Ordering number : EN4715A

Monolithic Linear IC

LA1193M, 1193V

SANYO

High-Performance FM Front End for Car Radios

Overview

The LA1193M and LA1193V are front-end ICs developed for use in car radios. It incorporates an extremely wide dynamic range mixer and a new AGC system consisting of a dual-system wide-band AGC and a new keyed AGC to provide excellent interference suppression characteristics.

Functions

- Double-balance mixer
- Pin diode drive output
- Differential IF amplifier
- Dual-system wide-band AGC circuit
- Local buffer output
- 3D-AGC system
- FET gate drive AGC output
- IF amplifier gain control pin

Features

- Improved interference characteristics
  - — Expanded mixer input dynamic range
    Mixer input usable sensitivity: 15 dBμ
    Mixer input I.M. QS: 90 dBμ
    (The dynamic range has been increased by 6 dB over the earlier LA1175M.)
  - — Development of a new wide-band AGC circuit
    Improved interference characteristics for both near-channel interference and far-channel interference
    Improved interference characteristics for the TV band
  - — Development of a 3D-AGC system
    The adjacent channel two-signal interference characteristics can be effectively improved without degrading the strong-field three-signal interference characteristics during keyed AGC operation.

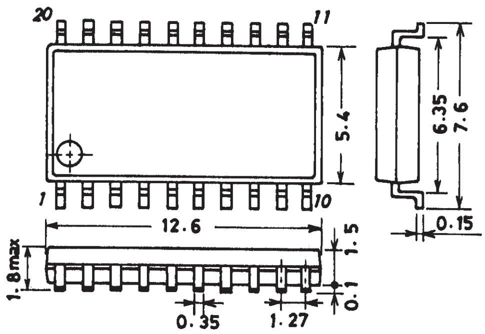
- Improved stability design
  - — AGC circuit local oscillator isolation
    Measures were taken to prevent the deterioration of AMR, noise level, THD and other characteristics during AGC operation.
  - — AGC circuit incorrect operation measures
    The LA1193M provides methods to prevent incorrect operation due to local oscillator injection and loss of DC balance.
- Improved temperature characteristics
  - — Conversion gain
  - — AGC sensitivity
  - — Antenna damping drive output current

Package Dimensions

unit: mm

3036B-MFP20

[LA1193M]

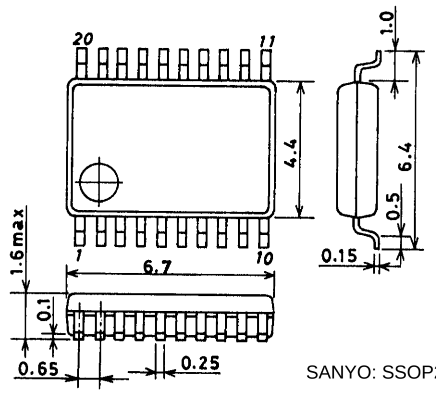


SANYO: MFP20

unit: mm

3179A-SSOP20

[LA1193V]



SANYO: SSOP20

Specifications

Maximum Ratings at Ta = 25°C

Parameter	Symbol	Conditions	Ratings	Unit
Maximum supply voltage	V_{CC} max	V_{CC} for pins 5 and 17	9	V
	V_{CC} max mix	V_{CC} for pins 10 and 11	15	V
Allowable power dissipation	Pd max	LA1193M: (Ta ≤ 70°C) Mounted on a 41 × 30 × 1.1 mm³ glass-Epoxy board	500	mW
	Pd max	LA1193V: (Ta ≤ 70°C) Mounted on a 23 × 36 × 1.6 mm³ glass-Epoxy board	500	mW
Operating temperature	Topr	*	–40 to +85	°C
Storage temperature	Tstg		–40 to +125	°C

Note: * Connect a resistor (up to 10 kΩ) between pins 17 and 19.

Operating Conditions at Ta = 25°C

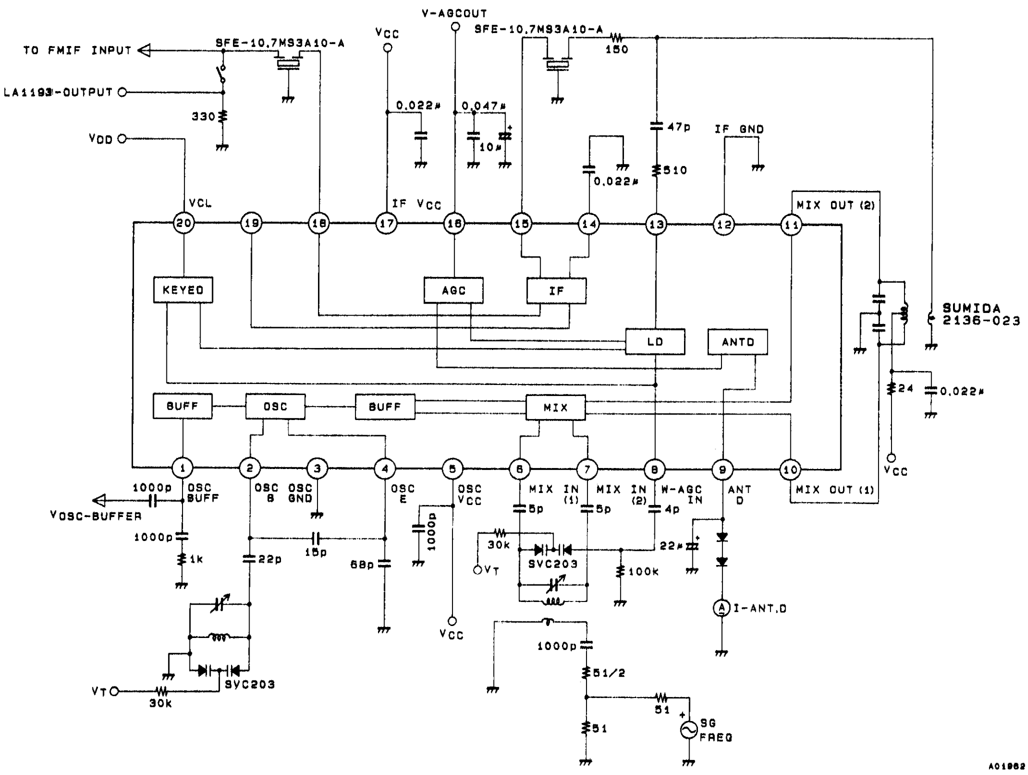
Parameter	Symbol	Conditions	Ratings	Unit
Recommended supply voltage	V_{CC}		8.0	V
Operating supply voltage range	V_{CC} op		7.6 to 9	V

Operating Characteristics at Ta = 25°C, V_{CC} = 8.0 V, in the specified test circuit, f = 88 MHz, f_{OSC} = 77.3 MHz

Parameter	Symbol	Conditions	Ratings			Unit
			min	typ	max	
Current drain	I_{CCO}	No input, V_{CONT} = 0 V	19	24	29	mA
Antenna damping current	ANT-DI	88 MHz, 100 dBμ, V_{CONT} = 4.0 V	7.0	9.5	12.5	mA
AGC high voltage	V_{AGC-H}	88 MHz, 0 dBμ, V_{CONT} = 4.0 V	7.6	7.9		V
AGC low voltage	V_{AGC-L}	88 MHz, 100 dBμ, V_{CONT} = 4.0 V		0.4	0.9	V
Saturation output voltage	V_{OUT}	88 MHz, 110 dBμ, V_{CONT} = 4.0 V	97	110		dBμ
–3 dB limiting sensitivity	Vi-Limit	88 MHz, 110 dBμ, V_{CONT} = 4.0 V	78	85	92	dBμ
Conversion gain	A. V	88 MHz, 75 dBμ, V_{CONT} = 4.0 V	98	101	104	dBμ
Local buffer output	V_{OSC}-Buff	No input, no modulation	105	109		dBμ
Narrow V_{AGC-ON}	V-NAGC	88 MHZ, V_{CONT} = 4.0 V, at an input level such that $V_{AGC-OUT}$ is 2 V or less	73 (76)	80 (83)	87 (90)	dBμ
Wide V_{AGC-ON}	V-WAGC	88 MHZ, V_{CONT} = 0 V, at an input level such that $V_{AGC-OUT}$ is 2 V or less	97	101	105	dBμ
3D-AGC-ON	V3D-AGC	88 MHZ, V_{CONT} variable, with 95 dBμ being the V_{CONT} voltage input such that $V_{AGC-OUT}$ switches from high to low and 2.0 V as the V_{AGC} threshold value.	0.4	0.6	0.8	V

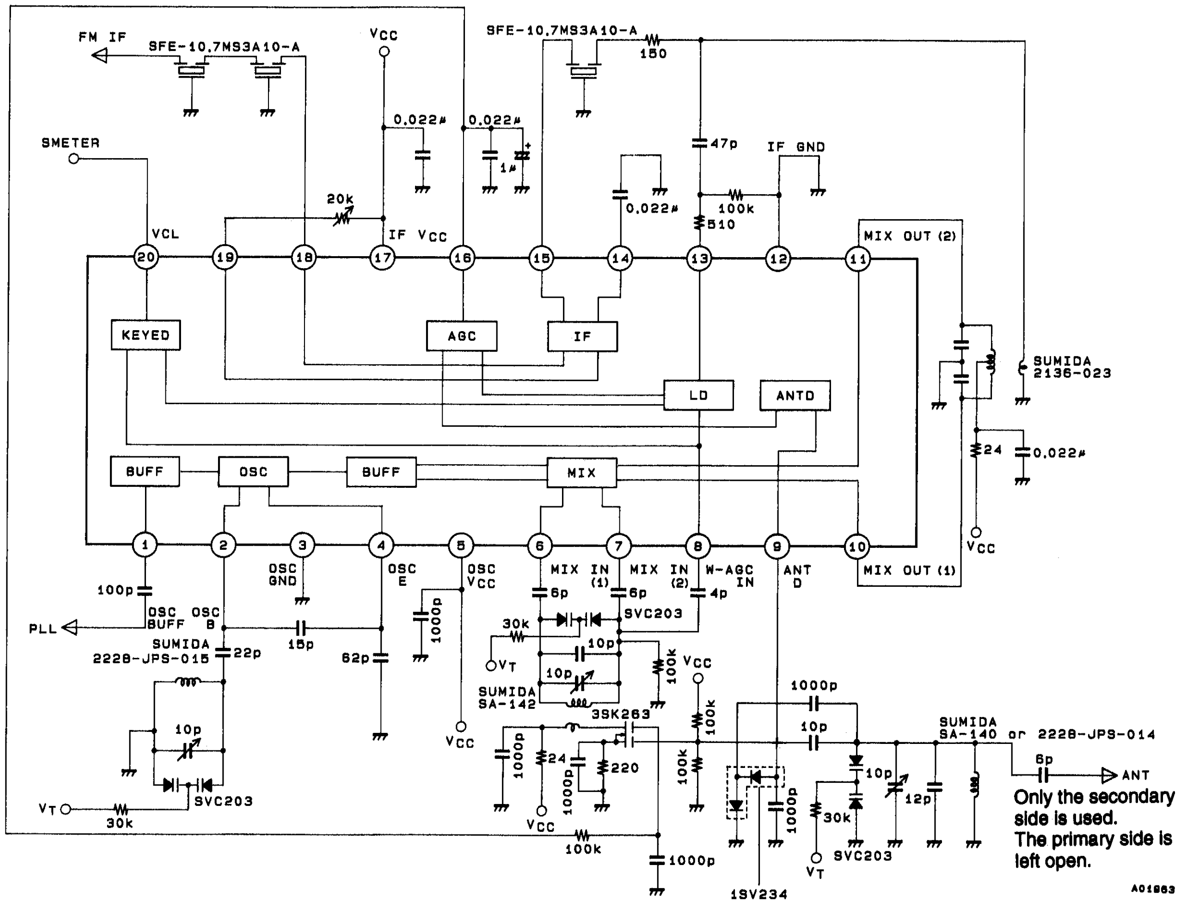
Note: Values in parenthesis are for LA1193V.

