APPLICATION MANUAL

Narrow Band FM IF
TK14489V

CONTENTS

MEETING YOUR NEEDS

TOKO, Inc.

Narrow Band FM IF
TK14489V

1. DESCRIPTION

The TK14489V for use in FM dual conversion communications equipment. This device includes a local oscillator, mixer, IF limiting amplifier, quadrature detector, filter amplifier, squelch.

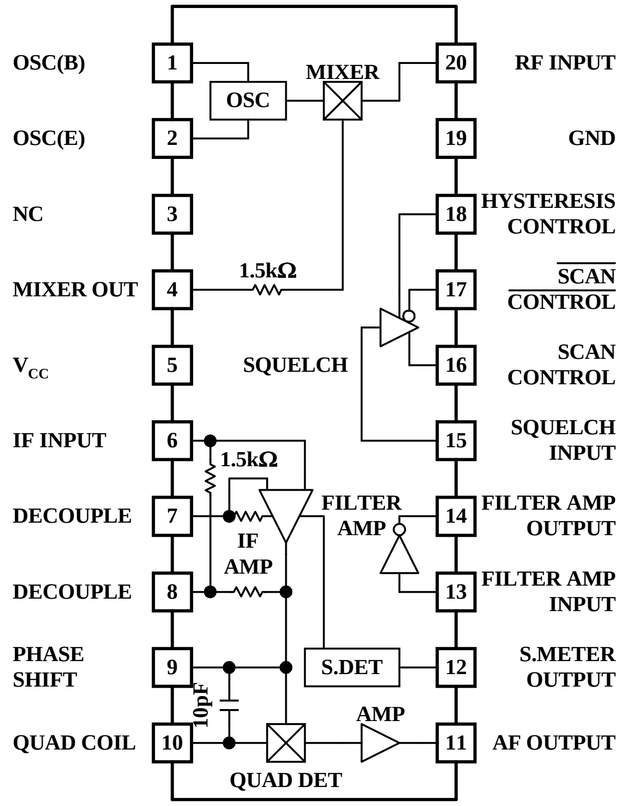
2. FEATURES

- ■ Low supply current 3.2mA typical @ V_{CC} =5.0V.
- ■ Wide V_{OP} range: operates from 2.5 to 8.5V Supply.
- ■ Excellent sensitivity: -3dB limiting sensitivity=6dBμ typical @ V_{CC} =5.0V.
- ■ Excellent Sensitivity: 12dB SINAD=8dBμ typical @ V_{CC}=5.0V.
- ■ Ceramic discriminator is available.
- ■ RSSI with wide dynamic range and excellent temperature characteristics.
- ■ Very small package TSSOP-20

3. APPLICATIONS

- ■ Amateur radio transceiver
- ■ Cordless phone
- ■ Weather band car tuner
- ■ Remote Controls
- ■ Other Communication Equipment

4. PIN CONFIGURATION/BLOCK DIAGRAM



5. ABSOLUTE MAXIMUM RATINGS

T_a=25°C

Parameter	Symbol	Rating	Units	Conditions
Supply Voltage	V_{CC}	10.0	V	
Power Dissipation	P_D	210	mW	*
Storage Temperature Range	T_{stg}	-55 ~ +150	°C	
Operating Temperature Range	T_{OP}	-40 ~ +85	°C	
Input Frequency	f_{MAX}	~ 130	MHz	
Operating Voltage Range	V_{OP}	2.5 ~ 8.5	V	

* P_D must be decreased at rate of 1.68mW/°C for operation at 25°C.

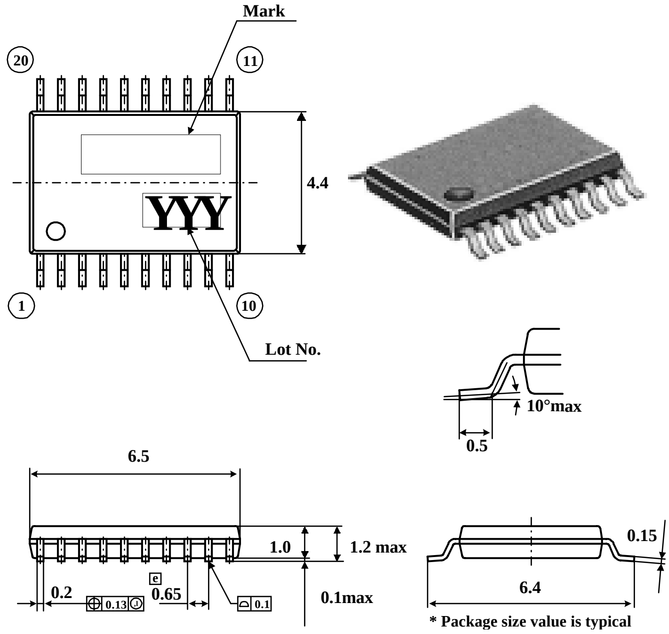
6. ELECTRICAL CHARACTERISTICS

V_{CC}=5.0V, T_a=25°C , f_{RF}=10.7MHz, f_m=1kHz, $f_{dev.}$=±3kHz, f_{LOCAL}=10.245MHz, V_{LO}=-5dBm

Parameter	Symbol	Value			Units	Conditions
		MIN	TYP	MAX		
Supply Current 1	I_{CC1}		3.2	4.8	mA	No signal, squelch "off"
Supply Current 2	I_{CC2}		4.5	6.8	mA	No signal, squelch "on"
-3dB Limiting Sensitivity	L_{imit}		6	12	dBμ	-3dB point
12dB SINAD Sensitivity	SINAD		8	14	dBμ	
Output Voltage	V_O	60	100	160	mVrms	V_{in}=+80dBμ, $f_{dev.}$=±3kHz
Output Impedance	Z_O		800	1500	Ω	V_{in}=+80dBμ, $f_{dev.}$=±3kHz
Total Harmonic Distortion	THD		0.5	2.5	%	V_{in}=+80dBu, $f_{dev.}$=±3kHz
Mixer Section						
Mixer Conversion Gain	G_M	25	31	37	dB	Mixer Output Pin: open
Mixer Input Resistance	R_{IM}	2.4	3.6	4.7	kΩ	DC Measurement
RSSI(S. Meter) Section						
Signal Meter Output 0	S_0	0.00	0.20	0.50	V	No signal, R_S=22kΩ
Signal Meter Output 1	S_1	0.20	0.55	0.85	V	V_{in}=+15dBμ, R_S=22kΩ
Signal Meter Output 2	S_2	0.80	1.15	1.50	V	V_{in}=+35dBμ, R_S=22kΩ
Signal Meter Output 3	S_3	1.40	1.80	2.15	V	V_{in}=+55dBμ, R_S=22kΩ
Signal Meter Output 4	S_4	1.95	2.30	2.70	V	V_{in}=+75dBμ, R_S=22kΩ
Signal Meter Output 5	S_5	2.15	2.50	2.90	V	V_{in}=+95dBμ, R_S=22kΩ
Filter Amplifier Section						
Filter Amplifier Gain	F_C	40	46	52	dB	f_{in}=10kHz, V_{in}=1mV
Filter Amplifier Output Terminal Voltage	F_{DC}	0.50	0.75	0.95	V	No Signal
Squelch Section						
Scan Control High Level	S_H	4.30	4.65	5.00	V	Squelch Input V_{SQ}=0.0V
Scan Control Low Level	S_L	-0.20	0.01	0.50	V	Squelch Input V_{SQ}=2.5V
$\overline{\text{Scan Control}}$ High Level	$\overline{S_H}$	4.30	4.95	5.00	V	Squelch Input V_{SQ}=2.5V
$\overline{\text{Scan Control}}$ Low Level	$\overline{S_L}$	-0.20	0.02	0.50	V	Squelch Input V_{SQ}=0.0V
Squelch Hysteresis	H_{YS}	40	80	180	mV	R_{HYS}=430Ω

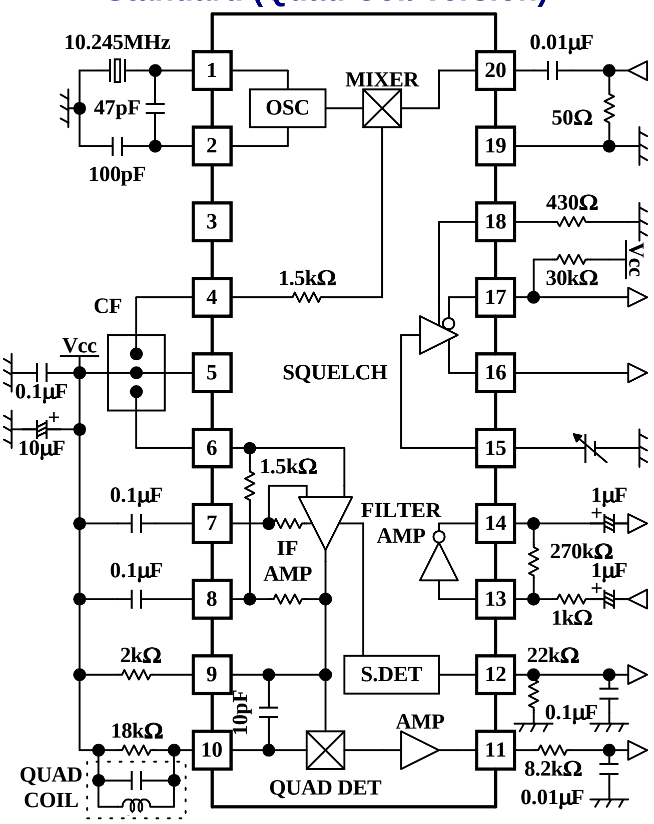
7. PACKAGE OUTLINE

■ TSSOP20



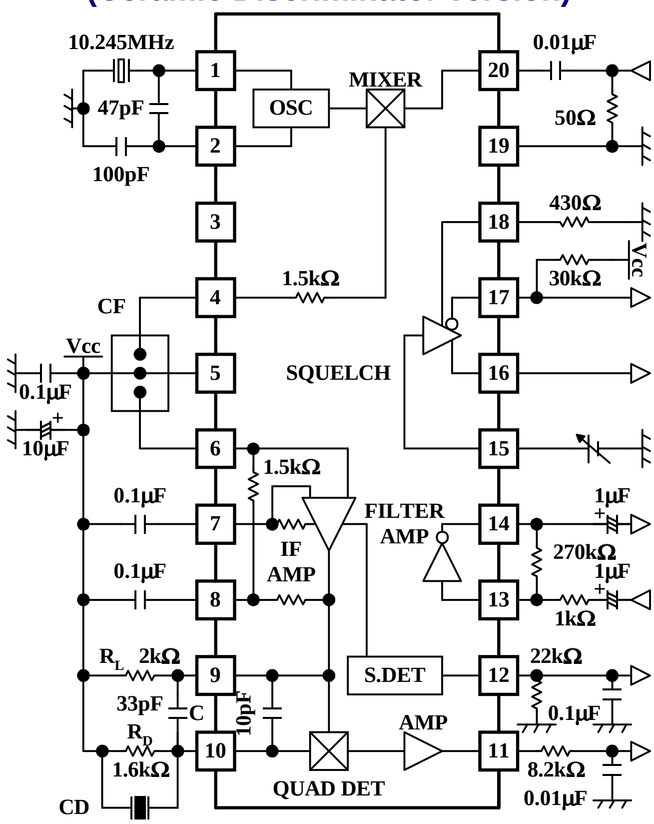
8. TEST CIRCUIT

Standard (Quad Coil version)



CF- BLFC455D(TOKO) or CFU455D2(MURATA) or equivalent
QUAD COIL- 7BRE-7437Z(TOKO) or equivalent

(Ceramic Discriminator version)

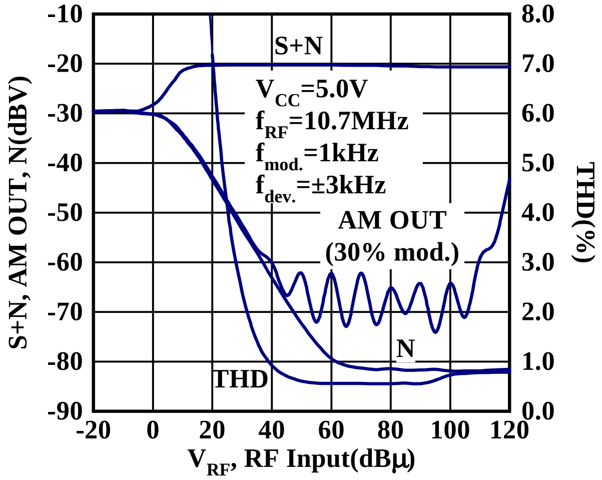


CD- CDA455C27(TOKO) or CDBM455C27(MURATA)

