIAGRAM




## ABSOLUTE MAXIMUM RATINGS

| SYMBOL | PARAMETER | | RATING | UNITS |
|---|---|---|---|---|
| $V_{CC}$ | Single supply voltage | | 9 | V |
| $T_{STG}$ | Storage temperature range | | -65 to +150 | °C |
| $T_A$ | Operating ambient temperature range NE625 | | 0 to +70 | °C |
| | | SA625 | -40 to +85 | °C |
| $\theta_{JA}$ | Thermal impedance | D package | 90 | °C/W |
| | | N package | 75 | °C/W |
| | | DK package | 117 | °C/W |

## DC ELECTRICAL CHARACTERISTICS

$V_{CC}$ = +6V, $T_A$ = 25°C; unless otherwise stated.

| SYMBOL | PARAMETER | TEST CONDITIONS | LIMITS | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| | | | NE625 | | | SA625 | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| $V_{CC}$ | Power supply voltage range | | 4.5 | | 8.0 | 4.5 | | 8.0 | V |
| $I_{CC}$ | DC current drain | | 5.1 | 5.8 | 6.7 | 4.55 | 5.8 | 6.75 | mA |
| | Mute switch input threshold (ON) | | 1.7 | | | 1.7 | | | V |
| | (OFF) | | | | 1.0 | | | 1.0 | V |

## AC ELECTRICAL CHARACTERISTICS

$T_A$ = 25°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 de-emphasis 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 CONDITIONS | LIMITS | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| | | | NE625 | | | SA625 | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| **Mixer/Osc section (ext LO = 300mV)** | | | | | | | | | |
| $f_{IN}$ | Input signal frequency | | | 500 | | | 500 | | MHz |
| $f_{OSC}$ | Crystal oscillator frequency | | | 150 | | | 150 | | MHz |
| | Noise figure at 45MHz | | | 5.0 | | | 5.0 | | dB |
| | Third-order input intercept point | f1 = 45.0; f2 = 45.06MHz | | -10 | | | -10 | | dBm |
| | Conversion power gain | Matched 14.5dBV step-up | 10.5 | 13 | 14.5 | 10 | 13 | 15 | dB |
| | | 50Ω source | | -1.7 | | | -1.7 | | dB |
| | RF input resistance | Single-ended input | 3.5 | 4.7 | | 3.0 | 4.7 | | kΩ |
| | RF input capacitance | | | 3.5 | 4.0 | | 3.5 | 4.0 | pF |
| | Mixer output resistance | (Pin 20) | 1.3 | 1.5 | | 1.25 | 1.5 | | kΩ |
| **IF section** | | | | | | | | | |
| | IF amp gain | 50Ω source | | 39.7 | | | 39.7 | | dB |
| | Limiter gain | 50Ω source | | 62.5 | | | 62.5 | | dB |
| | Input limiting -3dB, $R_{17}$ = 5.1k | Test at Pin 18 | | -113 | | | -113 | | dBm |
| | AM rejection | 80% AM 1kHz | 30 | 34 | 42 | 29 | 34 | 43 | dB |
| | Audio level, $R_{10}$ = 100k | 15nF de-emphasis | 110 | 150 | 250 | 80 | 150 | 260 | $mV_{RMS}$ |
| | Unmuted audio level, $R_{11}$ = 100k | 150pF de-emphasis | | 480 | | | 480 | | mV |
| | SINAD sensitivity | RF level -118dB | | 16 | | | 16 | | dB |
| THD | Total harmonic distortion | | -35 | -42 | | -34 | -42 | | dB |
| S/N | Signal-to-noise ratio | No modulation for noise | | 73 | | | 73 | | dB |
| | IF RSSI output, $R_9$ = 100kΩ[1] | IF level = -118dBm | 0 | 160 | 550 | 0 | 160 | 650 | mV |
| | | IF level = -68dBm | 2.0 | 2.5 | 3.0 | 1.9 | 2.5 | 3.1 | V |
| | | IF level = -18dBm | 4.1 | 4.8 | 5.5 | 4.0 | 4.8 | 5.6 | V |
| | IF RSSI output rise time (10kHz pulse, no 455kHz filter) (no RSSI bypass capacitor) | IF frequency = 455kHz | | | | | | | |
| | | RF level = -56dBm | | 1.2 | | | 1.2 | | µs |
| | | RF level = -28dBm | | 1.2 | | | 1.2 | | µs |
| | | IF frequency = 10.7MHz | | | | | | | |
| | | RF level = -56dBm | | 1.2 | | | 1.2 | | µs |
| | | RF level = -28dBm | | 1.1 | | | 1.1 | | µs |
| | IF RSSI output fall time (10kHz pulse, no 455kHz filter) (no RSSI bypass capacitor) | IF frequency = 455kHz | | | | | | | |
| | | RF level = -56dBm | | 2.1 | | | 2.1 | | µs |
| | | RF level = -28dBm | | 7.6 | | | 7.6 | | µs |
| | | IF frequency = 10.7MHz | | | | | | | |
| | | RF level = -56dBm | | 2.0 | | | 2.0 | | µs |
| | | RF level = -28dBm | | 7.3 | | | 7.3 | | µs |
| | RSSI range | $R_9$ = 100kΩ Pin 16 | | 90 | | | 90 | | dB |
| | RSSI accuracy | $R_9$ = 100kΩ Pin 16 | | ±1.5 | | | ±1.5 | | dB |
| | IF input impedance | | 1.40 | 1.6 | | 1.40 | 1.6 | | kΩ |
| | IF output impedance | | 0.85 | 1.0 | | 0.85 | 1.0 | | kΩ |
| | Limiter intput impedance | | 1.40 | 1.6 | | 1.40 | 1.6 | | kΩ |
| | Limiter output impedance | | | 300 | | | 300 | | Ω |
| | Limiter output level with no load | | | 280 | | | 280 | | $mV_{RMS}$ |

