6427525 N E C ELECTRONICS INC 05E 23020 D

BIPOLAR ANALOG INTEGRATED CIRCUIT

μPC1322CA

T-77-05-09

ELECTRONIC TUNING AM RADIO RECEIVER

DESCRIPTION

The μPC1322CA is a silicon monolithic integrated circuit designed for automotive AM radio receivers. The μPC1322CA consists of 1st mixer, 1st oscillator, oscillator buffer amplifier, 2nd mixer, 2nd oscillator, IF amplifier, detector, AGC circuit and IF output circuit for station detection. The IF output (SD OUT) is connected IF counter circuit of digital tuning microprocessor.

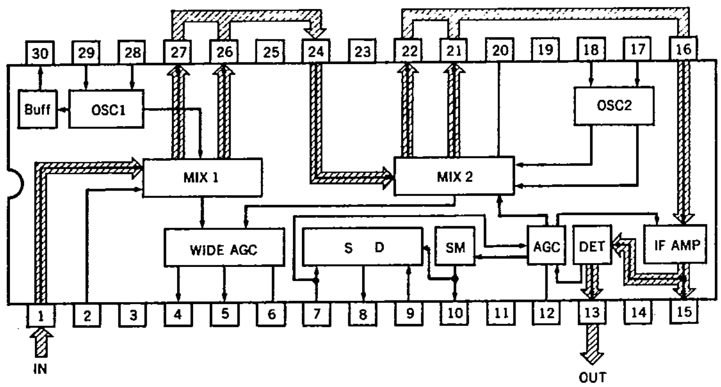
The μPC1322CA's 1st mixer and 1st oscillator convert station signal to 10.7 MHz. And 2nd mixer and 2nd oscillator convert 10.7 MHz signal to 450 kHz. Audio signal is detected from the 450 kHz signal after amplified by IF amplifier.

That is, the μPC1322CA uses up-conversion method, therefore a tracking adjustment free AM radio receiver can be made easily with employing the μPC1322CA.

FEATURES

- Tracking adjustment free
- MW/LW turnover switch is not necessary
- Excellent tweet characteristic
- Excellent sensitivity
- Good matching with AM stereo demodulator

BLOCK DIAGRAM



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ABSOLUTE MAXIMUM RATINGS (T_a = 25 °C)

DC Supply Voltage	V_{CC}	10	V
Package Dissipation	P_D	600	mW
Operating Temperature	T_{opt}	–30 to +75	°C
Storage Temperature	T_{stg}	–40 to +125	°C

RECOMMENDED OPERATING CONDITIONS (T_a = 25 °C)

DC Supply Voltage Range	V_{CC}	7.5 to 9	V

ELECTRICAL CHARACTERISTICS (T_a = 25 °C, V_{CC} = 8 V, f = 1 MHz, f_{mod} = 400 Hz, mod = 30 %)

CHARACTERISTIC	SYMBOL	MIN.	TYP.	MAX.	UNIT	TEST CONDITION
Circuit Current	I_{CC}	34	45	58	mA	NO SIGNAL (IC only)
Signal to Noise Ratio	S/N	51	61		dB	v_i = 74 dBμV
Detector Output Volt	v_o	150	190	220	$mV_{r.m.s.}$	v_i = 74 dBμV
Harmonic Distortion	THD_1		0.2	1.0	%	v_i = 74 dBμV
	THD_2		0.5	1.5	%	v_i = 74 dBμV, m = 80 %
	THD_3		0.4	1.5	%	v_i = 130 dBμV, m = 80 %
Signal Meter Output	V_{S1}		0	0.1	V	NO SIGNAL
	V_{S2}	1.2	2.4	3.0	V	v_i = 30 dBμV
	V_{S3}	3.0	4.0	5.3	V	v_i = 74 dBμV
OSC. Buff. Output	$V_{osc\ Buff}$	106	114	110	dBμV	

TUNER PERFORMANCE CHARACTERISTICS
(T_a = 25 °C, V_{CC} = 8 V, f = 1 MHz, f_{mod} = 400 Hz, mod = 30 %)

CHARACTERISTIC	TEST CONDITION	VALUE	UNIT
Maximum Sensitivity	v_o = 30 $mV_{r.m.s.}$	11	dBμV
Usable Sensitivity	S/N = 20 dB	27	dBμV
Detector Output Voltage	v_i = 74 dBμV	180	$mV_{r.m.s.}$
Total Harmonic Distortion	v_i = 74 dBμV	0.2	%
	v_i = 74 dBμV, mod = 80 %	0.5	%
	v_i = 130 dBμV, mod = 80 %	0.4	%
Signal to Noise Ratio	v_i = 74 dBμV	61	dB
Tweet	v_i = 74 dBμV, 2 IF = 900 kHz	61	dB
Signal Meter Output	NO SIGNAL	0	V
	v_i = 30 dBμV	2.4	V
	v_i = 74 dBμV	4.0	V
SD Sensitivity	8 pin Voltage L to H	21	dBμV

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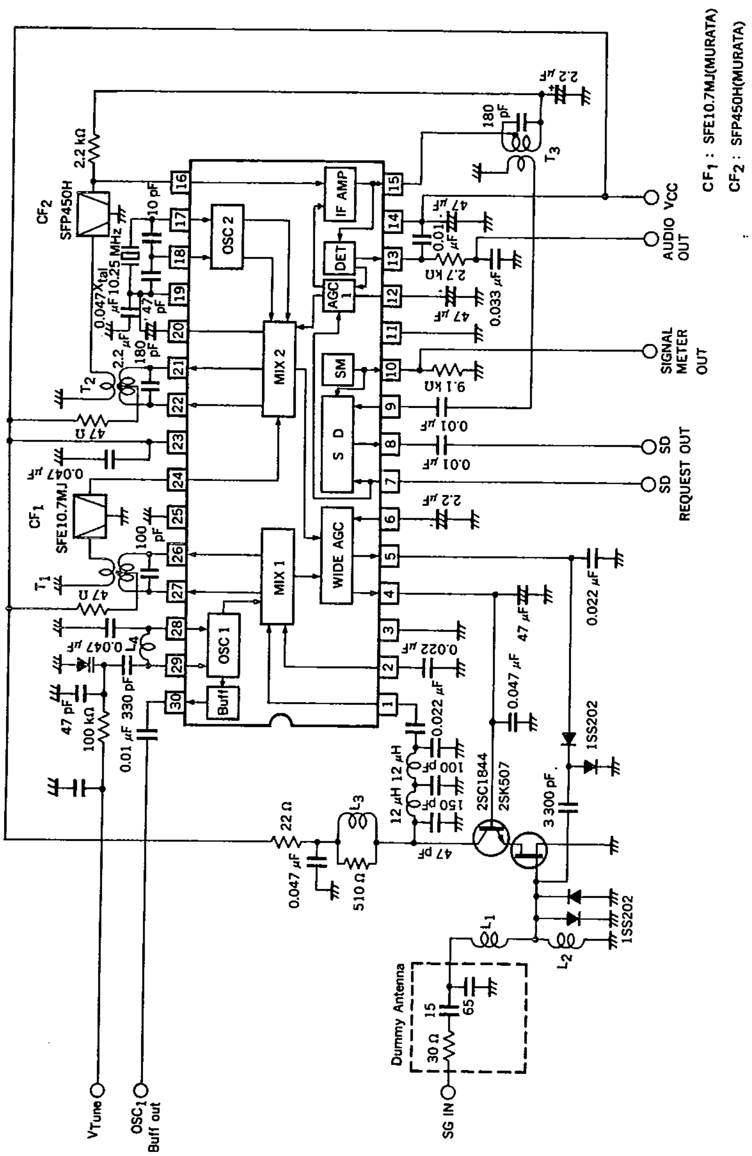
TEST CIRCUIT



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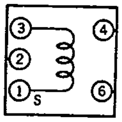
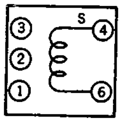
COIL DATA (TOKO INC.)

