



XEMICS

Reference Design

RD1218.01

VHF FM Radio Receiver based on the XE1218 Single Chip FM 230MHz

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INTRODUCTION

This reference design reports on how the RD1218.01 VHF FM Radio Receiver demonstrates the use of a highly integrated single chip audio receiver from antenna to loudspeaker for voice transmission applications. For details about the Single Chip FM 230MHz Receiver, refer to XE1218 Data sheet.

Traditionally, FM Receiver includes a high complexity design simplified by the use of a highly integrated single chip receiver.

XEMICS XE1218 FM Receiver has an ultra low voltage operation down to 1 volt and ultra low power consumption, 2mA. The sensitivity has been designed in order to obtain -107dBm with 6kHz audio bandwidth.

The XE1218 circuit includes a RF receiver section, demodulator and a directly connecting audio amplifier that fits to an external earpiece. It uses analog narrow-band FM modulation.

Based on low power-IF architecture, the XE1218 VHF receiver is designed with an on-chip channel filter and a delay line type demodulator. Moreover, a crystal oscillator generates the Local Oscillator frequency that can therefore be fixed between 130MHz-230MHz.

XE1218 BENEFITS

The use of the XE1218 VHF FM Receiver in audio RF application offers the following advantages:

- Low power consumption
- Highly integrated
- High sensitivity
- 6kHz audio bandwidth
- Integrated audio amplifier
- Very few external components

RD1218-01 OVERVIEW

The FMX Electronic module is a VHF FM radio receiver. It provides a cost-effective circuit enabling it to receive an audio signal from a walky-talky.

The system operates in the low power band 200MHz for short-range devices. It is a fixed frequency one-channel receiver. Its receiving frequency is defined by a quartz, which is soldered on the module. It can be chosen in the 173-225MHz band.

In Europe, the 173-225MHz band (formerly TV "VHF-II") has recently been assigned to short range radio communication equipment using a low power transmitter (for more information refer to norm ETS300422).

Typical applications using the XE1218 design are tour guide systems, wireless phone headsets, FM broadcasting miniature receivers, local/wide area voice paging and toys.

In the USA, the 216-217MHz band was freed in 1996 for a new Low Power Radio Service (LPRS) which includes auditory assistance devices, health care assistance devices and law enforcement tracking systems. The maximum allowable transmitter power is 100mW.

The FMX is an electronic module that allows the construction of a miniaturized radio receiver. It is supplied by a single 1.3V battery and has a low current consumption (1.5mA-3mA, depending on its mode).

RD1201.01 KEY FEATURES

- Low complexity hardware
- Small size
- A short wire printed antenna
- Direct connection with a loudspeaker
- Stand by mode $<50\mu\text{A}$.

