HA11120

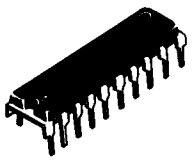
FM IF/AM Tuner for FM/AM Car Radios

■ FUNCTIONS

- FM IF Amp., FM Quadrature Det.
- AM RF Amp., AM IF Amp., AM Det.

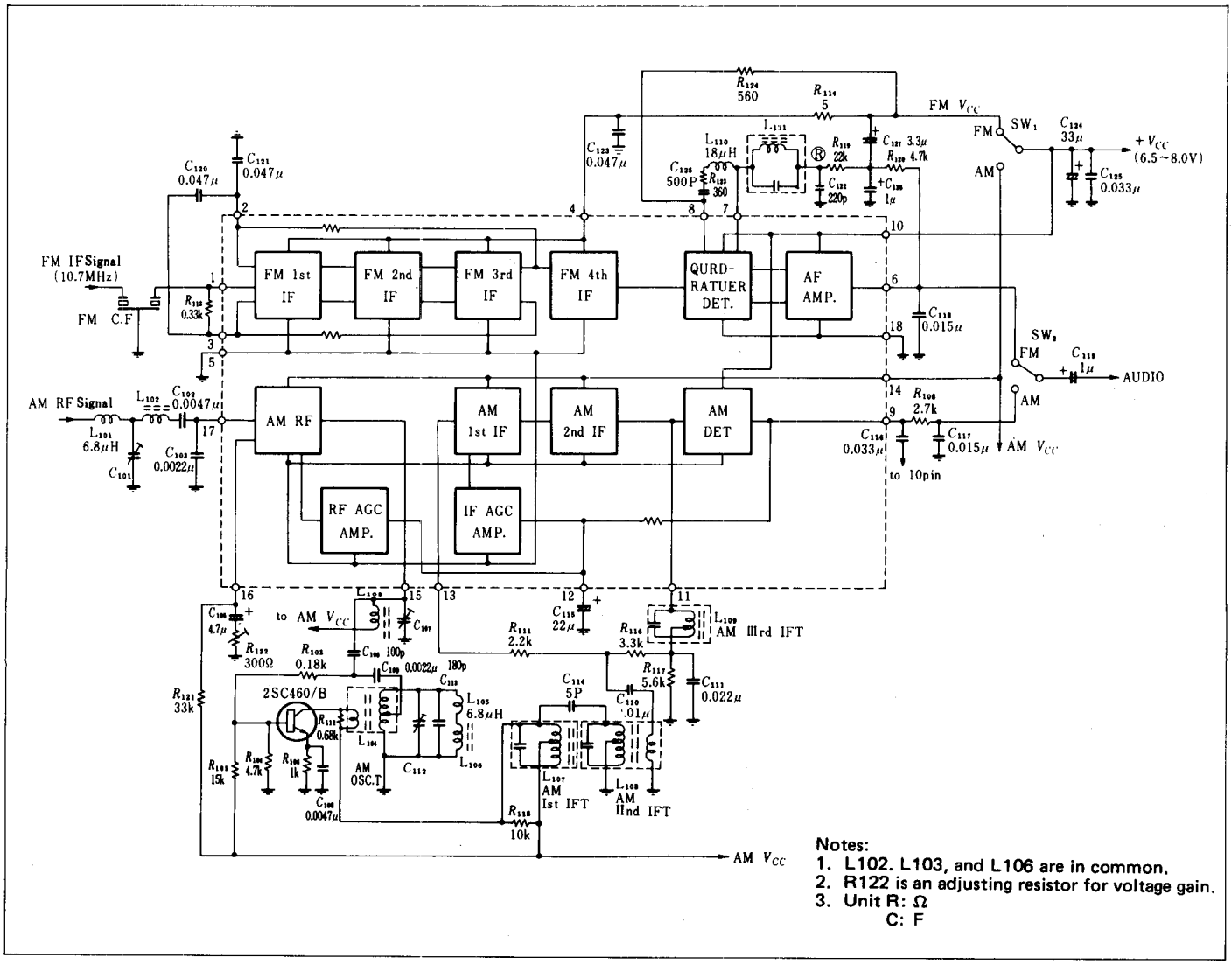
■ FEATURES

- Since the FM intermediate frequency amplification stage is constructed with a differential amplifier, the circuit operations are stable.
- Since the quadrature type detection circuit is employed at FM detection, there are fewer exterior parts, and the distortion factor is low. (Modulation 100%, 0.3%)
- FM detection output voltage is so high as 350 mV. (At 100% modulation)
- Distortion factor, at the time of AM strong input, is so low as 1% typ. at an input of 120dB.
- Even, if there is a neighborhood jamming facility, the radio interference to the desired receiving station signal is minimal.