L_1 X119FNS-16314Z



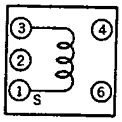
1 – 3 : 15 T
L = 4.7 μH
Q_u > 60

L_2 7PD-1043



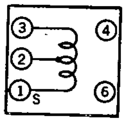
4 – 6 : 1440 T
L = 100 mH
Q > 45

L_3 247BR-0147Z



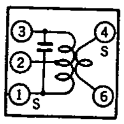
1 – 3 : 274 T
L = 2 mH
Q > 50

L_4 260LC-1694Y



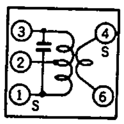
1 – 3 : 8 T 1 – 2 : 4 T
2 – 3 : 4 T
L = 1.8 μH
Q_u > 70

T_1 260LC-1635N



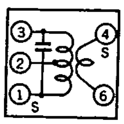
1 – 3 : 14 T 1 – 2 : 7 T
2 – 3 : 7 T 4 – 6 : 2 T
C = 47 pF
Q = 68±20 % f_o = 10.7 MHz

T_2 S7YC-1633N



1 – 3 : 150 T 1 – 2 : 75 T
2 – 3 : 75 T 4 – 6 : 20 T
C = 180 pF
Q = 42±20 % f_o = 450 kHz

T_3 CX7YCS-8986N



1 – 3 : 148 T 1 – 2 : 43 T
2 – 3 : 105 T 4 – 6 : 30 T
C = 180 pF
Q = 40±20 % f_o = 450 kHz

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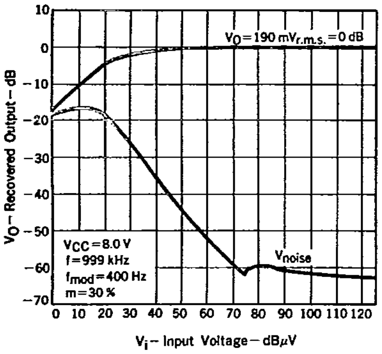
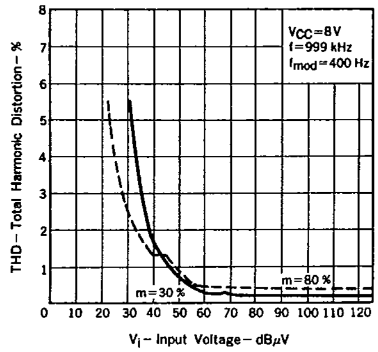
TYPICAL CHARACTERISTICS (T_a = 25 °C)

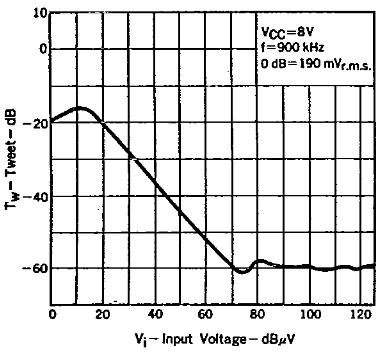
RECOVERED OUTPUT vs. INPUT VOLTAGE



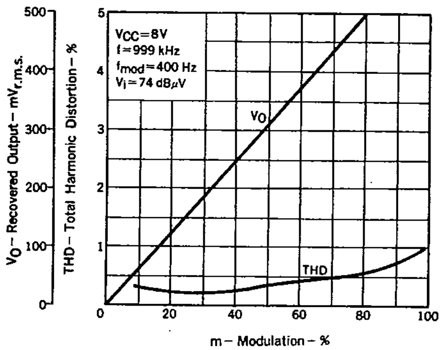
TOTAL HARMONIC DISTORTION vs. INPUT VOLTAGE



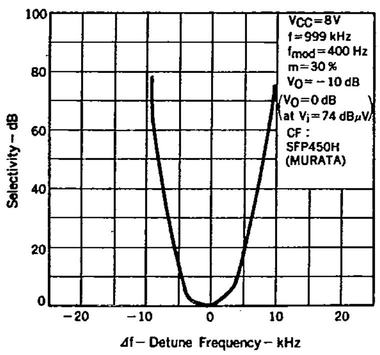
TWEET CHARACTERISTIC



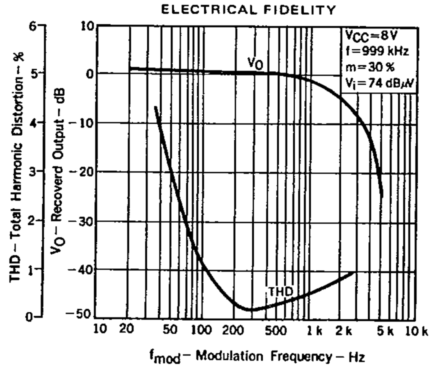
RECOVERED OUTPUT AND TOTAL HARMONIC DISTORTION vs. MODULATION



ONE-SIGNAL SELECTIVITY



ELECTRICAL FIDELITY



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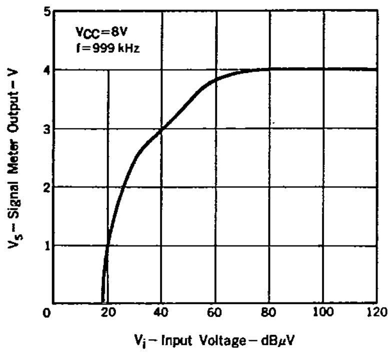
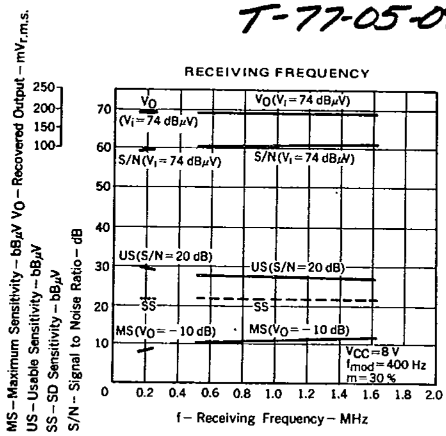
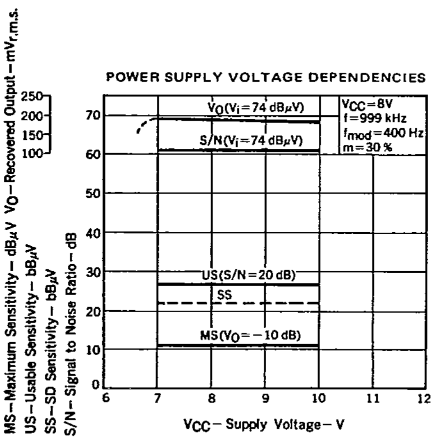
SIGNAL METER OUTPUT VOLTAGE vs. INPUT VOLTAGE



