APPLICATION MANUAL

Narrow Band FM IF IC
TK83361M

CONTENTS

MEETING YOUR NEEDS
TOKO, Inc.

Narrow Band FM IF IC
TK83361M

1. DESCRIPTION

The TK83361M is a narrow band FM IF IC designed for amateur radio transceivers, cordless phones, remote controls, and other communications equipment.
It integrates the mixer, oscillator, limiting amplifier, FM demodulator, filter amplifier and squelch circuit into a single surface mount SOP-16 package.

The TK83361M offers improved performance over the 3361, and is a drop-in replacement for the MC3361C.

2. FEATURES

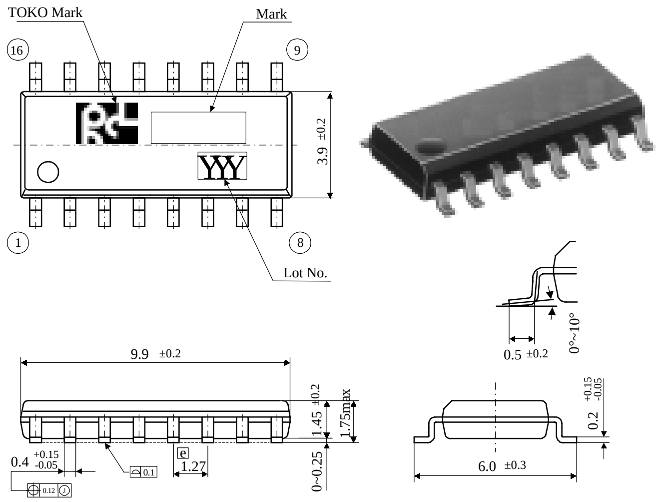
- Wide Operating Voltage Range V_{CC}=2.0~8.0V
- Excellent Limiting Sensitivity 8dBμ@V_{CC}=4.0V
- Excellent SINAD Sensitivity 6dBμ@V_{CC}=4.0V
- RF Input Frequency up to 220MHz
- Wide Mixer Output Dynamic Range:
  Intercept Point IIP3=0dBm(+107dBμ)
- Low Supply Current 2.8mA@V_{CC}=4.0V, squelch off
- Surface Mount Device Package SOP-16
- Low External Component Count

3. APPLICATIONS

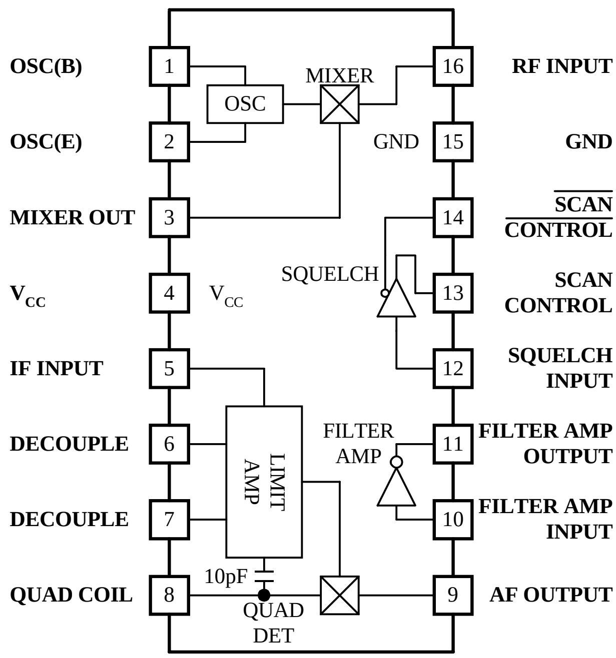
- Amateur Radio Transceivers
- Cordless Phones
- Remote Controls
- Other Communications Equipment

4. PACKAGE OUTLINE

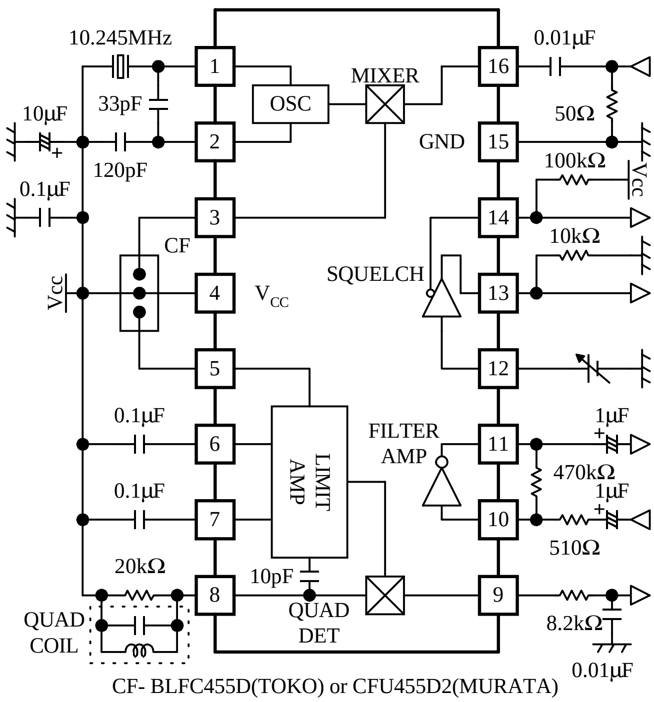
- SOP-16



5. PIN CONFIGURATION/BLOCK DIAGRAM



6. TEST CIRCUIT



CF- BLFC455D(TOKO) or CFU455D2(MURATA)
QUAD COIL- 7MCS-13546Z or 7MC-8128Z(TOKO)

7. ABSOLUTE MAXIMUM RATINGS

T_a=25°C

Parameter	Symbol	Rating	Units	Conditions
Supply Voltage	V_{CC}	10.0	V	
Power Dissipation	P_D	600	mW	*
Storage Temperature Range	T_{stg}	-55 ~ +150	°C	
Operating Temperature Range	T_{OP}	-30 ~ +70	°C	
Input Frequency	f_{MAX}	~ 220	MHz	
Operating Voltage Range	V_{OP}	2.0 ~ 8.0	V	

* P_D must be decreased at rate of 4.8mW/°C for operation at 25°C.

8. ELECTRICAL CHARACTERISTICS

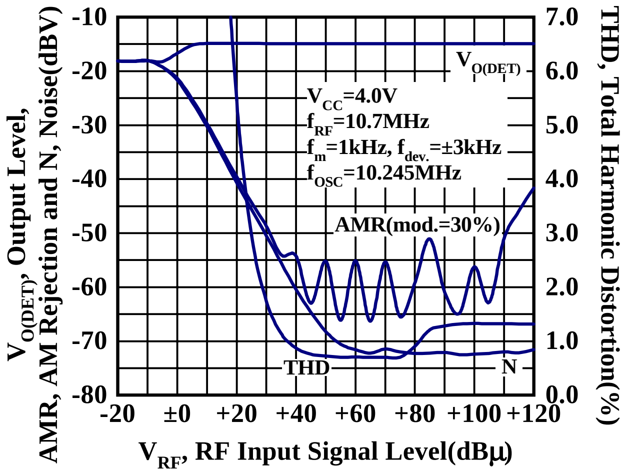
V_{CC}=4.0V, f_{RF}=10.7MHz, V_{RF}=+80dBμ, f_m=1kHz, $f_{dev.}$=±3kHz, f_{OSC}=10.245MHz, T_a=25°C