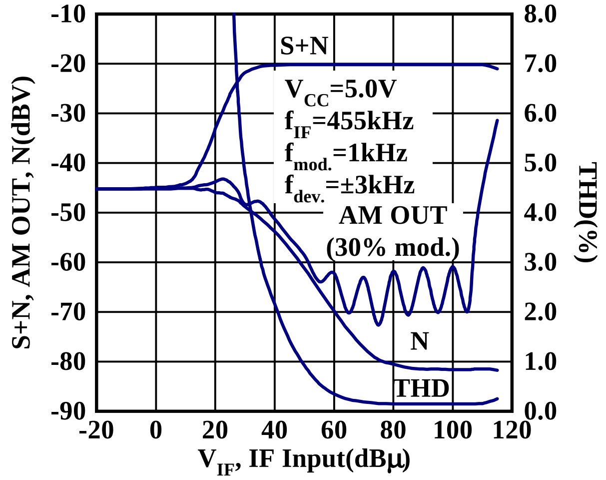
9. TYPICAL CHARACTERISTICS

9-1. Mixer + IF Section

■ $V_{O(DET)}$, AM OUT, N ,THD vs. RF Input(f_{in}=10.7MHz)

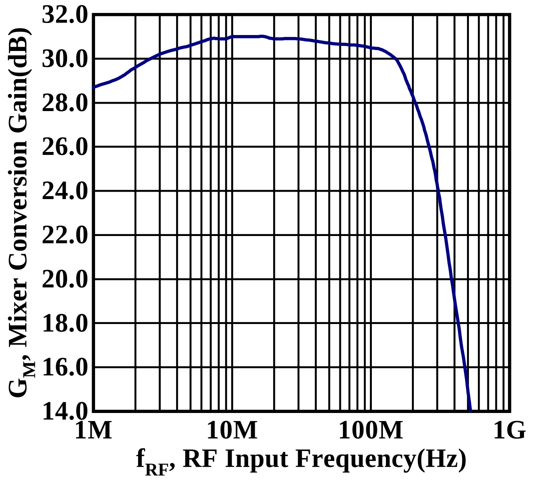


■ $V_{O(DET)}$, AM OUT, N ,THD vs. IF Input(f_{in}=455kHz)

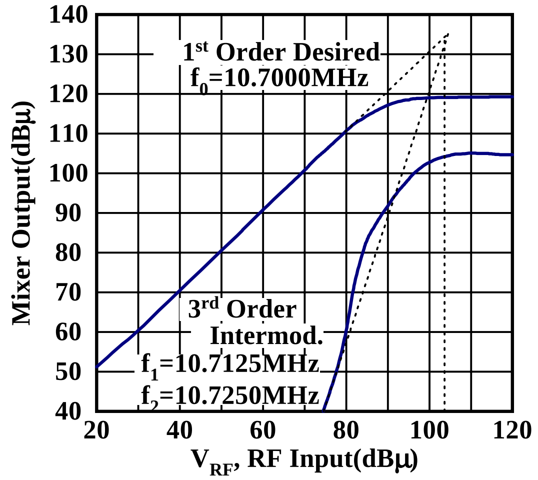


9-2. Mixer Section

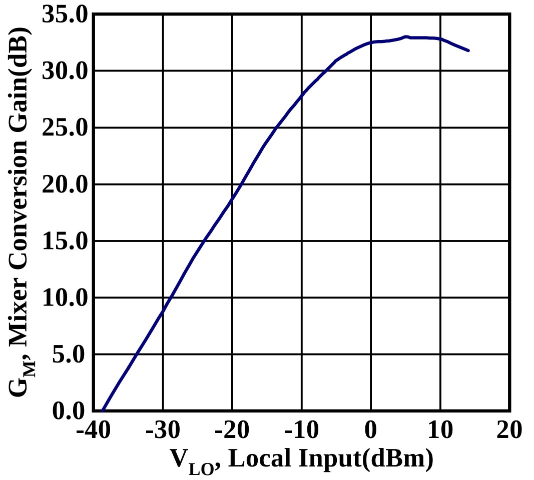
■ Mixer Conversion Gain versus RF Input Frequency



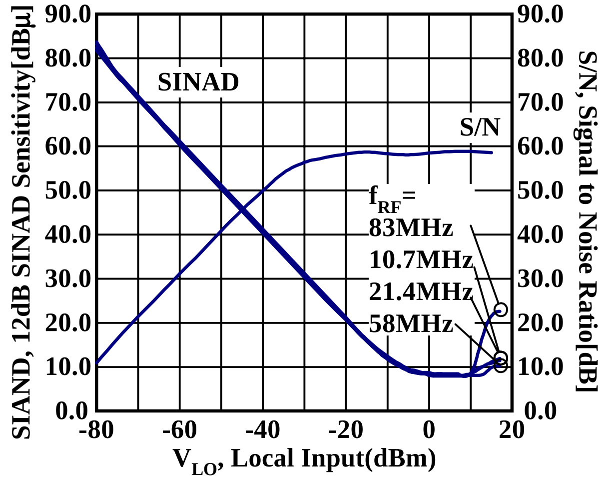
■ The 3rd Intercept Point



■ Mixer Conversion Gain versus Local Input

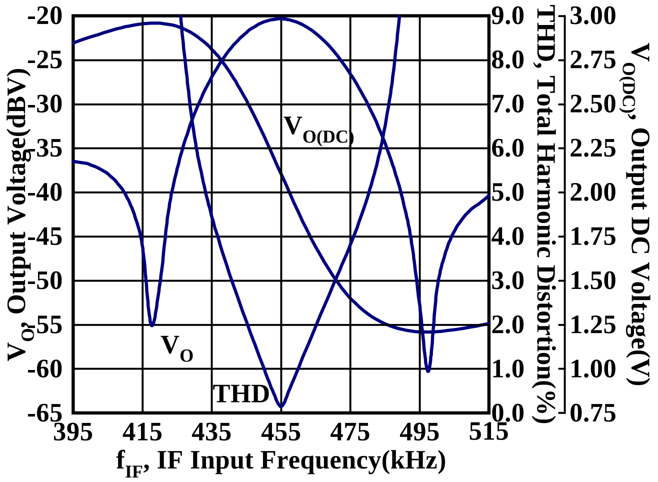


■ 12dB SINAD Sensitivity, Signal to Noise Ratio versus Local Input

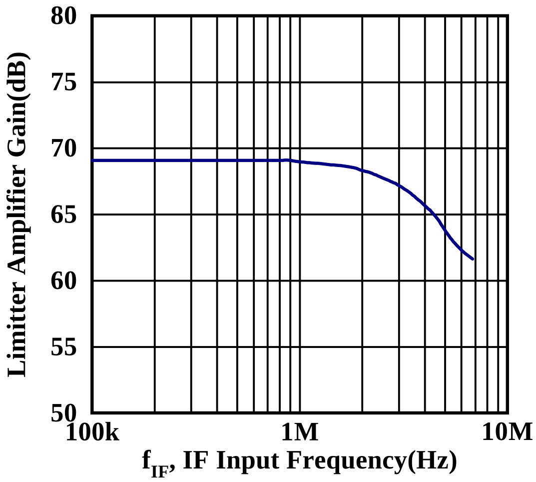


9-3. IF Section

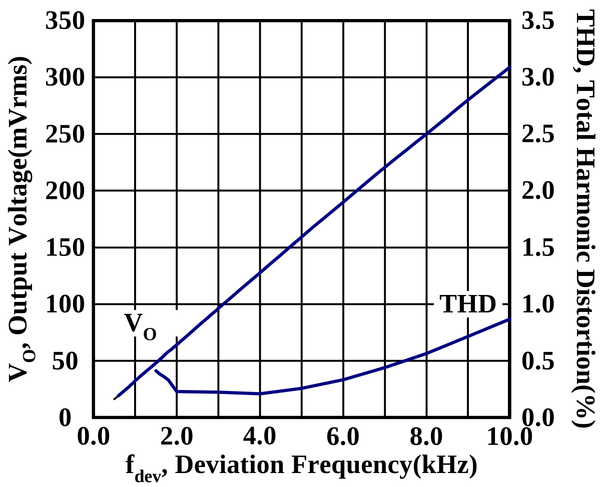
■ Output Voltage, Total Harmonic Distortion, Output DC Voltage versus IF Input Frequency



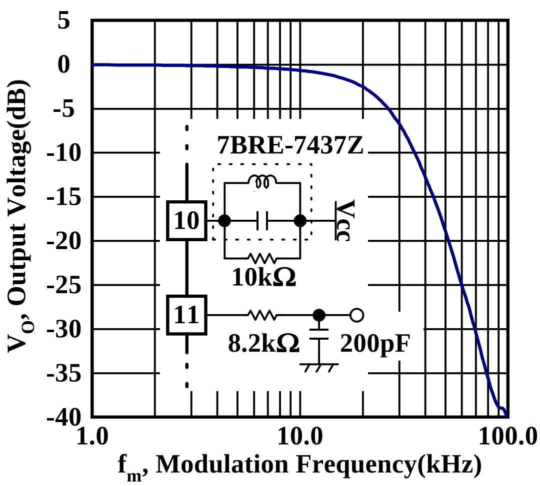
■ Limitter Amplifier Gain Frequency Response



■ Output Voltage, Total Harmonic Distortion versus Deviation Frequency

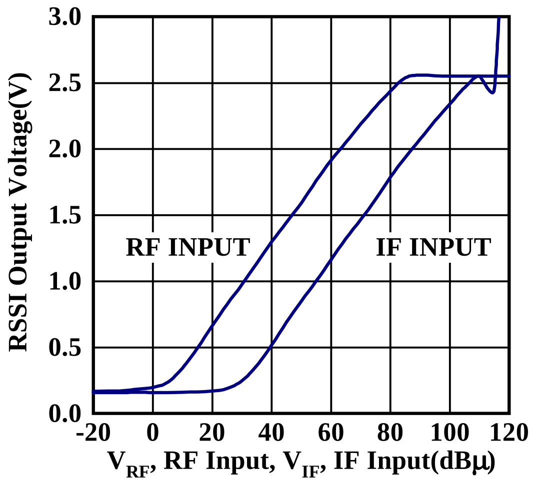


■ Output Voltage versus Modulation Frequency

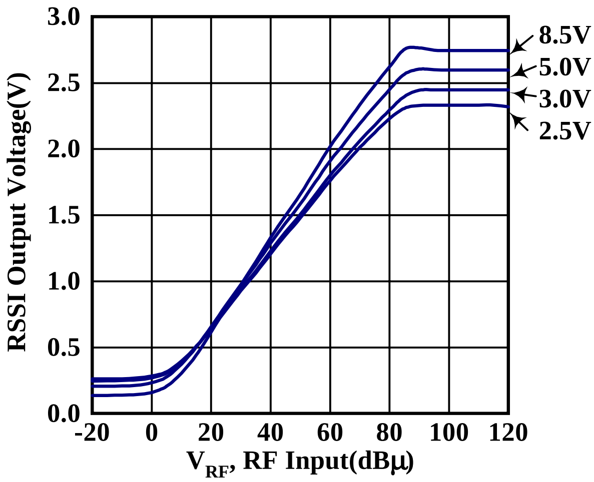


9-4. RSSI Section

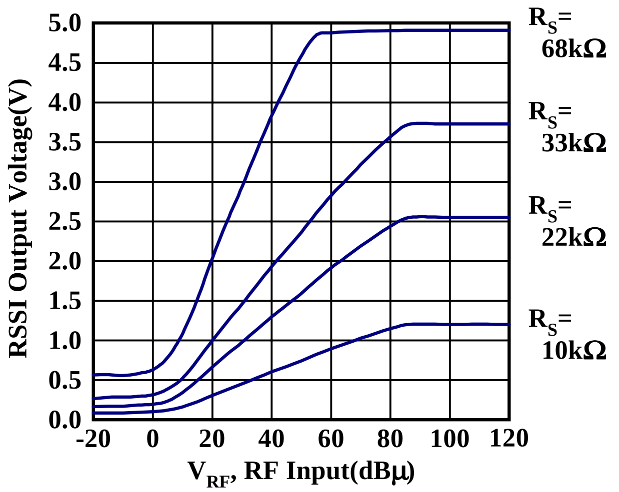
■ RSSI Response



■ RSSI Response(variables: Supply Voltage V_{CC})

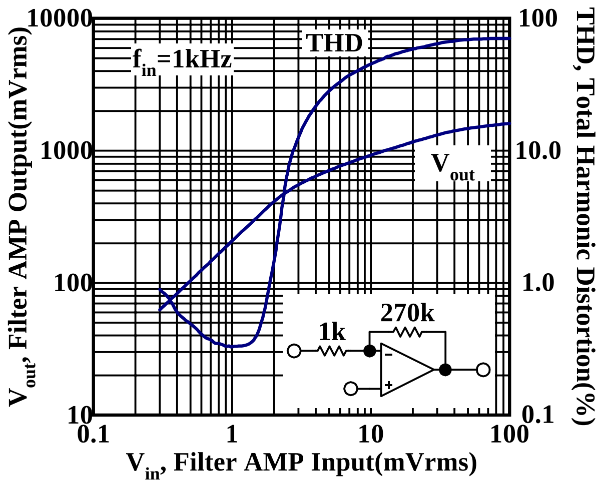


■ RSSI Response(variables: Conversion Resistor R_S)