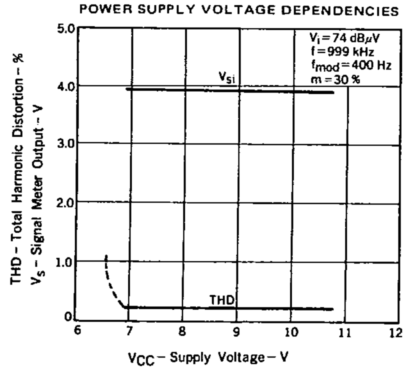
RECEIVING FREQUENCY



POWER SUPPLY VOLTAGE DEPENDENCIES



POWER SUPPLY VOLTAGE DEPENDENCIES



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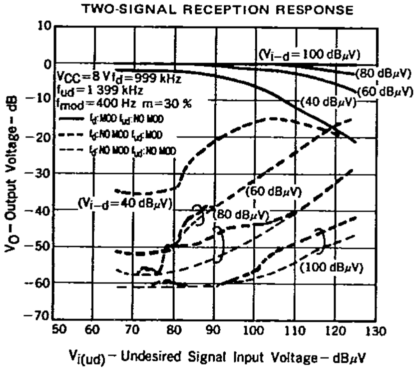
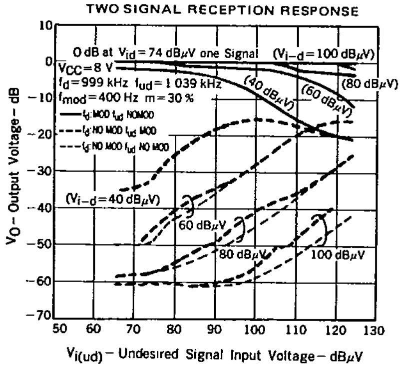
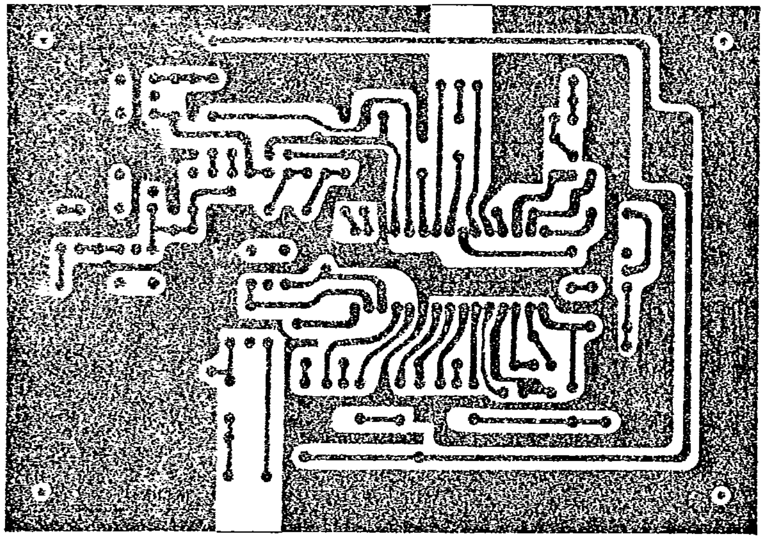
TWO-SIGNAL RECEPTION RESPONSE

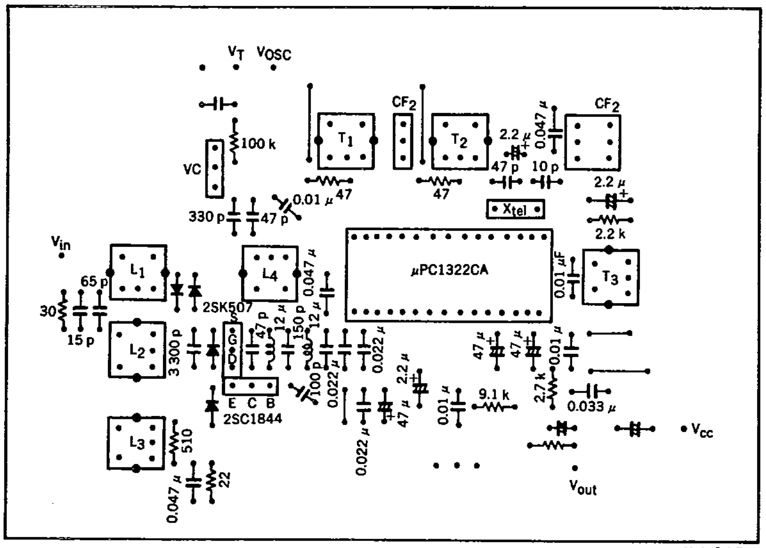


TWO SIGNAL RECEPTION RESPONSE



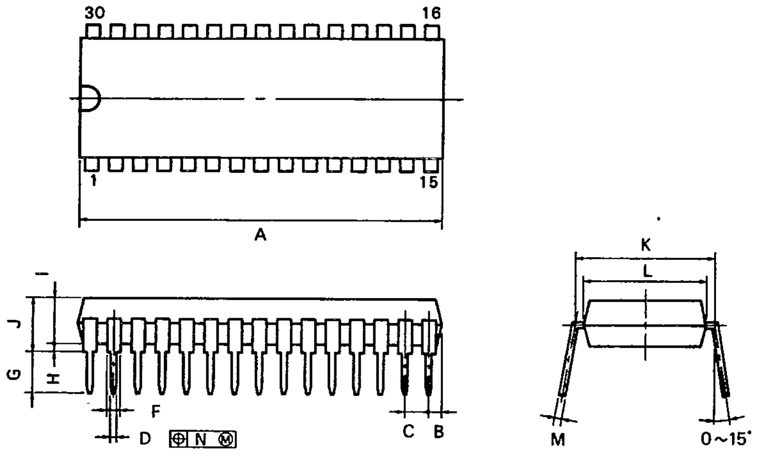
TYPICAL PCB (COPER SIDE)





Unit C : F
R : Ω

30PIN PLASTIC SHRINK DIP (400 mil)



S30C-70-400B

NOTES

1) Each lead centerline is located within 0.17 mm (0.007 inch) of its true position (T.P.) at maximum material condition.

2) Item "K" to center of leads when formed parallel.

ITEM	MILLIMETERS	INCHES
A	28.46 MAX.	1.121 MAX.
B	1.78 MAX.	0.070 MAX.
C	1.778 (T.P.)	0.070 (T.P.)
D	$0.50^{\pm 0.10}$	$0.020^{+0.004}_{-0.005}$
F	0.85 MIN.	0.033 MIN.
G	$3.2^{\pm 0.3}$	$0.126^{\pm 0.012}$
H	0.51 MIN.	0.020 MIN.
I	4.31 MAX.	0.170 MAX.
J	5.08 MAX.	0.200 MAX.
K	10.16 (T.P.)	0.400 (T.P.)
L	8.6	0.339
M	$0.25^{+0.10}_{-0.05}$	$0.010^{+0.004}_{-0.003}$
N	0.17	0.007

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1. GENERAL

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μPC1322CA is a monolithic integrated circuit developed as an AM tuner for car radios or car stereos. Double super-heterodyne method with IF_1 = 10.7 MHz and IF_2 = 450 kHz is employed. Consequently, this IC has free from tracking adjustment and flat sensitivity in the reception band.