Block Diagram and Test Circuit Diagram



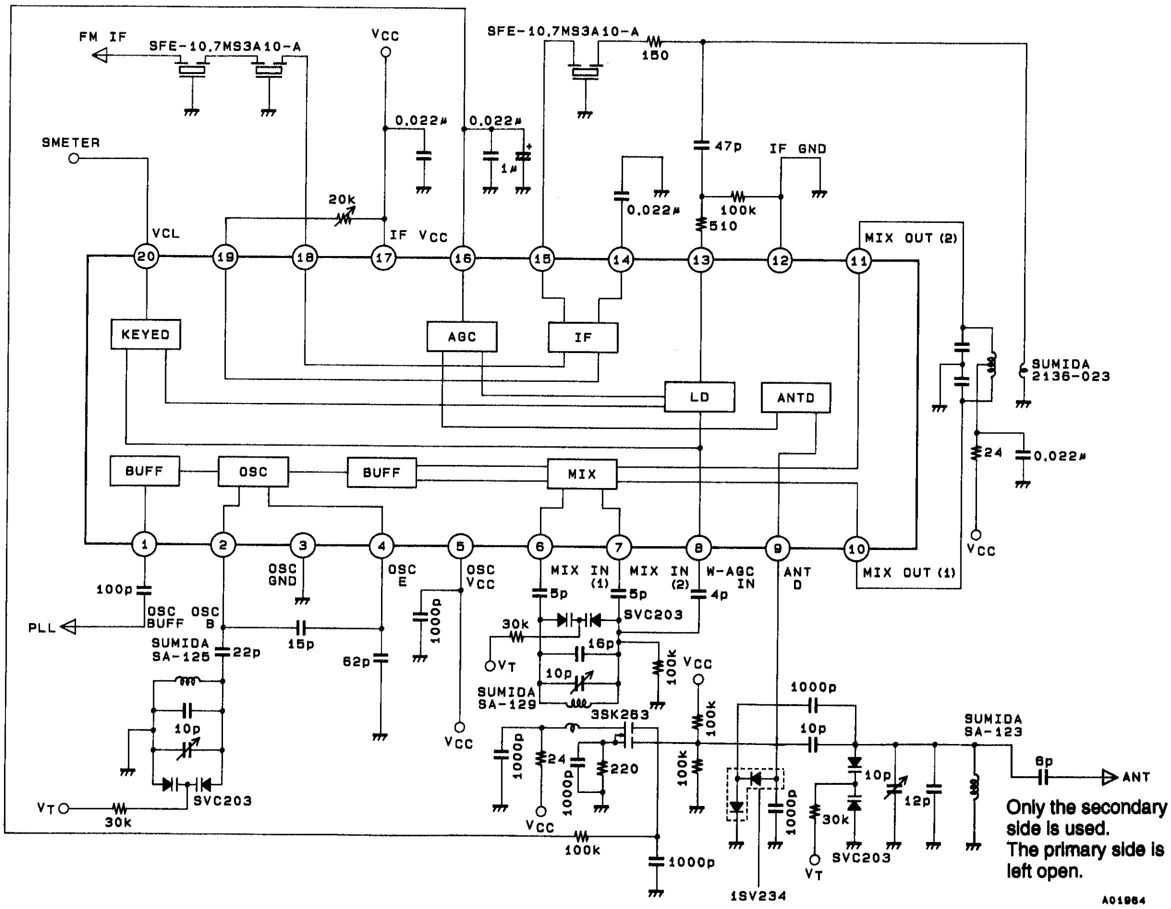
Unit (Resistance: Ω, Capacitance: F)

Application Circuit: USA and Europe



Unit (Resistance: Ω, Capacitance: F)

Application Circuit: Japan

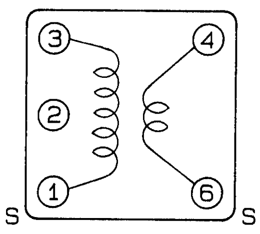


Unit (Resistance: Ω, Capacitance: F)

Coil Specifications

Coils Manufactured by Sumida Electronics

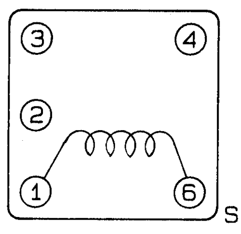
Japan band RF coil SA-129 or SA-143



6-4 3T
1-3 3T

A00944

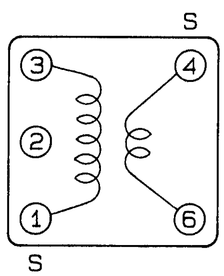
Japan oscillator coil SA-125



6-1 $3\frac{2}{4}$T

A00945

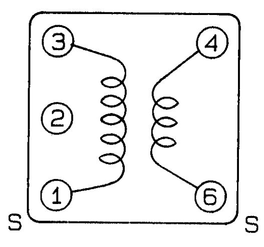
Japan antenna coil SA-123 or SA-144



4-6 $\frac{3}{4}$T
1-3 3T

A00946

US band RF coil SA142 or SA-250



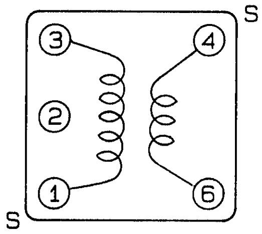
6-4 $2\frac{1}{2}$T
1-3 $2\frac{1}{2}$T

A00947

Continued on next page.

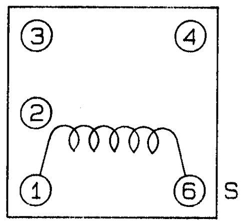
Continued from preceding page.

US band antenna coil SA-140 or SA-231



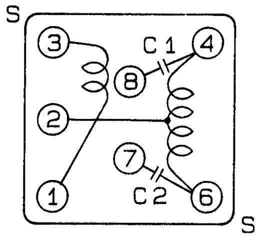
4-6 $\frac{3}{4}$ T
1-3 $2\frac{1}{2}$ T

US band oscillator coil SA-278



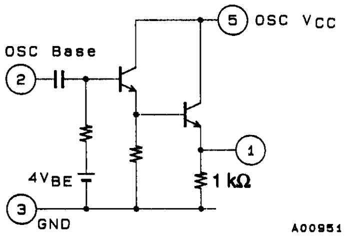
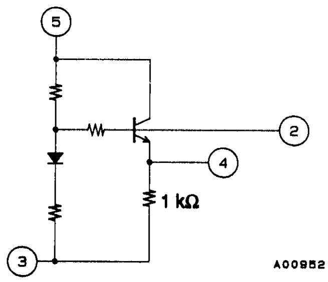
6-1 2T

Mixer coil (for both bands) SA-266



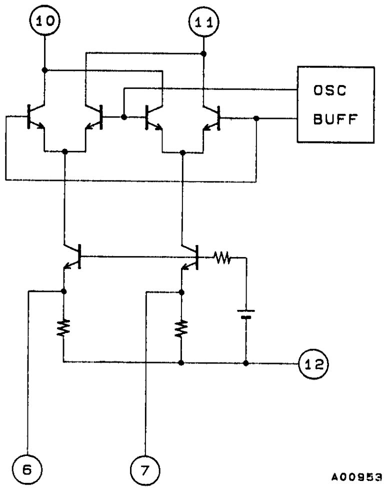
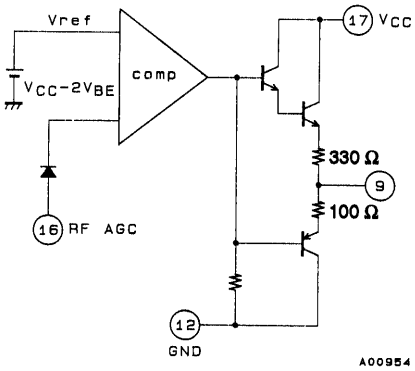
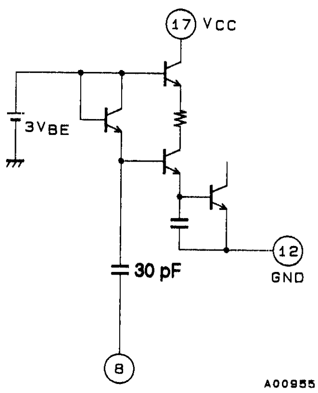
3-1 3T
6-2 $6\frac{1}{2}$ T
2-4 $6\frac{1}{2}$ T

Pin Functions

Pin No.	Function	Equivalent circuit	Note
1	OSC BUFF		
2 3 4 5	OSC Tr. base OSC GND OSC Tr. emitter OSC V_{CC}		Colpitts oscillator

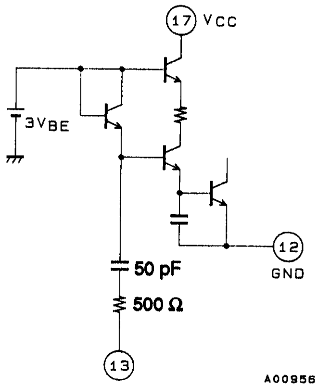
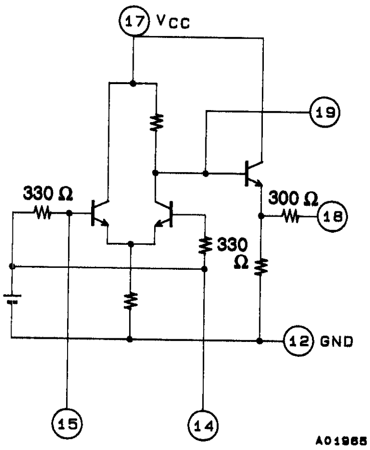
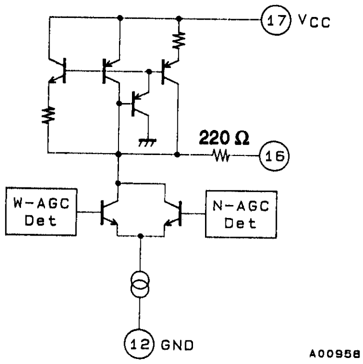
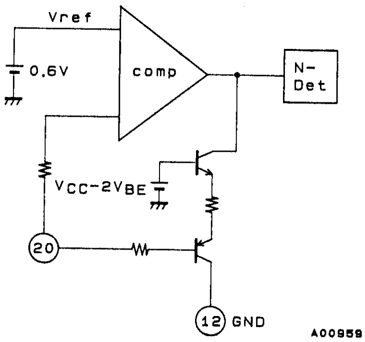
Continued on next page.