## AC ELECTRICAL CHARACTERISTICS(Continued)

| SYMBOL | PARAMETER | TEST CONDITIONS | LIMITS | | | | | | UNITS |
|---|---|---|---|---|---|---|---|---|---|
| | | | NE625 | | | SA625 | | | |
| | | | MIN | TYP | MAX | MIN | TYP | MAX | |
| IF section (continued) | | | | | | | | | |
| | Unmuted audio output resistance | | | 58 | | | 58 | | kΩ |
| | Muted audio output resistance | | | 58 | | | 58 | | kΩ |
| RF/IF section (Int LO) | | | | | | | | | |
| | Unmuted audio level | 4.5V = $V_{CC}$, RF level = -27dBm | | 450 | | | 450 | | $mV_{RMS}$ |
| | System RSSI output | 4.5V = $V_{CC}$, RF level = -27dBm | | 4.3 | | | 4.3 | | V |

NOTE:
1. The generator source impedance is 50Ω, but the NE/SA625 input impedance at Pin 18 is 1500Ω. As a result, IF level refers to the actual signal that enters the NE/SA625 input (Pin 8) which is about 21dB less than the "available power" at the generator

## CIRCUIT DESCRIPTION

The NE/SA625 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 39.7dB(v) of gain from a 50Ω source. The bandwidth of the limiter is about 28MHz with about 62.5dB(v) 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. Hartley 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.