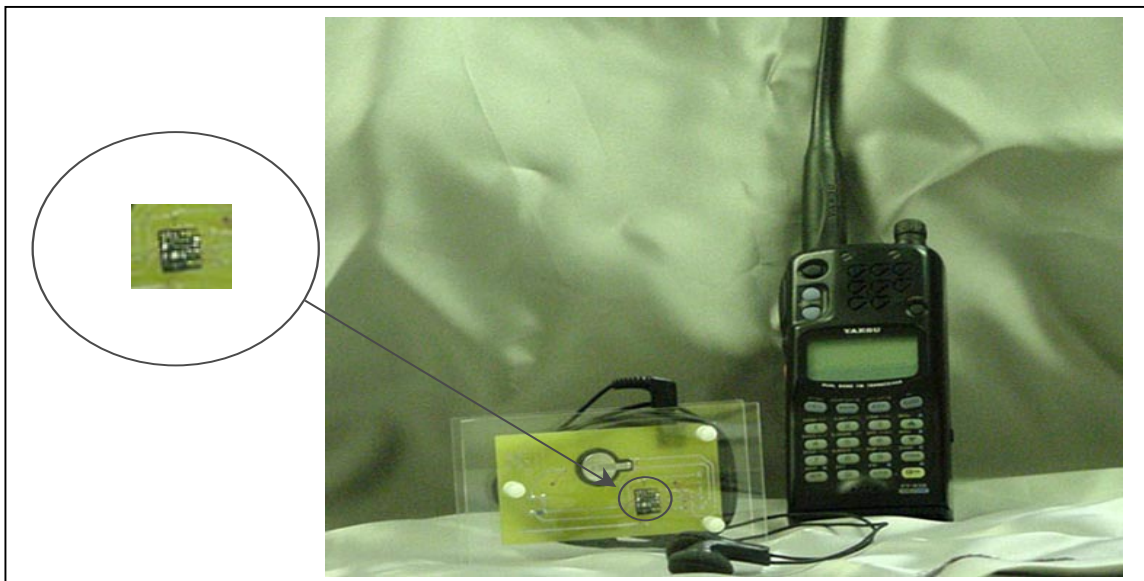


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SYSTEM OVERVIEW

The RD1218.01 Reference Design describes how to develop a cost effective and fully integrated FM Receiver. Using the XE1218, this application performs RF signal reception and Audio processing (antenna in, loudspeaker out).

This Reference Design is limited to receive only one frequency, which is fixed by a quartz (see design modification to change the LO frequency).

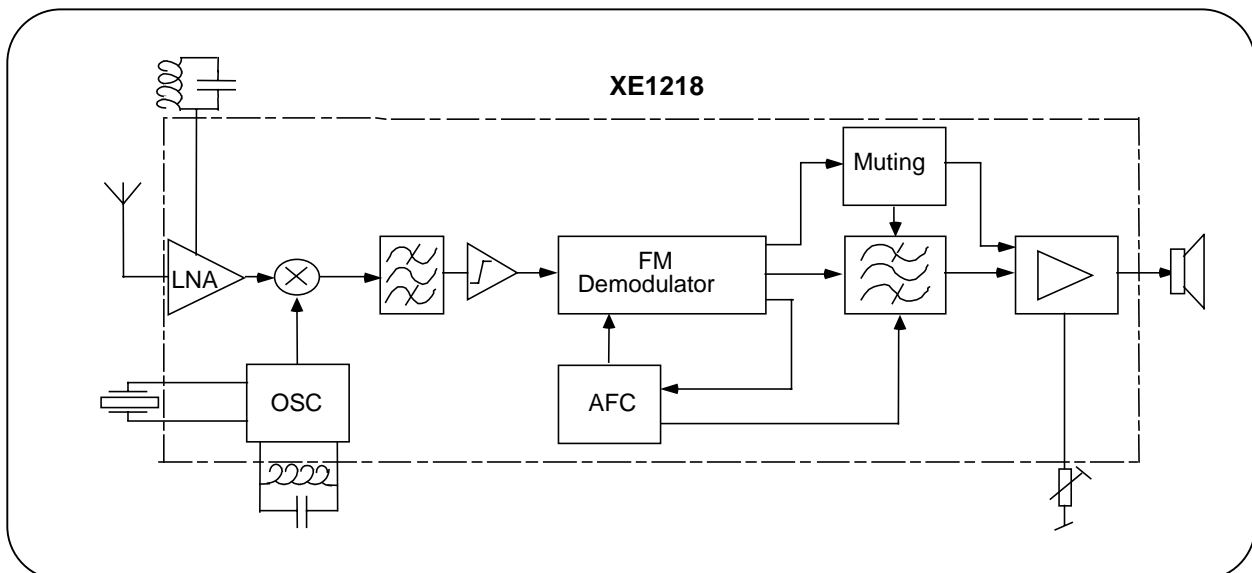
The Ultra Low Power VHF FM receiver, XE1218, is composed of the following main functional blocks:

- Receiver Chain including the audio output stage
- The Local Oscillator block
- The control and service blocks.

The receiver is implemented with the following blocks:

- A low noise amplifier
- A mixer used as a down converter to transfer the signal from VHF band to an intermediate frequency (IF) of 25kHz.