Continued from preceding page.

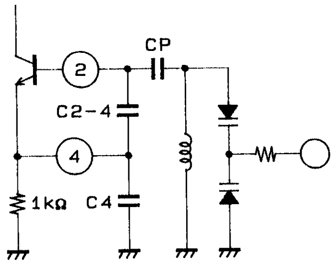
Pin No.	Function	Equivalent circuit	Note
6 7 10 11	Mix input (1) Mix input (2) Mix out (1) Mix out (2)		Mixer input usable sensitivity 15 dBμ Mixer input I.M. QS 90.5 dBμ (6.5 dB higher than previous products) Conversion gain 15 dB Input impedance 25 Ω
9	Antenna damping drive output		I_{ANTD} = 10 mA
12	IF GND		
8	W-AGC input		Since the DC cut capacitor is provided on-chip in the pin internal circuit, we have taken steps to prevent incorrect AGC operation due to inter-pin leakage currents.

Continued on next page.

Continued from preceding page.

Pin No.	Function	Equivalent circuit	Note
13	N-AGC input		Since the DC cut capacitor is provided on-chip in the pin internal circuit, we have taken steps to prevent incorrect AGC operation due to inter-pin leakage currents.
14 15 18 19	IF AMP bypass IF AMP input IF AMP output IF AMP gain adjust		IF gain: 25 dB Input and output impedances of 330 Ω The IF gain can be adjusted by inserting a resistor between pins 17 and 19. The gain is at its maximum when there is no resistor inserted.
16	RF AGC output		MOSFET Second gate control
17	IF, AGC, V_{CC}		
20	Keyed AGC input		Controls the narrow AGC.

1. Oscillator Circuit

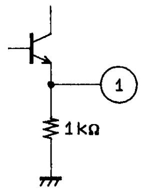


A00452

Steps were taken to prevent AMR degradation during earlier product type AGC operation, since the local oscillator block in this IC has independent Vd (pin 5) and ground (pin 3) connections.

This is a Colpitts oscillator and has the same structure as that used in earlier circuits. The oscillation level and intensity are changed by capacitors C_{2-4}, C_4 and C_P.

2. Local Oscillator Buffer Output



A00453

This buffer is an emitter follower circuit.

If desired, the buffer efficiency can be increased by inserting a resistor between pin 1 and ground to pass more current through the buffer transistor. However, this current must be limited so that Pdmax for the package is not exceeded.

3. Interference Characteristics

The LA1193M incorporates a newly developed 3D-AGC (triple dimension) circuit. This circuit allows three-signal interference characteristics (inter-modulation characteristics) and two-signal sensitivity suppression characteristics to be provided at the same time, a combination of characteristics previously thought difficult to achieve.

- Inter-Modulation Characteristics
  The LA1193M prevents inter-modulation distortion by applying two wide-band AGC circuits.

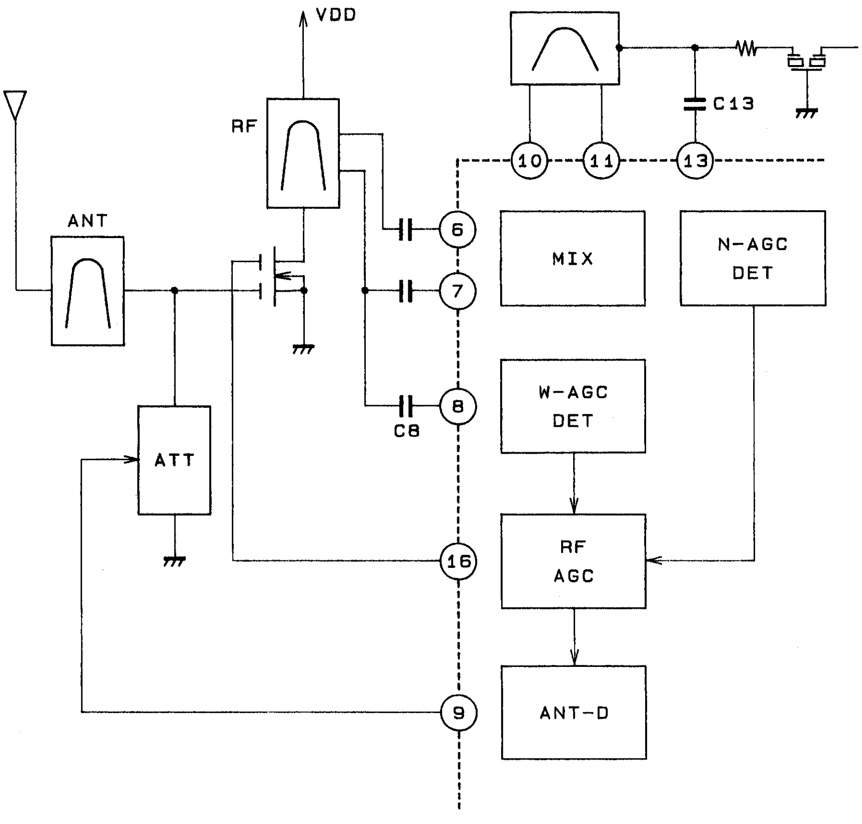


Figure 1

A00454

This double wide-band AGC system consists of two AGC circuits and a narrow AGC (pin 13 input, mixer input detection type) as shown in Figure 1. Figure 2 shows the antenna input frequency characteristics.

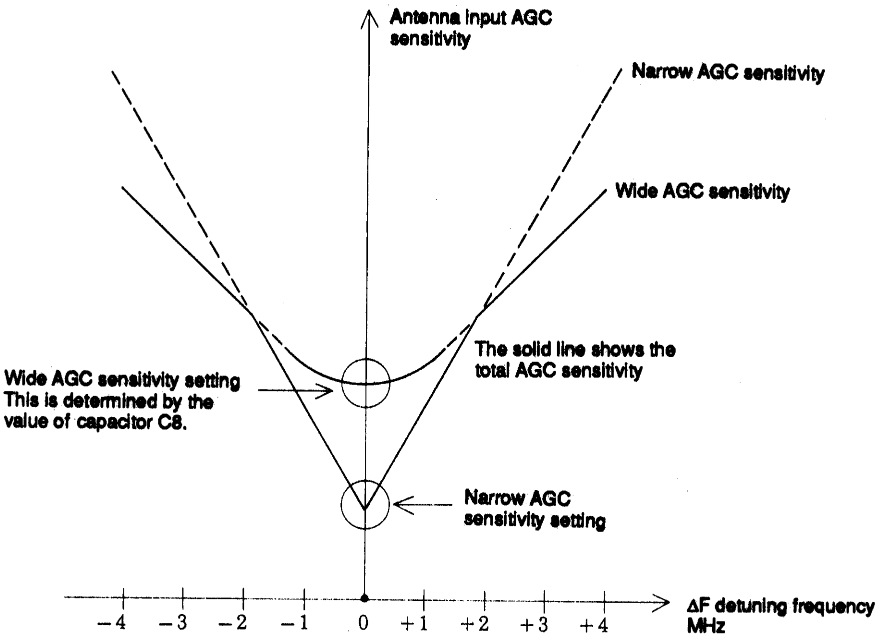


Figure 2 AGC Sensitivity Detuning Characteristics

Features of the Double Wide AGC System

— Since this is a mixer input detection wide-band AGC, it prevents the occurrence of intermodulation due to interfering stations with Δf > 1 MHz. (TV band interference prevention)
— Since this system uses a narrow AGC at the same time, the wide AGC sensitivity can be lowered, thus preventing incorrect operation due to local oscillator injection.
— Optimal sensitivities for any field conditions can be set, since the sensitivities of both the wide and narrow AGC systems can be set by changing the values of external components.
— The input level of the desired station is limited by the narrow AGC. As a result, excessive levels are no longer input to the stages that follow the mixer and the beats at multiples of 10.7 × A are reduced.

• Two-Signal Sensitivity Suppression Characteristics

Previously, keyed AGC systems were used to provide good intermodulation distortion and two signal sensitivity suppression characteristics at the same time. However, in previous keyed AGC systems, when the desired station would fade or drop out, the wide band AGC level would become essentially zero. As a result, the automatic station selection function would malfunction and blocking oscillation would occur in the presence of strong interfering stations. Thus keyed AGC systems were extremely hard to use in actual practice. Sanyo has developed a new AGC system (3D-AGC) that solves these problems and allows the construction of extremely simple application circuits. The LA1193M/V incorporates this AGC system.

What is the 3D-AGC system?

It is a system that determines the wide-band AGC level by using information that has the following three frequency characteristics.

RF and antenna circuit information	Mixer input AGC	Three dimensions
Mixer circuit information	Mixer output AGC	
C, F and selectivity information	S-meter output	

3D-AGC Features

Feature	Merit
The narrow AGC sensitivity, which operates for Δf of less than 1.5 MHz, is controlled independently according to the field strength of the desired station.	• This is effective as a measure for mitigating two signal sensitivity suppression.
The narrow AGC sensitivity is controlled at V20 values under 2 V.	• This allows two signal sensitivity suppression to be mitigated without deterioration in the three signal characteristics.
The wide AGC operates even when V_{20} is zero, i.e., when the desired station does not exist.	• This allows the prevention of incorrect stopping on intermodulation signals during search. • This allows the prevention of intermodulation occurring in the antenna and RF modulation circuits in the presence of strong interfering stations. Prevention of blocking oscillation due to AGC operation is also possible.
The N-AGC and the W-AGC sensitivities can be set independently.	• This allows optimal settings to match the reception field conditions.
The system has two AGC systems, the N-AGC and the W-AGC.	• Since the narrow AGC operates at the desired station and at adjacent stations, it is possible to reduce the wide AGC sensitivity. This prevents incorrect AGC operation due to local oscillator injection.