It contains two sets of MIX and OSC circuits and an IF amplifier, detector circuit, AGC circuit, and station detector circuit. An electronic tuning receiver can be incorporated with this IC, external RF amplifier and controller such as μPD1713 or μPD1719.

The AGC circuit has wide-band characteristic to provide excellent 2-signal interference characteristics.

The operation and internal circuits of this IC are explained here.

2. FEATURES

- Three varactor diodes with wide variable capacitance range and identical characteristics are not required to enable electronic tuning; Only one varactor diode with a narrow capacity range is necessary.
- Tracking adjustment free.
- Flat sensitivity in the received frequency band.
- Deterioration of cross modulation and blocking with high power input to varactor diode does not occur.
- Excellent image rejection.
- No coil and switching circuit for long waves.
- Use of the antenna AGC circuit enables employment of high $|y_{fs}|$ J-FET without deteriorating the cross modulation characteristics, thus enhancing the usable sensitivity.
- Good tweet characteristics.
- Good S/N ratio.
- The IF_2 ceramic filter determines selectivity and easily meet AM stereo applications.

3. ELECTRICAL CHARACTERISTICS

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Table 1 shows the main electrical characteristics as measured by the standard application circuit.

Table 1 Electrical Characteristics (T_a = +25 °C, V_{CC} = 8 V, f = 1 MHz, f_{mod} = 400 Hz, m = 30 %)

CHARACTERISTIC	SYMBOL	MEASURED VALUE	UNIT	CONDITIONS
Max. sensitivity	MS	11	dBμV	V_{in} at V_O = 10 dB
Usable sensitivity	US	27	dBμV	Input level when S/N = 20 dB
Signal-to-noise ratio	S/N	61	dB	V_i = 74 dBμV
Detection output	V_{OAF}	190	$mV_{r.m.s.}$	V_i = 74 dBμV
Total harmonic distortion	THD	0.2	%	V_i = 74 dBμV
Over load distortion	THD	0.4	%	V_i = 130 dBμV
Image rejection	IMR	–	dB	f = 1.4 MHz, V_O = 40 $mV_{r.m.s.}$, f + 2 IF
IF rejection	IFR	–	dB	f = 0.6 MHz, V_O = 40 $mV_{r.m.s.}$, IF = 450 kHz
Selectivity	ACA	60	dB	f = ±9 kHz
Tweet	Tw	–61	dB	V_i = 74 dBμV, 2 IF
Local oscillation buffer output	$V_{OSC\text{-}out}$	114	dBμV	
SD sensitivity	SS	21	dBμV	Input with 8 pin goes DC High
SD buffer output	SD_{out}	1.8	$V_{p\text{-}p}$	V_i = 70 dBμV
Signal meter output voltage	V_{S1}	0	V	V_i = 0 dBμV
	V_{S2}	2.4	V	V_i = 30 dBμV
	V_{S3}	4.0	V	V_i = 74 dBμV

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4. BLOCK DIAGRAM AND PACKAGE DIMENSION

Figure 1 shows a block diagram. Figure 2 shows package dimension.

Figure 1 Block Diagram

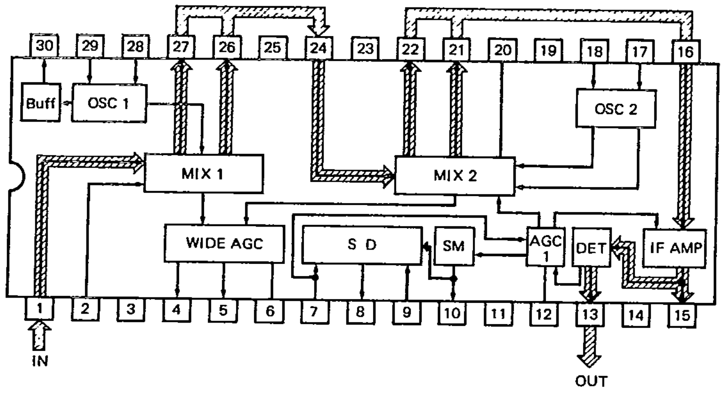
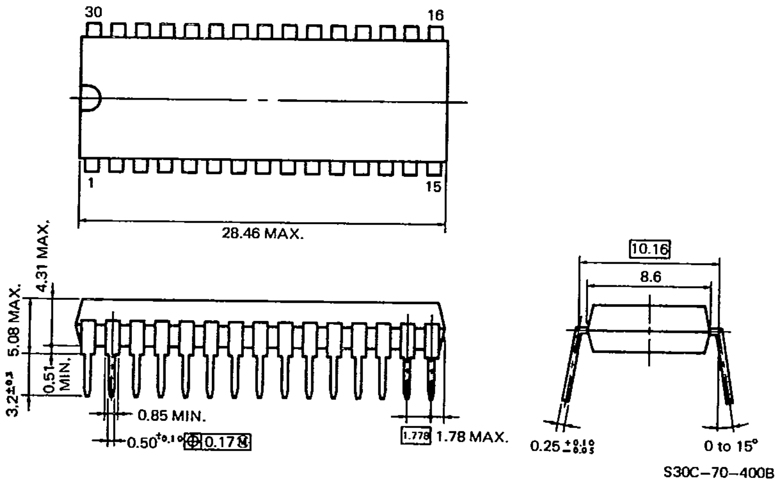


Figure 2 30-pin Plastic Shrink DIP (400 mil) Package Dimensions (Unit : mm)



5. GENERAL OPERATION OF THIS IC

Figure 3 shows the standard application circuit, and Table 3 shows the coil specifications.

The input signal from the antenna is amplified by the non-tuning RF amplifier circuit, passes through the low pass filter (LPF) of approximately 6 MHz, and is input to the first mixer.

To set the first intermediate frequency (IF_1) at 10.7 MHz, the first local oscillation frequency is determined as "Desired frequency + 10.7 MHz" for tuning, and the signal converted into 10.7 MHz passes through the 10.7MHz filter and is input to the second mixer. To pass the 450 kHz filter for selectivity, the second local oscillation frequency is set as 10.25 MHz, converted into the second intermediate frequency of 450 kHz, and 450 kHz signal amplified, and then detected as the audio signal.

Table 2 shows the relationship of these frequencies.