Parameter	Symbol	Value			Units	Conditions
		MIN	TYP	MAX		
Supply Current 1	I_{CC1}		2.8	3.5	mA	No Signal, squelch "off"
Supply Current 2	I_{CC2}		3.8	4.9	mA	No Signal, squelch "on"
-3dB Limiting Sensitivity	L_{imit}		8	15	dBμ	-3dB point(1kHz)
Output Voltage	V_O	130	170		mVrms	V_{RF}=+80dBμ, $f_{dev.}$=±3kHz
Output Impedance	Z_O		450		Ω	V_{RF}=+80dBμ, $f_{dev.}$=±3kHz
Total Harmonic Distortion	THD		0.86	2.5	%	V_{RF}=+80dBμ, $f_{dev.}$=±3kHz
Mixer Conversion Gain	G_M	21	28		dB	3rd pin(Mixer Output Pin) : terminated.
Mixer Input Resistance	R_{IM}		3.3		kΩ	DC Measurement
Filter Amplifier Gain	G_f	40	50		dB	f_{in}=10kHz, V_{in}=0.3mV
Filter Amplifier Output Terminal Voltage	f_{OC}	0.5	0.7	0.9	V	No Signal
Scan Control High Level	S_H	3.0	3.9		V	Squelch Input V_{SQ}=0.0V
Scan Control Low Level	S_L		0.0	0.4	V	Squelch Input V_{SQ}=2.5V
$\overline{\text{Scan Control}}$ High Level	$\overline{S}_H$	3.0	3.9		V	Squelch Input V_{SQ}=2.5V
$\overline{\text{Scan Control}}$ Low Level	$\overline{S}_L$		0.0	0.4	V	Squelch Input V_{SQ}=0.0V
Squelch Hysteresis	H_{YS}		45	100	mV	

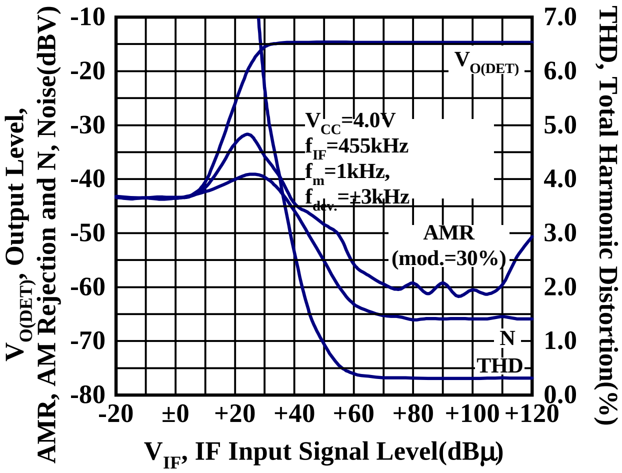
9. TYPICAL CHARACTERISTICS

9-1. Mixer + IF Section

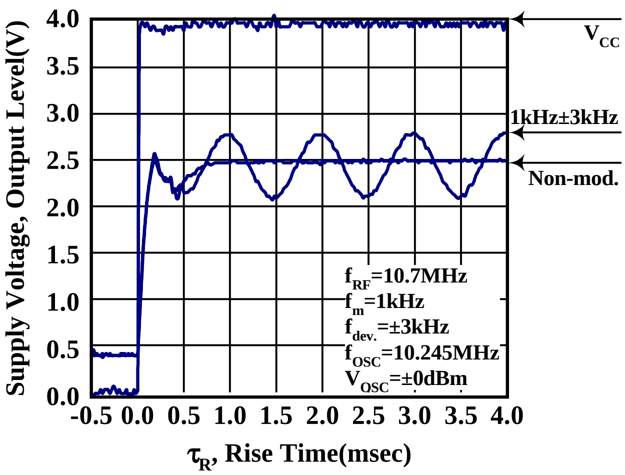
■ $V_{O(DET)}$, AMR, N, THD versus RF Input(f_{IF}=10.7MHz)



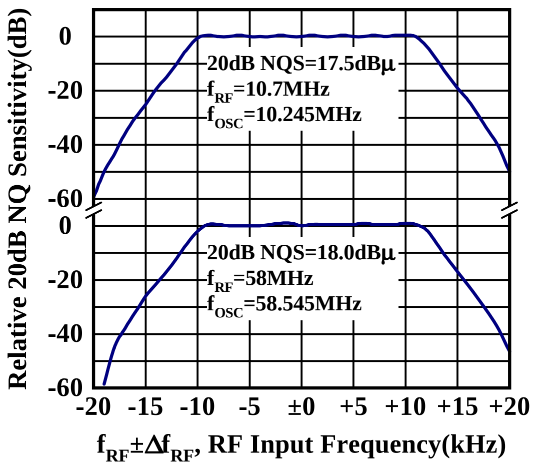
■ $V_{O(DET)}$, AMR, N, THD versus RF Input(f_{IF}=455kHz)



