

# BA1404 BA1404F

## FM stereo transmitter

The BA1404 and BA1404F monolithic ICs are stereo transmitters

Each IC consists of a stereo modulator that creates stereo composite signals, an FM modulator that creates FM signals, and an RF amplifier. The stereo modulator develops composite signals made up of a MAIN (L+R) signal, a SUB (L-R) signal and a pilot (19 kHz) signal using 38 kHz crystal oscillators.

The FM modulator has carriers on the FM broadcast band (75 ~ 108 MHz)

The RF amplifier transmits the stereo encoded FM signals and is also a buffer for the FM modulator.

The stereo transmitter is equipped with a constant voltage pin for a variable capacitor that is used to finely adjust the FM frequency.

### Features

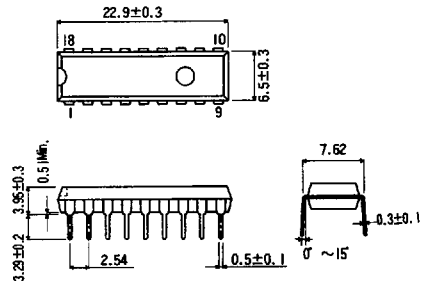
- available in DIP18 and SOP18 packages
- low operating voltage range (1.0 V ~ 2.0 V)
- low power consumption, typically 3 mA
- requires few external components

### Applications

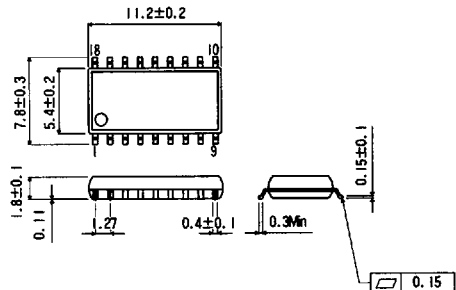
- FM stereo transmitters
- Wireless microphones

### Dimensions (Units : mm)

#### BA1404 (DIP18)



#### BA1404F (SOP18)



Block diagram

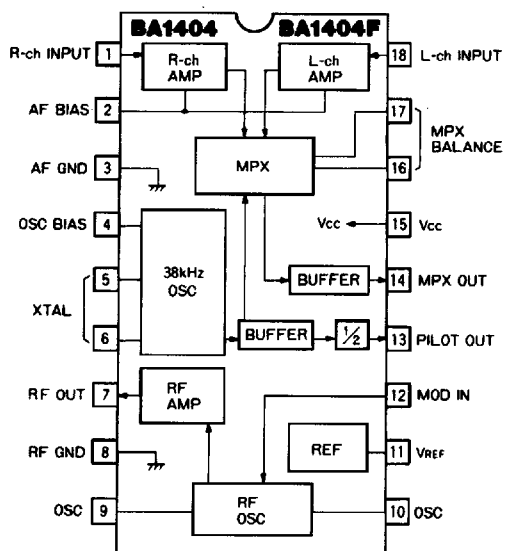


Table 1 Pin description

| Pin no. | Pin name                      | Description  |
|---------|-------------------------------|--|
| 1       | R-ch audio input              | Connects to the pre-emphasis circuit                     |
| 2       | Input amplifier bypass        | Connects to the bypass capacitor                         |
| 3       | GND                           | Low frequencies  |
| 4       | 38 kHz oscillator bypass      | Connects to bypass capacitor                             |
| 5       | 38 kHz oscillator             | Connects to 38 kHz crystal oscillators                   |
| 6       | 38 kHz OSC                    | Connects to load capacitor of crystal oscillator         |
| 7       | RF output                     | Connects to LC resonator                                 |
| 8       | GND                           | High frequency   |
| 9       | RF oscillator                 | Connects to bypass capacitor                             |
| 10      | RF oscillator                 | Connects to capacitor and LC resonator                   |
| 11      | Voltage supply                | Connects to variable capacitor                           |
| 12      | Modulation signal input       | Connects to bypass capacitor and modulated signal source |
| 13      | Pilot signal output           | Connects to RC mixer circuit                             |
| 14      | Multiplexer signal output     | Connects to RC mixer circuit                             |
| 15      | V <sub>CC</sub>               | Power supply   |
| 16      | Multiplexer modulator balance | Connects to trimpot resistor                             |
| 17      | Multiplexer modulator balance | Connects to trimpot resistor                             |
| 18      | L-ch audio input              | Connects to pre-emphasis circuit                         |

