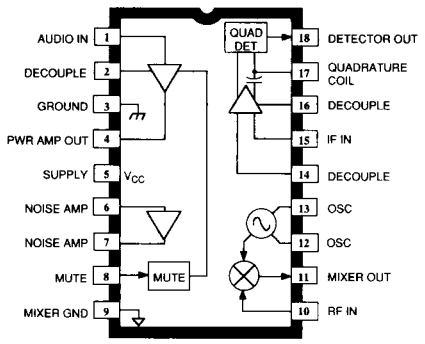
3883

FM COMMUNICATIONS IF AND AUDIO SYSTEM



Dwg. PS-019

The ULN3883A low-power, narrow-band FM IF system provides the second converter, second IF demodulator, and audio amplifier circuitry for communications and scanning receivers. A double-balanced mixer permits low-noise operation while eliminating spurious responses, effectively rejecting IF feedthrough, and reducing local oscillator radiation. The mixer high input impedance matches popular 10.7 MHz crystal filters and is designed to handle strong adjacent signal rejection, while its open-collector output is suitable for driving tuned transformer networks. Although designed for use with a 10.7 MHz first IF and a 455 kHz second IF, the mixer operates at other RF or IF input frequencies through 50 MHz. After the second IF filter, a multistage 1 MHz differential amplifier/limiter operates as a high-gain stage with excellent common-mode rejection. Audio is recovered by a quadrature FM detector that requires only a single low-cost tuned circuit. An on-board audio amplifier provides 250 mW output (at V_{CC} = 5 V) with low distortion for driving a speaker. The audio switches OFF in the mute mode, thus reducing power consumption.

This communications IF system meets the stability requirements of many automotive applications and also meets the low-power demands of portable radio design. Internal voltage regulators and bias supplies ensure stable performance despite variations in external supply voltage (3 V to 9 V) or temperature (-20°C to +85°C).

The ULN3883A is supplied in an 18-pin dual in-line plastic package with a copper lead frame that eliminates many decoupling problems.

FEATURES

- Dual Conversion
- Wide Operating Voltage Range
- High Sensitivity
- Large Dynamic Range Mixer
- Audio Power Amplifier OFF in Standby

APPLICATIONS

- Cordless Telephones
- Scanning Receivers
- Amateur Radio
- Land-Mobile Service

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{CC} . . . . . **12 V**
Mixer Input Voltage, V_{in} . . . . . **1 Vrms**
Mute Input Voltage Range,
V_8 . . . . . **-0.5 V to +12 V**
Package Power Dissipation, P_D . . . . . **1.2 W**
Operating Temperature Range,
T_A . . . . . **-20°C to +85°C**
Storage Temperature Range,
T_S . . . . . **-65°C to +150°C**

Always order by complete part number: **ULN3883A** .

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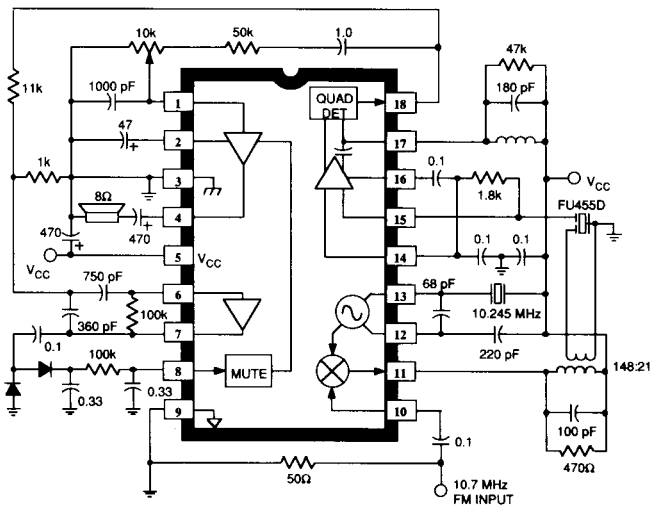
ELECTRICAL CHARACTERISTICS at T_A = +25°C, V_{CC} = 4.8 V, f_{in} = 10.7 MHz, f_m = 1 kHz, f_d = ±3 kHz, R_L = 8Ω (unless otherwise specified).

Characteristic	Test Pin	Test Conditions	Limits			
			Min.	Typ.	Max.	Units
Operating Voltage Range	5	Functional	3.0	4.8	9.0	V
Quiescent Current	5	Mute ON	–	3.0	6.0	mA
		Mute OFF	–	10	15	mA
Input Limiting Threshold	10	-3 dB Limit	–	5.4	8.0	µV
Detector Output Voltage	18		1.1	1.3	1.4	V
Recovered Audio	18	V_{CC} = 3.0 V, V_{in} = 1 mV	95	–	–	mV
		V_{CC} = 4.8 V, V_{in} = 1 mV	100	170	–	mV
		V_{CC} = 9.0 V, V_{in} = 1 mV	110	–	–	mV
Muting Attenuation	4	Mute ON	–	>100	–	dB
Audio Amplifier Gain	4		30	35	–	dB
Power Amplifier THD	4	P_o = 100 mW	–	1.0	3.0	%
Audio Power Output	4	V_{CC} = 3.0 V, f = 1 kHz, THD = 10%	50	–	–	mW
		V_{CC} = 3.6 V, f = 1 kHz, THD = 10%	–	93	–	mW
		V_{CC} = 4.8 V, f = 1 kHz, THD = 10%	160	260	–	mW
		V_{CC} = 9.0 V, f = 1 kHz, THD = 10%	300	–	–	mW
Mute Control Threshold	8		–	0.6	–	V
Quiescent Noise Amp. Volt.	7		0.9	1.6	2.2	V
Noise Amplifier Gain	6–7	V_{in} = 600 µV, f = 4 kHz	45	53	–	dB

NOTE: Typical values are given for circuit design information only.