3D-AGC Sensitivity, Δf and V20 Characteristics

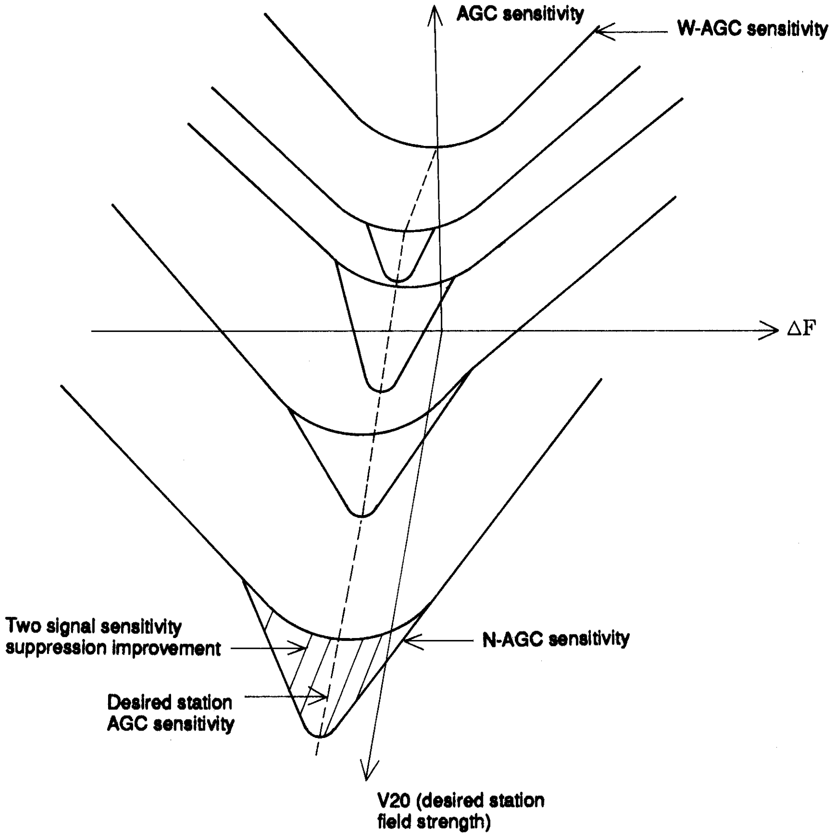


Figure 3 3D-AGC Sensitivity, Δf and V20 Characteristics

— The W-AGC sensitivity is determined by the antenna RF circuit selectivity independently of V_{20}.

— The N-AGC sensitivity is determined by the antenna, RF and mixer circuit total selectivity when V_{20} is 0.6 V or greater. It is determined by that selectivity and V_{20} when V_{20} is over 0.6 V.

— The improvement in two-signal sensitivity suppression is the shaded area in the total AGC sensitivity and corresponds to the section occupied by the N-AGC.

4. Mixer

The mixer circuit used in this IC is a balanced input/balanced output double balance mixer circuit.

- Input Format

Emitter input
Input impedance: 25 Ω

Optimization of the component geometry, emitter current and bias allow this circuit to achieve the following performance.

Mixer input usable sensitivity: 15 dBμ
Mixer input IMQS*: 90.5 dBμ

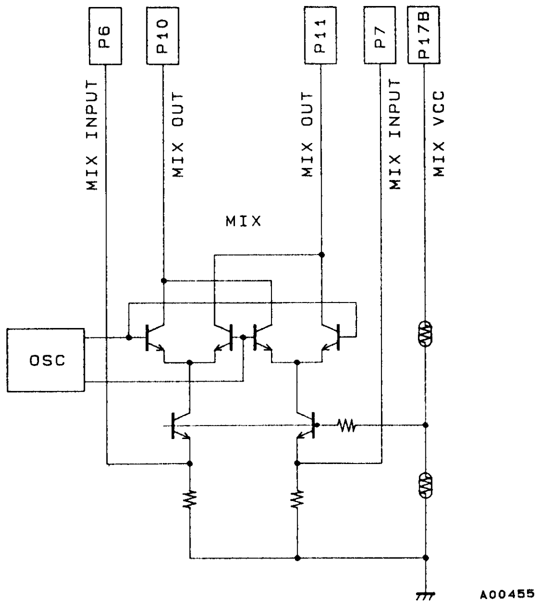


Figure 4 Mixer Circuit
(Improved by 6.0 dBμ over previous products.)

Note: * Mixer input IMQS is defined as follows:

f_r = 98.8 MHz, no input
f_{u1} = 98.8 MHz, 1 kHz, 30% modulation
f_{u2} = 99.6 MHz, no modulation

IMQS is the interference 1 and 2 input levels such that when an interference signal with the same level is input to the mixer and distortion occurs at the mixer, the generated IM output has a S/N ratio of 30 dB.

5. IF Amplifier

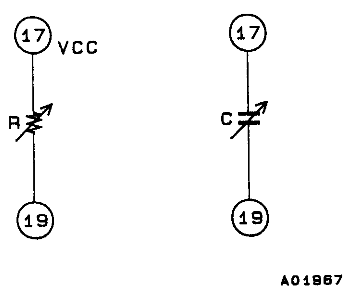
This IF amplifier is a single stage differential amplifier.

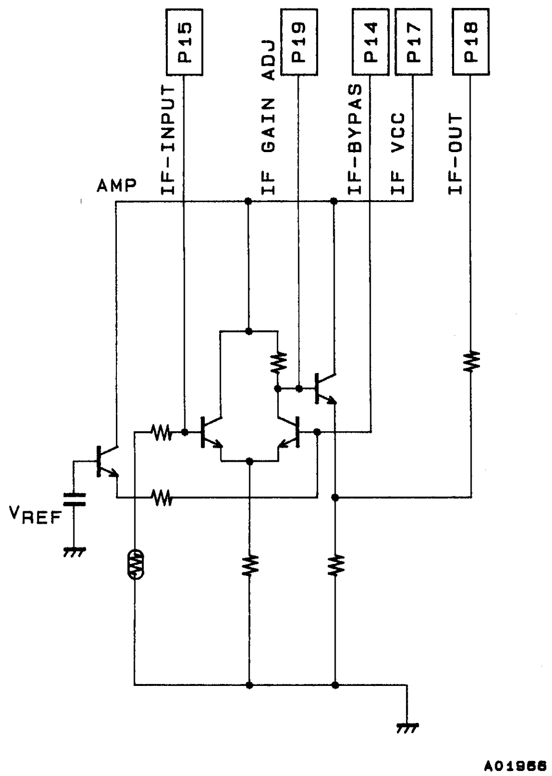
Specifications

Input impedance:	330 Ω
Output impedance:	330 Ω
Gain:	25 dB

Gain adjustment can be provided using either of the methods shown.

IF Gain adj





Temperature Characteristics

The LA1193M/V uses Vref temperature characteristics correction to hold the gain temperature characteristics to the low level of about 1 dB over the range –30 to +80°C.

6. AGC Circuit

The LA1193M/V uses pin diode antenna damping (pin 9) and MOSFET second gate voltage control (pin 16) for AGC. The AGC operating sequence is as follows:

Antenna damping (pin diode) → MOSFET second gate voltage control
(attenuation) 20 dB (attenuation) dB

The above AGC sequence is used for the following reasons.

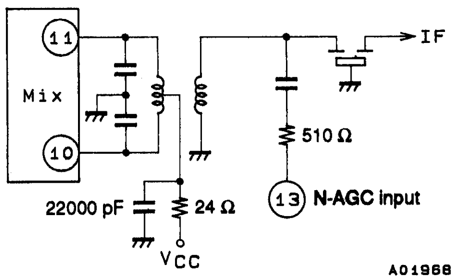
- Intermodulation distortion can occur if a signal of 110 dBμ or larger is input to the antenna circuit varactor diode. In such situations, if the AGC sequence was MOSFET second gate voltage control followed by pin diode antenna damping, as long as the receiver was not in a strong field where the 60 dB or higher AGC attenuation operates, input limitation due to the antenna circuit varactor diode would operate. Therefore, we feel that the AGC operating sequence employed is appropriate.

- Consider the problem of AGC loop stability. If the two AGC loops (the antenna damping AGC loop and the MOSFET second gate control AGC loop) operate, the AGC system would become unstable and have an excessively large influence on the transient response. Therefore the following structure cannot be used.
  MOSFET second gate control → antenna damping → MOSFET second gate control
  The AGC operating conditions are the same as those for the LA1175M.

- Narrow AGC circuit

  Since the LA1193M/V's N-AGC (which detects the mixer output) is set to have a high sensitivity, care is required to avoid incorrect operation. In particular, there must be adequate separation from the local oscillator block on the printed circuit board pattern. Also, a resistor of at least 500 Ω must be inserted at the pin 13 input. A low-pass filter is formed by the insertion of this resistor. This low-pass filter prevents incorrect AGC operation due to the local oscillator.

- The AGC sensitivity setting can be changed by adjusting the value of the capacitor connected at pin 13. Although the AGC sensitivity can be lowered by increasing the value of the series resistor, caution is required since the AGC has its own frequency characteristics.



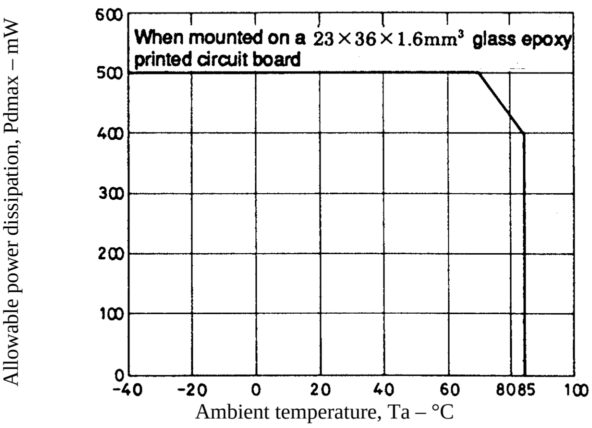
- Wide AGC circuit

  The wide AGC sensitivity is set by the value of the capacitor on pin 8. However, since incorrect operation due to the local oscillator signal may occur if this capacitor is too large, its value must be chosen carefully.

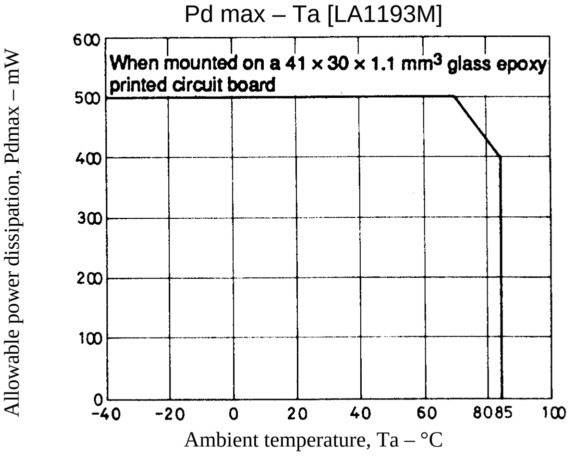
- 3D-AGC

  If the difference in sensitivity between the N-AGC and the W-AGC systems is too large during 3D-AGC operation, the S/N ratio can be degraded in the vicinity of the input where the AGC switches. Therefore, the 3D-AGC setting values must be selected carefully. Although this problem can be ameliorated by applying a time constant to pin 20, in principle, this S/N ratio degradation should be prevented by limiting the sensitivity difference between the two AGC systems.