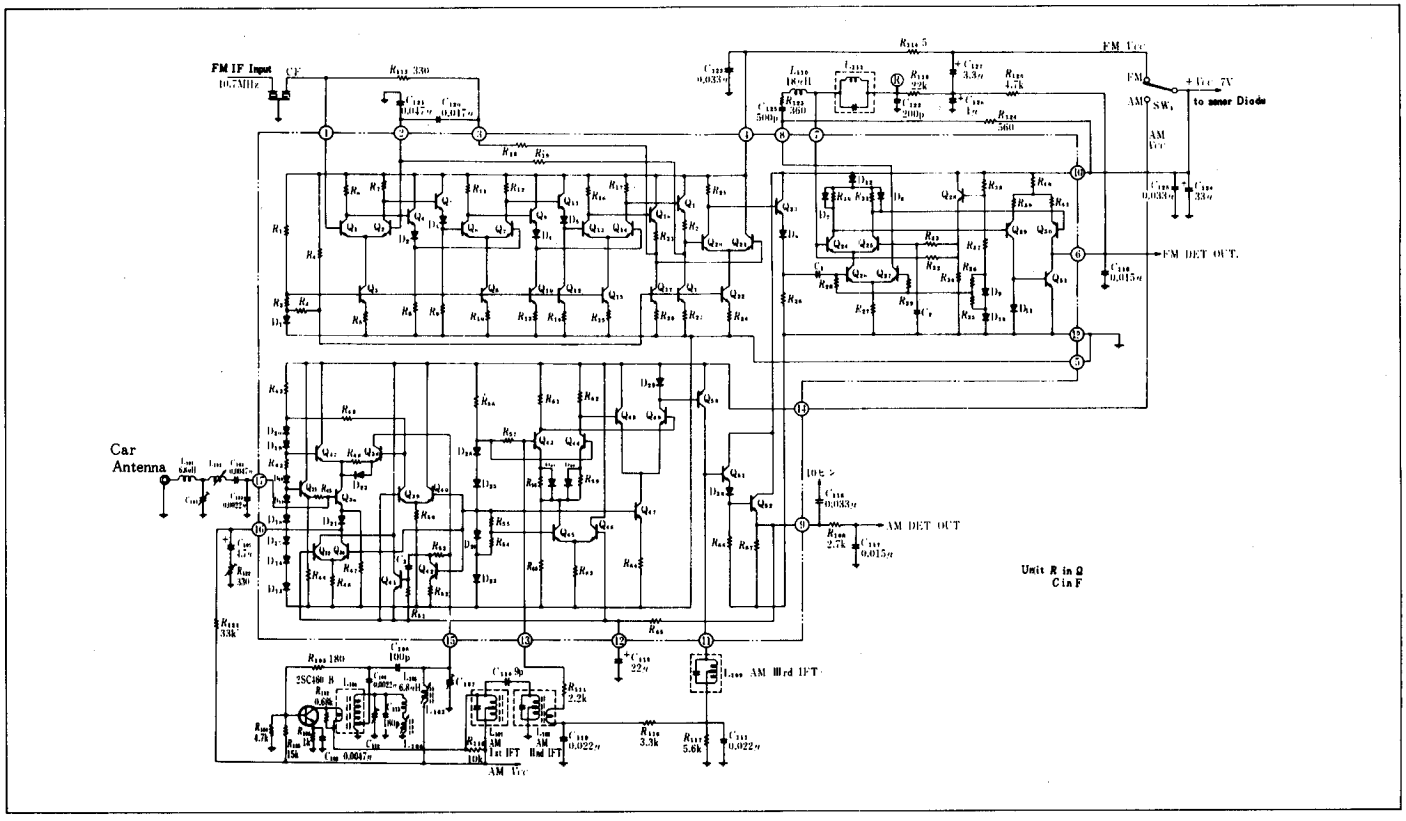
(DP-16-2)