■ Transient Characteristics

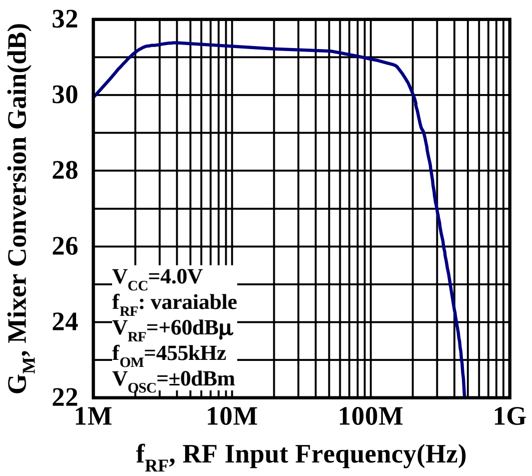


■ 20dB NQ Sensitivity versus RF Input Frequency

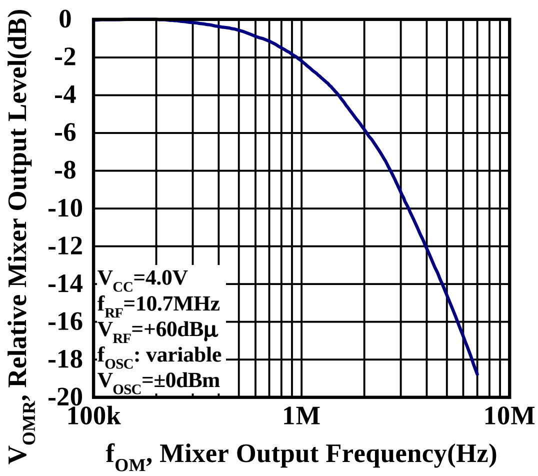


9-2. Mixer Section

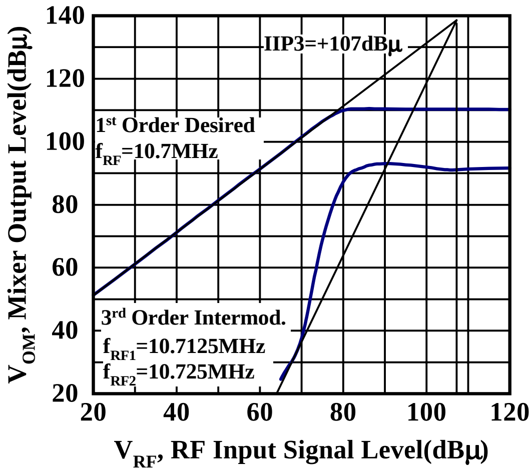
■ Mixer Input Frequency Response



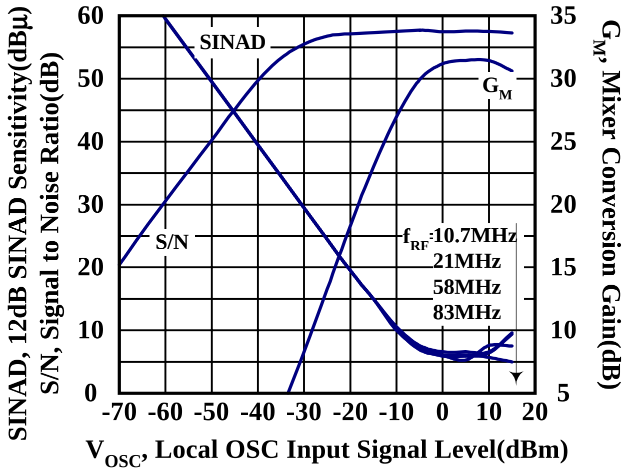
■ Mixer Output Frequency Response



■ The 3rd Intercept Point

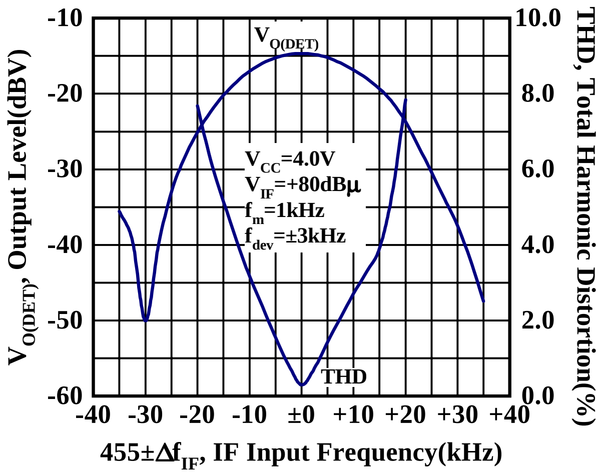


■ SINAD, G_M, S/N versus Local OSC Input

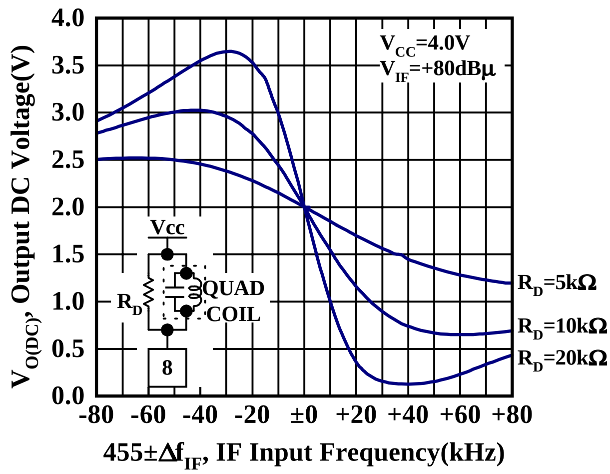


9-3. IF Section

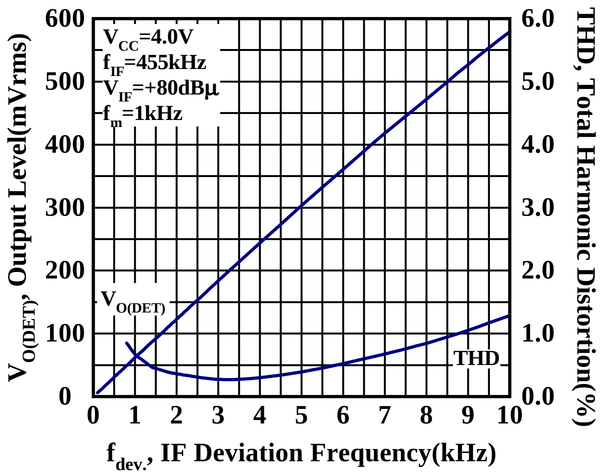
■ Output Level, Total Harmonic Distortion versus IF Input Frequency



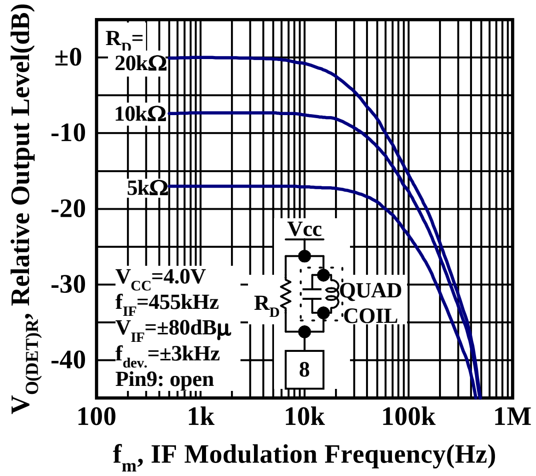
■ Output DC Voltage versus IF Input Frequency