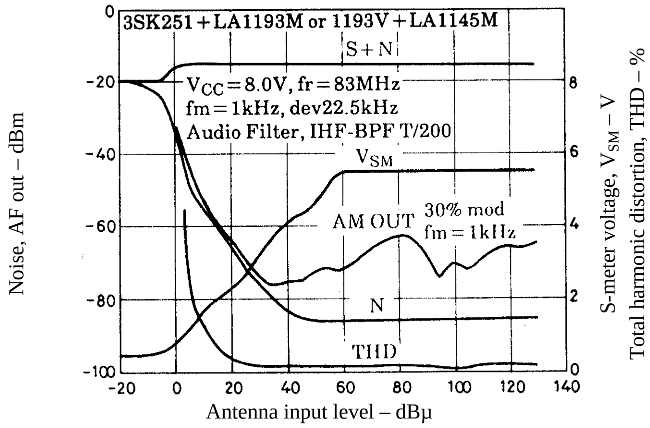
Pd max – Ta [LA1193M]



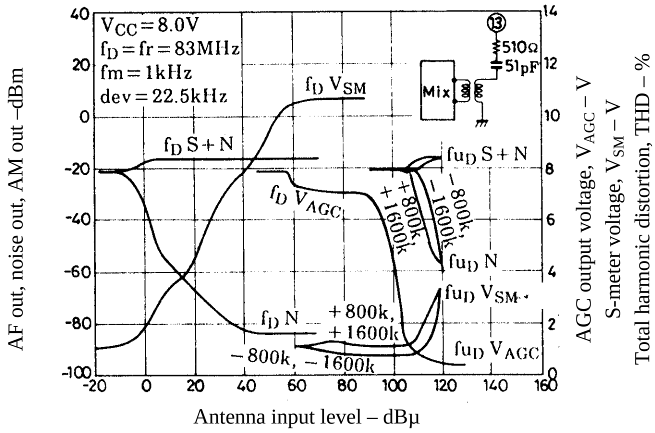
Pd max – Ta [LA1193M]



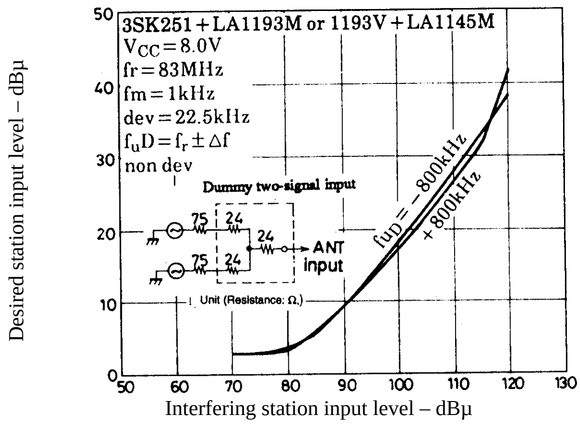
I/O characteristics



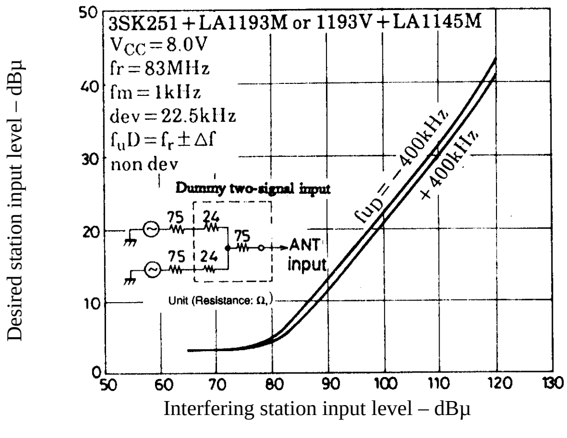
I/O characteristics



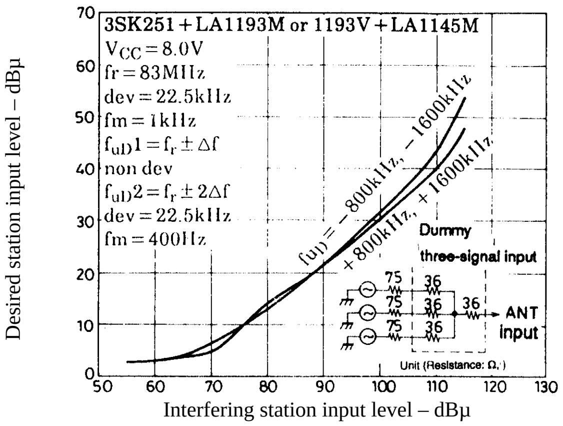
Two-signal interference characteristics



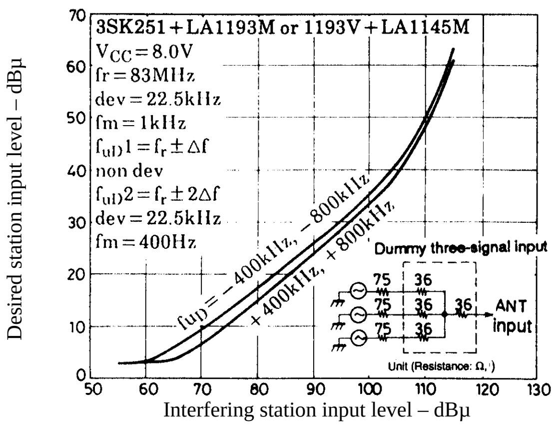
Two-signal interference characteristics



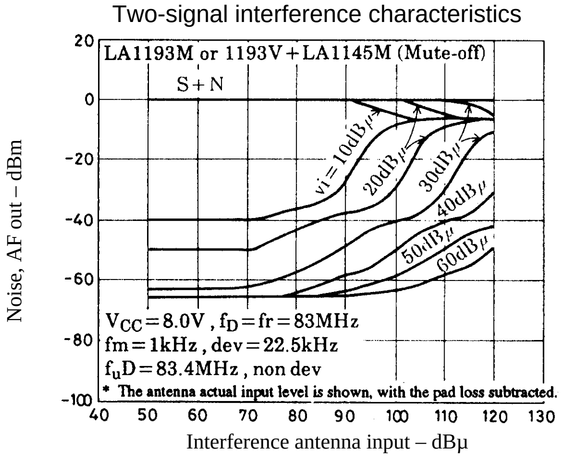
Three-signal interference characteristics



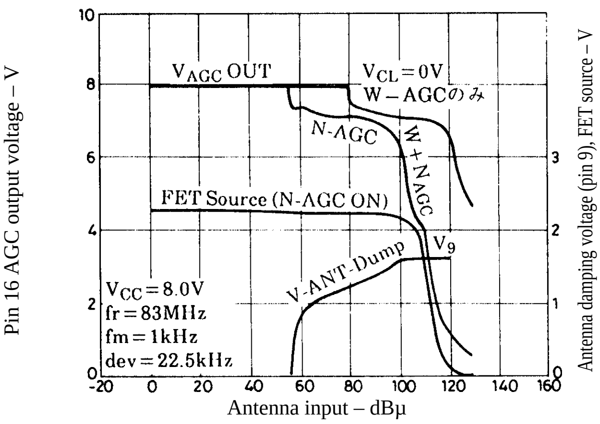
Three-signal interference characteristics



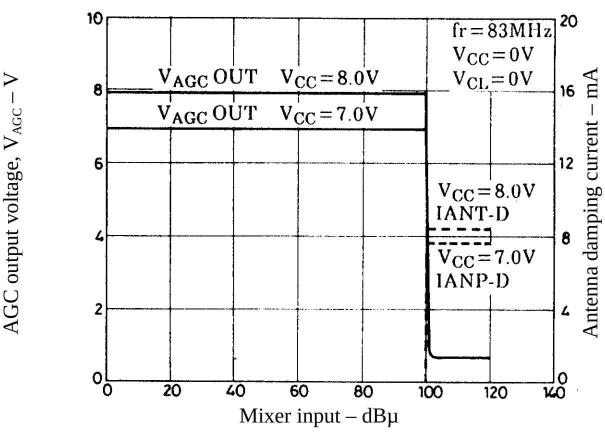
Two-signal interference characteristics

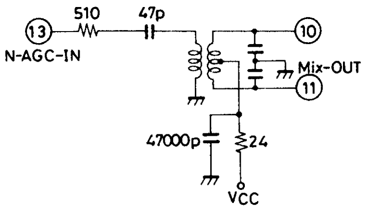


$V_{O\ AGC}$, antenna dump, FET source – $V_{IN\ ANT}$

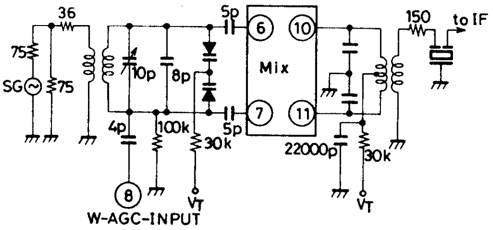


$V_{O\ AGC}$, $I_{ANT\text{-}D}$ – V_{IN} MIX



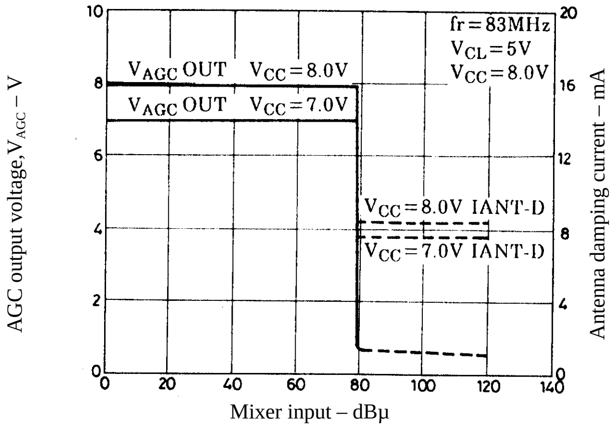


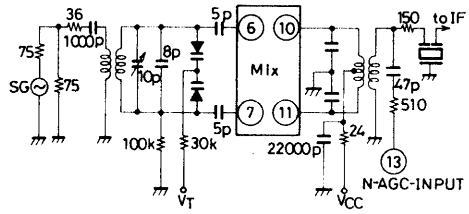
Unit (Resistance: Ω, Capacitance: F)



Unit (Resistance: Ω, Capacitance: F)

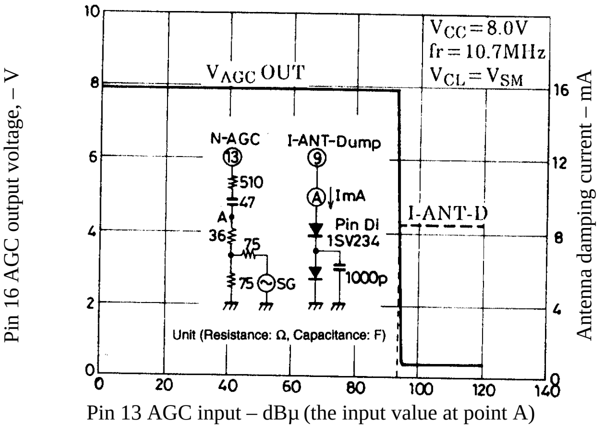
$V_{O\,AGC}$, $I_{ANT\text{-}D}$ – V_{IN} MIX