■ BLOCK DIAGRAM



Notes:
1. L102. L103, and L106 are in common.
2. R122 is an adjusting resistor for voltage gain.
3. Unit R: Ω
   C: F

■ CIRCUIT SCHEMATIC AND TYPICAL APPLICATION CIRCUIT



■ ABSOLUTE MAXIMUM RATINGS

Item	symbol	Rating	Unit
Supply Voltage	V_{CC}	8	V
Power Dissipation	P_T*	420	mW
Operating Temperature	T_{opr}	−30 to +70	°C
Storage Temperature	T_{stg}	−55 to +125	°C

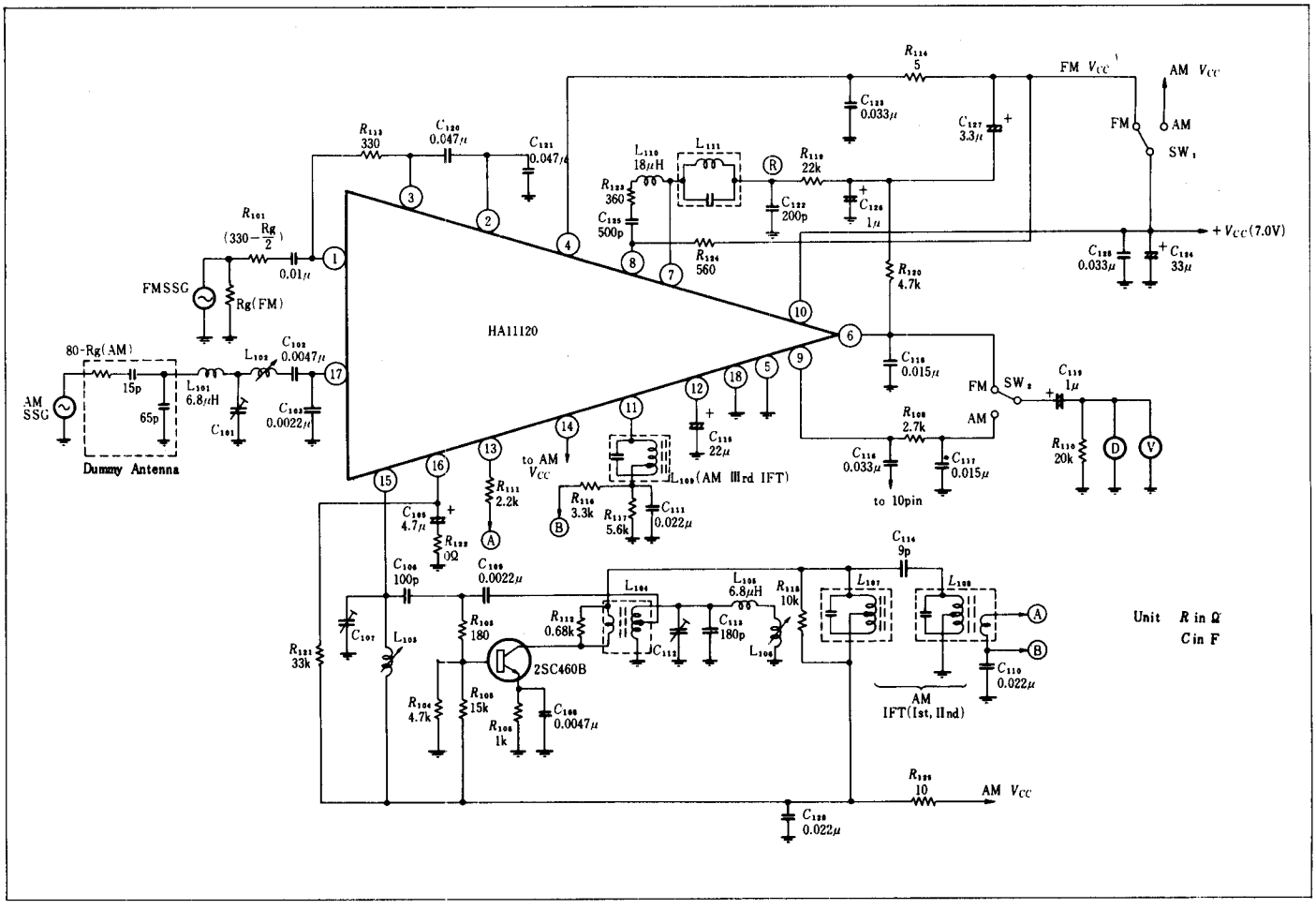
*Value at Ta=70°C

■ ELECTRICAL CHARACTERISTICS (V_{CC}=7V, Ta=25°C)