■ Output Level, Total Harmonic Distortion versus IF Deviation Frequency

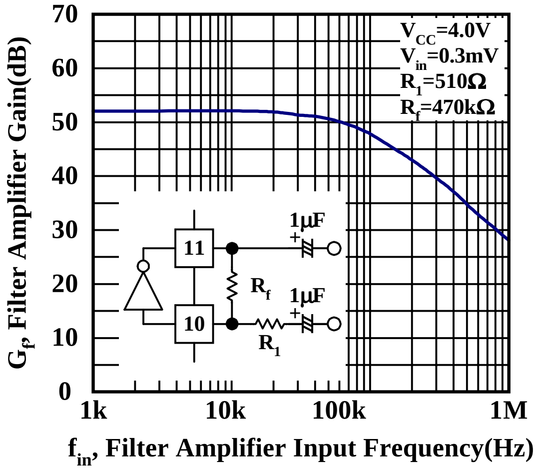


■ Output Level versus IF Modulation Frequency

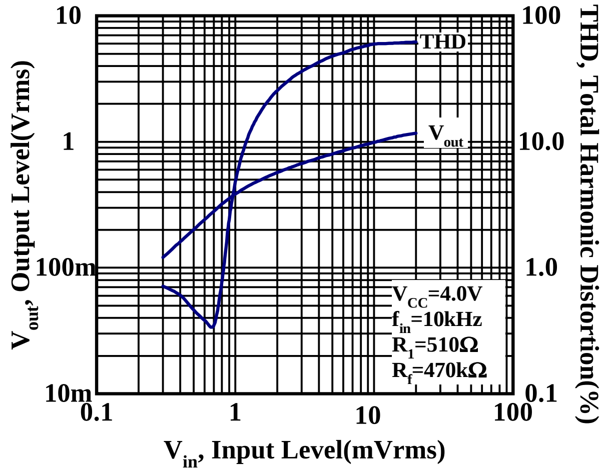


9-4. Filter Amplifier Section

■ Filter Amplifier Gain versus Input Frequency

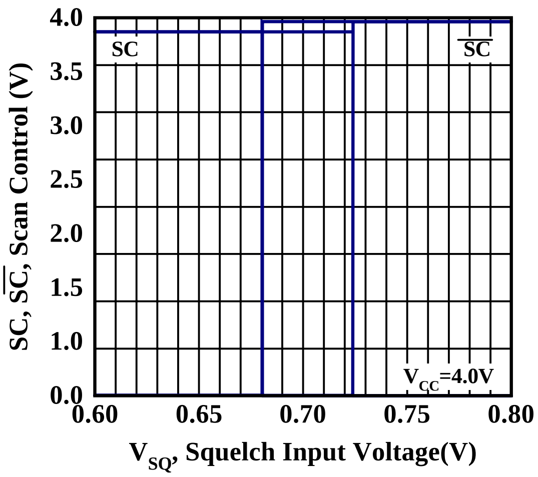


■ Filter Amplifier Input Response



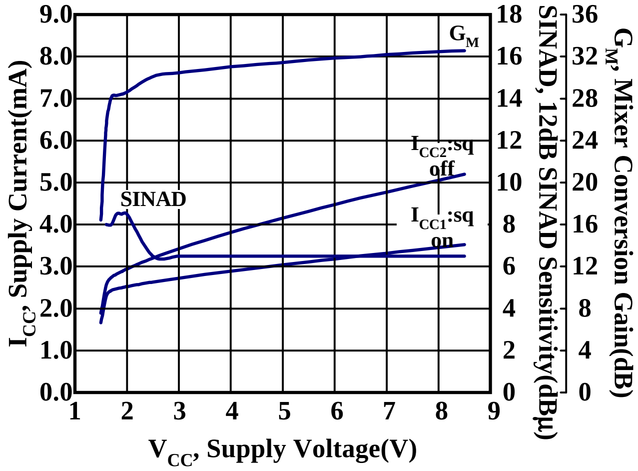
9-5. Squelch Section

■ Scan Control, $\overline{\text{Scan Control}}$ versus Squelch Input

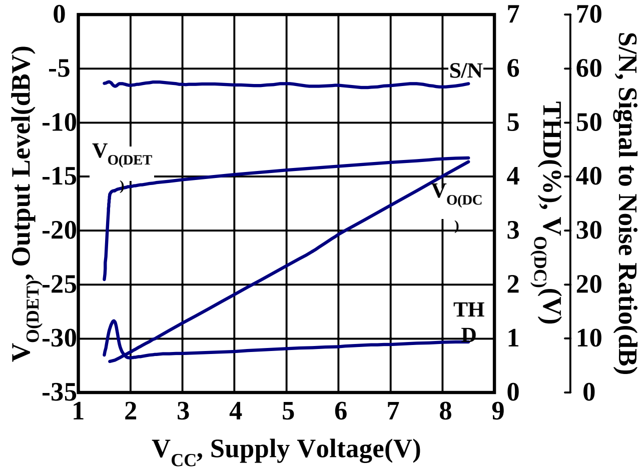


9-6. Versus Supply Voltage Characteristics

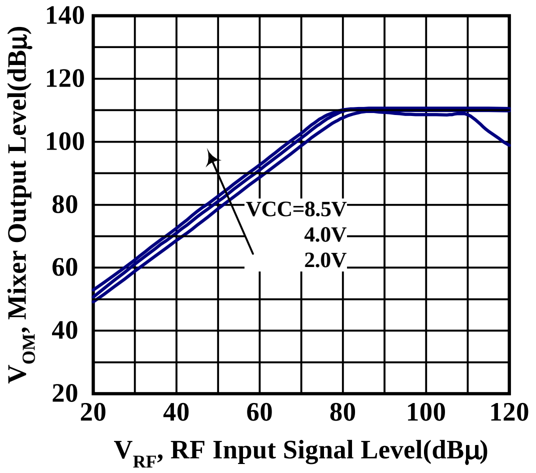
■ Supply Current, 12dB SINAD Sensitivity, Mixer Conversion Gain versus Supply Voltage



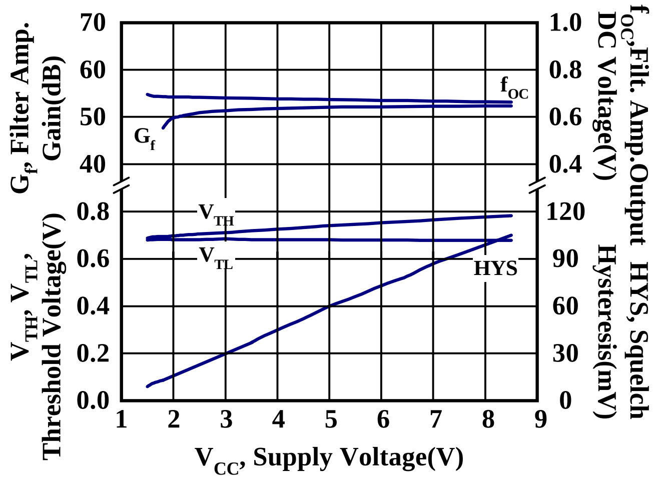
■ Output Level, Total Harmonic Distortion, Signal to Noise Ratio, Output DC Voltage versus Supply Voltage



■ Mixer Output Level versus Supply Voltage

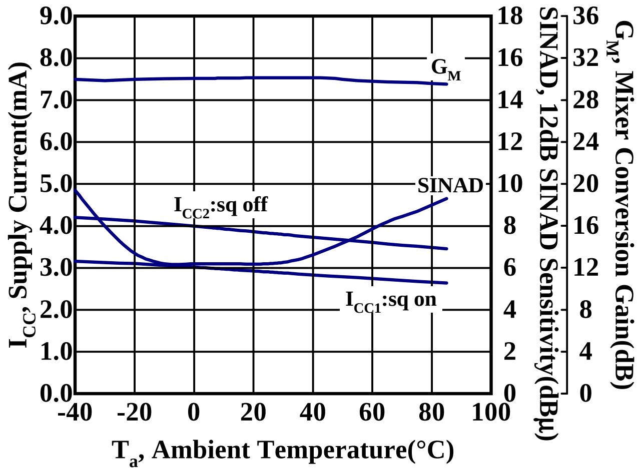


■ Filt. Amp. Gain, Output DC Voltage, Squelch Threshold Voltage, Hysteresis versus Supply Voltage

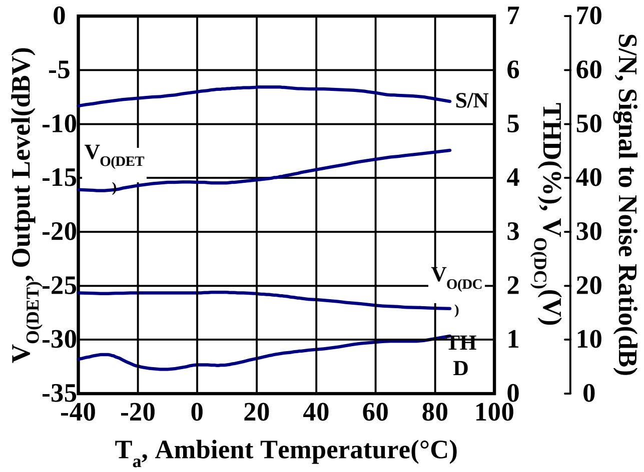


9-7. Versus Ambient Temperature Characteristics

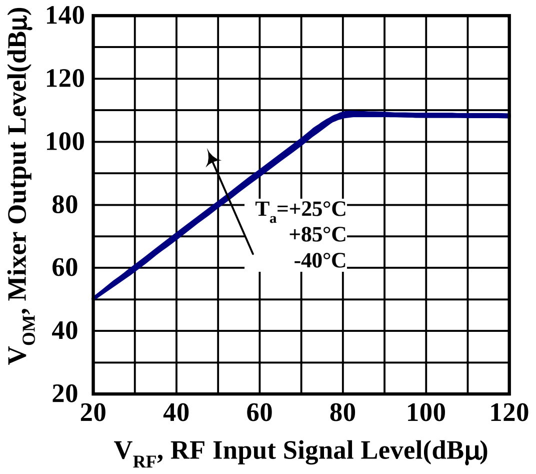
■ Supply Current, 12dB SINAD Sensitivity, Mixer Conversion Gain versus Ambient Temperature