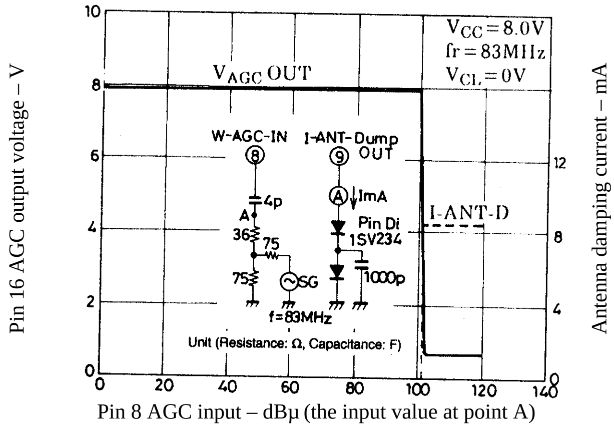


Unit (Resistance: Ω, Capacitance: F)

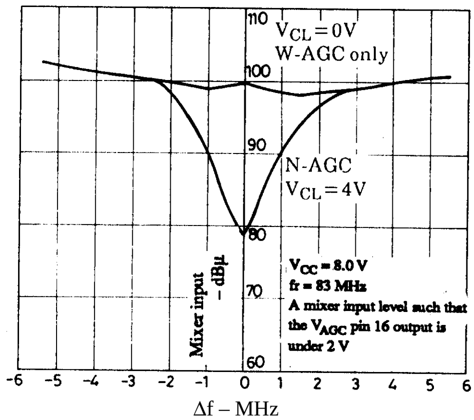
$V_{O\,AGC}$, $I_{ANT\text{-}D}$ – $V_{IN\,AGC}$

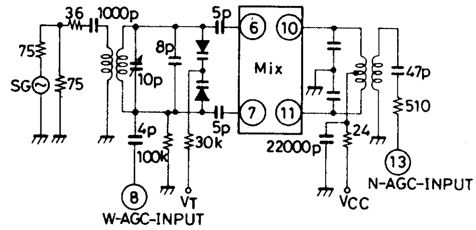


$V_{O\,AGC}$, $I_{ANT\text{-}D}$ – $V_{IN\,AGC}$



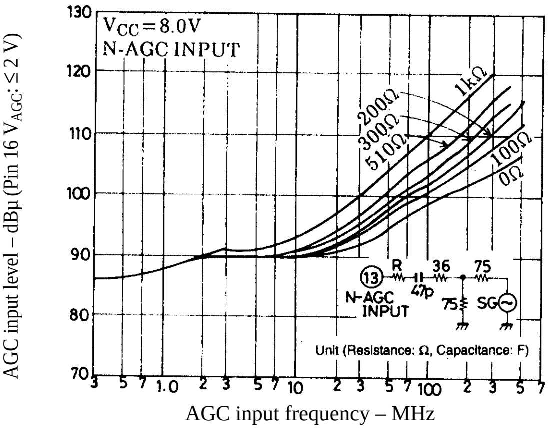
Mixer input – Δf



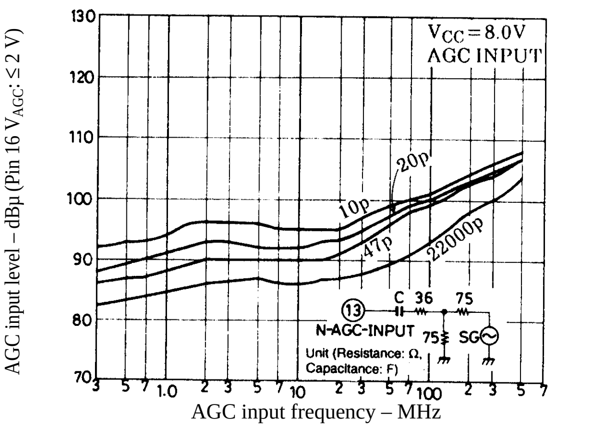


Unit (Resistance: Ω, Capacitance: F)

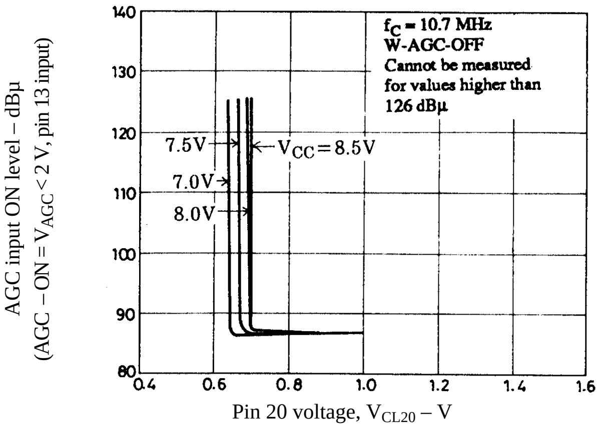
AGC frequency response



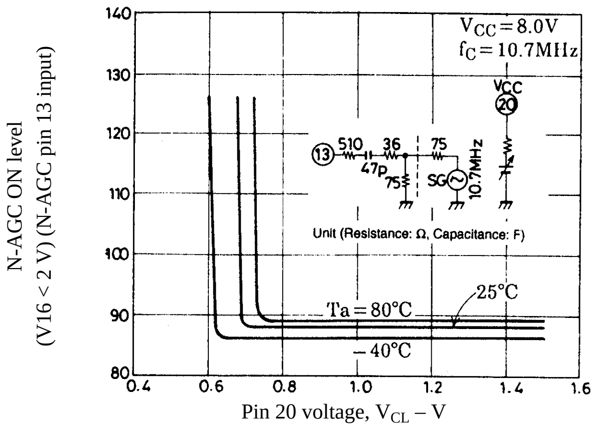
AGC frequency response



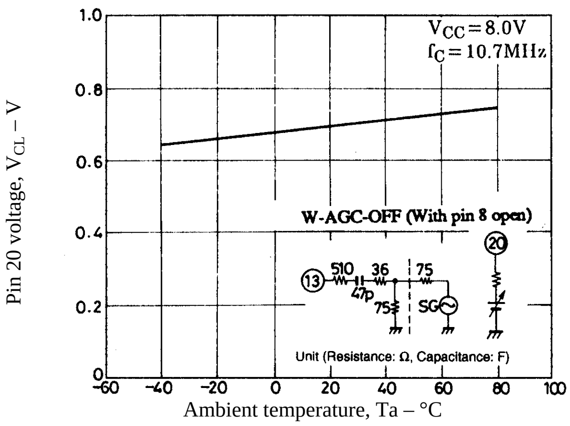
$V_{AGC} – V_{CL20}$



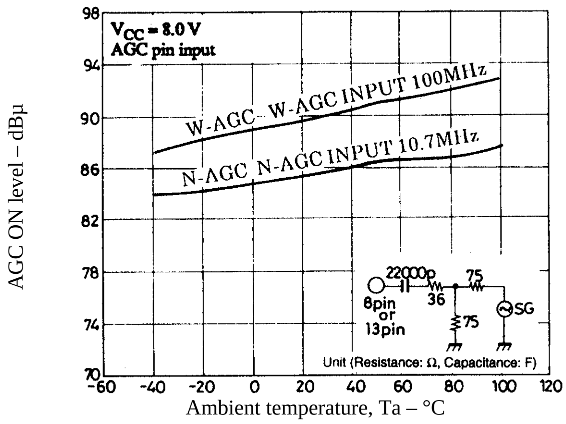
$V_{AGC20} – V_{CL20}$



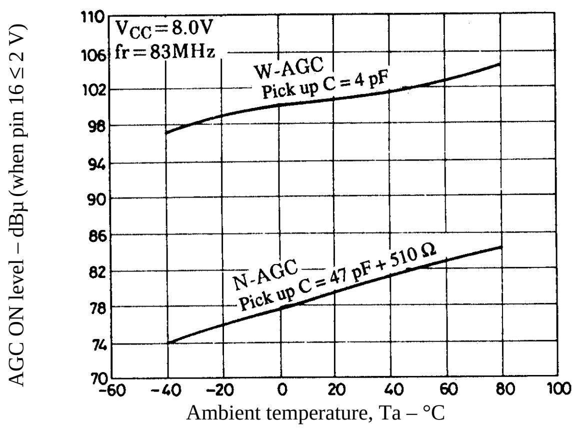
AGC ON level– Ta

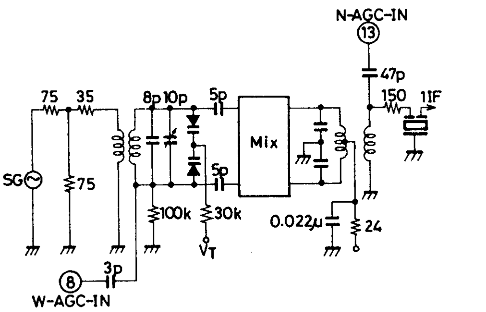


AGC ON level – Ta



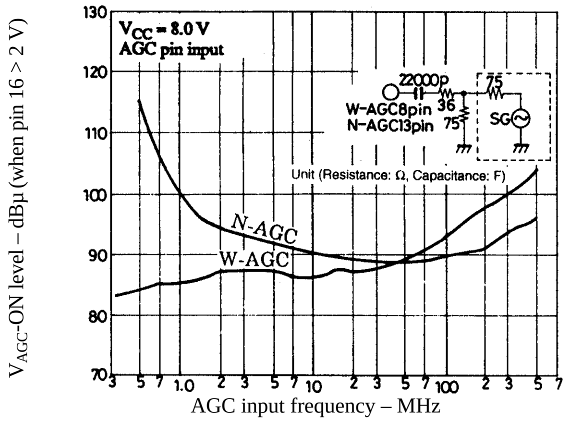
AGC ON level – Ta



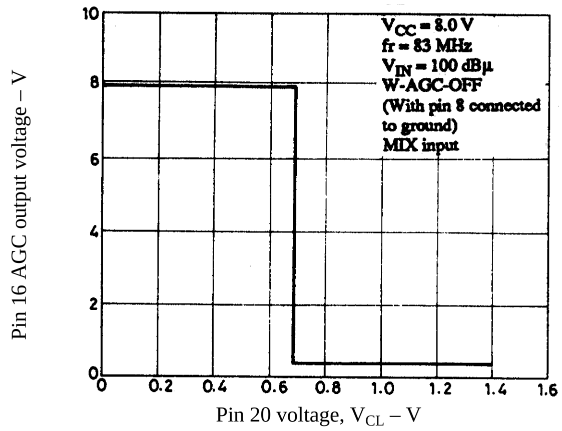


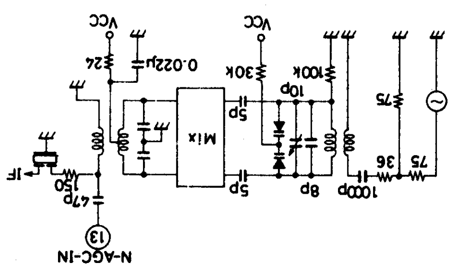
Unit (Resistance: Ω, Capacitance: F)