- An offset cancellation block used to attenuate the DC.
- An IF Filter chain used to amplify and filter the IF signal.
- A limiter providing the demodulator with fully digital signals.
- A digital delay line FM demodulator that converts the signal from limiter into a pulse width modulated signal at twice the IF frequency. This block also generates AFC and MUTE signals; the AFC signal is used inside the demodulator in order to track the clock frequency of the IF frequency.
- An audio stage used to filter the input PWM signal and to provide volume control and output buffering. The block uses the MUTE signal generated by the demodulator to switch on/off the output buffer driving the EAR output.



SYSTEM DETAILS

The receiving frequency of the FMX is determined by the quartz frequency. The receiver XE1218 is a super-heterodyne receiver having an IF of 25kHz. It has two receiving frequencies that are +/-25kHz offset with respect to the quartz frequency.

The image frequency is not rejected, this simplification has been made in order to achieve the lowest current consumption. The image frequency is located very close to the receiving frequency, therefore the probability of interference, on this image, by other low power transmitters remains low.

The antenna circuitry has to be adjusted (Trimmer on the module), because it depends on the chosen antenna type.

Power Supply

A single 1.0-1.6V battery supplies the receiver. The battery shall be connected between +Vdd and GND.

Audio Outputs

The module FMX has 3 outputs each of which serving different purposes:

- OUTL and OUTH (not accessible with demonstrator) are low-level outputs for connection to loudspeaker input.
- EAR is a high level output. It is the output of a class A amplifier and can be directly connected to an earphone.

| Audio Pad | Output Level | Output Impedance | Recommended Load Impedance |
|-----------|------------------|-------------------------|----------------------------|
| OUTL | 10mVrms ±3dB | <100Ω, serie 4.7μF | >1kΩ |
| OUTH | 40mVrms ±3dB | 10kΩ ±25%, serie 1μF | Any |
| EAR | 250mVrms ±3dB | Vbias=0.3V ±100mV | Rdc (earphone)>200 Ω |

Audio Output Level Control

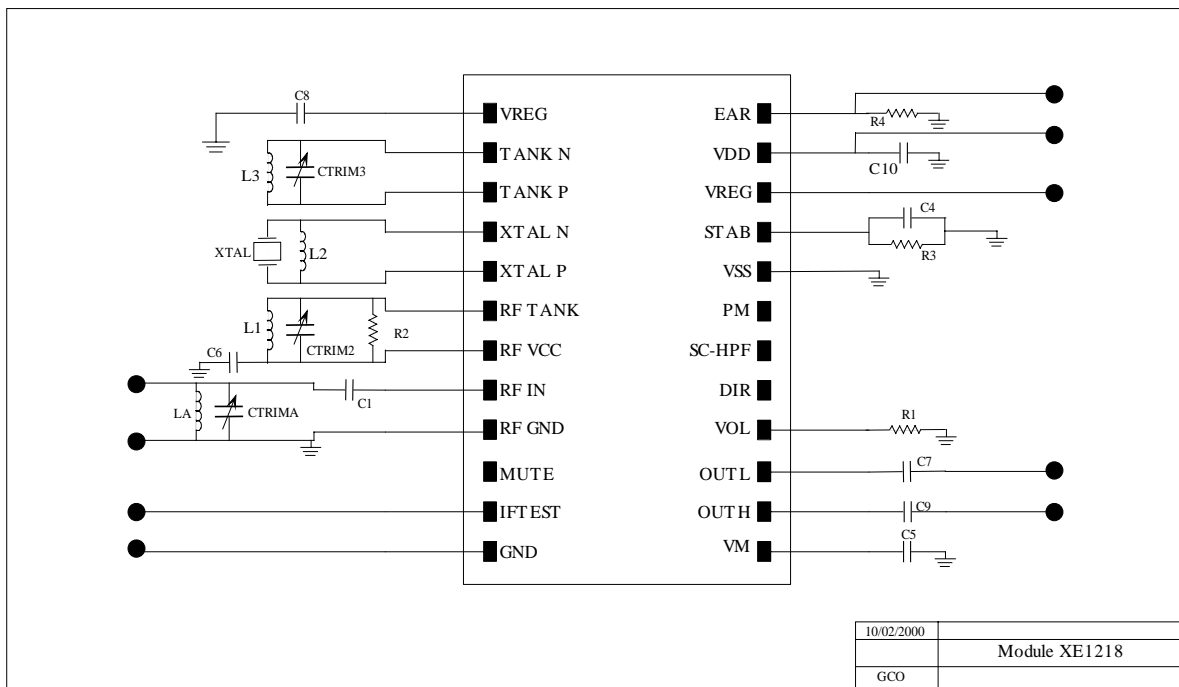
The Audio output level depends on the value of the resistor R1 (see fig). The default value is 470kOhm.