Table 2 Frequency Relationship of μPC1322CA

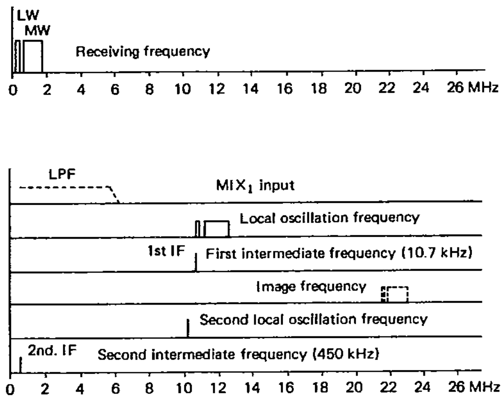


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Figure 3 Standard Application Circuit

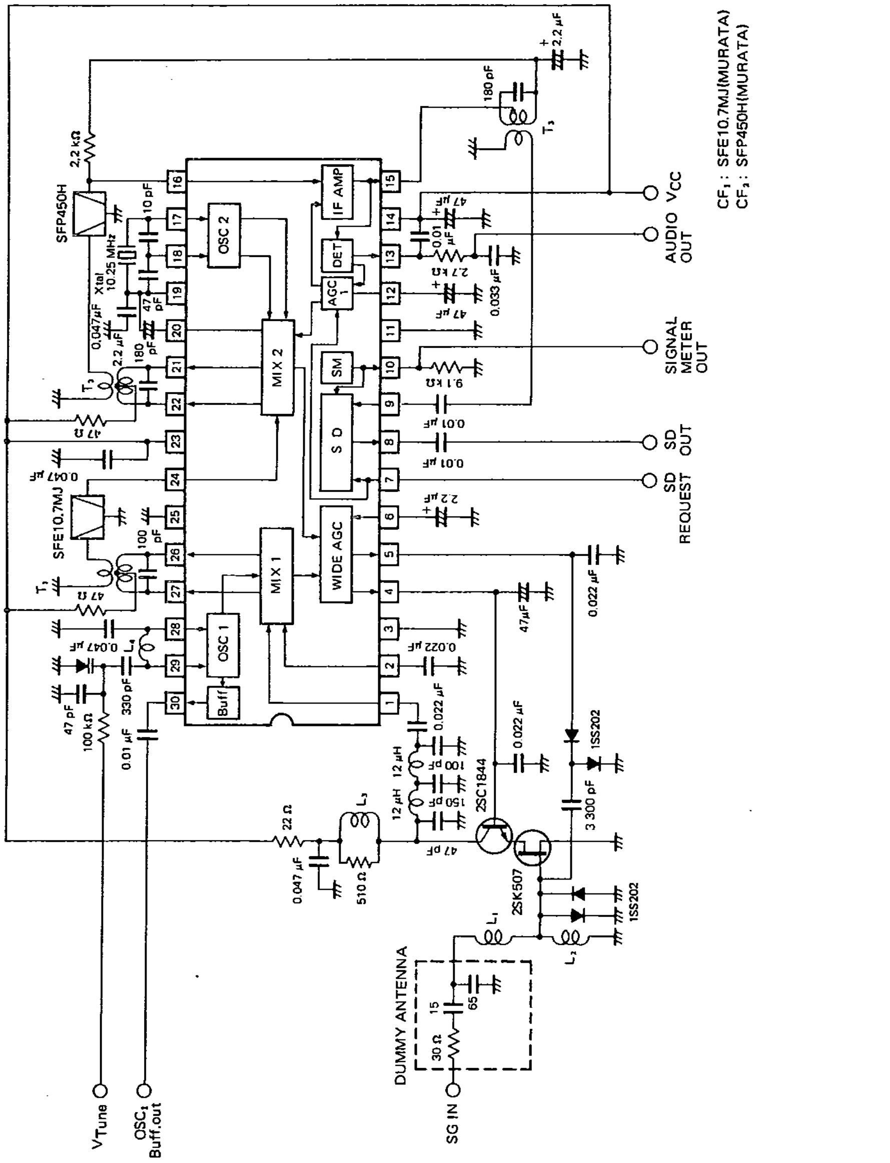
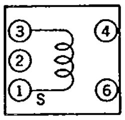
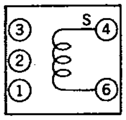
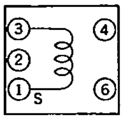
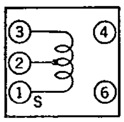
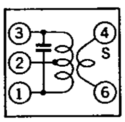
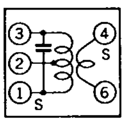
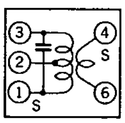


Table 3 Coil Specifications (Toko Corporation) T-77-05-09

ITEM No.	CONNECTION DIAGRAM	TYPE No.	SPECIFICATIONS
L_1		X119FNS – 16314Z	①—③ 15T L = 4.7 μF Q_u > 60
L_2		7PD – 1043	④—⑥ 1440T L = 100 mH Q > 45
L_3		247BR – 0147Z	①—③ 274T L = 2 mH Q > 50
L_4		260LC – 1694Y	①—③ 8T, ①—② 4T, ②—③ 4T L = 1.8 μH Q_u > 70
T_1		260LC – 1635N	①—③ 14T, ①—② 7T, ②—③ 7T, ④—⑥ 2T C = 47 pF Q = 68 ± 20 % f_o = 10.7 MHz
T_2		S7YC – 1633N	①—③ 150T, ①—② 75T, ②—③ 75T, ④—⑥ 20T C = 180 pF Q = 42 ± 20 % f_o = 450 kHz
T_3		CX7YCS – 8986N	①—③ 148T, ①—② 43T, ②—③ 105T, ④—⑥ 30T C = 180 pF Q = 40 ± 20 % f_o = 450 kHz

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6. OPERATION EXPLANATION OF EACH STAGE

6.1 RF Amplifier Circuit Stage

Figure 4 RF Amplifier Circuit Stage

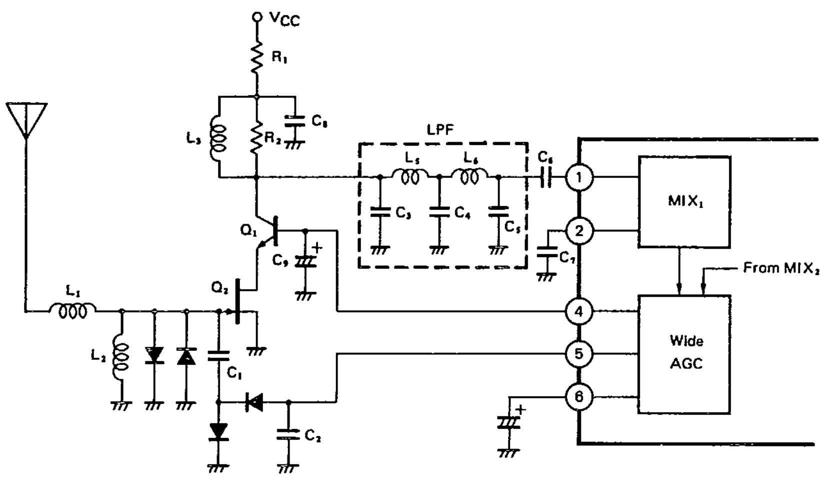


Figure 4 shows the RF amplifier circuit stage.

The car radio antenna is capacity-dependent in the AM band, so that the antenna capacity varies depending on the antenna length, diameter, and cable length. A J-FET is used for its high antenna load impedance and good linearity.