$V_{AGC} – f$



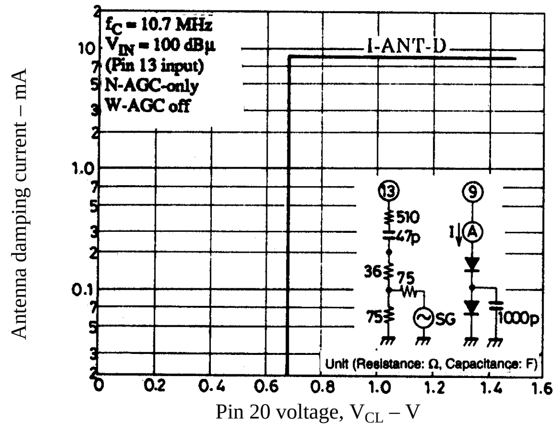
$V_{AGC\ OUT} - V_{CL}$



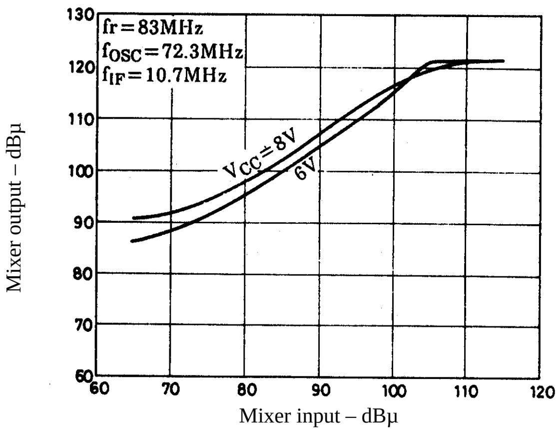


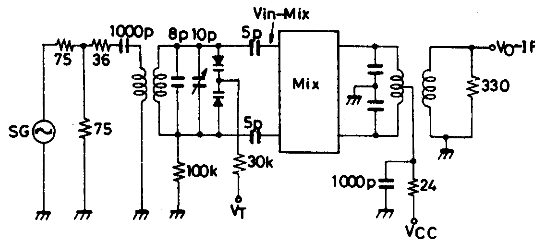
Unit (Resistance: Ω, Capacitance: F)

$I_{ANT\text{-}D} - V_{CL}$



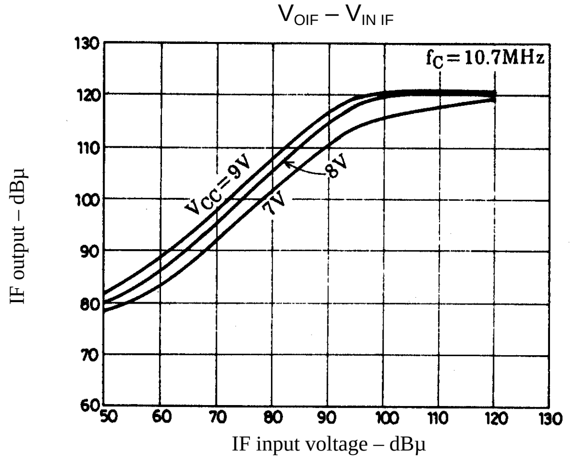
$V_O\ MIX - V_{IN}\ MIX$

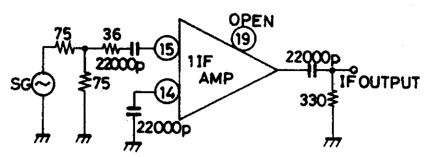




Unit (Resistance: Ω, Capacitance: F)

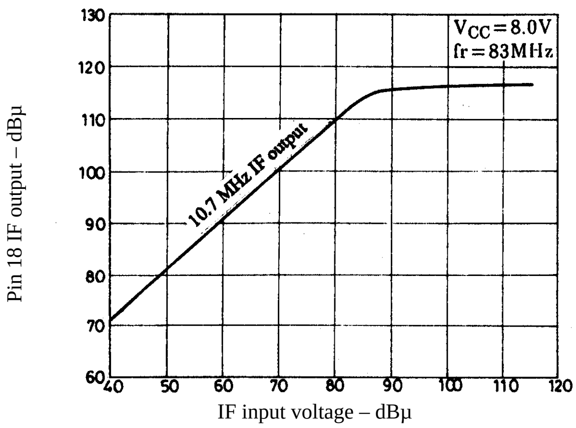
$V_{OIF} - V_{IN\ IF}$

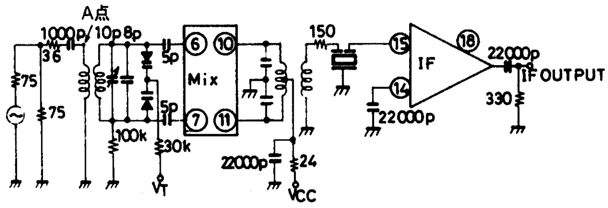




Unit (Resistance: Ω, Capacitance: F)

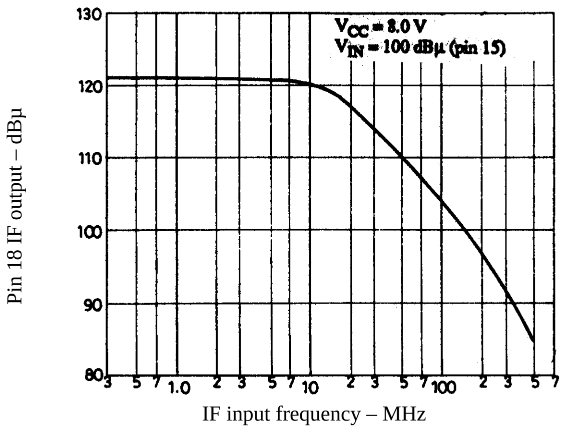
V_O IF – Ta

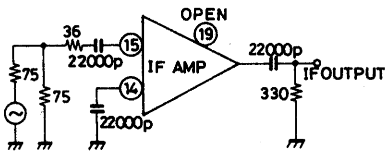




Unit (Resistance: Ω, Capacitance: F)

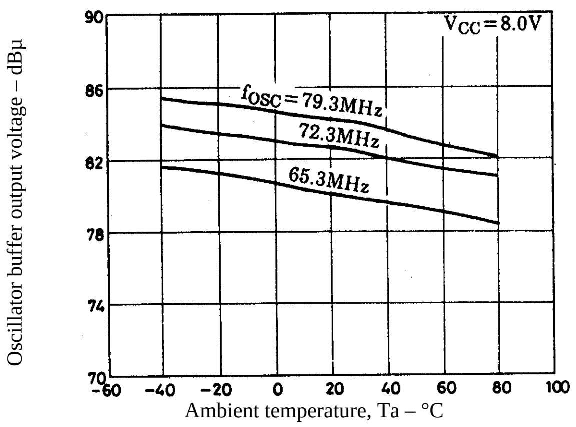
IF AMP – f

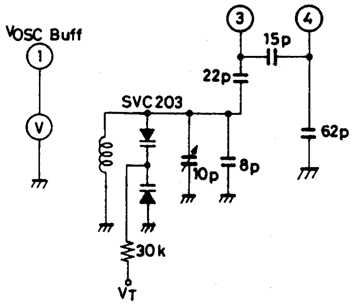




Unit (Resistance: Ω, Capacitance: F)

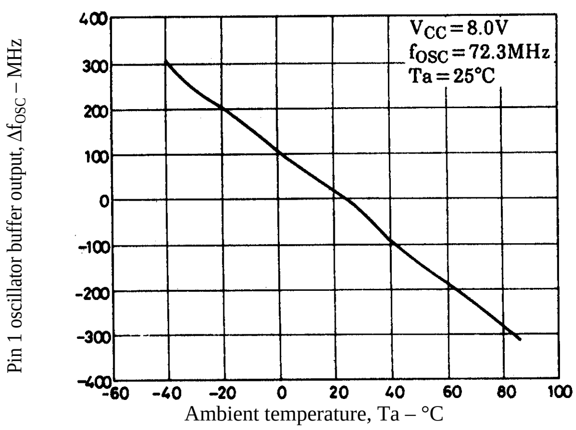
V_{OSC} – Ta

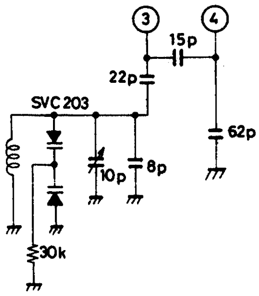




Unit (Resistance: Ω, Capacitance: F)

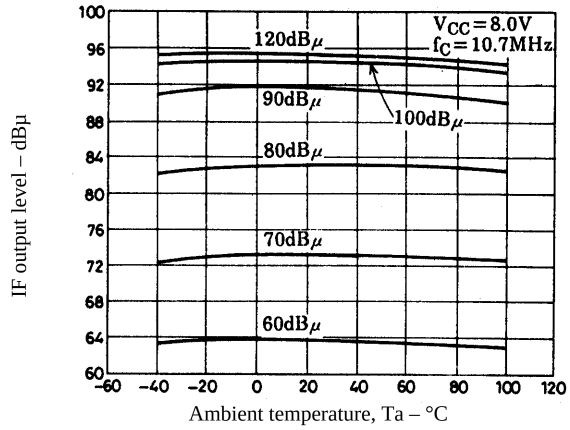
Δf_{OSC} – Ta

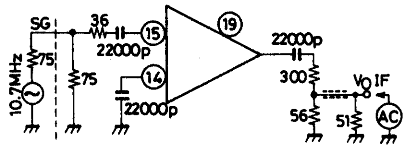




Unit (Resistance: Ω, Capacitance: F)

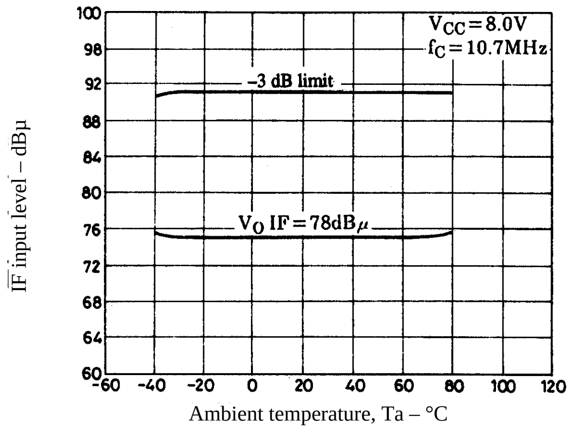
V_{OIF} – Ta

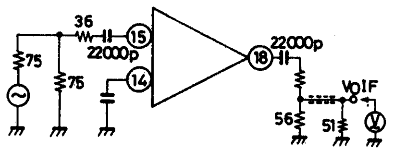




Unit (Resistance: Ω, Capacitance: F)

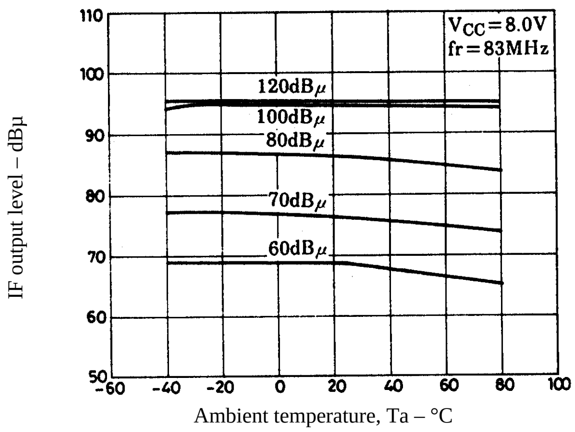
$V_{IN\ IF}$ – Ta

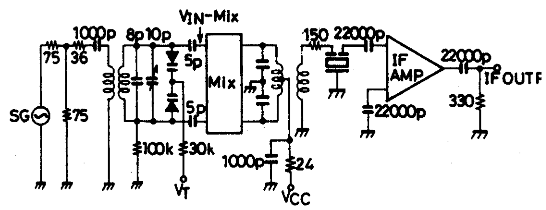




Unit (Resistance: Ω, Capacitance: F)