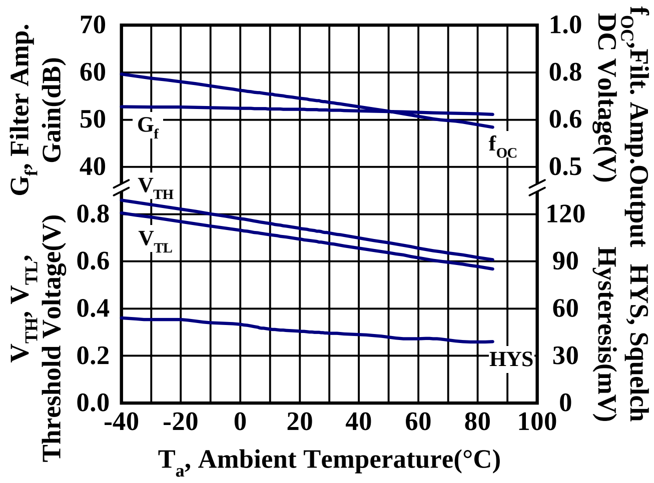
■ Output Level, Total Harmonic Distortion, Signal to Noise Ratio, Output DC Voltage versus Supply Voltage



■ Mixer Output versus Ambient Temperature

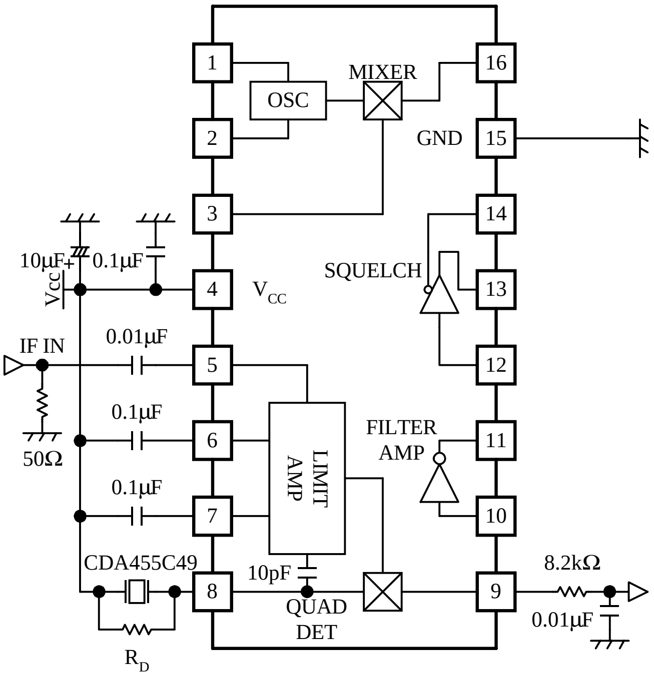


■ Filt. Amp. Gain, Output DC Voltage, Squelch Threshold Voltage, Hysteresis versus Ambient Temp.



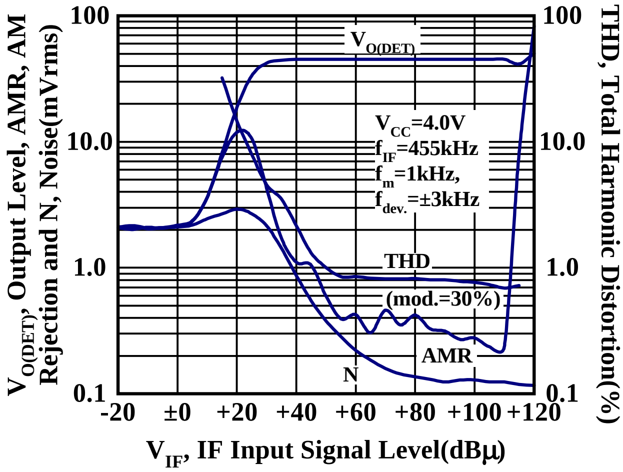
9-8. Characteristic Using Ceramic Discriminator

Figure 1: Test Circuit

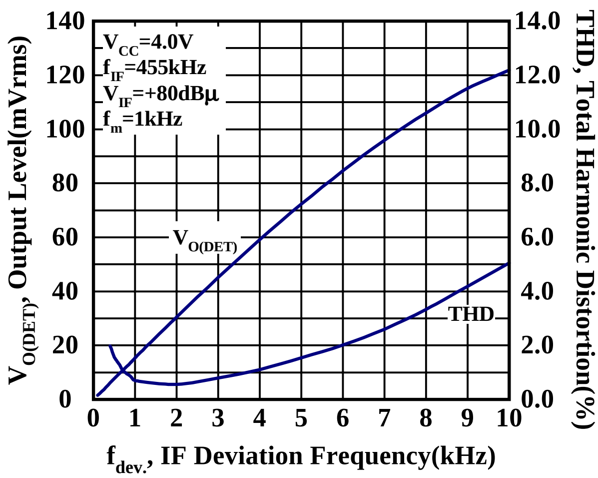


* CDA455C49: TOKO

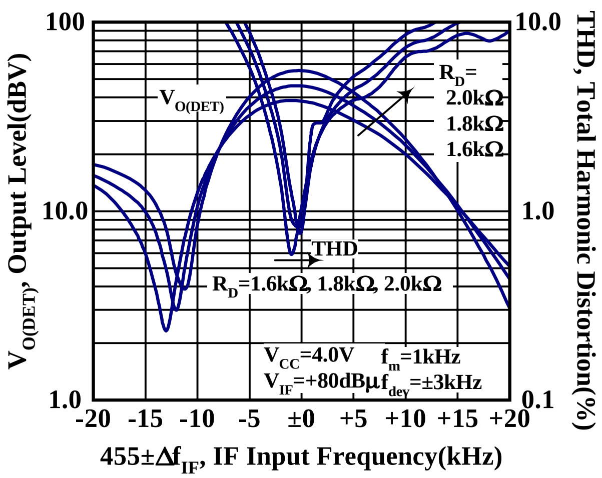
■ VO(DET), AMR, N, THD versus IF Input



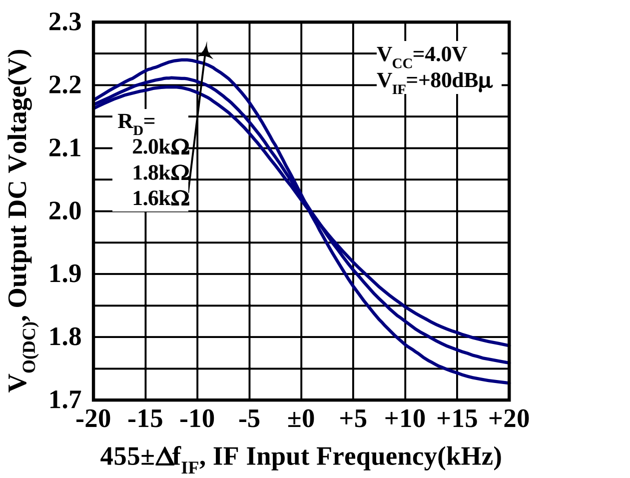
■ Output Level versus IF Deviation Frequency



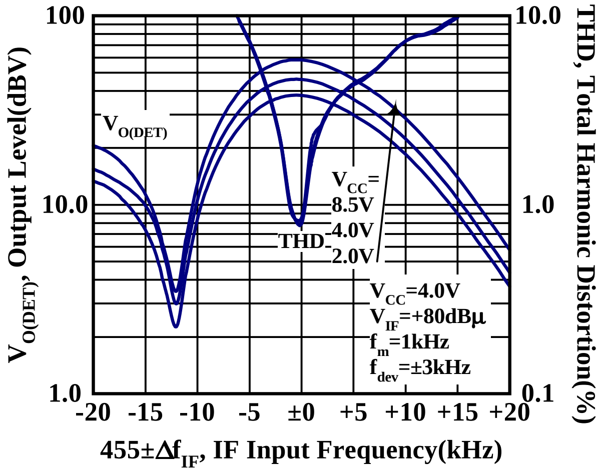
■ Output Level, Total Harmonic Distortion versus IF Input Frequency(variables: Damping Resistor R_D)