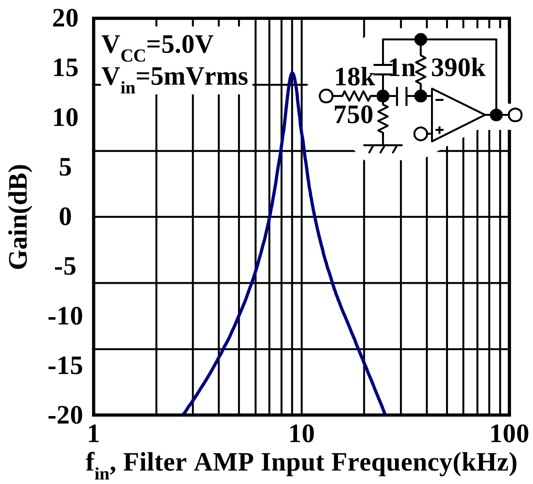


9-5. Filter Amplifier Section

■ Filter Amplifier Response

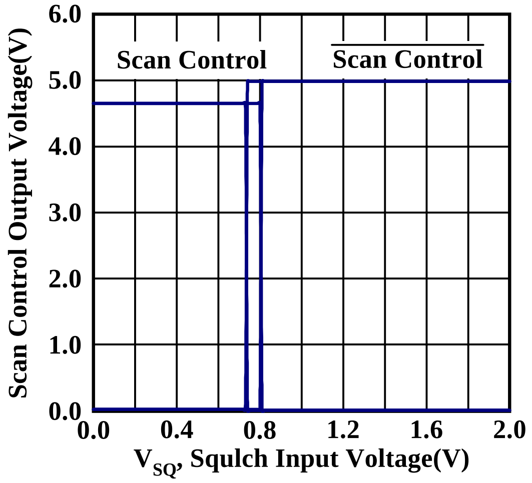


■ BPF

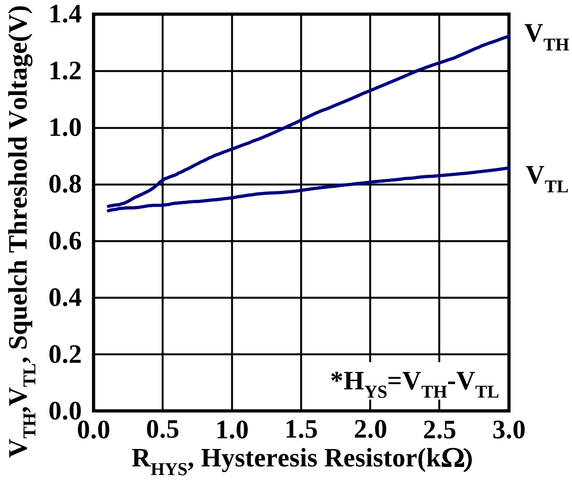


9-6. Squelch Section

■ Scan Control Output Voltage, Inverting Scan Control Output Voltage versus Squelch Input Voltage

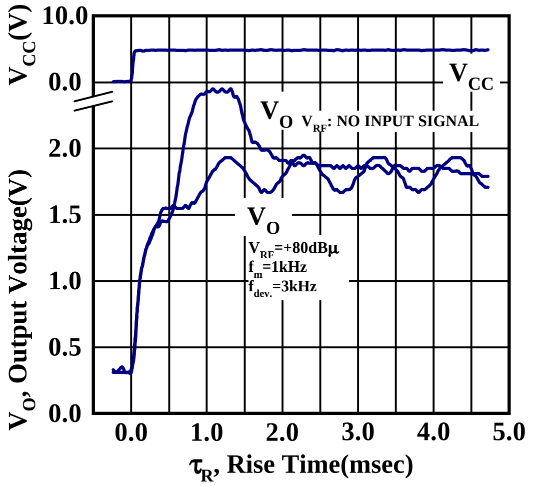


■ Squelch Threshold Voltage versus Squelch Hysteresis Resistor

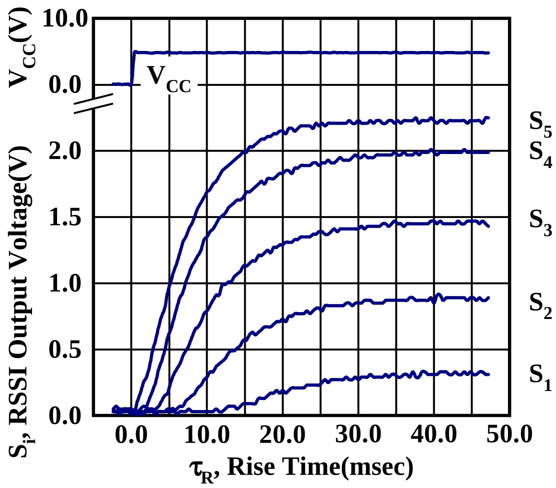


9-7. Transient Characteristics

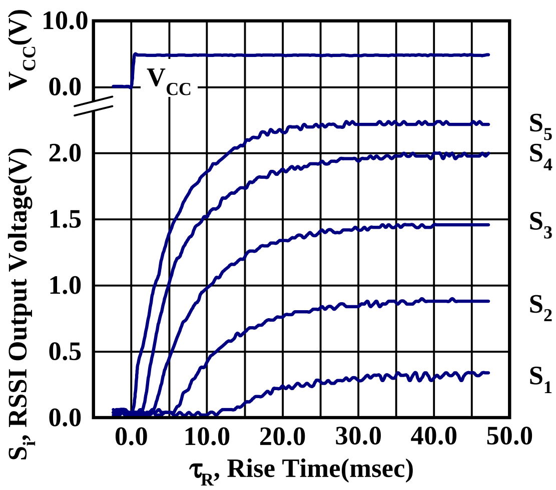
■ Output Voltage Transient Response: Supply Voltage on/off



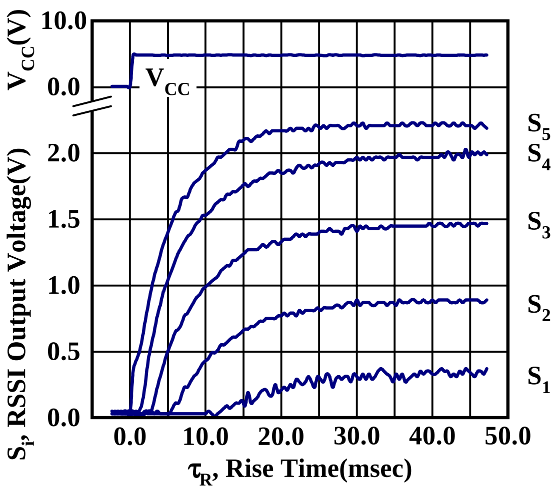
■ RSSI Output Voltage Transient Response: Supply Voltage on/off (Smoothing Capacitor C_S=0.1μF)



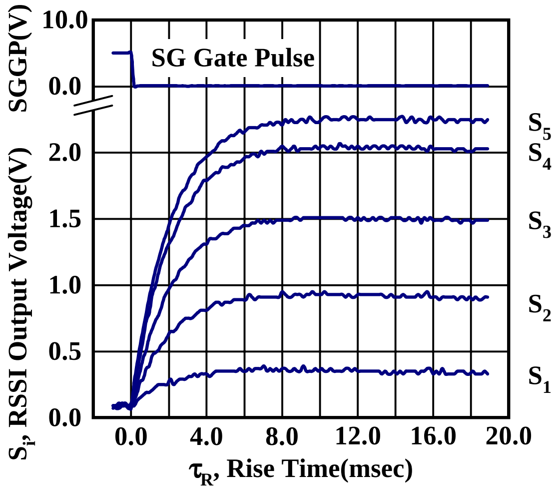
■ RSSI Output Voltage Transient Response: Supply Voltage on/off (Smoothing Capacitor C_S=0.01μF)

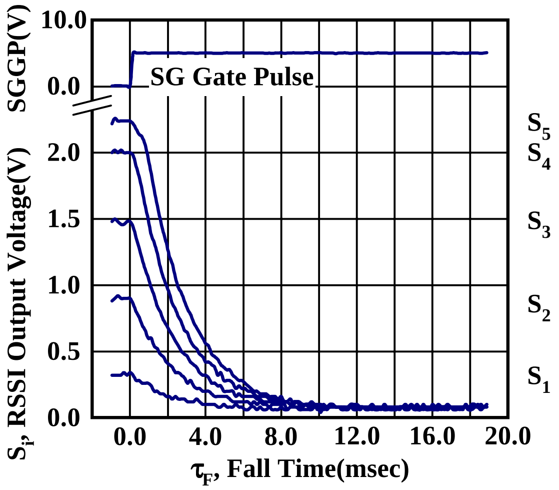


■ RSSI Output Voltage Transient Response: Supply Voltage on/off (Smoothing Capacitor C_S=0.001μF)

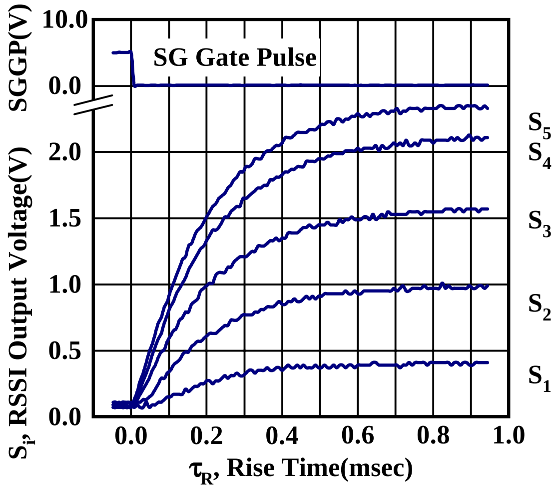


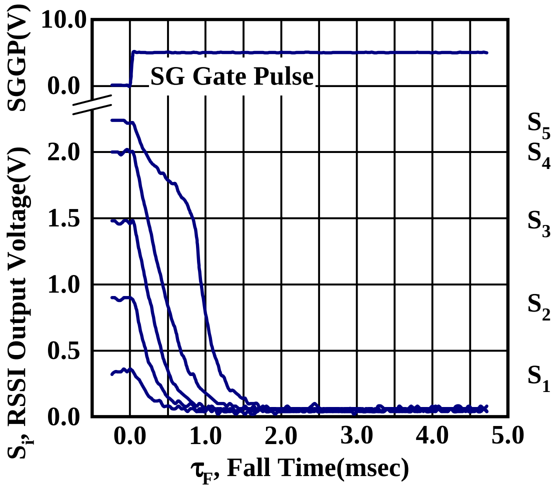
■ RSSI Output Voltage Transient Response: RF Input on/off (Smoothing Capacitor C_S=0.1µF)



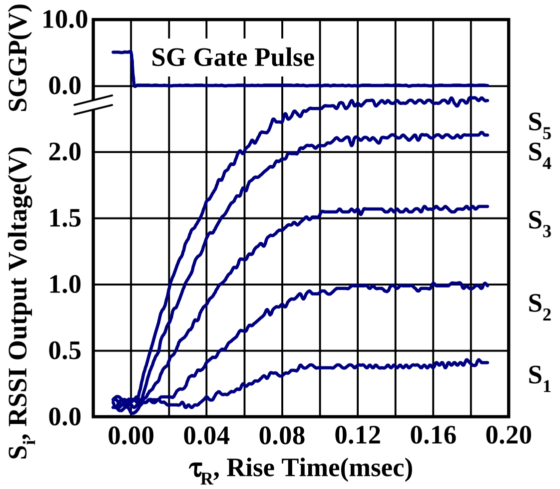


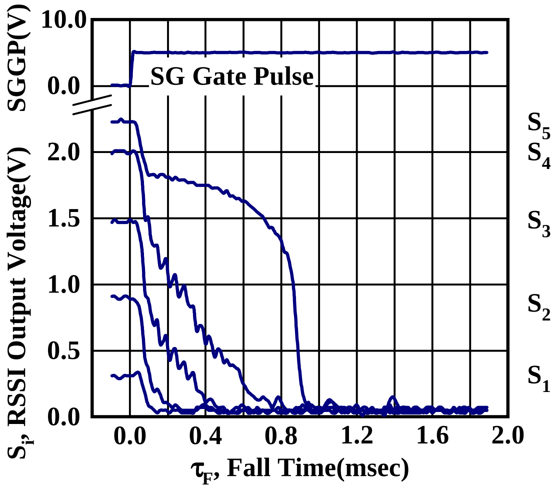
■ RSSI Output Voltage Transient Response: RF Input on/off (Smoothing Capacitor C_S=0.01µF)





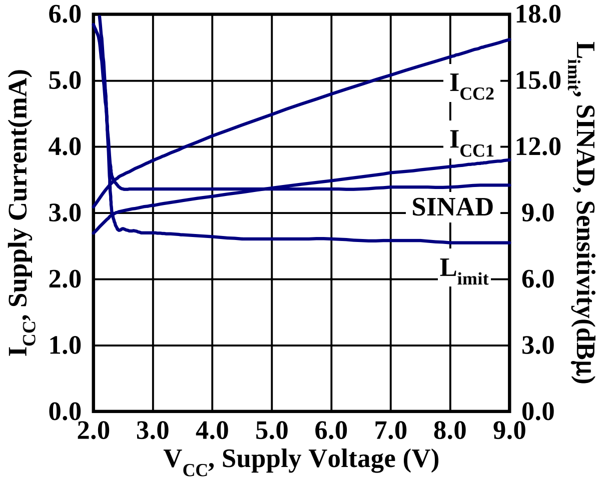
■ RSSI Output Voltage Transient Response: RF Input on/off (Smoothing Capacitor C_S=0.001µF)