Antenna Circuit

The simplest receiving antenna is a short wire of length 4cm (electrical antenna)

It is possible to use a magnetic LOOP antenna with a 2 square centimeter area. In that case, the SMD coil LA must be removed and CT1 again bring the whole antenna circuitry at resonance on the frequency. The magnetic antenna is less sensitive to de-tuning by the proximity of the body than the electrical antenna.

Electrical Schematic of the Module

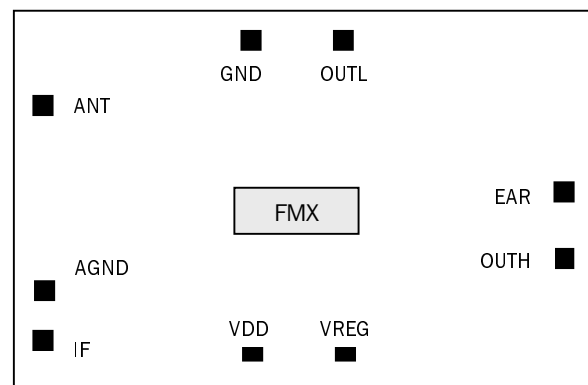


GENERAL SPECIFICATION

| Parameter | Specification |
|------------------------------|---|
| Type of Modulation | FM, $\Delta f_{dev}=5\text{kHz}$ max. |
| Alignment Range | 173-225MHz |
| Switching Range | One channel receiver, (quartz controlled) |
| Sensitivity | SINAD>10dB @ $P_{in}=-105\text{dBm}$, $f_{mod}=1\text{kHz}$, $\Delta f_{dev}=3\text{kHz}$ |
| Channel Selectivity | >50dB (@200kHz channel spacing) |
| Current Consumption | Stand-by mode<50 μA Squelch or active mode:1.5mA-2.1mA |
| Operating Temperature Range | -10°to +55°C (extreme) |
| Audio Signal Frequency Range | 100Hz – 6kHz |
| SNR | 45dB |
| THD | <3% ($f_{mod}=1\text{kHz}$, $\Delta f_{dev}=5\text{kHz}$) |
| Spurious Emissions | Far below -57dbm ERP |

Symbol and List of the connection

| PAD | Description |
|------|--|
| GND | Negative Supply (GND) |
| VDD | Positive Supply |
| VREG | Sense Input for the standby modus |
| EAR | Earphone Output or high level audio output |
| OUTL | Low Impedance Output for hearing aids |
| OUTH | High Impedance output for hearing aids |
| IF | Test pad |
| ANT | Antenna input |
| AGND | Antenna ground |



Bill of Material

| Components | Type | Value |
|------------|---------------------------------------|---|
| Xtal 1 | Overtone crystal, Serial resonance | Ex, F=171.525 Cs=0.17fF, Rs<120ohm Q>40000 Cp=3,2pF |
| L1 | | 0.15uH |

| | | |
|----------|--|--------|
| L2 | | 0.18uH |
| L3 | | 0.18uH |
| C1 | | 1pF |
| Ctrim1 | | 10pF |
| Ctrim2 | | 2.5pF |
| Ctrim3 | | 3.2pF |
| C4,C5,C6 | | 10pF |
| C7 | | 4.7uF |
| C8 | | 4.7uF |
| C9 | | 10uF |