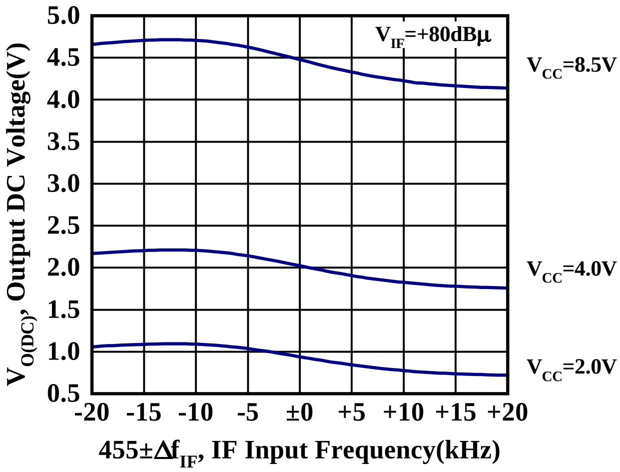
■ Output DC Voltage versus IF Input Frequency (variables: Damping Resistor R_D)



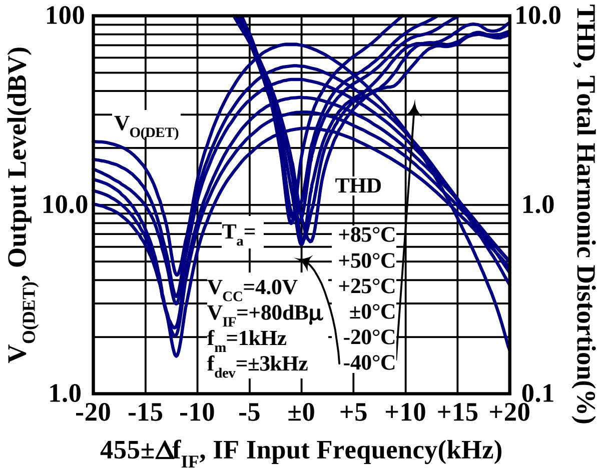
■ Output Level, Total Harmonic Distortion versus IF Input Frequency (variables: V_{CC})



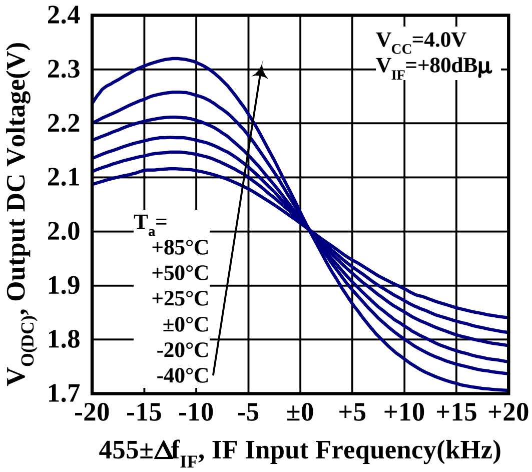
■ Output DC Voltage versus IF Input Frequency (variables: V_{CC})



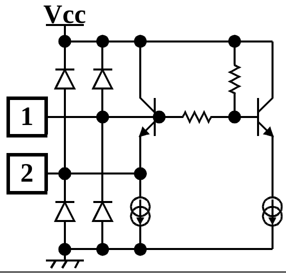
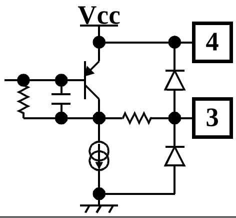
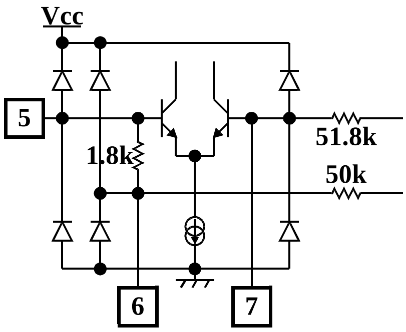
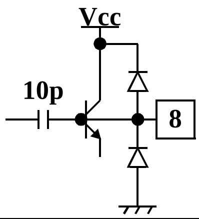
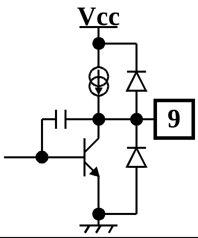
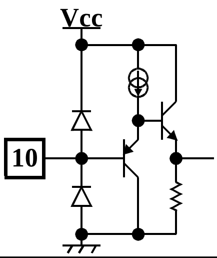
■ Output Level, Total Harmonic Distortion versus IF Input Frequency(variables: T_a)

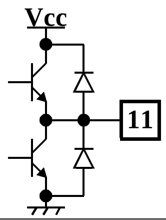
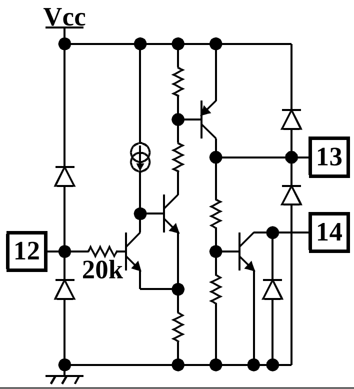
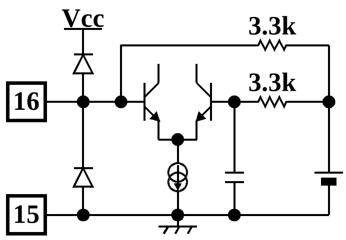


■ Output DC Voltage versus IF Input Frequency (variables: T_a)



10. PIN DESCRIPTION

Pin No,	Pin Description	Internal Equivalent Circuit	Description
1	OSC(B)		■ The base of the Colpitts oscillator. ■ The Colpitts oscillator is composed of Pin 1 and Pin 2.
2	OSC(E)		■ The emitter of the Colpitts oscillator. ■ Using an external OSC source, local level must be injected into Pin 1, and Pin 2 must be opened.
3	MIXER OUT		■ Output of the Mixer.
4	V_{CC}		■ Supply Voltage.
5	IF INPUT		■ Input to the IF limiter amplifier. ■ This pin is terminated by internal 1.8kΩ resistor.
6	DECOUPLE		■ IF Decoupling.
7	DECOUPLE		■ IF Decoupling.
8	QUAD COIL		■ Phase Shifter.
9	AF OUTPUT		■ Recovered Audio Output.
10	FILTER AMPLIFIER INPUT		■ Filter Amplifier Input.

Pin No,	Pin Description	Internal Equivalent Circuit	Description
11	FILTER AMPLIFIER OUTPUT		■ Filter Amplifier Output.
12 13 14	SQUELCH INPUT SCAN CONTROL SCAN CONTOROL		■ Squelch Input. ■ Scan Control. ■ Scan Control .
15	GND		■ Ground.
16	RF INPUT		■ Mixer Input.