**Absolute maximum ratings ( $T_a = 25^\circ\text{C}$ )**

| Parameter             |         | Symbol    | Limits          | Unit             | Conditions   |
|-----------------------|---------|-----------|-----------------|------------------|--|
| Power supply voltage  |         | $V_{CC}$  | 2.5             | V                |  |
| Power dissipation     | BA1404  | $P_d$     | 1200            | mW               | Reduce power by 12.0 mW for each degree above $25^\circ\text{C}$ . |
|                       | BA1404F |           | 450             |                  | Reduce power by 4.5 mW for each degree above $25^\circ\text{C}$ .  |
| Operating temperature |         | $T_{opr}$ | $-25 \sim +75$  | $^\circ\text{C}$ |  |
| Storage temperature   |         | $T_{stg}$ | $-50 \sim +125$ | $^\circ\text{C}$ |  |

**Recommended operating conditions ( $T_a = 25^\circ\text{C}$ )**

| Parameter            | Symbol   | Min | Typical | Max | Unit |
|----------------------|----------|-----|---------|-----|------|
| Power supply voltage | $V_{CC}$ | 1   | 1.25    | 2   | V    |

**Electrical characteristics ( $T_a = 25^\circ\text{C}$ ,  $V_{CC} = 1.25\text{ V}$ )**

| Parameter                      | Symbol    | Min | Typical | Max | Unit                | Conditions                      |
|--------------------------------|-----------|-----|---------|-----|---------------------|---------------------------------|
| Quiescent current              | $I_Q$     | 0.5 | 3       | 5   | mA                  |                                 |
| Input impedance                | $Z_{IN}$  | 360 | 540     | 720 | $\Omega$            | $f_{IN} = 1\text{ kHz}$         |
| Input/output gain              | $G_V$     | 30  | 37      |     | dB                  | $V_{IN} = 0.5\text{ mV}$        |
| Channel balance                | CB        |     |         | 2   | dB                  | $V_{IN} = 0.5\text{ mV}$        |
| Multiplexer output voltage     | $V_{OM}$  | 200 |         |     | $\text{mV}_{pk-pk}$ | THD $\leq 3\%$                  |
| Multiplexer 38 kHz leakage     | $V_{OO}$  |     | 1       |     | mV                  | No signal                       |
| Pilot output voltage           | $V_{OP}$  | 460 | 580     |     | $\text{mV}_{pk-pk}$ | No load                         |
| Channel separation             | Sep       | 25  | 45      |     | dB                  | With a standard demodulator     |
| Input conversion noise voltage | $V_{NIN}$ |     | 1       |     | $\mu\text{V}_{rms}$ | IHF-A when 38 kHz is terminated |
| RF output voltage              | $V_{OSC}$ | 350 | 600     |     | $\text{mV}_{rms}$   |                                 |