	Item	Symbol	Test Condition		min	typ	max	Unit
FM	Limiting Sensitivity	$V_{in(lim)}$	−3dB point		—	38	44.5	dBμ
	Recovered AF Voltage	$V_{O(AF)}$	100dBμ, 10.7MHz Mod. 400Hz 100%		200	350	500	mV
	Total Harmonic Distortion	T.H.D			—	0.3	1.0	%
	Signal-to-Noise Ratio	S/N			63	78	—	dB
	Rejection Ratio	AMR	FM 100% 400Hz, AM 30% 1kHz mod.	80dBμ	35	50	—	dB
				−3dB point	—	25	—	
	Noise Level	N.L	Normalized. with 74dBμ and 100% mod.		—	−40	−34	dB
	Quiescent Current	I_{FM}	Non-signal		—	18.5	—	mA
AM	Recovered AF Voltage	$V_{O(AF)}$	20dBμ, Pin 12 : GND		29	90	—	mV
			74dBμ 400Hz 30% mod.		115	180	230	
	Signal-to-noise Ratio	S/N	40dBμ		30	35	—	dB
			74dBμ		45	52	—	
	AGC Figure of Merit	AGCFOM	Between 74dBμ and it's-10dB		—	63	—	dB
	Total Harmonic Distortion	T.H.D	74dB 400Hz 30%mod.		—	0.8	4	%
			120dB 400Hz 30% mod.		—	1.0	10	
	Quiescent Current	I_{AM}	Non-signal. includes current of conv. stage		—	14.5	—	mA

Notes : 1. FM Input Level ; voltage leven when SG terminated with SG's Rg (50 or 75Ω)
2. AM Input Level ; voltage level when SG output is open

■ TEST CIRCUIT



■ EXPLANATION OF CIRCUIT OPERATIONS

1. EXPLANATION OF FM

The FM circuit is classified by dividing it into intermediate frequency (IF) and detection (DET), and since DET adopts the quadrature type circuit, the exterior parts compared to the ratio detection circuit are minimal with good distortion factor. (At 100% modulation, it is 0.3%)

Since the IF is constructed with a 4 stage differential circuit, even in spite of the high gain amplifier employed, the detection operations are stable.

The FM signal of 10.7 MHz which is contained by pin 1 is amplified by Q1 and Q2, however, it employs the low noise transistors. Threfore, when mounted to the set, of the set practical sensitivity is not due to IC.

The output signals of Q1 and Q2 are transmitted to the emitter follower circuit of Q4 and Q5, and enters the differential circuit of Q6 and Q7. Q4 and Q5 function as the first stage differential amplifier and as the buffer stage of the second differential amplifier.

In such a way, the basic circuit is constructed by the repetition of the differential amplifier and the buffer circuit. The combination of the IF stage and the DET stage is joined by the combined capacity (C1), which is constructed in IC.

FM detector is employed quadrature detection circuit, which is constructed by transistor Q24, Q25, Q26 and Q27. The input signal of detector is provided to the base of Q26. Q26 and Q27 construct differential amplifier, the output signal of Q26 is provided to the emitters of Q24 and Q25. The output signal of Q27 is provided to L110 (18μH) and L111 (10.7MHz turning coil), which construct phase shifter, and phase-shifted signal is provided to the base of Q24.

Therfore two signal above mentioned is multiplied by differential amplifier (Q24, Q25), and audio signal are obtained. And detected audio signal is amplified by the audio amplifier, which is constructed by Q30, Q31, Q32, D13. So audio signal is delivered to pin 6.

The carrier signal is grounded and for pin 6 a demodulation signal and direct current signal are obtained by the demphasis circuit (constructed by R120 and C118) provided at the exterior of pin 6.

The demodulation signal enters the audio section through the volume, while the DC signal is utilized as the AFC signal.

AFC is operated by applying the direct voltage between pin 6 and the R point (indicated in the circuit diagram) to the variable capacitor diode for AFC.

The direct current peak voltage of S-curve can be controlled by changing the resistance (R119 + R120), and the alternative peak voltage can be controlled by changing the resistance R120.