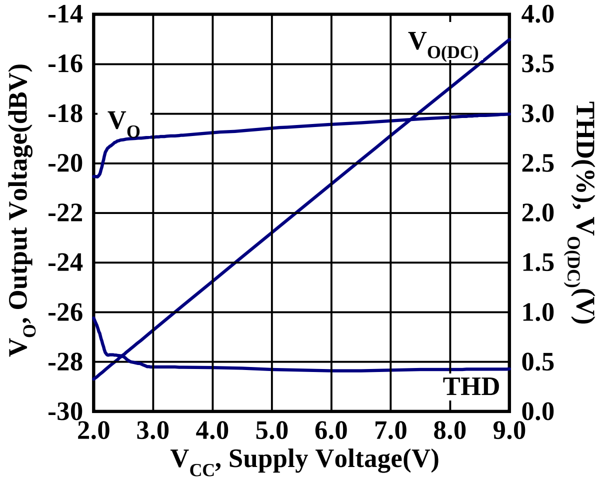


9-8. Versus Supply Voltage Characteristics

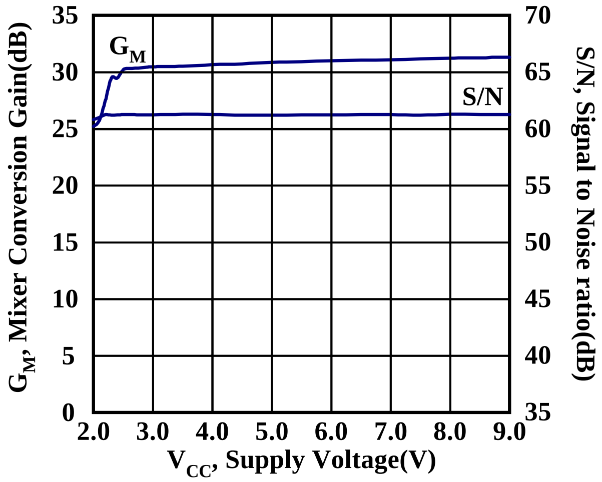
■ Supply Current, 12dB SINAD Sensitivity, -3dB Limiting Sensitivity versus Supply Voltage



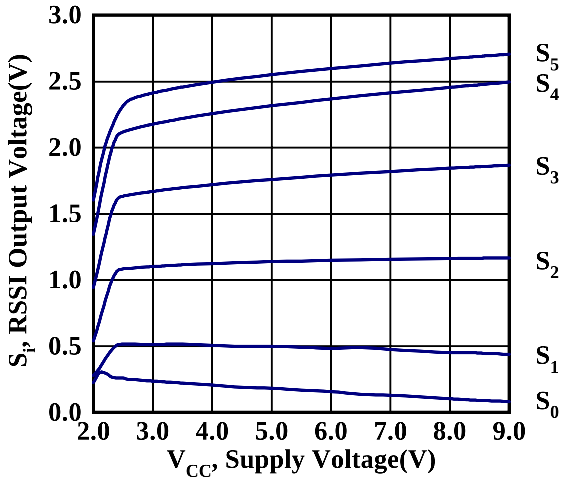
■ Output Voltage, Total Harmonic Distortion, Output DC Voltage versus Supply Voltage



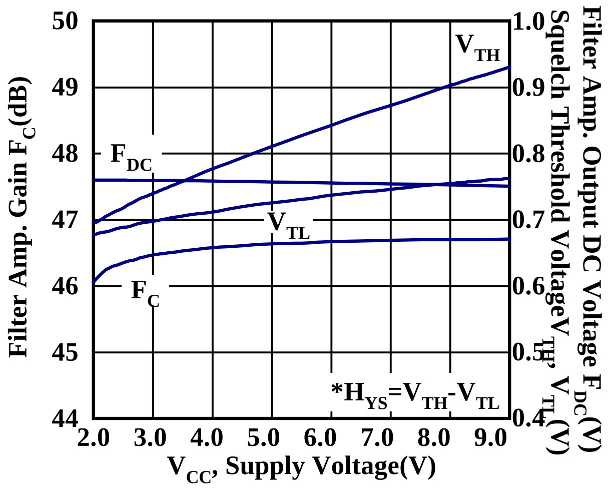
■ Mixer Conversion Gain, Signal to Noise Ratio versus Supply Voltage



■ RSSI Output Voltage versus Supply Voltage

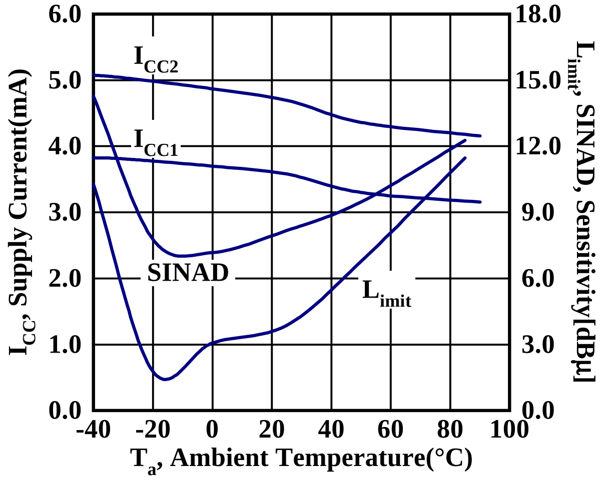


■ Filter Amplifier Gain, Filter Amplifier Output Terminal DC Voltage, Squelch Threshold Voltage versus Supply Voltage

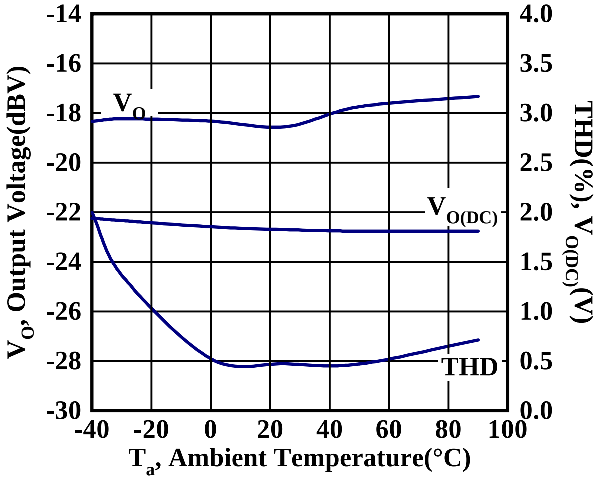


9-9. Versus Ambient Temperature

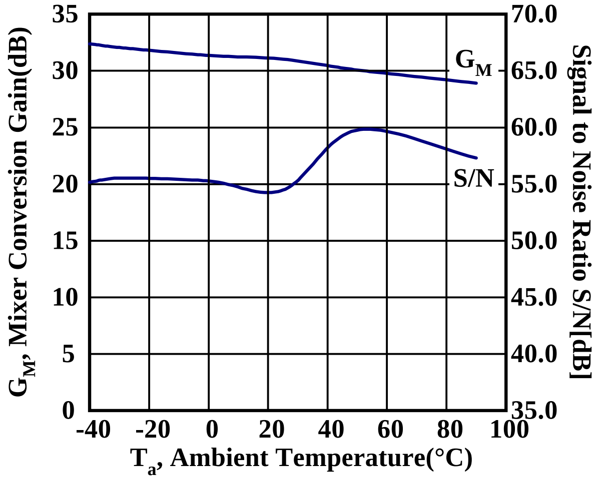
■ Supply Current, 12dB SINAD Sensitivity, -3dB Limiting Sensitivity versus Ambient Temperature



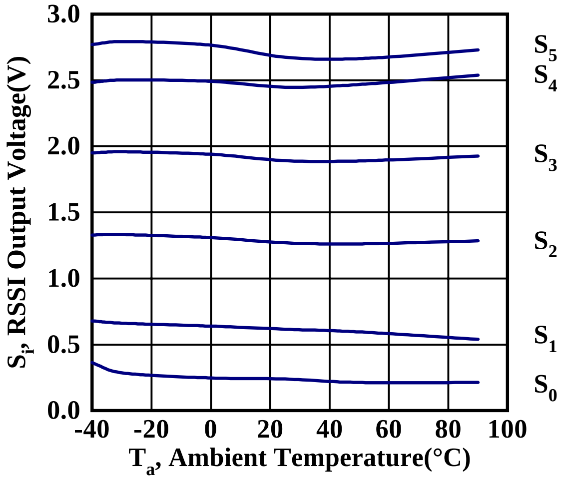
■ Output Voltage, Total Harmonic Distortion, Output DC Voltage versus Ambient Temperature



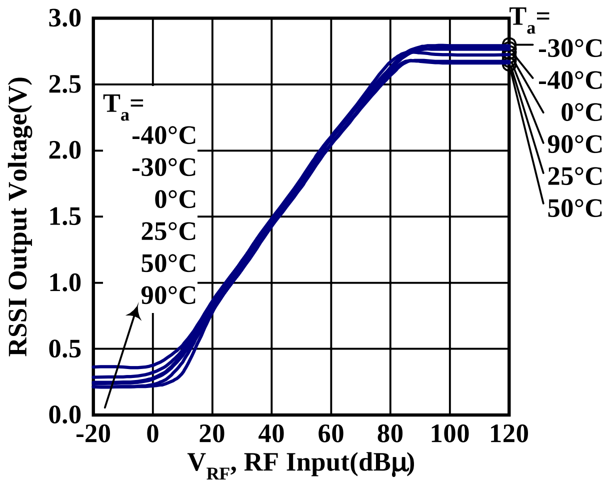
■ Mixer Conversion Gain, Signal to Noise Ratio versus Ambient Temperature



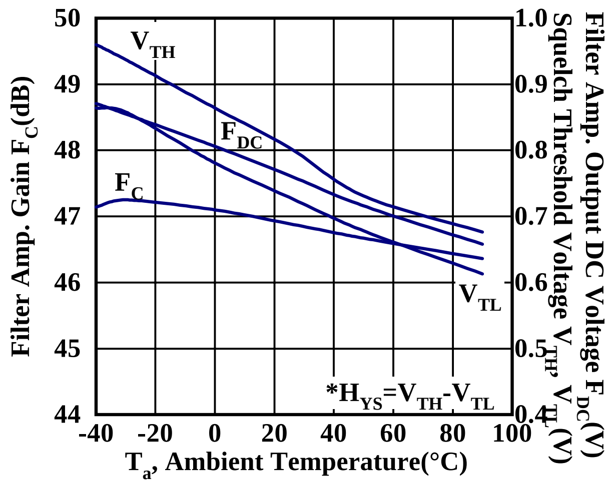
■ RSSI Output Voltage versus Ambient Temperature



■ RSSI Output Voltage versus Ambient Temperature



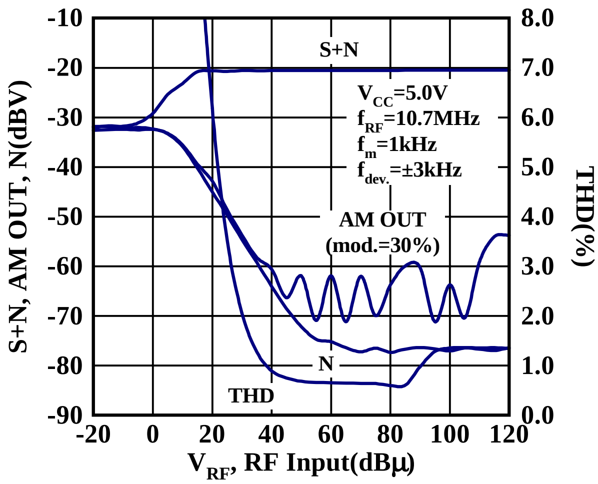
■ Filt. Amp. Gain, Output DC Voltage, Squelch Threshold Voltage versus Supply Voltage



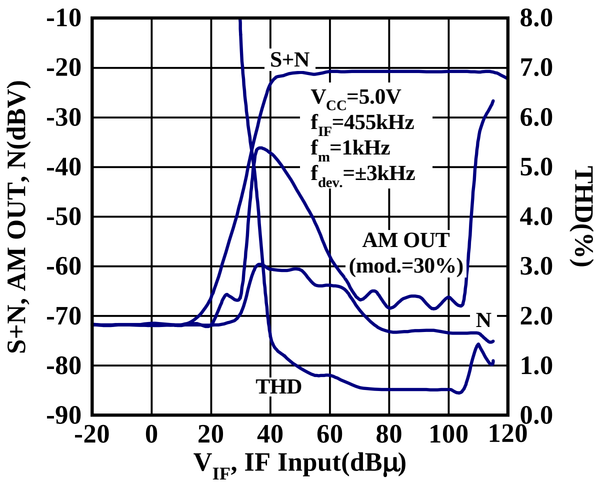
9-10. Characteristics Using Ceramic Discriminator

9-10-1. CDA455C27(TOKO)