Figure 1 Test circuit

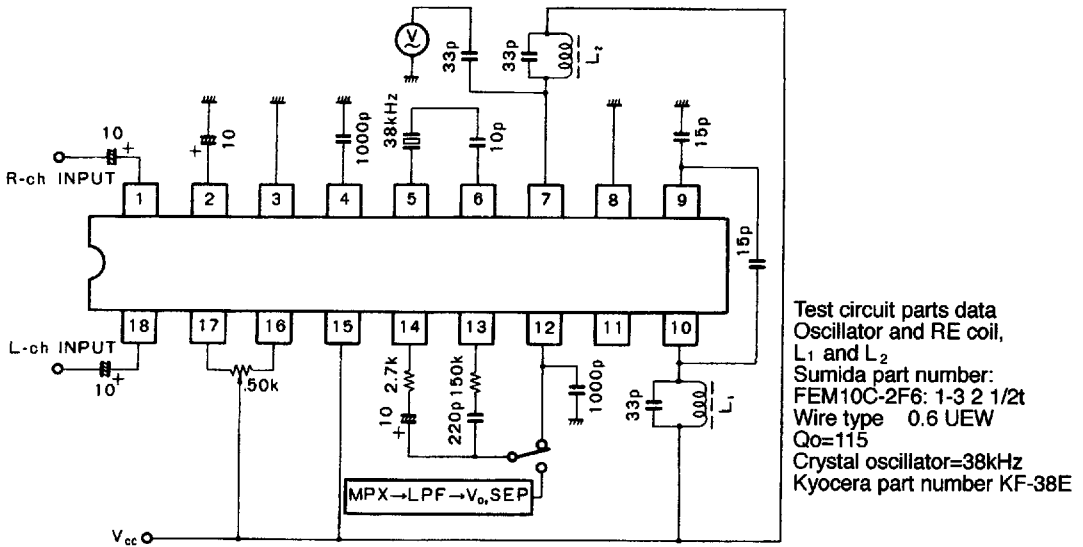
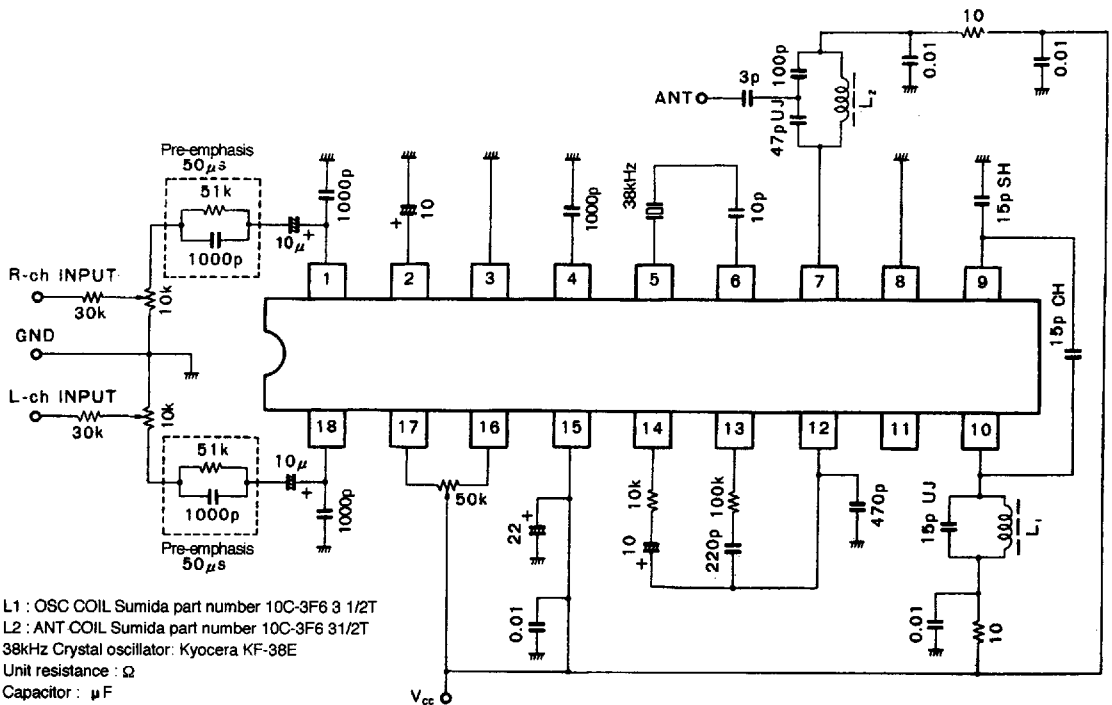