2. EXPLANATION OF AM

In the beginning, the circuit operations will be explained in connection with the input level while the AGC is not yet in operation.

The signal received by the rod antenna enters pin 17 through the external antenna circuit (constructed by L101, C101, L102, C102, and C103). The input signal is amplified by the cascode amplifier of Q36 and Q38. Then, the signal that has been outputed to pin 15, passes through the high frequency (RF) signal selection circuit, which consists of L103, C106, C107, and C109 and enters into the IC, again, only detecting the IF signal by the intermediate frequency (IF) transformer of L107 and L108 after entering the external frequency conversion stage (Emitter ground, self-conversion type). The signal which entered pin 13 is amplified by a 2 stage direct coupling differential circuit consisting of Q43, Q44, Q48, and Q49 and the succeeding D29 and Q50 function as an output amplifier.

The signal that has been amplified by IF, moreover, passes the IF selection element of L109 and enters the detection circuit The direct current level is shifted by Q51 and Q30, and enters the emitter follower type detector.

For pin 9, the direct current level corresponding to the demodulation signal and input signal level is outputed, and among these, the direct current level is used as the AGC signal.

Next, we will explain the circuit operations while the input increases and the AGC circuit is operating. AGC reduces the gain by reducing the current which leads to the controlled stage. If the differential circuits (Q32 and Q34, Q39 and Q40, and Q45 and Q46) are used for the current supply circuit, the current is applied through the resistance (R65 10 kΩ) from pin 9 using the base of one transistor (Q32, Q39 and Q46) in common, and the base of other transistor (Q34, Q40 and Q45) is set at the direct current level, and it is possible to operate the AGC is turn as the voltage of pin 9 rises. At first, the collector current of Q45 will decrease by the conduction of Q46, and the on-state resistance is increased as the direct current that is flowing to the diodes D27 and D28 approaches zero very fast, and the gain is attenuated. AGC's control range for the IF stage is 34dB, and when the larger input enters, the linear operations begin again and the next AGC circuit will begin operation. When the AGC of the IF stage terminates and the linear operation is started, the conduction of Q32 begins. As the result, the current that is flowing to D21 decreases, and the gain is attenuated as the on-state resistance of the diode increases. In this case, the range of AGC is influenced by the gain controlling resistance (R122 220Ω) which is externally attached to pin 16, but it is 48dB at R122 = 0.

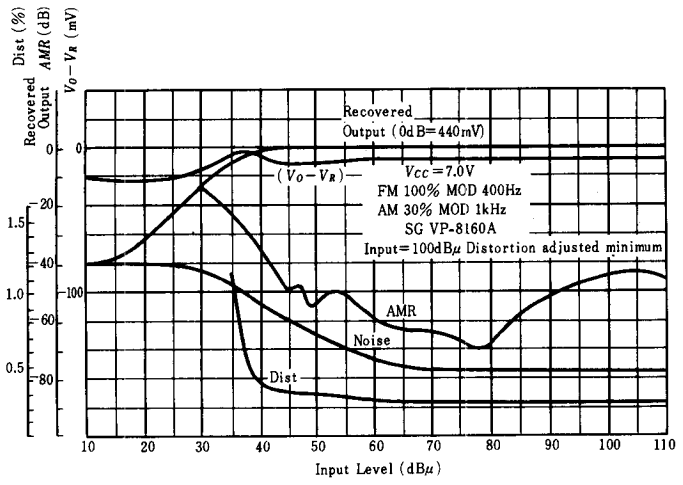
Then AGC of No. 3 starts, when the conduction of Q39 begins. When the conduction of Q39 begins, the base electric potential of Q38 decreases, and Q37 enters the conduction range from the cut-off range, and AGC begins operations by passing a part of the collector current of Q36 to the power source line, and changing the ratio of the collector current of Q36 and the output current of pin 15.

Through the operations of the above 3-stage AGC, it is possible, without sacrificing any practical sensitivity, to improve the strong input characteristics and obtain the distortion factor of 1% TYP, at the time of 30% modulation even at an input of 120dBμ.