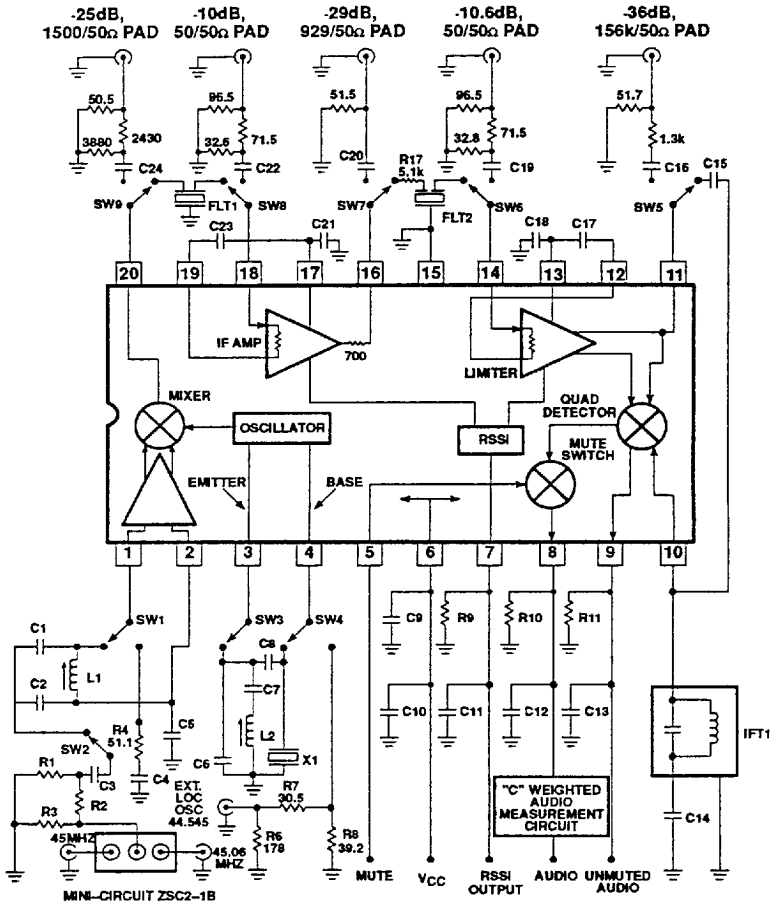
The signal from the second limiting amplifier goes to a Gilbert cell quadrature detector. One port of the Gilbert cell is internally driven by the IF. The other output of the IF is AC-coupled to a tuned quadrature network. This signal, which now has a 90° phase relationship to the internal signal, drives 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: $dB(v) = 20\log V_{OUT}/V_{IN}$