11. TEST BOARD

Figure 2: Solder Side View(Circuit Side View)

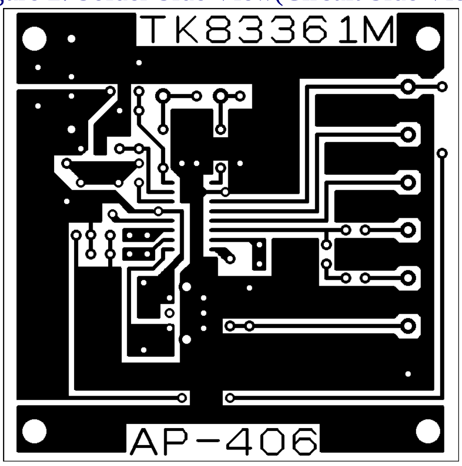
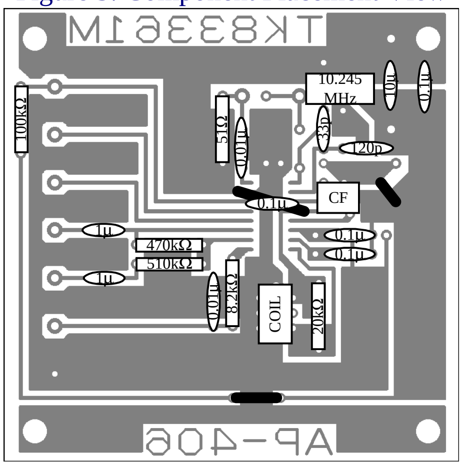


Figure 3: Component Placement View



NOTES:
1. Above test board is laid out for the TEST CIRCUIT (page 2).
2. Scale 1:1 (60mm×60mm)
3. 10.245MHz Fundamental mode crystal, about 30pF load.
4. 455kHz CF, TOKO Type BLFC455D or MURATA Type CFU455D2 or equivalent.
5. COIL, TOKO Type 7MCS-13546Z or 7MC-8128Z or equivalent.

12. APPLICATIONS INFORMATION

12-1. Mixer Section

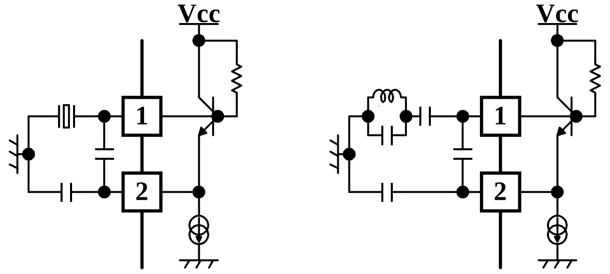
The mixer consists of a Gilbert cell and a local oscillator. The mixer conversion gain, when Pin 4 is terminated, is 28dB.
The RF input is unbalanced.

12-1-1. A Local OSC

The oscillator included is a general Colpitts type OSC. The drive current of OSC is 200µA. Examples of components are shown in Fig. 4. The examples are explained in the next paragraph.

Figure 4: Oscillator Components

i) Under Crystal Control ii) Parallel LC Components



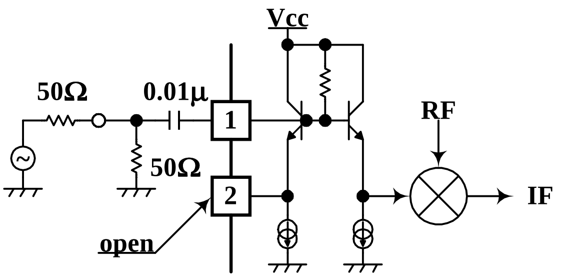
(1) Using an External Oscillator Source

The circuit composition using an external oscillator source is shown in Fig. 5. When using an external oscillator source instead of the internal oscillator, the local level must be injected into Pin 1 by capacitor couppling.

In this case, Pin 2 must be open.

The local oscillator operates as an emitter follower for a multiplier by opening Pin 2 and injecting into Pin 1.

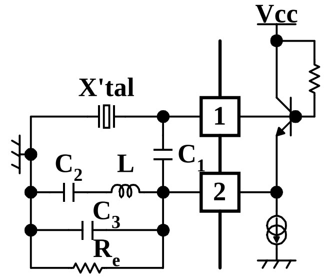
Figure 5: External Injection



(2) For 3rd Overtone mode

In general, a crystal oscillator can oscillate in the fundamental mode and overtone mode. For example, it is easy for a 30MHz-overtone crystal to oscillate at 10MHz, fundamental mode. The reason is because the impedance of the fundamental mode is the same as the impedance of the overtone. Therefore, it is necessary for the circuit to select the overtone frequency by using a tuning coil. How to oscillate a general 3rd overtone oscillator is explained. In the case of an overtone mode of 30MHz and higher, using a crystal oscillator, we recommend the circuit in Fig. 6 to suppress the fundamental mode oscillation.

Figure 6:Overtone Mode Circuit

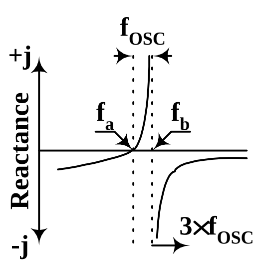


The following explains how to decide the circuit constants of the overtone-crystal-oscillation fundamental circuit. As the operating frequency increases the oscillation amplitude decreases because of a shortage of g_m of the oscillator. It is easy to increase the drive current by connecting resistor R_e between Pin 2 and GND. Being short of drive current, it makes g_m increase to increase the drive current by connecting external resistor R_e . In that case, the amount of drive current increase, I_e, is shown in Eq.(1).

$$I_e = \frac{V_{CC} - V_{BE}}{R_e} = \frac{V_{CC} - 0.7}{R_e} \qquad (1)$$

In order to oscillate at the 3 rd overtone frequency, the values of C_2, C_3 and L (Fig. 6) are selected. Fig. 7 shows a 2-port impedance response of the C_2~C_3~L loop network. Regarding the condition of oscillation, the impedance characteristic is capacitive at the vacinity of the overtone frequency. It is reactive at the vicinity of the fundamental frequency.
The condition of oscillation is as follows:
f_{OSC} is between f_a and f_b ,
$3\times f_{OSC}$ is f_b and higher. Please see Fig. 7

Fig 7: 2-port Impedance Response of Resonance Network



Where,
f_a: series resonant freq.
f_b: parallel resonant freq.
f_{OSC}: fundamental mode freq.
$3\times f_{OSC}$: 3rd order overtone freq.

Equations of 3rd overtone oscillation are shown below.

$$f_a = \frac{1}{2\pi\sqrt{L \times C_2}}, \quad f_b = f_a\sqrt{1+\frac{C_2}{C_3}} \qquad (2)$$

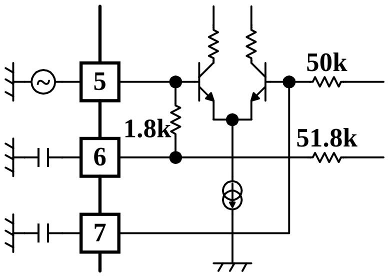
The series value of the equivalent capacitance at the 3rd order overtone freq. of this network, which is decided in the above -mentioned, and the capacitance of C_1 must be equal to load capacitance C_L . Being short of negative resistance of the circuit, increase the transistor's bias current by decreasing R_e . It is able to decide the OSC level for minute adjusting R_e. Please refer the most suitable OSC level range to 12dB SINAD sensitivity versus local OSC input signal level in TYPICAL CHA-RA CTERISTICS. The saturating range is the most suitable OSC level range. It is comparatively easy to decide the circuit constant by examining it with a network analyzer.

12-2. IF Section

The IF section includes a 6 stage differential amplifier. The fixed internal input matching resistor is 1.8k Ω.The total gain of the limiting amplifier section is approximately 77dB.

The decoupling capacitors of Pin 6~7 must be connected as near as possible to the GND pin of the IC . And, make the impedance of the connecting-to-GND line to be as small as possible. If the impedance is not small enough, the sensitivities may worsen.

Figure 8: IF Limiter Amplifier Input Block



12-3. FM Demodulator

A quadrature FM demodulator using a Gilbert cell is included.