The load of Q_2 is R_2, and L_3 is used for bias voltage between the Q_2 source and drain. This IC has the high IF_1 (10.7 MHz). The image frequency (higher than 21.4 MHz) is removed by the low-pass-filter consisting of L_5, L_6, C_3, C_4, and C_5.

This IC has flat sensitivity in the received band because eliminating the tuning circuit that a conventional IC has.

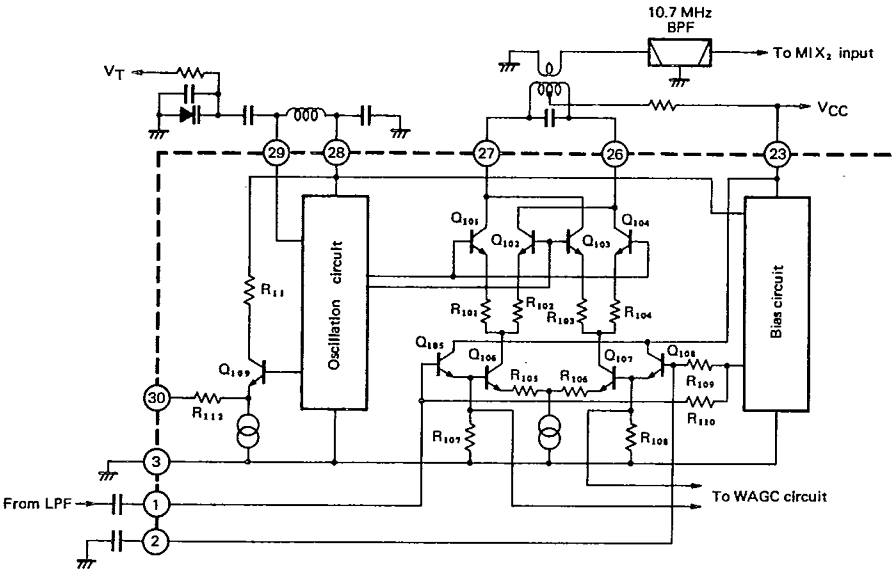
Wide AGC consists of $WAGC_1$ shorting the input signal by C_1 and $WAGC_2$ lowering the voltage between FET source and drain by Q_1.

Low noise, high $|y_{fs}|$, low capacitance FET for Q_2 and Low noise Transistor for Q_1 are required for good sensitivity.

The bias of cascade transistor Q_1 shall be set $V_C > V_B$.

6.2 First Frequency Mixer Stage

Figure 5 First Frequency Mixer Stage



The first mixer circuit is a double-balanced mixer that consists of transistors Q_{101} through Q_{108} (Figure 5). The oscillation output injected to the bases of transistors Q_{101} through Q_{104}, and the RF signal input to the base of Q_{105} are mixed. If mixed frequency matches the resonance frequency of IFT, the output signal is generated from pins 26 and 27. R_{110} related to the input impedance to pin 1 is 1.2 kΩ.

The RF signals input to the base of Q_{105} are sensed by R_{107} and R_{108}, which connects to the wide-band AGC circuit.

The local oscillation output is amplified by the buffer amplifier Q_{109} and output to pin 30. This output is approximately 114 dBμV, and can be directly input to the CMOS LSI for the PLL synthesizer.

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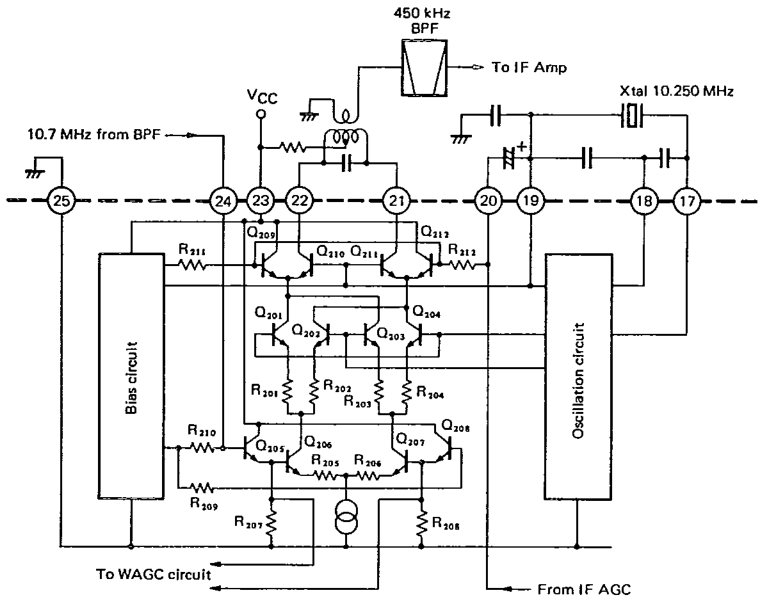
6.3 Second Frequency Mixer Stage

Figure 6 Second Frequency Mixer Stage



The second mixer stage is a double-balanced mixer with almost the same construction as the first mixer. (See Figure 6.) Difference of the first mixer is differential circuits (Q_{209} through Q_{212}). The base potentials of Q_{212} and Q_{209} change the currents of Q_{210} and Q_{212}, and it perform the AGC operation. R_{210} related to the input impedance of this MIX is 300 Ω.

6.4 Intermediate Frequency Amplifier and Detector Stage

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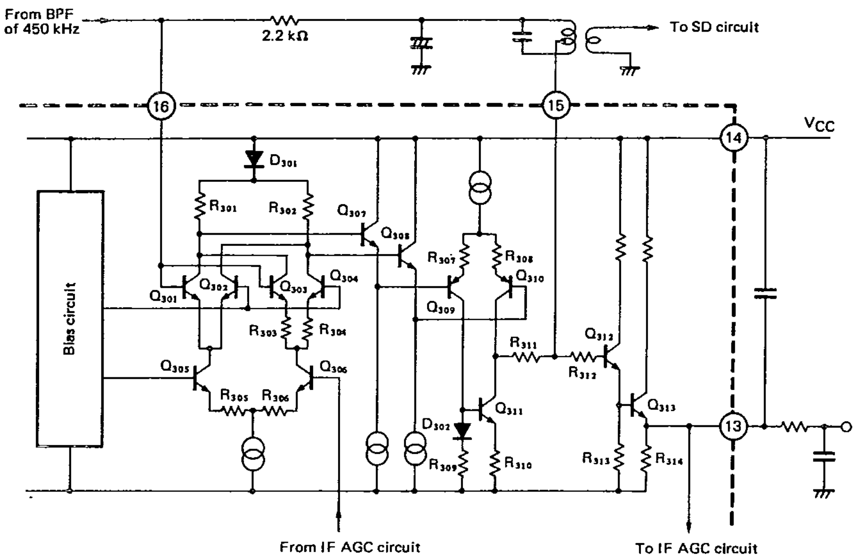
Figure 7 Intermediate Frequency Amplifier and Detector Stage