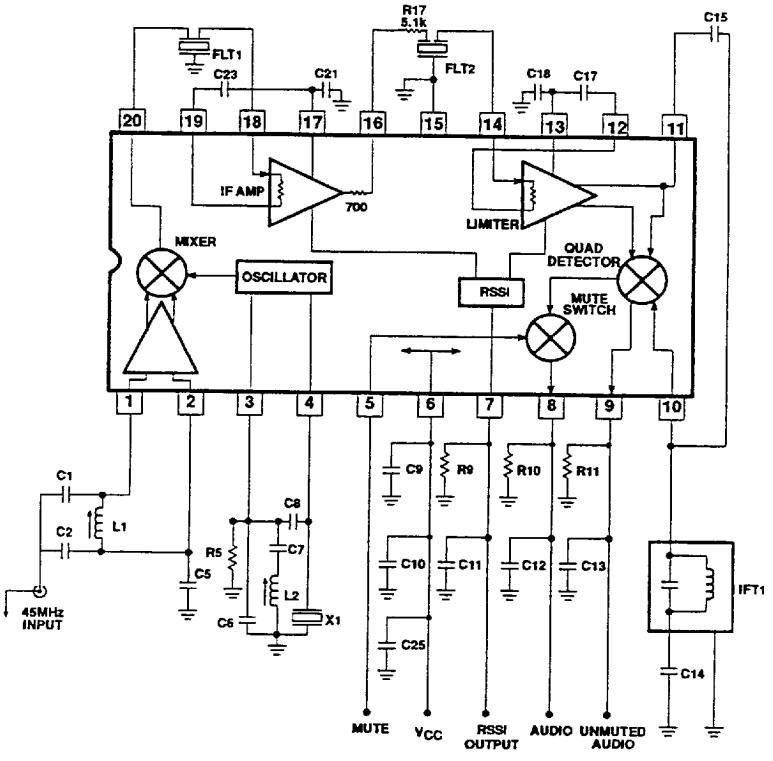



**Automatic Test Circuit Component List**

| | | | |
|---|---|---|---|
| C1 | 100pF NPO Ceramic | C21 | 100nF ±10% Monolithic Ceramic |
| C2 | 390pF NPO Ceramic | C23 | 100nF ±10% Monolithic Ceramic |
| C5 | 100nF ±10% Monolithic Ceramic | C25 | 100nF ±10% Monolithic Ceramic |
| C6 | 22pF NPO Ceramic | Flt 1 | Ceramic Filter Murata SFG455A3 or equiv |
| C7 | 1nF Ceramic | Flt 2 | Ceramic Filter Murata SFG455A3 or equiv |
| C8 | 10.0pF NPO Ceramic | IFT 1 | 455kHz (Ce = 180pF) Toko RMC–2A6597H |
| C9 | 100nF ±10% Monolithic Ceramic | L1 | 147–160nH Coilcraft UNI–10/142–04J08S |
| C10 | 6.8μF Tantalum (minimum) * | L2 | 0.8μH nominal Toko 292CNS–T1038Z |
| C11 | 100nF ±10% Monolithic Ceramic | X1 | 44.545MHz Crystal ICM4712701 |
| C12 | 15nF ±10% Ceramic | R9 | 100k ±1% 1/4W Metal Film |
| C13 | 150pF ±2% N1500 Ceramic | R17 | 5.1k ±5% 1/4W Carbon Composition |
| C14 | 100nF ±10% Monolithic Ceramic | R10 | 100k ±1% 1/4W Metal Film (optional) |
| C15 | 10pF NPO Ceramic | R11 | 100k ±1% 1/4W Metal Film (optional) |
| C17 | 100nF ±10% Monolithic Ceramic | | |
| C18 | 100nF ±10% Monolithic Ceramic | | |

*NOTE: This value can be reduced when a battery is the power source.

Figure 1. NE/SA625 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 | 6.8µF 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 | 0.8µH nominal<br>Toko 292CNS–T1038Z |
| 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) |

*NOTE: This value can be reduced when a battery is the power source.

Figure 2. NE/SA625 45MHz Application Circuit

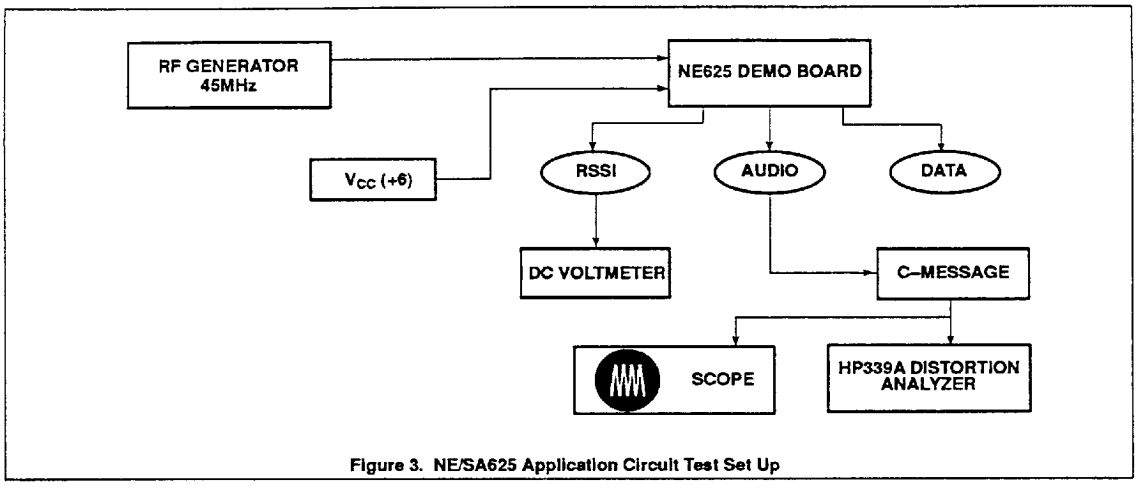



**Figure 3. NE/SA625 Application Circuit Test Set Up**

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 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 10-15µF 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 44.545MHz oscillator improves sensitivity by 2-3dB.
8. R5 can be used to bias the oscillator transistor at a higher current for operation above 45MHz. Recommended value is 22kΩ, but should not be below 10kΩ.