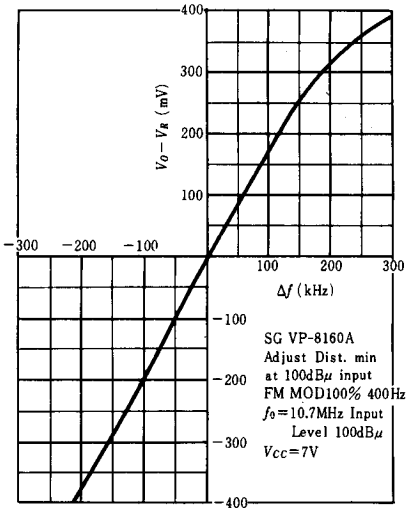
For the IC, other than the above, there is one more AGC circuit. That circuit is provided to cope with the interference caused at the strong input. At the time of strong input detuning, since the IF signal is detuned and the input signal does not exist on the detection stage, no AGC signal is produced.

However, since the selective characteristics of the antenna circuit are broad, the strong input signal is added on the RF stage and saturates the circuit, making interference easy. However, as the IC detects the signal of the RF output terminal (Pin 15) and is superposed at the AGC line, the RF stage performs linear operations and the AGC operates even at the time of detuning. As the result, a good selection characteristics can be obtained.