Figure 2 Application example



**Circuit operation**

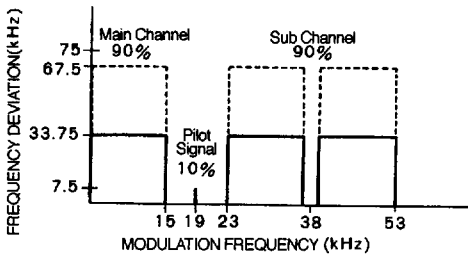
**Stereo modulator**

The R-channel audio is input from pin 1 and the L-channel from pin 18. Each audio signal is amplified about 37 dB by independent amplifiers and output to the multiplexer.

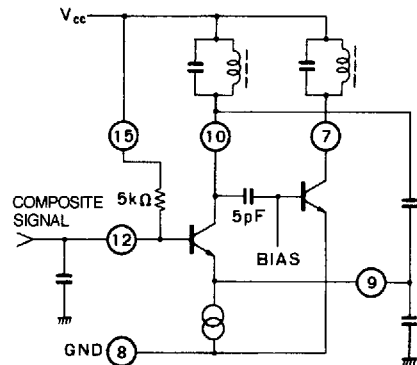
The 38 kHz crystal oscillator, connected between pin 5 and pin 6, creates a 38 kHz subcarrier and a 19 kHz pilot signal with the same phase but delayed by a 1/2 cycle.

The audio signals and the 38 kHz subcarrier are balanced and modulated in the multiplexer. The L + R signal and the 38 kHz subcarrier, which are a DSB-modulated signal at L-R, are added to create the main carrier, which is output from pin 14.

The potentiometer between pins 16 and 17 can be used to lessen the subcarrier leakage due to unbalance in the multiplexer.



**Figure 3 Modulation spectrum of pilot tone**



**Figure 4 FM modulator**

**FM modulator**

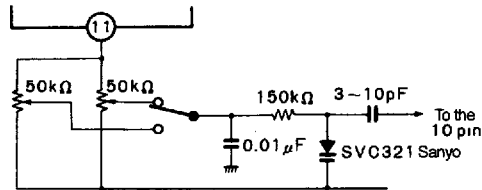
The high-frequency oscillator is a collector tuning-type or Collpits oscillator as shown in Figure 4. The composite signal is input from pin 12 to the base of the transistor. By adding the audio signal to the base, the reactance of the transistor changes. By changing the time constant of the tuning circuit in the oscillator, the frequency is modulated.

The oscillation frequency is determined by the LC resonator that is connected between pin 10 and the V<sub>CC</sub>. Because this oscillator does not compensate for V<sub>CC</sub> fluctuation and temperature changes, the frequency changes are large, and, when the receiver is part of a synthesizer (digital tuning) system, tuning should be separated from V<sub>CC</sub>.

It is suggested that you use a variable capacitor (AFC) system, or an external FM modulator when frequency stability is required.

It is possible to change the oscillator frequency with the DC voltage by using the stable output voltage on pin 11 and a variable capacitor as shown in Figure 5. Pin 11 voltage is approximately  $(V_{CC}-0.7)$  V.

**Figure 5** Setting oscillator frequency using pin 11



**High-frequency amplifier**

The high-frequency amplifier is a single-stage amplifier with its emitter connected to ground, as shown in Figure 4.

The RF output (on pin 7) is connected to the tuning circuit of the antenna by an open collector.

**Other application examples and operation precautions**

**Not operating the FM modulator** Unused pins should be connected as follows:

- 7         $V_{CC}$
- 8        GND
- 9        open
- 10        $V_{CC}$
- 11       open
- 12        $V_{CC}$

In particular, do not leave pin 7 and pin 10 open. If this is done, the transistor may be saturated and other components will operate poorly.

**Operating monaurally** Unused pins should be connected as follows:

- 4        open
- 5        GND
- 6        open
- 13       open

The other pins should be connected as shown in the application circuit in Figure 2. In particular, do not leave pin 5 open. This will cause parasitic oscillation that will appear as noise on pin 14. Pin 1 should be used for audio input.