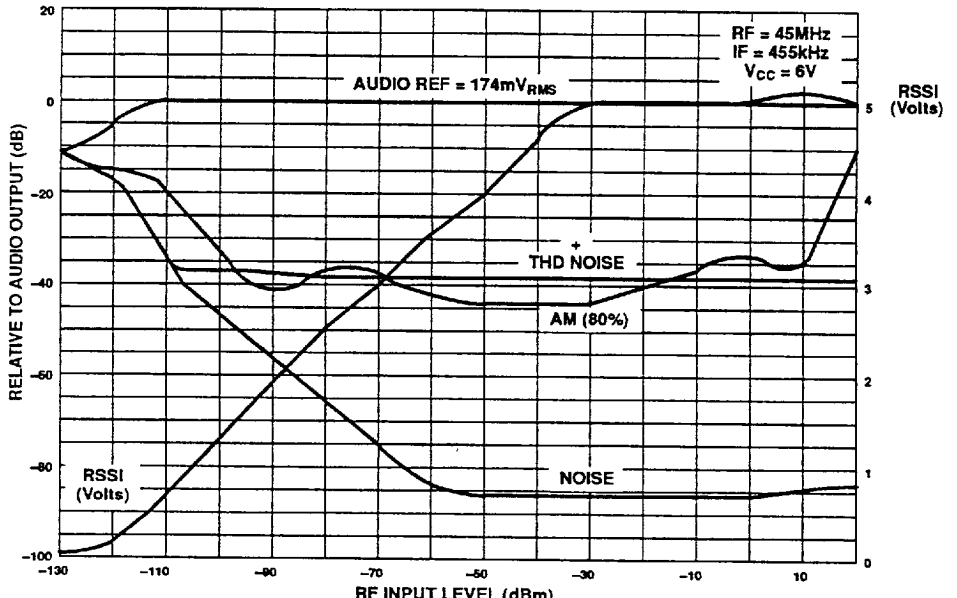



Figure 4. NE625 Application Board at 25°C

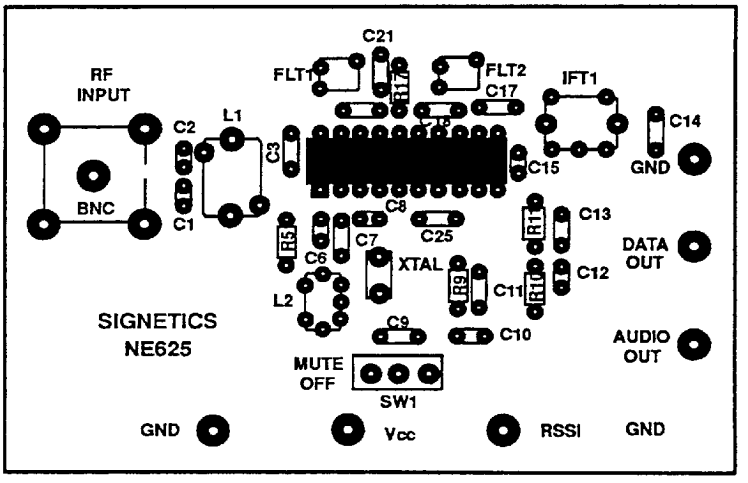
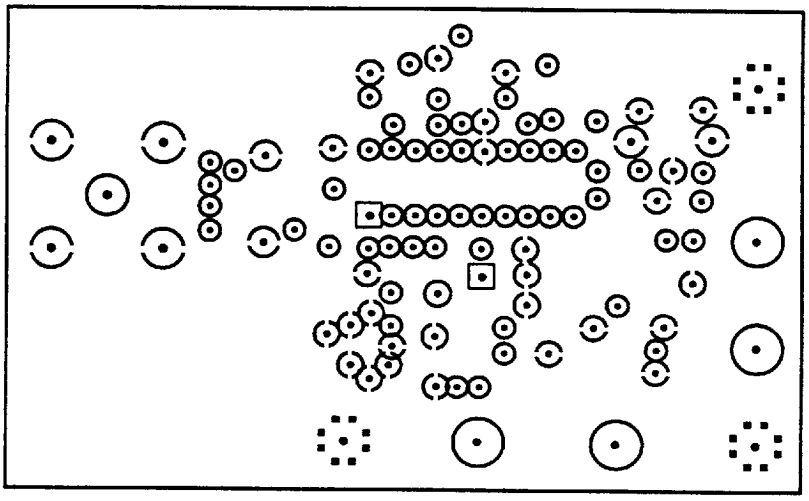
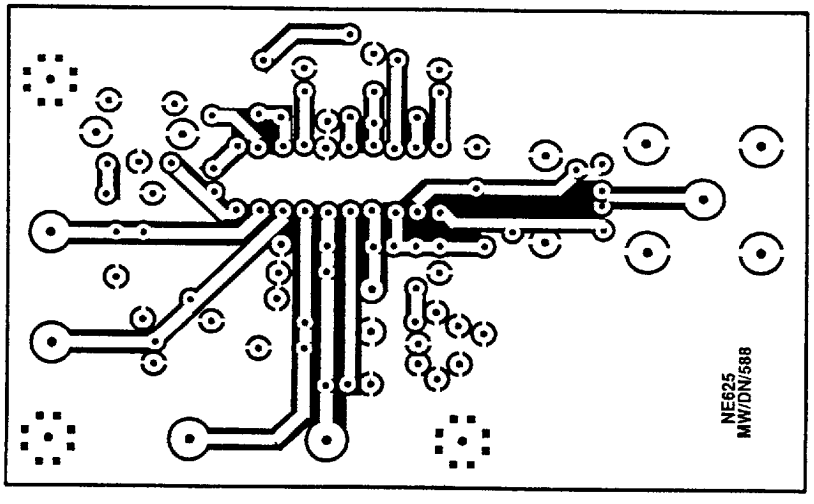