TEST CIRCUIT AND TYPICAL APPLICATION



CIRCUIT DESCRIPTION AND APPLICATIONS INFORMATION

A test circuit and typical application (such as might be used for a low-cost cordless telephone) is shown. The oscillator uses a 10.245 MHz crystal to convert the first IF signal to 455 kHz. The second IF filter consists of a tuned transformer matched to a ceramic filter with about a 15 kHz bandwidth.

The output of the ceramic filter is matched with a 1.8 kΩ resistor at the input of the IF amplifier. The detector coil is loaded with a 47 kΩ resistor to give a loaded Q of about 25 to produce an audio output of about 170 mVrms with a 3 kHz peak deviation. This is more than enough to drive the audio amplifier, so a resistor between the detector output and volume control can be added together with a capacitor to produce a desired de-emphasis network. Muting is accomplished by amplifying the noise present at the detector output in the absence of a signal, rectifying it and applying the rectified signal to the mute input. The audio amplifier is turned OFF when the voltage at pin 8 exceeds 0.6 V. The internal noise amplifier is connected as an active band-pass filter centered at 7 kHz. In a telephone application, this filter could be designed to respond to the guard tone signal being transmitted.

MIXER (pins 10 and 11)

The mixer is internally biased, so that only a coupling capacitor is needed at the input. The mixer ground is pin 9 and should be connected to the input circuit ground. Pin 10 is equivalent to 3 kΩ in parallel with 20 pF. The mixer output current is about 400 μA and the output is equivalent to about 100 kΩ in parallel with 3 pF. Conversion transconductance is 600 μmho. The mixer can be used as an IF preamplifier, instead of a mixer, by connecting pin 12 to 13. In this configuration its transconductance is about 1.4 mmho.

OSCILLATOR (pins 12 and 13)

The oscillator is a transistor with the base connected to pin 13 and the emitter through a 400 μA current source to pin 12. The stray capacitance at pin 13 is about 7 pF.

IF AMPLIFIER (pins 14, 15, and 16)

Pin 15 is the base of the first stage, and it is biased through the 1.8 kΩ resistor from pin 14 but this can be from 0 to about 10 kΩ for proper balance of the IF amplifier. The -3 dB frequency response of the IF amplifier is about 1.5 MHz, and it falls off at about 6 dB per octave above this. The -3 dB limiting sensitivity at 455 kHz is about 13 μV.

DETECTOR (pins 17 and 18)

The IF output is a 570 mVpp square wave in series with a 10 pF capacitor to the detector input. The detector transistors at pin 17 should have at least 100 mVrms across them for linear detector operation. The quadrature coil R and C values are selected as:

$$C = \frac{1400\ Q_L}{V_{17}} - 10 \text{ and } R = \frac{Q_O\ X_C\ Q_L}{Q_O - Q_L}$$

The detector output is an emitter with a low output impedance of approximately 400 Ω. Some of the 455 kHz signal appears at the output, and the circuit layout should separate the pin 18 and pin 16 circuitry.

AUDIO AMPLIFIER (pins 1, 2, 3, and 4)

Pin 3 is the main circuit ground and the ground for the audio power amplifier. The speaker ground should be connected close to this pin. The output coupling capacitor at pin 4 can be selected to give a desired -3 dB low-frequency response and to reduce power consumption by reducing the low-frequency output. The capacitor at pin 3 serves as the bypass for the internal amplifier feedback and also determines the response speed of the mute circuit. Pin 1, the amplifier input, is the base of a pnp transistor, and an external resistance of less than 50 kΩ to ground is needed.

NOISE AMPLIFIER/MUTE DRIVER (pins 6 and 7)

The noise amplifier is an inverting amplifier with a typical gain at 4 kHz of 53 dB. DC feedback between pins 6 and 7 is required. A low-pass, band-pass, or high-pass filter can be built with this configuration.

In the band-pass configuration, ceramic capacitors should not be used because of their usually low Q. Polystyrene- or polycarbonate-film capacitors are recommended. The gain of the active filter must be high enough so that the output can be rectified to drive the mute input. This depends on the output level of the detector, the bandwidth of the IF filter, and the active filter frequency. For example, an IF bandwidth of 15 kHz will result in a detector output roll-off around 7 kHz, so the amplifier operating frequency should not be set much higher than this. The active filter can be used instead as a low-pass filter in the audio circuit to improve sensitivity or to remove unwanted tones, or as a high-pass filter to amplify tones to be applied to tone-detector circuits. It is recommended that impedances be kept less than 100 kΩ in order to avoid the loading effects of the noise amplifier.

MUTE INPUT (pin 8)

The mute input is a 22 kΩ resistor in series with the base of a grounded emitter transistor. Thus, the mute threshold is about 0.6 V. A capacitor from pin 8 to ground filters the output of the rectifier circuit and should be selected to give the desired mute characteristics for marginal signals.