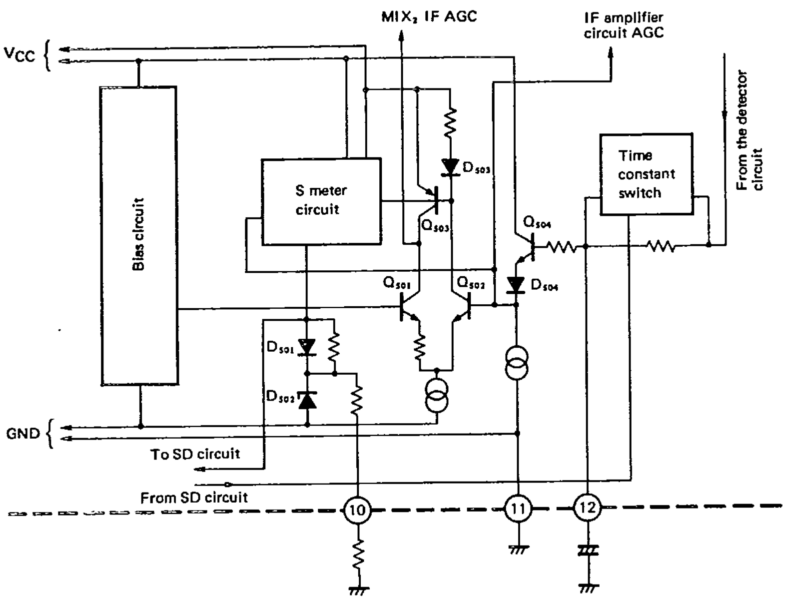
The intermediate amplifier stage consists of the two amplifiers, emitter follower circuits. (See Figure 7.) The first amplifier is the differential amplifier consisting of Q_{301}, Q_{302}, Q_{303}, and Q_{304}. The base potential of Q_{306} changes the current of this differential amplifier and perform the AGC operation. The IF_2 signal amplified by the first amplifier and passed through the emitter follower circuit of Q_{307} and Q_{308}, is amplified by the second amplifier consisting of Q_{309} and Q_{310}.

The detector stage consists of Q_{312} and Q_{313} and the audio signal outputs from pin 13.

6.5 AGC Circuit Stage

μPC1322CA has two independent AGC circuits: the IF AGC corresponding to the IF stage, and the wide AGC corresponding to the RF stage.

Figure 8 IF AGC Stage



The IF AGC, as explained in Section 6.3 and 6.4, is controlled by pin 12 voltage which is smoothed detector output (pin 13) voltage by capacitor. The signal meter output is provided to output the current in proportion to the operating voltage of AGC circuit.

Figure 9 shows the relationship between the IF AGC operating voltage and input voltage characteristics, and Figure 10 shows the relationship between the signal meter voltage and input voltage characteristics.

Figure 9 Relation between IF AGC Operating Voltage and Input Voltage Characteristics

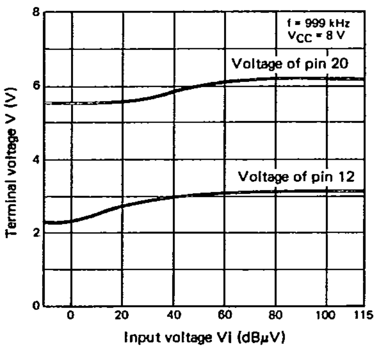


Figure 10 Relation between Signal Meter Output Voltage and Input Voltage Characteristics

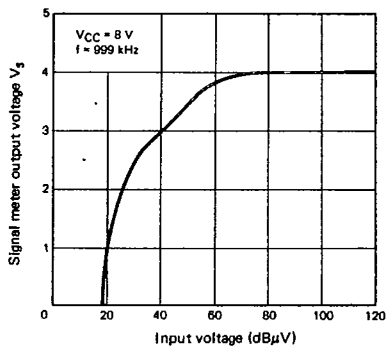
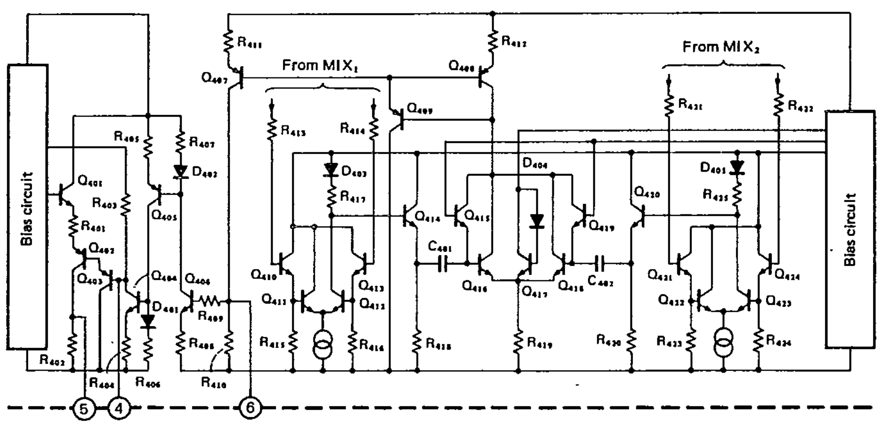


Figure 11 Wide AGC Stage



The wide AGC circuit is shown in Figure 11. The wide AGC input signals are MIX_1 and MIX_2, these signals amplify with the amplifier circuits of Q_{410} through Q_{414} and Q_{420} through Q_{424}, adds with the detector of Q_{415} through Q_{419}, and converts them into the DC signals with Q_{406} through Q_{408}. The wide AGC enables Q_{401} through Q_{405} to generate both signals $WAGC_1$ of antenna short-circuit type and $WAGC_2$ of cascade connection type explained in Section 6.1.

Figure 12 shows the operations of pins 4, 5, and 6 for the input signals. Figure 13 shows the operations of pins 4 and 5 for the frequencies.

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Figure 12 WAGC Terminal Voltage vs. Input Voltage

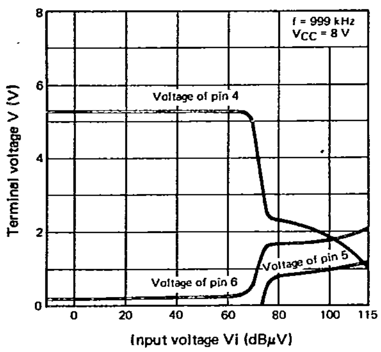
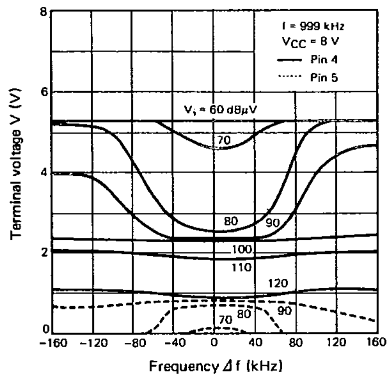


Figure 13 WAGC Terminal Voltage vs. Input Voltage



Since WAGC adds the first MIX input and second MIX input as shown above, it has the frequency characteristics in the IF_1 filter band between V_i = 70 dBμV and 100 dBμV for the desired receiving frequency. That is, AGC operates faster near the desired frequency and slower as the frequency drifts away from the desired frequency.