Figure 5. Component Placement for NE625 Application Circuit



TOP VIEW




BOTTOM VIEW

Figure 6. Layout for NE/SA625 Application Board

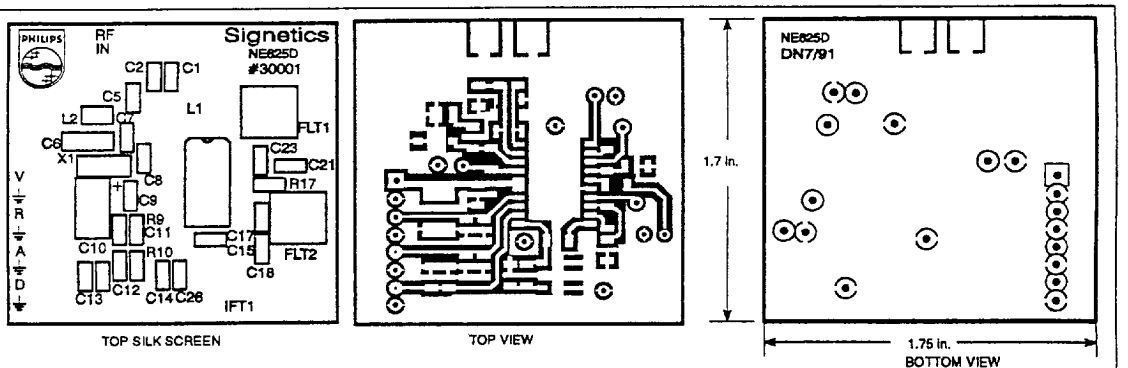



Figure 7. NE625 SO Demo-board Layout (Not Actual Size)