**When operating only the FM modulator** Unused pins should be connected as follows:

|   |                 |    |      |
|---|-----------------|----|------|
| 1 | open            | 13 | open |
| 2 | V <sub>CC</sub> | 14 | open |
| 4 | open            | 16 | open |
| 5 | open            | 17 | open |
| 6 | GND             | 18 | open |

### Multiplexer balance

Even if the resistor between pin 16 and pin 17 is not connected, the IC has its own capability of achieving multiplexer balance. If no resistor is connected, however, there is a decrease in gain of approximately 1.5 dB in the input amplifier.

### Crystal oscillators

To generate the 38 kHz carrier, use crystal oscillators. The recommended part is Kyocera KF-38E.

Start-up takes some time after the 38 kHz oscillator has been powered up. With a recommended load of 10 pF for the crystal oscillator, startup time is approximately 1.5 s. When the load is 33 pF, startup time is about 1 s. The startup time will not be reduced for loads greater than 33 pF.

### RF oscillator

The built-in RF oscillator is an LC-resonator. When an absolutely stable frequency is required, use an external FM modulator. For an external modulator, separation adjustment is made with the RC tuner on pin 13.

The built-in FM modulator can be operated in the 30 ~ 110 MHz range.

The RF oscillator frequency drift following power-up of the power supply becomes small when the V<sub>CC</sub> is low. The frequency drift after 5 s is as follows:

| V <sub>CC</sub> (V) | Drift (kHz) |
|---------------------|-------------|
| 1.25                | 85          |
| 2                   | 85          |
| 3                   | 130         |

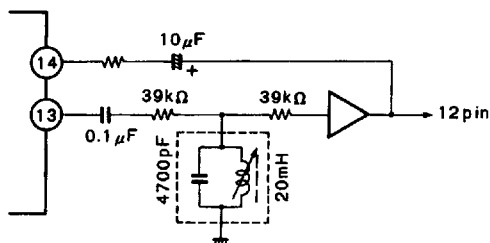
### Noise

Be sure to connect a 1000 pF capacitor between pin 1 and ground. Do the same for pin 18. This prevents the S/N ratio from deteriorating due to high frequencies.

If beats or noise are present on the output, and the input capacitors are in place, the noise may be due to the third or higher harmonics from the pilot signal and the subcarrier. Look for a 57 kHz signal. This can be removed by adding a filter as shown in Figure 6

When 15 kHz or greater signal is input, it causes a beat on the pilot signal (19 kHz). In addition, high frequency signals are particularly large because of the pre-emphasis of high frequency signals. Therefore excessive input of 15 kHz frequencies or more should be limited before input to the IC.

**Figure 6 Beat frequency filter**

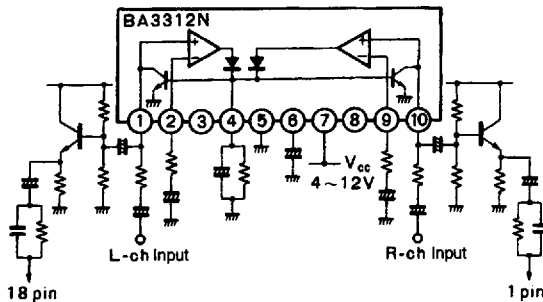


**Expanding the dynamic range of the multiplier**

When the  $V_{CC}$  is raised, the dynamic range of this IC expands. The input amplifier and the multiplier bias point are not set at  $1/2 V_{CC}$ , however.

This is why the top of the wave form is clipped beforehand. The maximum input voltage is approximately  $-60$  dB ( $1 \text{ mV}_{\text{rms}}$ ). To make the waveform symmetrical, a resistance of  $3.6 \text{ k}\Omega$  is inserted between pin 2 and ground. This increases the maximum output voltage by approximately 6 dB. In this case, however, the voltage characteristic deteriorates to 1.5 V.