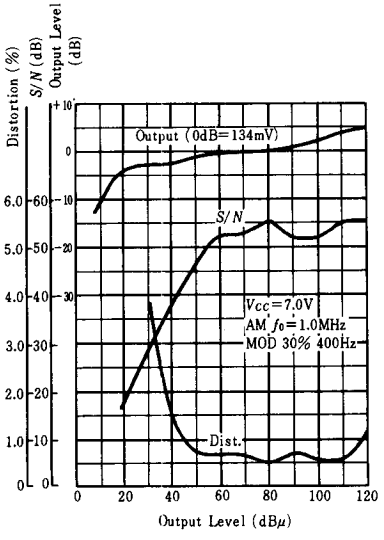
FM CHARACTERISTICS VS. INPUT LEVEL



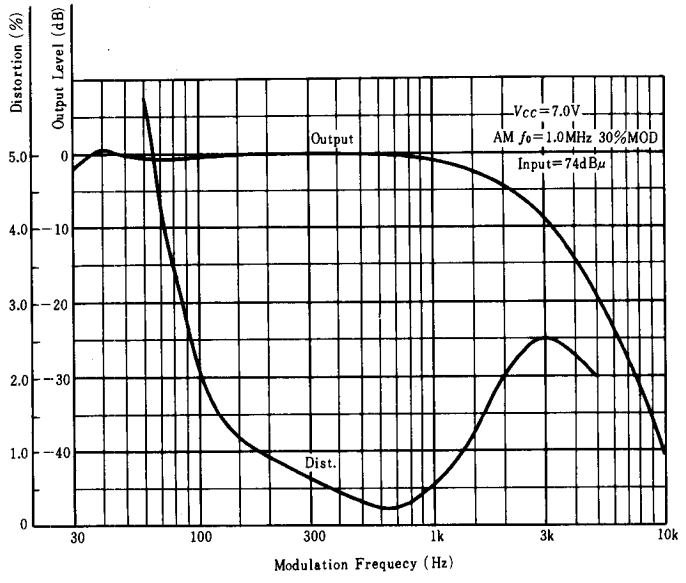
AFC CHARACTERISTICS



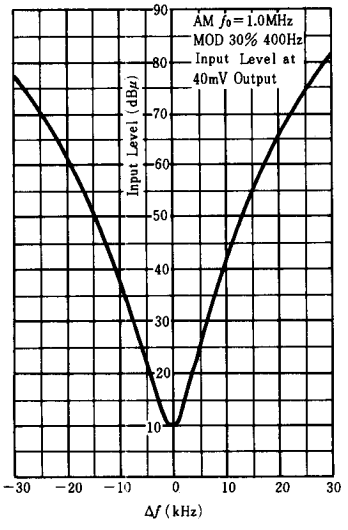
AM CHARACTERISTICS VS. INPUT LEVEL



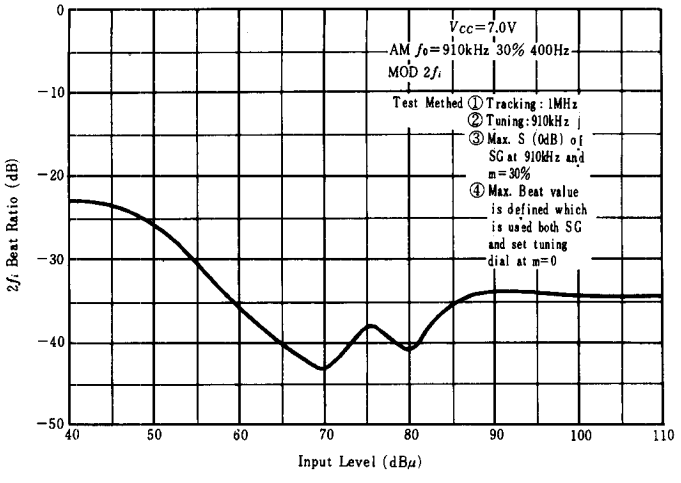
AM CHARACTERISTICS VS. MODULATION FREQUENCY



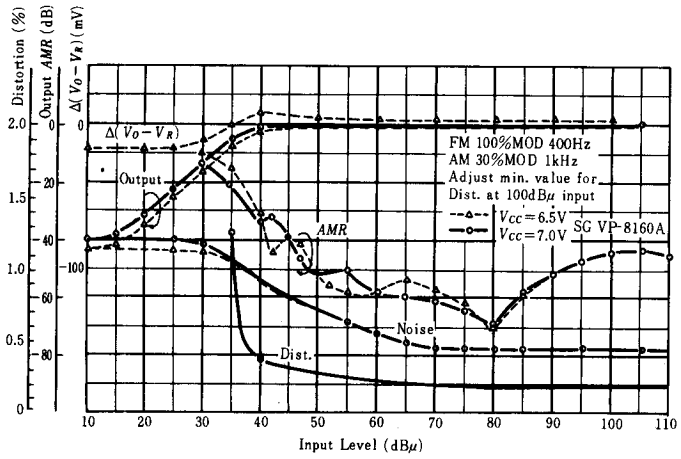
SELECTIVITY CHARACTERISTIC (AM)



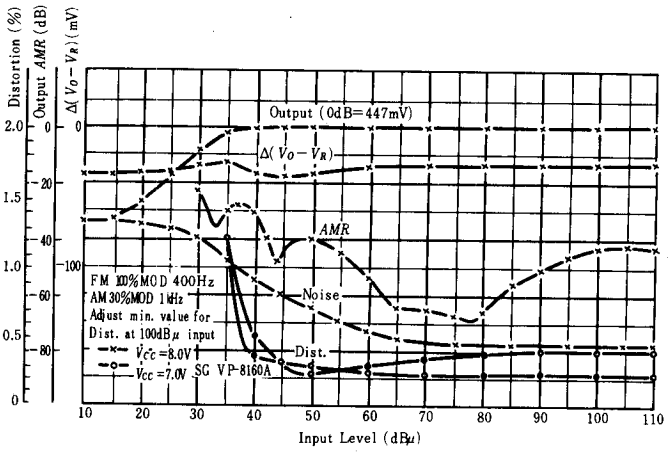
2fi BEAT RATIO VS. INPUT LEVEL (AM)



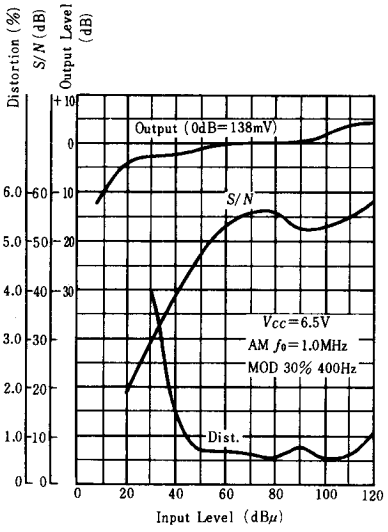
FM CHARACTERISTICS VS. INPUT LEVEL (1)



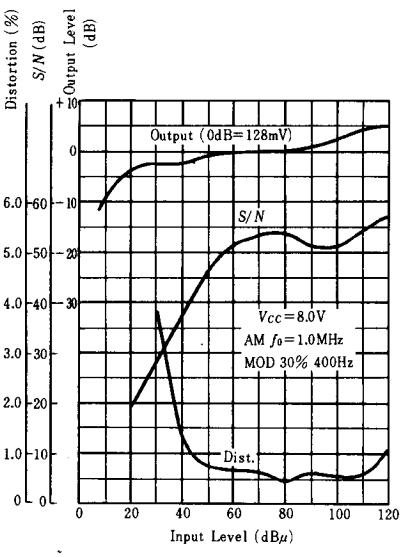
FM CHARACTERISTICS VS. INPUT LEVEL (2)