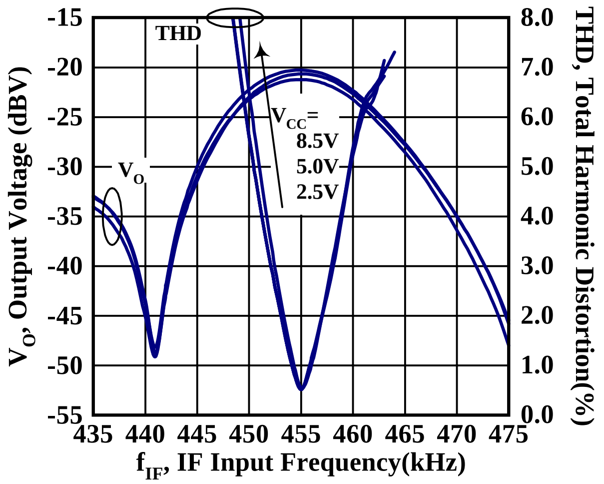
■ S+N, AM OUT, N, THD vs. RF Input(f_{in}=10.7MHz)



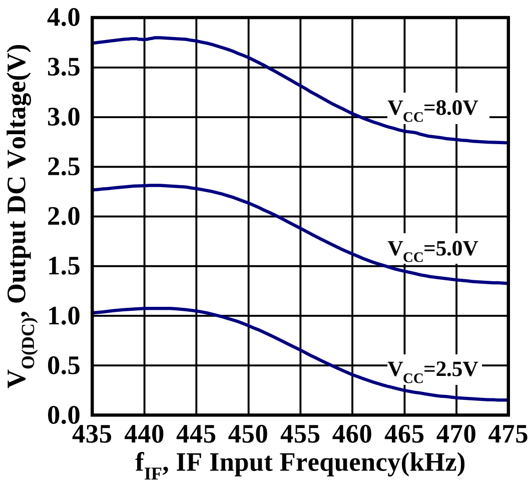
■ S+N, AM OUT, N, THD vs. IF Input(f_{in}=455kMHz)



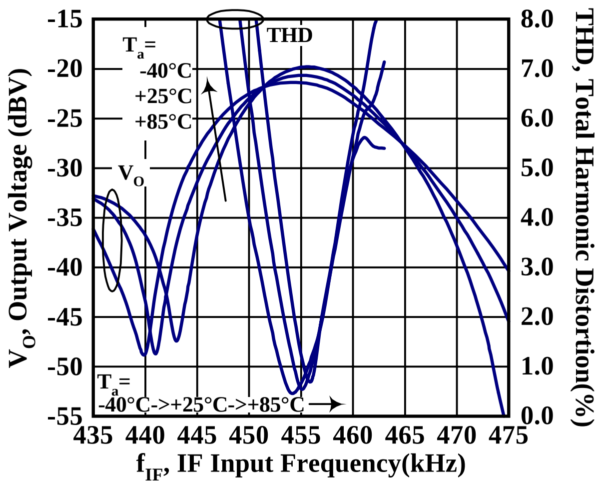
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: V_{CC})



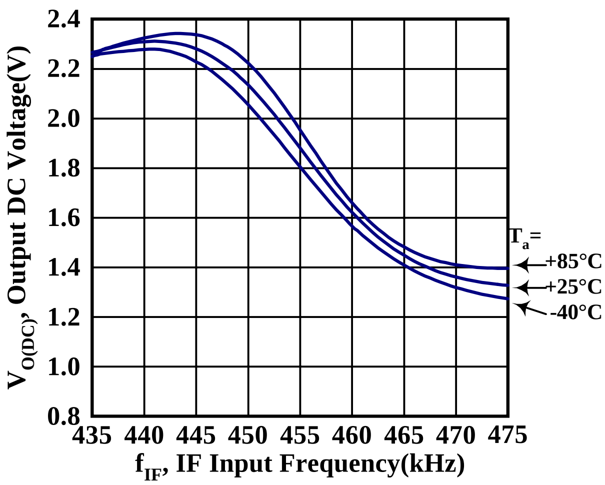
■ Output DC Voltage vs. IF Input Frequency(variables: V_{CC})



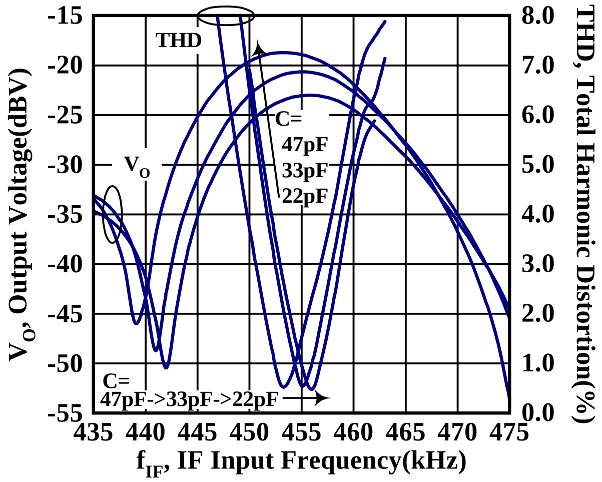
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Ambient Temperature)



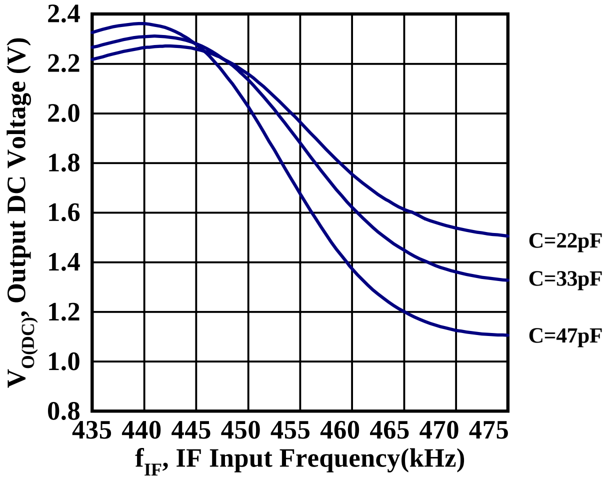
■ Output DC Voltage vs. IF Input Frequency(variables: Ambient Temperature)



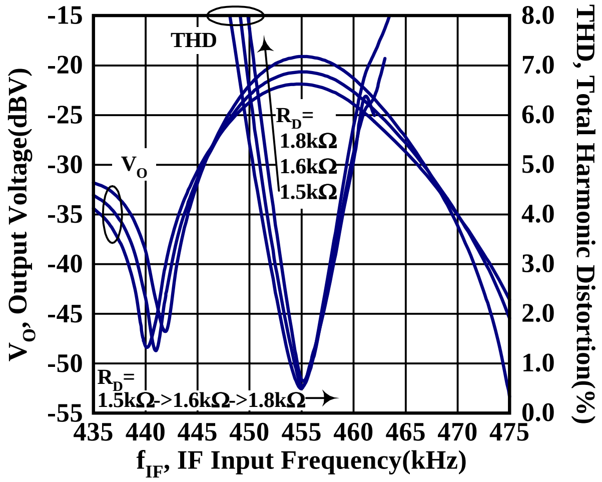
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Phase Shift Capacitance C)



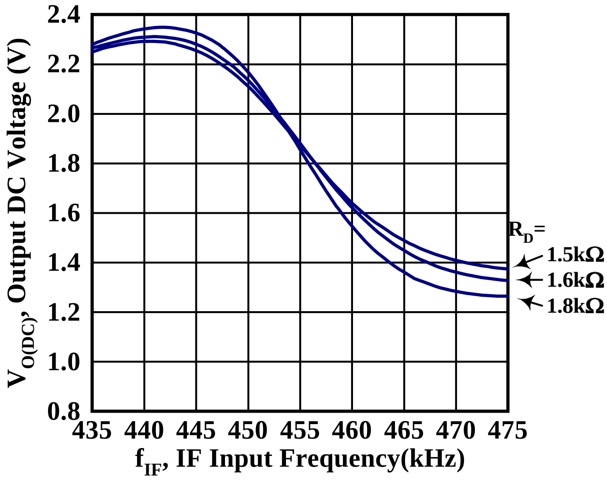
■ Output DC Voltage vs. IF Input Frequency(variables: Phase Shift Capacitance C)



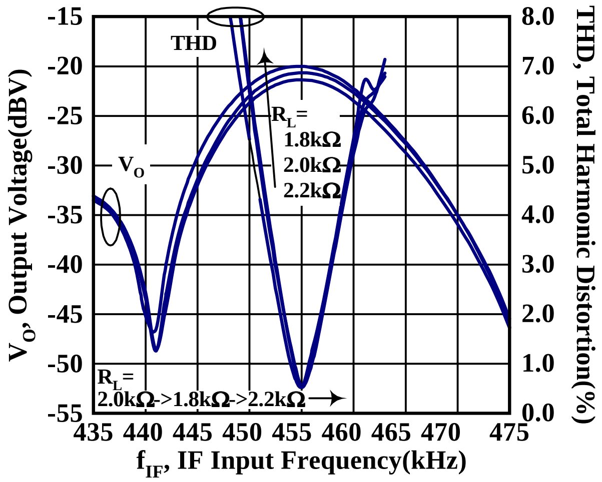
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Damping Resistor R_D)



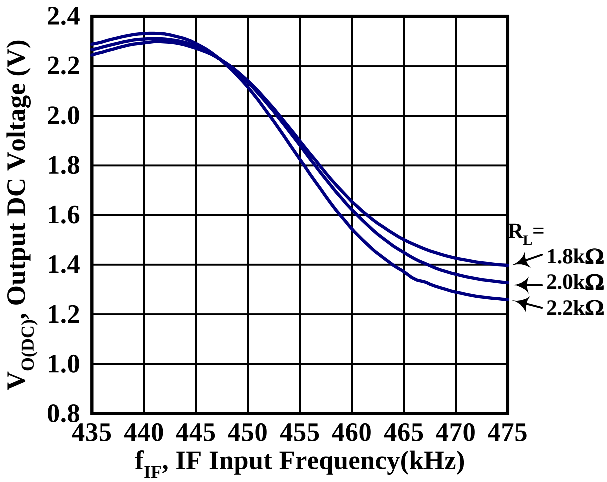
■ Output DC Voltage vs. IF Input Frequency(variables: Damping Resistor R_D)



■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Limitter Load Resistor R_L)

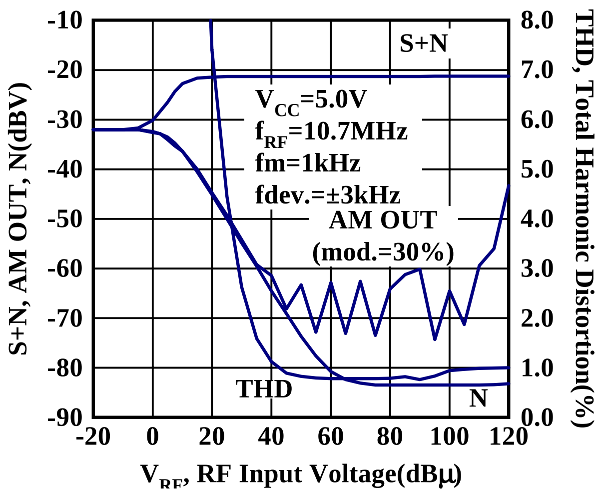


■ Output DC Voltage vs. IF Input Frequency(variables: Limitter Amplifier Load Resistor R_L)

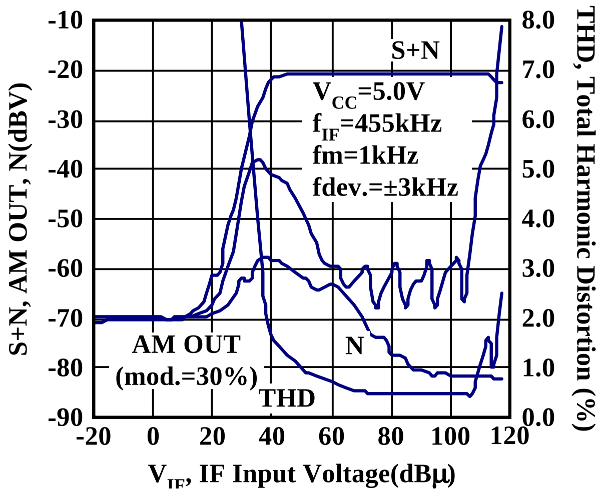


9-10-2. CDBM455C27(Murata)

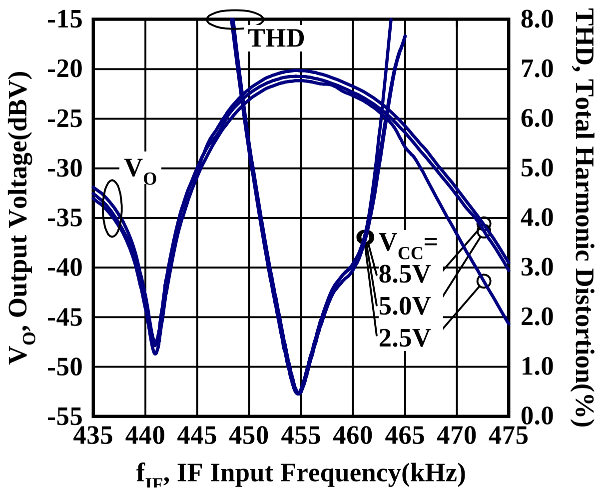
■ S+N, AM OUT, N, THD vs. RF Input(f_{in}=10.7MHz)