**Figure 7**



**Method for limiting input voltage**

Input control can be carried out using the preamplifier IC and the ALC of the BA3312N. Please see the BA3312N application notes for the constant.



Electrical characteristic curves

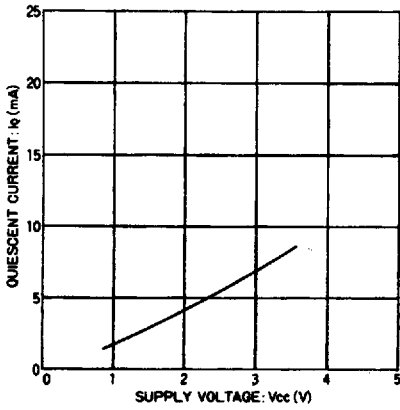


Figure 8

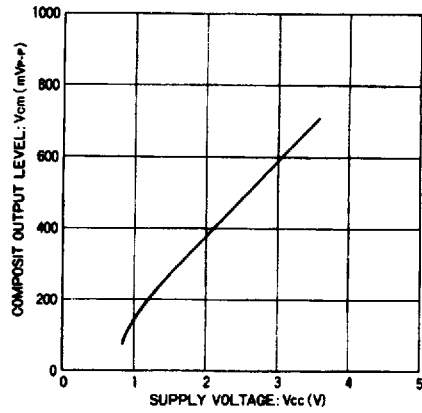


Figure 9

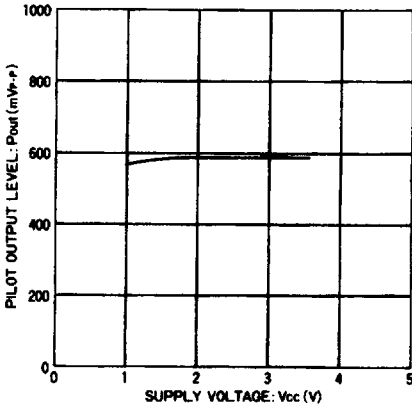


Figure 10

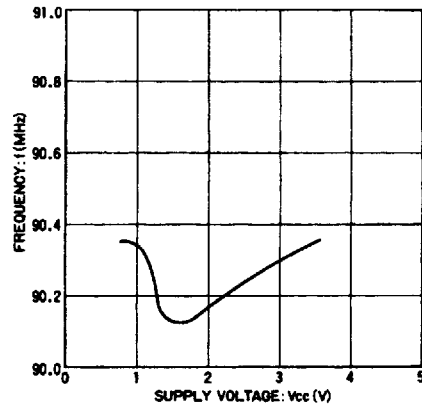


Figure 11

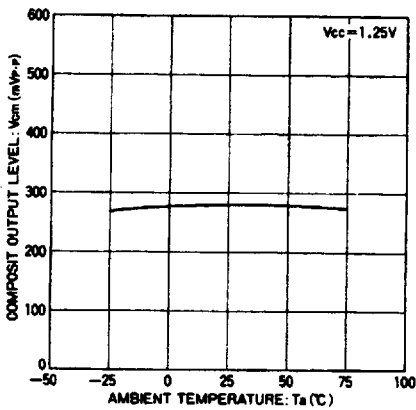


Figure 12

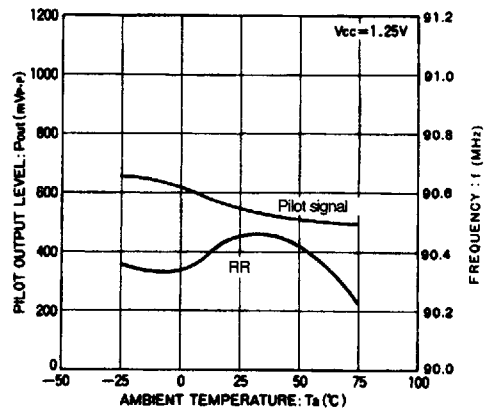


Figure 13