12-3-1. Internal Equivalent Circuit of Demodulator

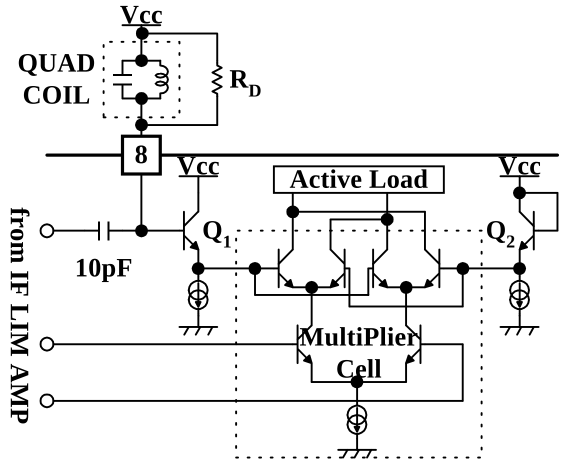
The internal equivalent circuit is shown in Fig. 9.

<u>**Note at this point to add the bias voltage at Pin 8 from external source.**</u>

The signal from the phase shifter is put into the multiplier cell through the emitter follower of transistor Q_1. Pin 8 is single-connected with the base terminal. And, it is necessary for Pin 8 to add the same voltage, as the base terminal of Q_2 of the opposite side of Q_1 through the multiplier is connected with the supply voltage.

If the base voltages differ between transistors Q_1 and Q_2 , it alters the DC zero point or worsens the distortion of the demodulation output.

Figure 9: Internal Equivalent Circuit of Demodulator



12-3-2. Phase Shifter

The IF signal from the limiter amplifier is provided with 90° phase shift and drives the quadrature detector.

The parallel RCL resonance circuit is capable of using the internal 10pF phase shift capacitor.

12-3-3. Audio Output

After quadrature detection, the audio signal is pulled out through Pin 9.

The required signal is pulled out through the LPF.

12-3-4. For Stable Operation

To prevent worsening the distortion, observe the following notes:

(1) Demodulated Output Voltage (Pin 9)

Too large of a demodulated output voltage will worsen the distortion due to the dynamic range of the demodulator.

(2) The Signal Level in Phase Shifter (Pin 8)

If the phase shifter signal level is too small, the noise level grows worse. This will cause the distortion to grow worse.

(3) Band Width of Phase Shifter (Pin 8)

If the bandwidth of the phase shifter is narrower than IF bandwidth, including the demodulated element, the distortion will grow worse.

12-4. Filter Amplifier Section

An inverting op amp has an output at Pin 11 and the inverting input at Pin 10. The op amp, which has a wide stable operating temperature range, may be used as an active noise filter.

12-4-1. Active BPF Application

An active BPF application is shown in Fig. 10, and its Response is shown in Fig. 11.

Figure 10: Active BPF

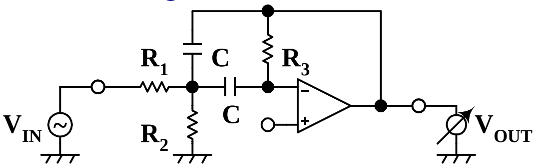
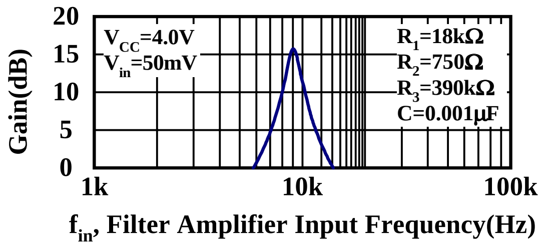


Figure 11: Frequency Response



Eq.(3) is formularized, where G_0 is the gain at center frequency f_0, and 3dB bandwidth $Q=f_0/BW$.

$$R_1=\frac{R_3}{2G_0},\quad R_2=\frac{R_1R_3}{4Q^2R_1-R_3},\quad R_3=\frac{Q}{\pi f_0 C} \qquad (3)$$

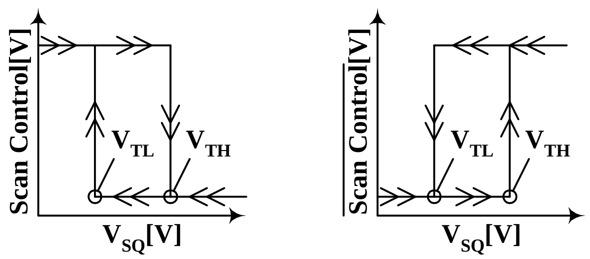
12-5. Squelch Section

The output, which is controlled in accordance with the noise level from the rectifier, is injected into the squelch-input pin. There is about 45mV of hysteresis at the Squelch Input to prevent jitter.

V_{TH} indicates the Hi threshold voltage, V_{TL} indicates the Lo threshold voltage in Fig. 12.

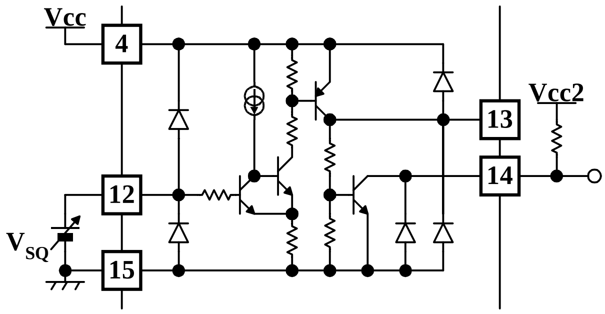
Figure 12: Squelch Output versus Squelch Input

i) Pin 13 Output ii) Pin 14 Output



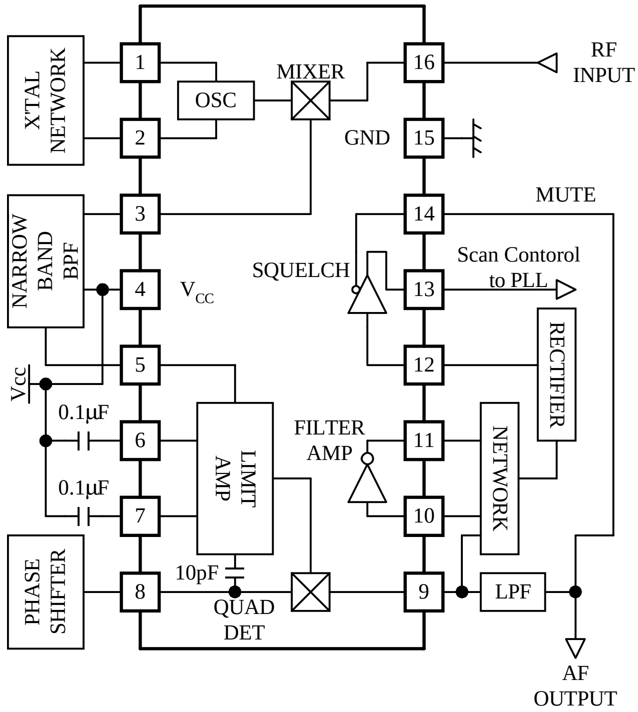
As Fig. 13 shows, $\overline{\text{Scan Control}}$ (Pin 14) is "open collector". So this pin operates normally if this is pulled up the voltage which is over supply voltage but it's under the maximum voltage.

Figure 13: Squelch



12-6. Application Example

Figure 14: Application Example Block Diagram



12-7. Attentions to Layout Design

As this product is considered for stable operation, the mixer block and the other block that includes IF stage, OP amp and squelch are independent from each other. However in order to realize stable operation, please pay attention to the following, because of high frequency operation.

(1) Bypass Capacitor

A bypass capacitor must be connected with minimum distance between the V_{CC} pin and the GND pin.

(2)V_{CC}/GND Pattern

In order to make low impedance V_{CC}/GND lines, please keep the pattern as wide as possible.

(3) Pattern near Demodulator

Pattern layout around the phase shifter for demodulator: please keep as short as possible.

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