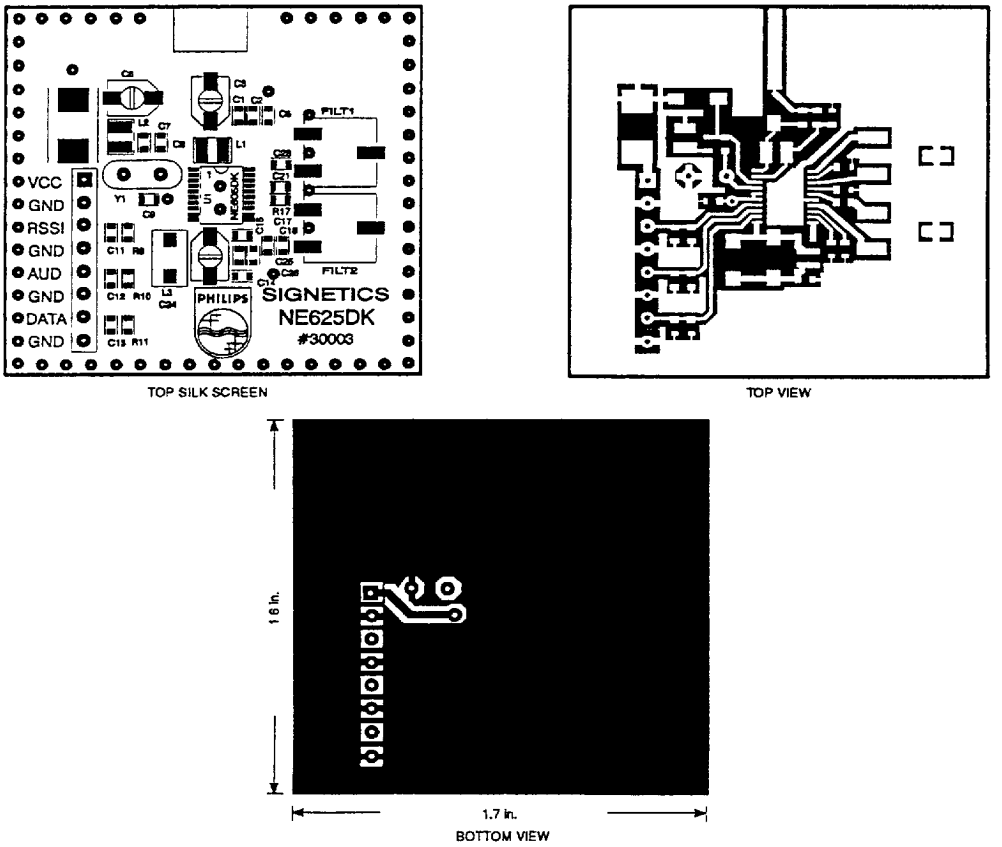



Figure 8. NE625 SSOP Demo-board Layout (Not Actual Size)