Figure 14 Cross Modulation Characteristics (400 kHz)

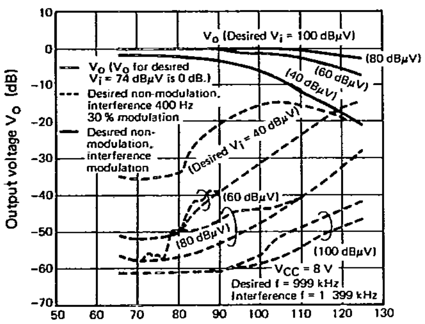


Figure 15 Cross Modulation Characteristics (40 kHz)

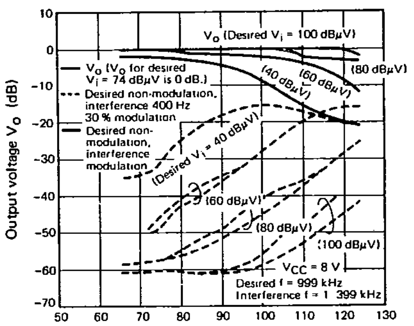


Figure 14 shows how the desired station signal is interfered by signal strength (antenna input) $V_{i(ud)}$ of this interference station if the broadcasting station of antenna input $V_{i(d)}$ is received with frequency 999 kHz and the interference station is located at 1 399 kHz, 400 kHz away from this receiving frequency.

Figure 15 shows the 2-signal characteristics if the desired station is 40 kHz away from the interference station.

If a desired signal is received from the broadcasting station with the high signal strength of 60 dBμV or more, the desired signal sensitivity is suppressed slightly if there is a broadcasting station generating the interference signal with the signal strength of 120 dBμV. However, if a desired signal is received from the broadcasting station with the signal strength with 40 dBμV, the desired signal sensitivity is suppressed by the interference signal.

In the above figure, the upper side of the dotted line indicates how much the crossmodulated signal is output when the desired signal is not modulated and the interference signal is modulated by 400 Hz/30 % to vary its signal strength. It also indicates how much the cross modulated signal is output if the signal strength of the desired signal is changed at this time.

If the desired signal is received from the broadcasting station with high signal strength of 80 dBμV or more, there is no problem for hearing because the ratio of the desired signal output to the cross modulated signal output is 30 dB or more if there is the interference signal with signal strength 120 dBμV. However, if the desired signal from the broadcasting station with the signal strength of 60 dBμV is received, this ratio becomes 30 dB or less when there is the interference signal with the signal strength of 100 dBμV. Since this is the same level as the noise output at non-modulation of the interference signal described below, it can be heard only as noise and does not cause cross modulation. That is, only the signal-to-noise ratio is lowered to cause no problem for hearing the car radio, which always varies the signal strength. When there is the interference signal with the signal strength of 80 dBμV or more at 400 kHz away or with the signal strength of 75 dBμV or more at 40 kHz away from the broadcasting station and the desired signal with the signal strength of 40 dBμV, the ratio of the desired signal output to the cross modulated signal output becomes 30 dB or less. However, there is no problem for hearing because it is only noise.

The lower side of the dotted line indicates how much noise is generated if the interference signal strength is changed when both the desired signal and the interference signal are not modulated. It also indicates how much the noise is output when the desired signal strength is changed in this case.

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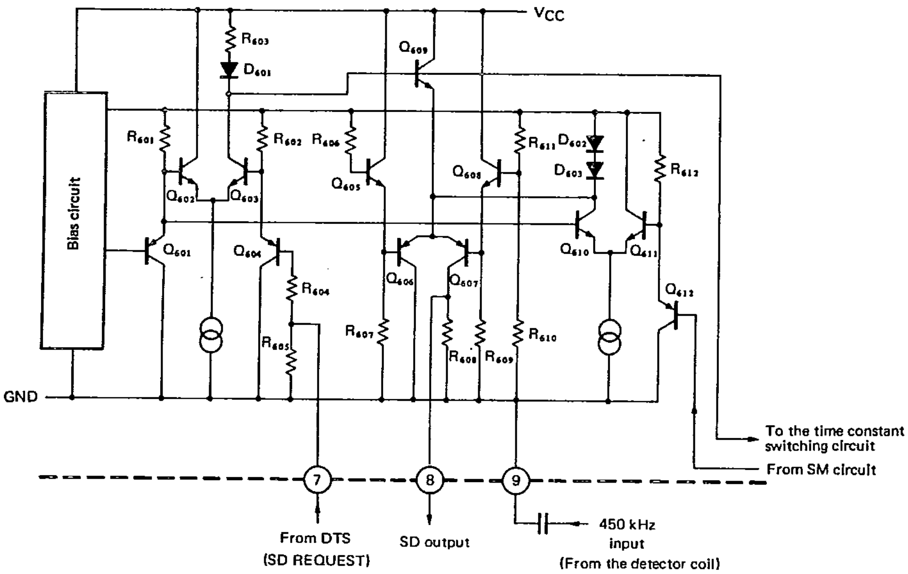
6.6 Station Detector Circuit Stage

Figure 16 Station Detector Circuit Stage



The station detector (SD) circuit is provided to stop the scan/seek operation if a broadcasting station is detected during automatic scanning or seek tuning. The SD circuit in this IC outputs the intermediate frequency signal (f ≒ 450 kHz). The output intermediate frequency signal is counted by the controller (such as μPD1713G) built into the counter circuit to lock the PLL of the controller. The station detector circuit (Figure 16) is operated by the DC voltage, which is output from the controller during automatic scanning or seek operation, from pin 7.

This DC voltage causes Q_{603} and then Q_{609} to be turned ON, and the time constant for IF AGC to be switched. If the signal meter voltage is low, the current of Q_{609} flows into collector Q_{610}. If the signal meter voltage reaches a certain value, the current from Q_{609} drives differential amplifiers Q_{606} and Q_{609} to amplify the IF signal input from pin 9 and output it to pin 8.

If PLL is locked by the controller, pin 7 inputs 0 V to turn OFF Q_{603} and then Q_{609} to stop the output to pin 8.

6.7 Other

Table 3 shows the DC voltage of each pin of this IC.

Table 3 DC Voltage of Each Pin (Standard application circuit, V_{CC} = 8.0 V, Unit : V)

Pin No.	V_{in} = 0	V_{in} = 74 dBμV	Pin No.	V_{in} = 0	V_{in} = 74 dBμV
1	3.6	3.6	16	3.6	3.6
2	3.6	3.6	17	5.3	5.3
3	GND	GND	18	4.7	4.7
4	5.7	2.8	19	6.0	6.0
5	0	0	20	5.5	6.0
6	0.2	1.6	21	7.7	7.9
7	0	0(*5.0)	22	7.7	7.9
8	0	0(*1.0)	23	8.0(V_{CC})	8.0(V_{CC})
9	5.3	5.3	24	3.6	3.6
10	0	4.0	25	GND	GND
11	GND	GND	26	7.7	7.7
12	2.3	3.1	27	7.7	7.7
13	2.3	3.1	28	6.0	6.0
14	8.0(V_{CC})	8.0(V_{CC})	29	6.0	6.0
15	3.6	3.6	30	3.3	3.3

(*) Indicates the value when 5 V is impressed to pin 7.

Figure 17 shows the application circuit which combines DTS IC μPD1713AG-018 with this IC.

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Figure 17 Application Circuit Example Combined with DTS