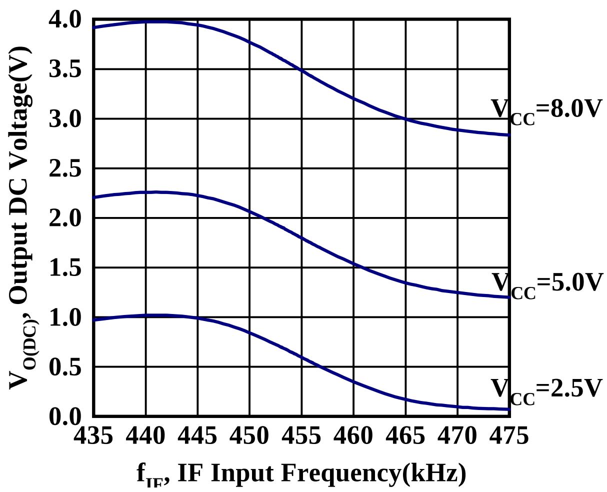
■ S+N, AM OUT, N, THD vs. IF Input(f_{in}=455kMHz)



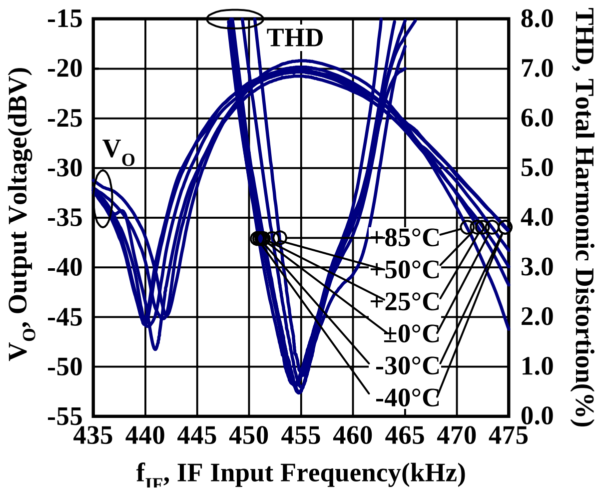
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: V_{CC})



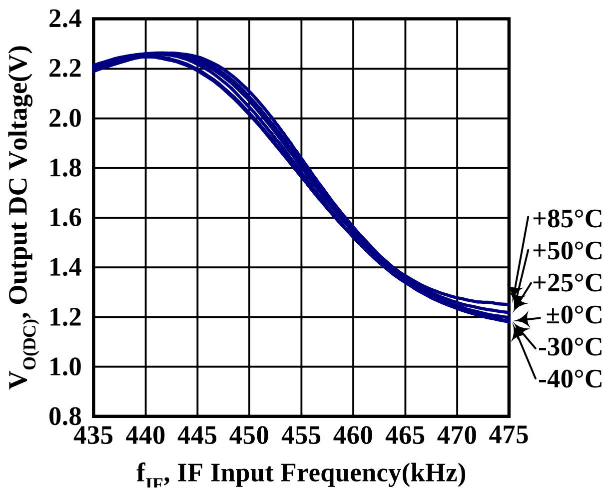
■ Output DC Voltage vs. IF Input Frequency(variables: V_{CC})



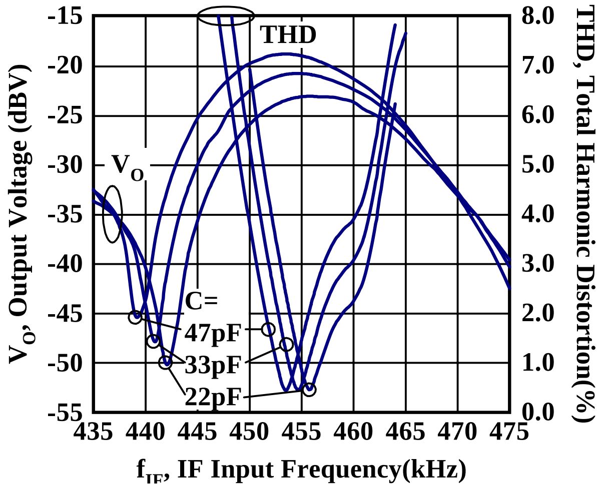
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Ambient Temperature)



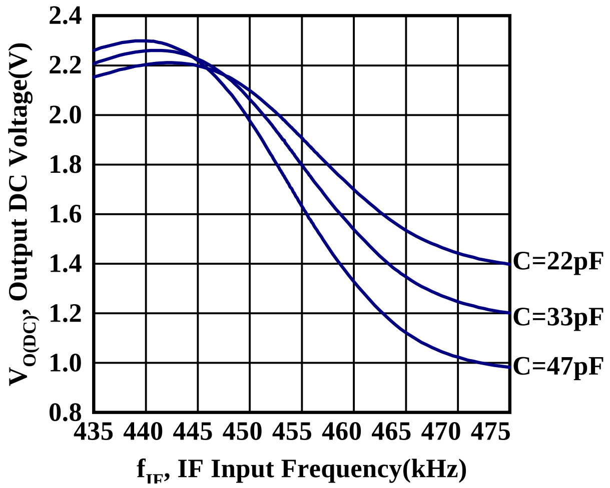
■ Output DC Voltage vs. IF Input Frequency(variables: Ambient Temperature)



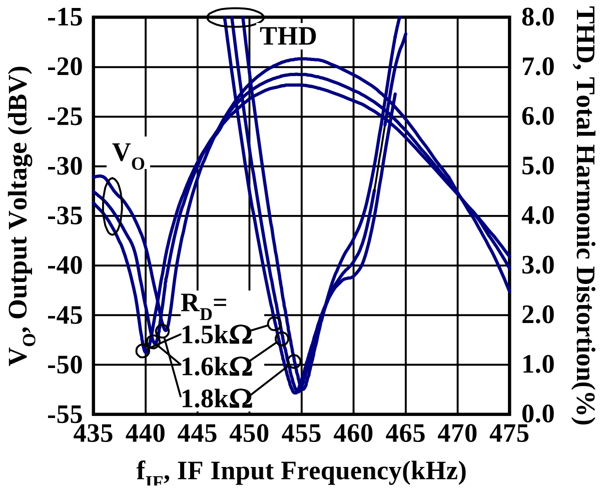
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Phase Shift Capacitance C)



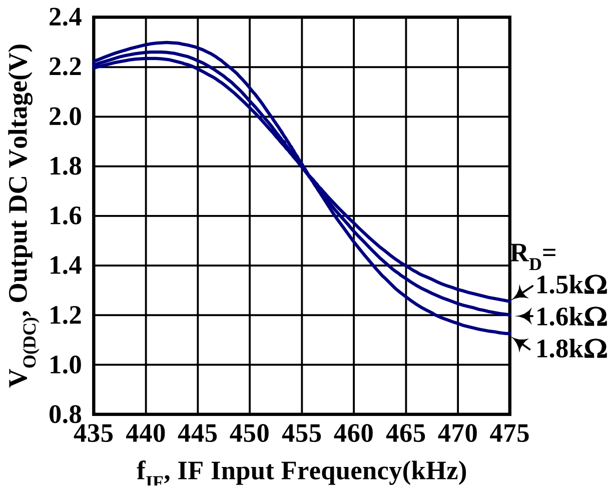
■ Output DC Voltage vs. IF Input Frequency(variables: Phase Shift Capacitance C)



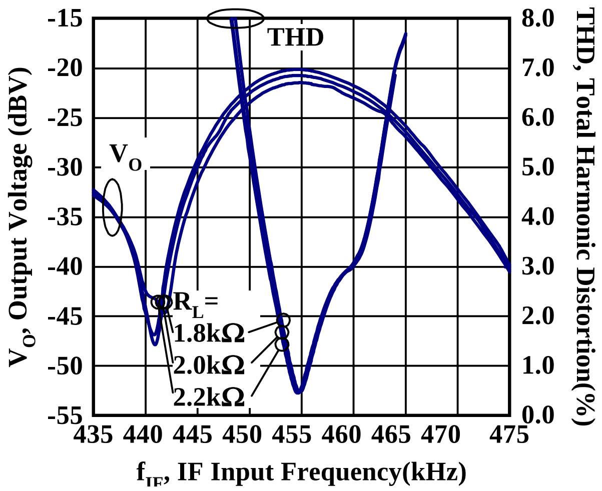
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Damping Resistor R_D)



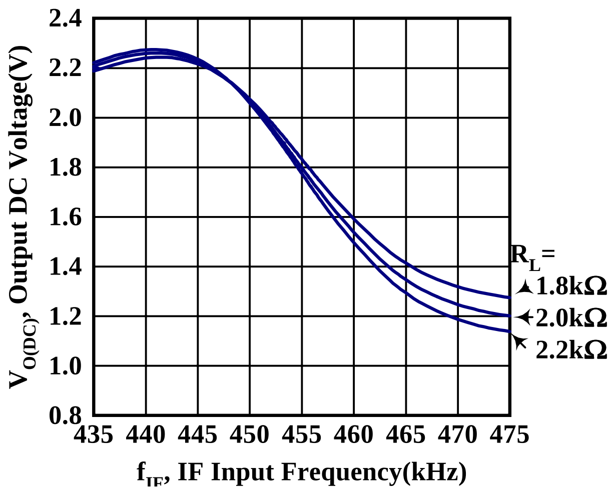
■ Output DC Voltage vs. IF Input Frequency(variables: Damping Resistor R_D)



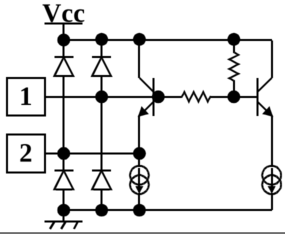
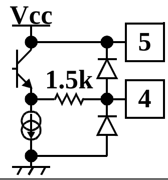
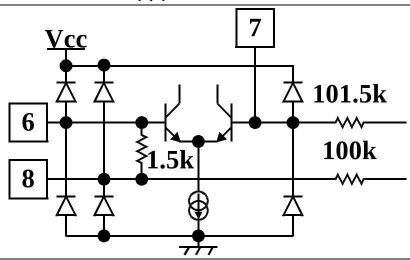
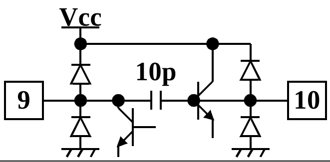
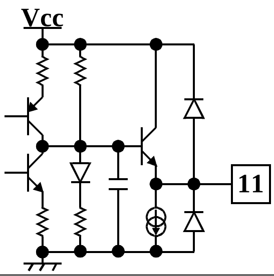
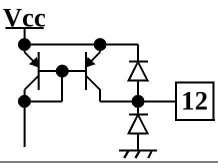
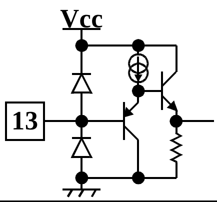
■ Output Voltage, Total Harmonic Distortion versus IF Input Frequency(variables: Limitter Load Resistor R_L)

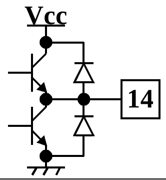
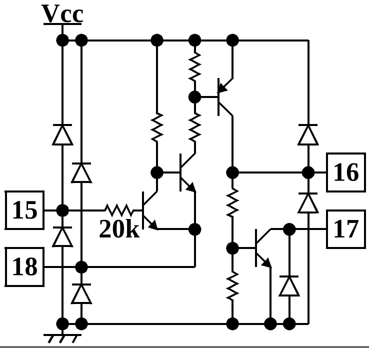
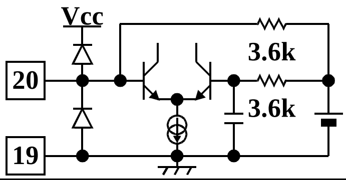


■ Output DC Voltage vs. IF Input Frequency(variables: Limitter Amplifier Load Resistor R_L)



10. PIN DESCRIPTION

Pin No.	Pin Description	Internal Equivalent Circuit	Description
1 2	OSC(B) OSC(E)		■ Base pin of Colpitts type oscillator. ■ Colpitts type oscillator consists of 1st and 2nd pin. ■ Emitter pin of Colpitts type oscillator. ■ Inputting power from an external one for a local oscillator, injected into 1st pin and open 2nd pin.
3	NC		
4	MIXER OUT		■ Mixer output pin. Mixer output is outputted from a emitter follower through 1.5kΩ resistor.
5	V_{CC}		■ Supply voltage pin.
6 7 8	IF INPUT DECOUPLE DECOUPLE		■ IF limitter amplifier input pin. ■ This pin is terminated with inner 1.5kΩ resistor. ■Decoupling(bypass) capacitor connection pin. ■ Decoupling(bypass) capacitor connection pin.
9 10	PHASE SHIFT QUAD COIL		■ Limiter amplifier load resistor connection pin. ■ Phase shifter connection pin.
11	AF OUTPUT		■ Audio output pin.
12	RSSI OUTPUT		■ RSSI(S meter) output pin. ■ RSSI This pin is opencollector output by PNP transistor.
13	FILTER AMP INPUT		■ Filter amplifier input pin.

Pin No.	Pin Description	Internal Equivalent Circuit	Description
14	FILTER AMP OUTPUT		■ Filter amplifier output pin.
15	SQUELCH INPUT		■ Squelch input pin.
16	SCAN CONTROL		■ Scan control pin.
17	$\overline{\text{SCAN CONTROL}}$		■ $\overline{\text{Scan control}}$ pin.
18	HYSTERESIS CONTROL		■ Hysteresis resister connection pin.
19	GND		■ Ground.
20	RF INPUT		■ Mixer input pin.