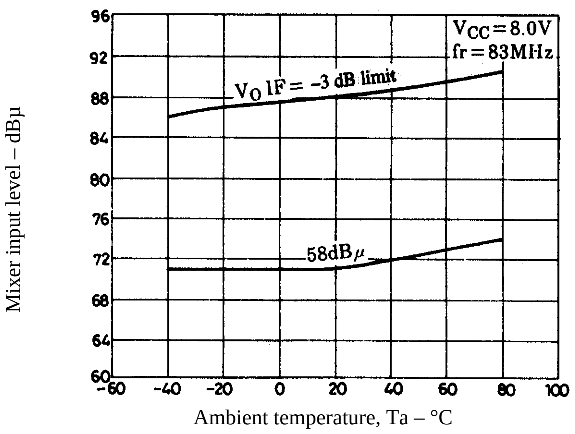
V_O IF – Ta

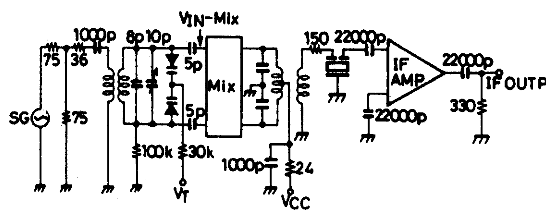




Unit (Resistance: Ω, Capacitance: F)

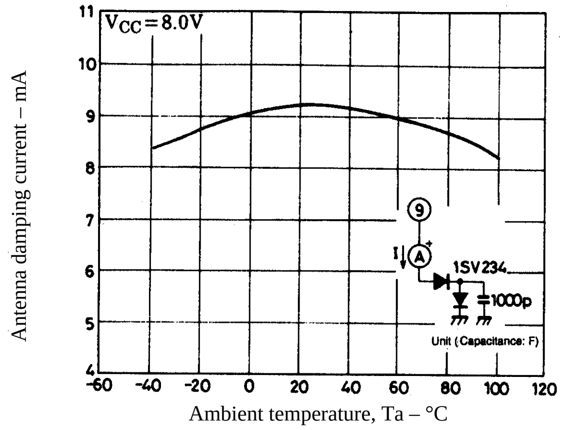
MIX – Ta



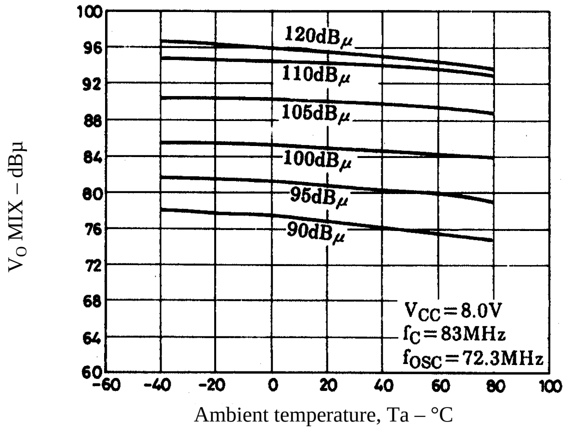


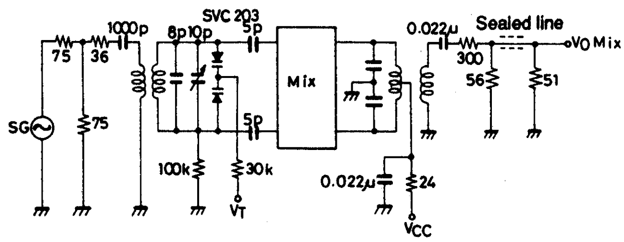
Unit (Resistance: Ω, Capacitance: F)

$I_{ANT\text{-}D}$ – Ta



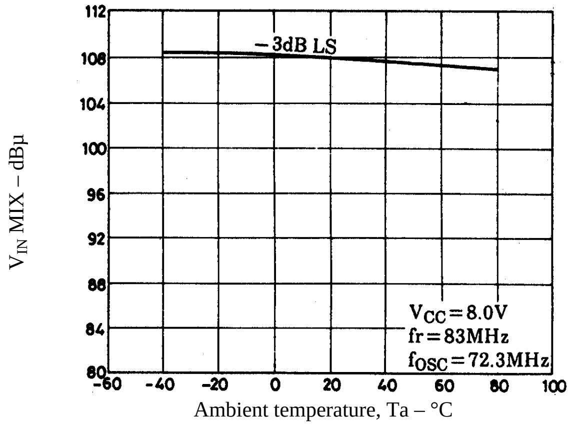
V_O MIX – Ta

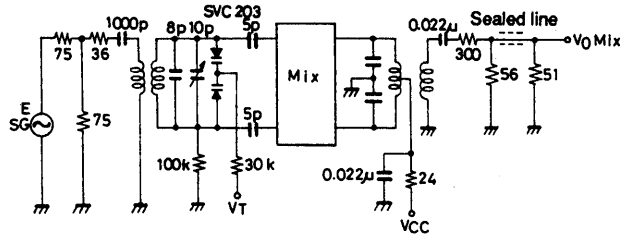




Unit (Resistance: Ω, Capacitance: F)

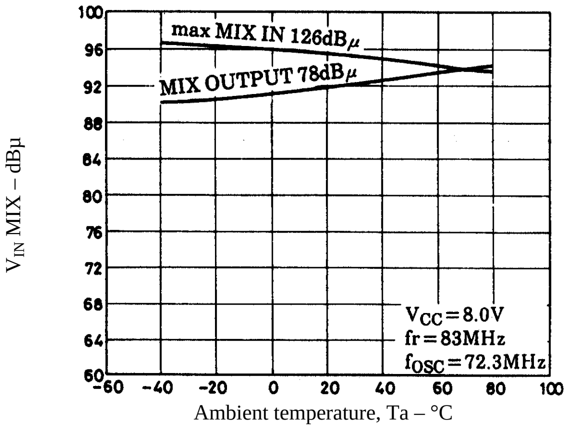
V_{IN} MIX – Ta

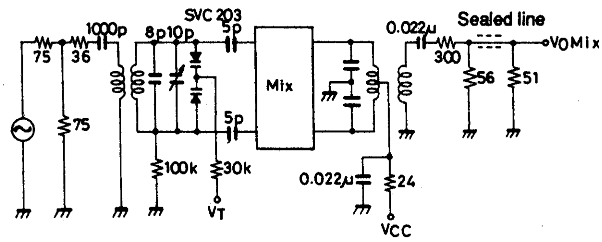




Unit (Resistance: Ω, Capacitance: F)

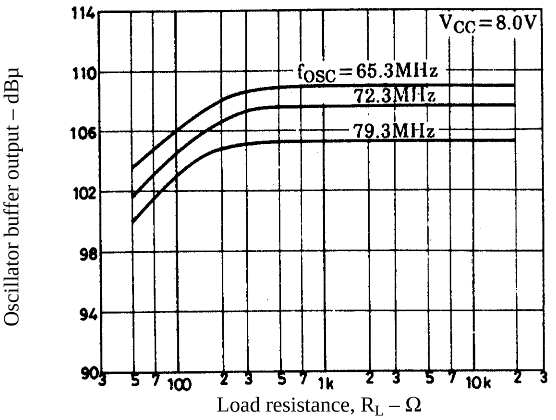
V_{IN} MIX – Ta

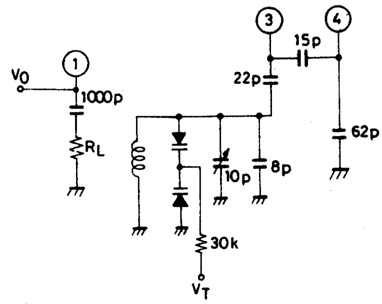




Unit (Resistance: Ω, Capacitance: F)

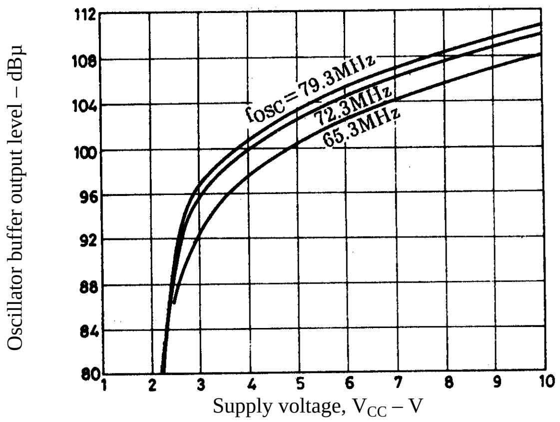
$V_{OSC} - R_L$

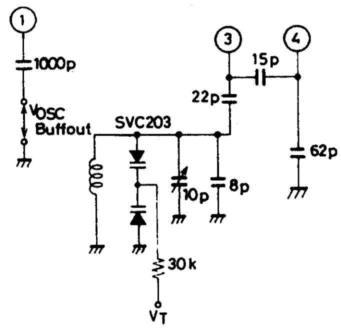




Unit (Resistance: Ω, Capacitance: F)

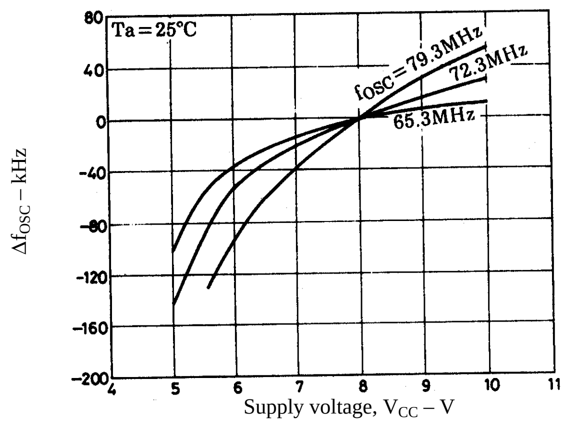
$V_{OSC} - V_{CC}$

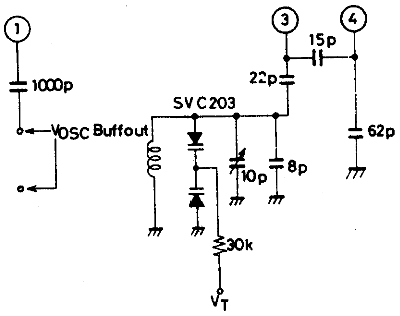




Unit (Resistance: Ω, Capacitance: F)

$\Delta f_{OSC} - V_{CC}$





Unit (Resistance: Ω, Capacitance: F)