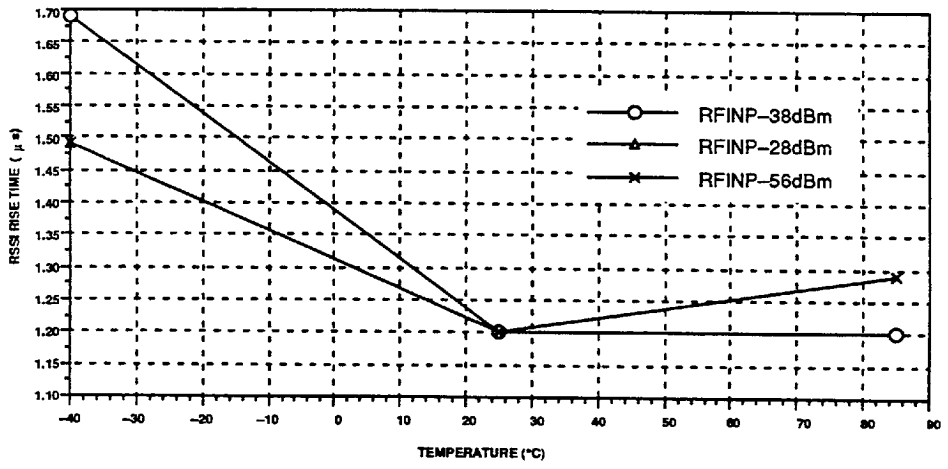



Figure 9. NE/SA625 Rise Time 455kHz IF Frequency

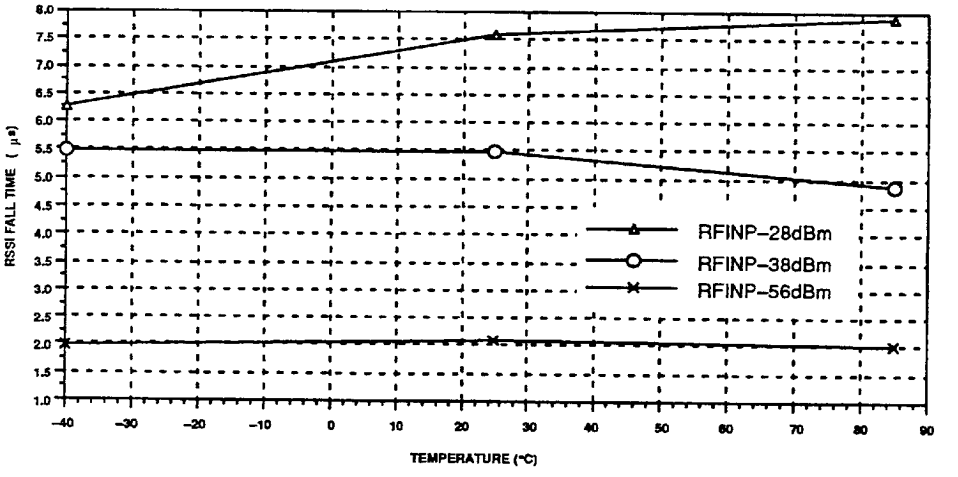



Figure 10. NE/SA625 Fall Time 455kHz IF Frequency

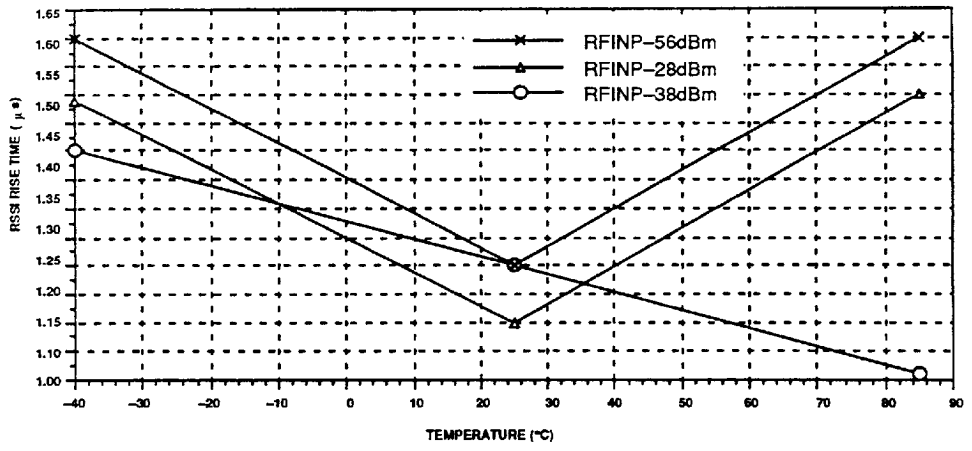



Figure 11. NE/SA625 Rise Time 10.7MHz IF Frequency

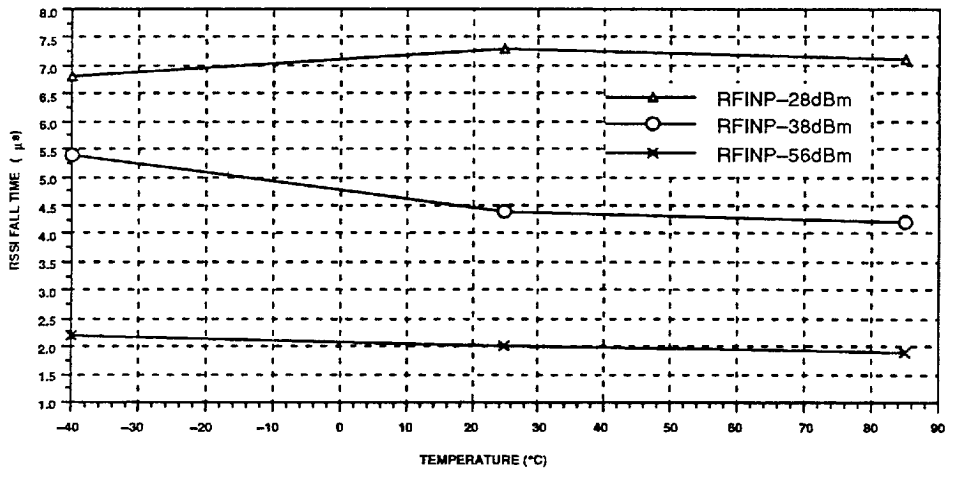



Figure 12. NE/SA625 Fall Time 10.7MHz IF Frequency