11. TEST BOARD

Figure 1: Solder Side View(Circuit Side View)

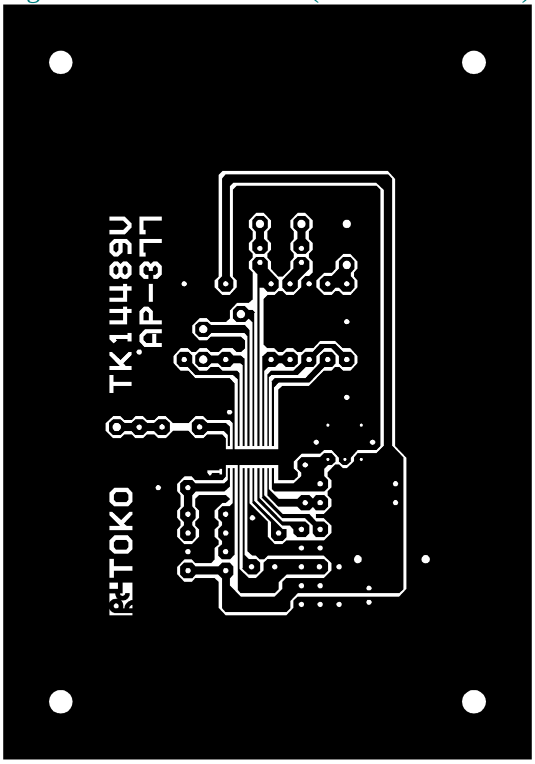
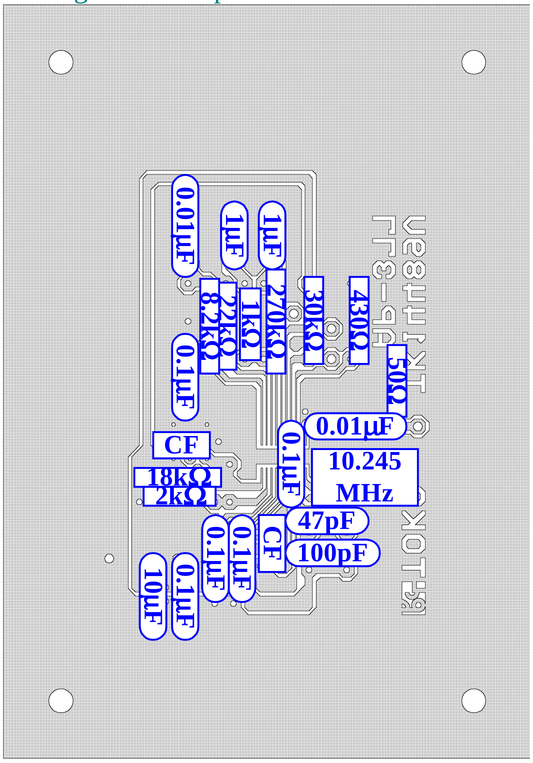


Figure 2: Component Placement View



NOTES:
1. Above test board is laid out for the TEST CIRCUIT.
2. Scale 1:1(1 (70mm×100mm)
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 7BRE-7437Z or equivalent.

12. APPLICATIONS INFORMATION

12-1. Operations Account

RF signal, which is inputted into pin 20, and local oscillator signal from local oscillator are mixed in multiplier. Mixer output, which is frequency-converted RF signal as IF signal, is outputted to pin 4. Mixer output is inputted into pin 6, which is IF limitter amplifier input pin, through external narrow band width BPF. IF signal, which is limiting amplitude in IF limitter amplifier, is phase-shifted by pin 10. After quadrature-detected, IF signal is outputted from pin 11 pin as AF output signal.
RSSI signal is outputted to pin 12 pin. IF signal diverged from IF limitter amplifier is converted current that is suitable for input level by demodulator. After that, converted signal is outputted from pin 12.
Noise level, which increase being inverse proportion to signal level, is inputted squelch rectified through an active filter which center frequency is established over the AF.
An inverting amplifier, which has input terminal of pin 13 pin and output terminal of pin 14, and impedance circuits are constituted an active filter. A rectifier is structured on external parts.
Output from rectifier, which is controlled as noise level, is injected into pin 15. Pin 16 is GND level and pin 17 is "off" mode when the voltage adding in pin 15 is 0.7V or more. Pin 16 is Hi level and Pin 17 is " on " mode when the voltage adding in Pin pin is less than 0.7V . Normally, pin 18 is connected with GND by resistor. Squelch input has hysteresis to obstruct input jitter. Hysteresis width is variable by changing value of hysteresis resistor.

12-2. Mixer Section

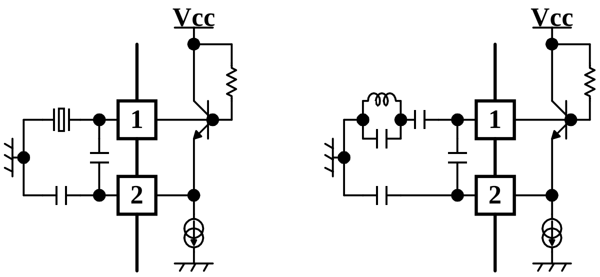
12-2-1. Mixer

Mixer consists of Gilbert cell and a local oscillator.
Mixer realizes wide dynamic range with high conversion gain, 31dB when output terminal is open.
RF input is unbalanced input.

12-2-2. Local Oscillator

Figure 3: Examples of Oscillator

i) X'tal Oscillation ii) LC Oscillation

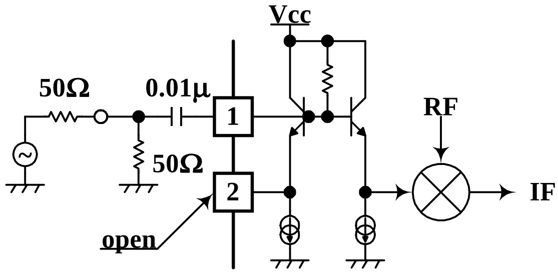


Oscillator includes normal common collector Colpitts oscillator. Its operating current is about 100μA.
It is indicated examples of oscillator circuits in fig. 3.
We explain the examples since next paragraph.

(1)A case of using external SSG or oscillator

It showed circuit composition in fig. 4, using external oscillator. In the case of not using an inner oscillator but use an external oscillator, local level must be injected into pin 1 by capacitor cappling.
<u>**In that case, pin 2 must be opened.**</u>
The local oscillator operates as only an emitter follower by opening pin 2 and injecting into pin 1.

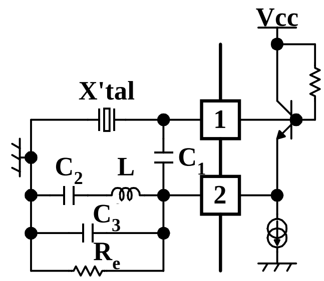
Figure 4: External Injection



(2)A case of the 3rd overtone oscillation

In general, crystal oscillator can oscillate fundamental oscillation and overtone oscillation. For example, it is easy for 30MHz overtone oscillator to oscillate 10MHz, fundamental oscillation. The reason is why the impedance of fundamental oscillation is little as same as the impedance of overtone. It is necessary for circuit side to choice overtone frequency using a tuning-coil and so on, to get overtone oscillation.
We explain how to oscillate normal 3rd overtone oscillator. In the case of overtone oscillation of 30MHz or more, using a crystal oscillator, we recommend a circuit in fig. 5 to suppress fundamental-wave-mode-oscillation.

Figure 5: Overtone X'tal Oscillator

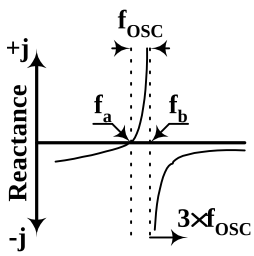


We explain how to decide circuit constant of overtone-crystal-oscillation fundamental circuit. It happens to drop oscillation intensity when it is short of g_m of oscillator, as operation frequency grows high. It is easy to increase operation current connecting resistor R_e between pin 2 and GND. It makes g_m increase to increase operation current by connecting external resistor R_e, if it is short of oscillator operation current. In that case, the amount increased of oscillator operation current I_e showed as following expression (1).

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

Values of C2~C3~L loop circuit network in fig. 5 is established which is filled in oscillation condition at only 3rd overtone frequency. A 2 port impedance characteristic of C_2~C_3~L loop oscillation circuit is shown in fig. 6. As the oscillation condition, the impedance characteristic is capacitansive at the vicinity of the overtone frequency, reactansive at the vicinity of the fundamental frequency. Therefore, the oscillation condition is filled in, established the fundamental wave oscillation frequency is included between the series oscillation frequency f_a and the parallel oscillation frequency f_b in fig.6, besides the overtone frequency $3\times f_{OSC}$ is f_b or more.

Figure 6: 2 Port Impedance Characteristics of Oscillation Circuit Network (Reactance Characteristics)



where,
f_a: series resonant freq.
f_b: parallel resonant freq.
f_{OSC}: fundamental wave mode freq. of X'tal oscillator
$3\times f_{OSC}$: 3rd order overtone frequency of X'tal oscillator

It shows expressions of 3rd order overtone oscillation as follows.

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

A series value of the equivalent capacitance at 3 rd order overtone frequency of this circuit network which is decided in the above-mentioned and the capacitance of C_1, which must be equal to load capacitance C_L.

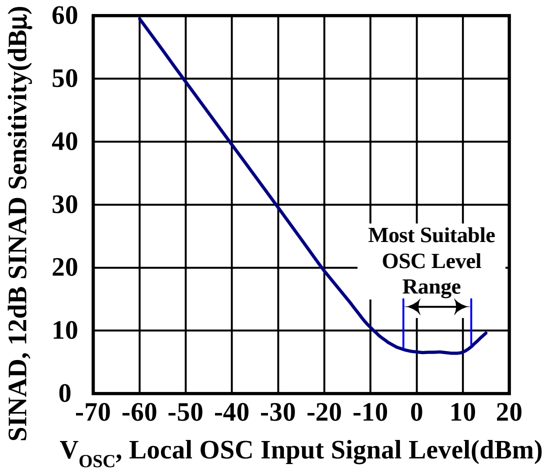
(3)Oscillation level fitting

Being shortage of negative resistor of the circuit, increase bias current of transistor by decreasing R_e. The oscillation level is decided by minute adjustment of R_e.

(4)Most suitable oscillation level range

Please refer the most suitable oscillation level range to 12dB SINAD sensitivity versus oscillation input voltage in TYPICAL CHARACTERISTICS. The saturating range is the most suitable oscillation level range. It is comparative easy to decide circuit constant, examining it by a network analyzer.

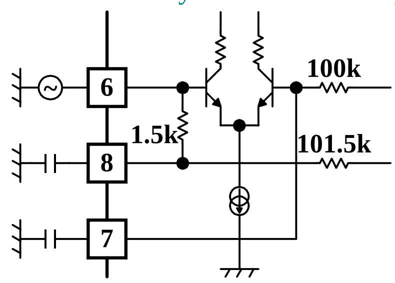
Figure 7: Most Suitable Oscillation Level Range



12-3. IF Section

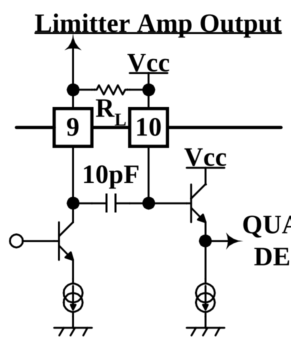
The IF limitter amplifier is composed of 6 stage direct connecting emitter-coupled pairs. The input block include a matching resistor, which value is 1.5kΩ. The gain of IF limited amplifier is high, 70dB@f_{IF}=455kHz. IF output is outputted in pin 11 through emitter follower. AF output level is 250mV_{P-P} at this terminal.
Decoupling capacitances must be connected to GND as near GND terminal of IC as possible. And, make the impedance of connecting-to-GND lime to be as small as possible. It is happened to be worth sensitivities and so on, if the impedance is enough small.

Figure 8: The Vicinity of IF Limiter Amplifier



(1)Limitter amplifier single use

Figure 9: Limitter Amplifier Single Use Application



It is possible to use the included limitter amplifier as single in addition to the standard application which use is detecting through a phase shifter.
As the composition of pin 9 is shown in fig.9, pin 9 is usable as a limitter amplifier but it needs pin 9 is bias by a proper resistor R_L
If the detector isn't used, pin 10 must be connected by V_{CC}. We recommend R_L=2kΩ as standard, but it is usable so far as 10kΩ.

12-4. RSSI Section

The signal, which is pulled out from middle stage of IF limitter amplifier, enters RSSI circuit (S meter detector). RSSI output is the current mode. It is converted the voltage mode by a conversion resistor RS connected between pin 12 and GND.

12-4-1. Time Constant

Time constant τ is decided by the product $R_S \times C_S$ of an external conversion resistor R_S and a smoothing capacitor C_S which is parallel the conversion resistor.
As time constant $\tau = (R_S \times C_S)$ grows large, it becomes hard to be influenced external disturbance or the ingredients of amplitude modulation, but RSSI output voltage transient response characteristics become dull. Determine the time constant τ by the uses.

12-4-2. RSSI Output Voltage Range

The slope of RSSI curve is variable by an external conversion resistor R_S. If RSSI slope is varied, the maximum range of voltage-converted RSSI output is the low limit GND level to the top limit about V_{CC}-0.2 which is the value that the supply voltage subtract the collector saturation voltage $V_{CE(SAT)}$ of output transistor.

12-4-3. Temperature Characteristics

It is possible to change the temperature characteristics of RSSI output voltage by changing the temperature coefficient of an external conversion resistor. Normally, the temperature characteristics of RSSI output voltage is enough stable by using the carbon resistor or metal film resistor which temperature coefficient is 0~200ppm/°C.

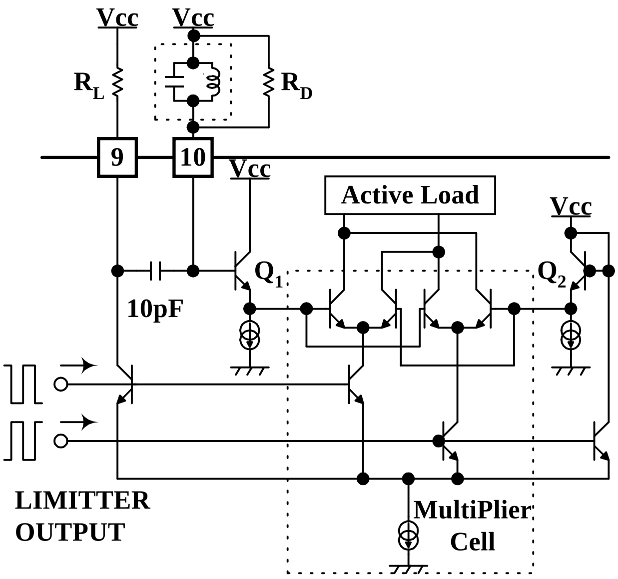
12-5. FM Demodulator

It is included the quadrature FM demodulator used Gilbert cell.

12-5-1. Internal equivalent circuit

Inner equivalent circuit of demodulator is showed as following draw, fig.10.

Figure 10: Internal Equivalent Circuit of Demodulator



Attentions in this point is to add the bias voltage in pin 9~10 from external source.

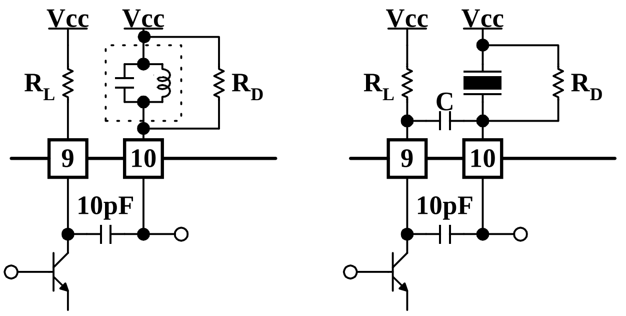
The signal from the phase shifter is put in the multiplier in a dotted line through emitter follower of transistor Q_1. The notice to use is pin 10 pin have to impress the bias voltage from external source, because pin 10 is single-connected with the base terminal. It is necessary for pin 10 to add same voltage, as the base terminal of Q_2 of the opposite side of Q_1 through the multiplier is connected with the supply voltage.
The case of using LC resonance circuit has no problem as fig. 10. However, it is need enough care to use the ceramic discriminator. If the base voltages difference between transistor Q1 and Q2 exists, it is occurred the alteration of DC zero point or the growing worse of the distortion of demodulation output.
It is ideal that pin input level is saturated at the multiplier. It is ease to disperse the modulation output when this level becomes low. From this viewpoint, it is ideal to be stable operation that amplitude of IF signal at pin is $100mV_{P-P}$ or more.

12-5-2. Phase Shifter

The phase of IF limiter amplifier is made be shifted 90° for quadrature detecting.
It is possible to use either type the RCL resonance and or ceramic discriminator. It is capable to use inner phase shift capacitance (10pF) in the case of RCL resonance.
The following draws show the examples of phase shifter.
In the case of using the ceramic discriminator, it is necessary to increase phase-shift-capacitance C by adding external capacitance.

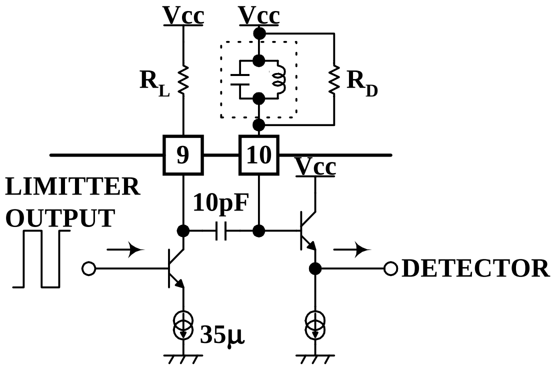
Figure 11: Examples of Phase Shifter

i) RCL Resonance circuit ii) Ceramic Discriminator



(1)RCL Phase Shifter Constants Establishment

Figure 12: RCL Phase Shifter Constants Establishment



R_L is the resistor, the limitter amplifier resistor, that decide signal level inputted from limitter amplifier output into phase shifter. Below equation sets this signal level.

$$V_{O@9PIN} = R_L \times 35\mu A \times 2 \tag{3}$$

R_D is Q-damping resistor of phase shifter.
The signal level is able to be controlled by R_L and R_D. At the points of demodulation sensitivity and distortion, please set up R_L and R_D as pin 10 output level is 100mV_{P-P} more .

(2)Ceramic Discriminator Phase Shifter Constants Establishment

Setting up phase shifter constants(C, R_L, R_D) using ceramic discriminator, cut and try them according to below order.

1) Set up R_D that is given as the expected output voltage.
2) Set up C as THD becomes minimum in the case that the change or R_D causes minimum THD point change.
3) Output voltage is change as C is changed, so set up R_D that is given as the expected output voltage again.
4) Search the constants that the expected output voltage point corresponds with minimum THD point.
5) Rise R_L if adjustment of 4) rise up output voltage even the expected.

Refer "TYPICAL CHARACTERIS TICS" about characteristics behavior in according to changes of constants, C, R_L, R_D.

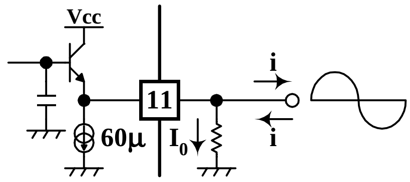
12-5-3. Audio Output

After quadrature detecting, the audio signal is outputted from pin 11 through an emitter follower.
The needful signal is pulled out through LPF.

(1)Waveform Distortion Improvement

In the cases that output voltage is very large, or heavy load is connected with demodulated output, it happens the drive power of demodulated output being short, so the waveform distortion occurs at minus half cycle. Shown in fig13, demodulated output is an emitter follower. So it is able to improve the waveform distortion being connected with resistor between pin 11 and GND. This is effective that the emitter follower drive current increase.

Figure 13: Demodulated Output Drive Current Increase



12-5-4. For Stable Operation

To prevent worsening the distortion, observe the following notes:

(1) Demodulated Output Voltage (Pin 11)

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 10)

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 10)

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

12-6. Filter Amplifier

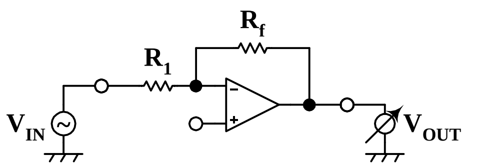
This block is the inverting OPAMP block. The OPAMP has superior temperature characteristics, can be capable of a filter amplifier for noise detector and so on. pin 13 is input port, pin 14 is output port. The filter amplifier and external parts constitute noise-remove BPF.

12-6-1. Inverting OP Amp

It show in fig. 14 as a example of inverting OPAMP component. Its gain F_C is expressed as below. The minus symbol in the expression means phase inverting from input to output (180°).

$$G_f = -20\log_{10}\left(\frac{R_f}{R_1}\right) \quad (dB) \qquad (4)$$

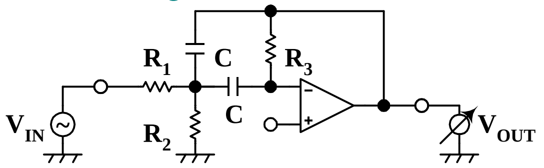
Figure 14: Inverting OP Amp



12-6-2. Active BPF

Examples of active BPF application as following draw in fig. 15, and its frequency characteristics as following draw in fig.16.

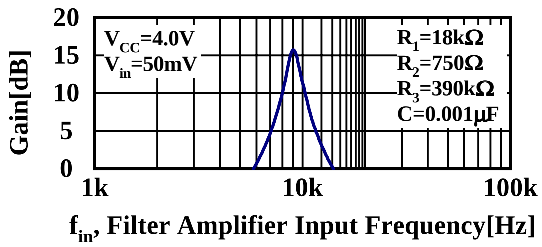
Figure 15: Active BPF



Next expressions are formularized, however, G_0 is the gain at center frequency f_0, and 3dB band width $Q=f_0/BW$.

$$R_1 = \frac{R_3}{2G_0}, \quad R_2 = \frac{R_1 R_3}{4Q^2 R_1 - R_3}, \quad R_3 = \frac{Q}{\pi f_0 C} \qquad (5)$$

Figure 16: Frequency Response



12-7. Squelch

The output, which is controlled in accordance with noise level from the rectifier, is injected into squelch input terminal.

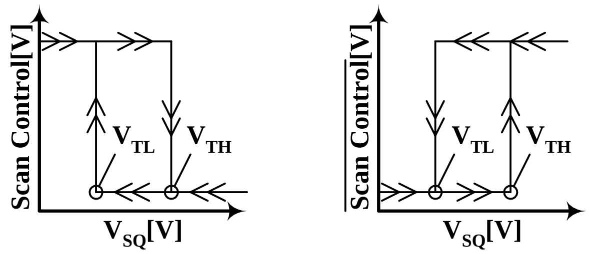
Squelch input has hysteresis to obstruct input jitter.

The threshold voltage and the hysteresis width are variable by changing hysteresis resistor RHYS connecting with pin 18.

V_{TH}: Hi Threshold Voltage, V_{TH}: Lo Threshold Voltage in fig.17.

Figure 17: Squelch Response

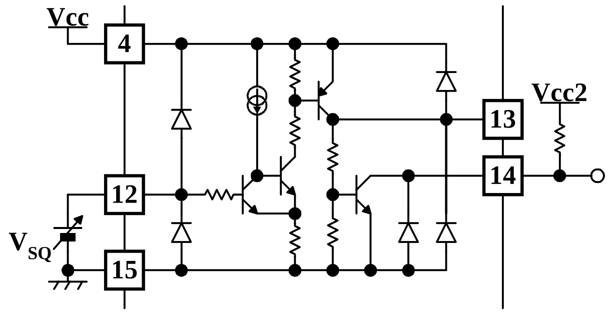
i) Pin 13 Output ii) Pin 14 Output



*V_{TH}: Hi Threshold Voltage, V_{TL}: Lo Threshold Voltage

As Fig. 18 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.

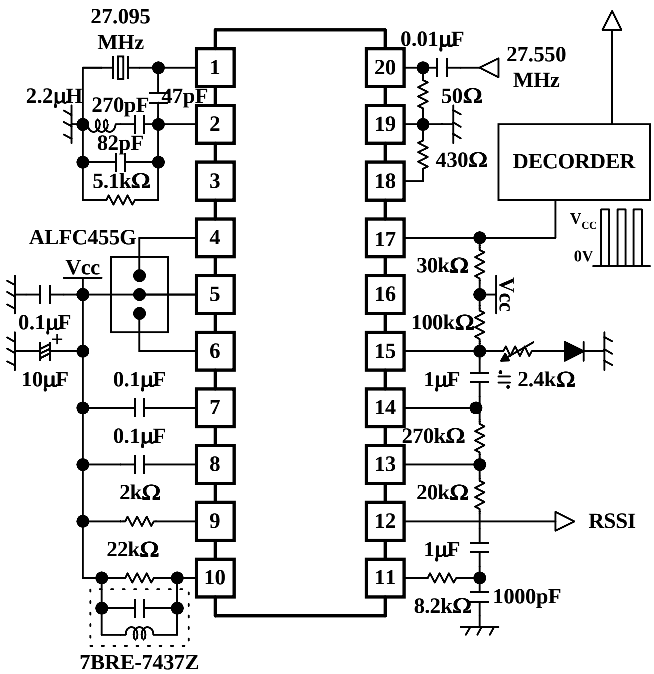
Figure 18: Squelch



12-8. FSK

A FSK application example is shown in fig.19.

Figure 19: FSK Application



Waveform-shaping of FSK demodulated signal is done

by a noise amplifier for squelch and a comparator.
For capacitor cappling, waveform-shapable low frequency is decided by couppling capacitor value. In this example, it is able to shape waveform until about 60kHz. High band is decided by band width of ceramic filter and RC type LPF on pin 11.
The threshold voltage of including comparator is equivalent to V_{BE} of transistor, so it gets needful bias voltage(about 0.8V) series-connecting a diode and a resistor, and realize temperature compensation. This bias voltage is changed due to supply voltage, please set up it according to supply voltage which you use.

12-9. 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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