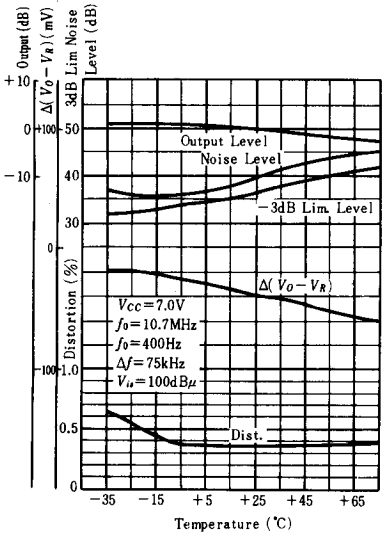
AM CHARACTERISTICS VS. INPUT LEVEL (1)



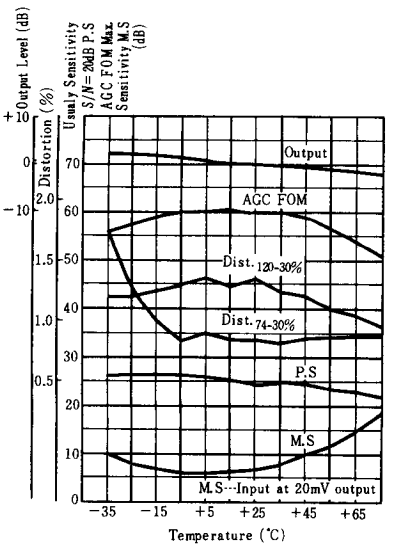
AM CHARACTERISTICS VS. INPUT LEVEL (2)



FM CHARACTERISTICS VS. AMBIENT TEMPERATURE (1)



FM CHARACTERISTICS VS. AMBIENT TEMPERATURE (2)



■ EXTERNAL COMPONENTS

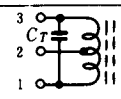
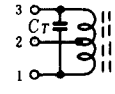
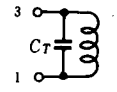
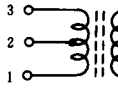
Unit R : (Ω), C : (F), L : (H)

Parts No.	Recommended Value	Purpose	Influence		Remarks
			Larger than recommended value	Smaller than recommended value	
R_{101}	$330-\frac{Rg}{2}$	Ceramic filter equilvalent Signal source resistor	———	———	Rg is the internal resistor of FM and SG
R_{103}	180	For local oscillation stabilization	Smaller oscillation voltag Poor sensitivity	Smaller effective stabilization, promoting abnormal oscillation	
R_{104}	4.7k	Bias resistor of transistor for AM frequency conversion	———	———	
R_{105}	15k		———	———	
R_{106}	1k		———	———	
R_{108}	2.7k	For smoothing circuit 455kHz	Larger decrement 4kHz	Smaller smoothing effect and 455kHz leaks into the audio section. In extreme cases the output clips to the lower part of output	
R_{110}	20k	Measuring circuit load resistance	———	———	
R_{111}	2.2k	For gain control	Sensitivity decreases (Max)	Large noise	
R_{112}	680	Damper effect of oscillation coil	Easy occurrance of abnormal oscillation	Smaller oscillation voltage and decrease in gain	
R_{113}	330	FM IF bias circuit	Unstable FM IF, mismatching of ceramic filter	Decrease in gain of IF stage mismatching of ceramic filter	
R_{114}	5	For decoupling (FM IF and DET stage)	Gain fluctuation of IC promoted	Stable FM IF system	
R_{116}	3.3k	AM IF bias circuit	Large fluctuation of detection output at 74dBμ input	Feedback of signal poor distortion	
R_{117}	5.6k	AM IF bias circuit	Poor gain and distortion	Poor gain and distortion	
R_{118}	10k	Damper effect of AM lst IFT	Unstable IF stage	Poor selectivity	
R_{119}	22k	FM detection stage bias circuit	Large direct current offset voltage	Small AFC voltage narrow effective range	
R_{121}	33k	For improving distorton factor around input 130dB	Poor distortion factor at input 130dBμ	Large variation of sensitivity by the temp	
R_{122}	Semi-fixed resistor (330Ω)	For AM Gain control	———	———	
R_{123}	360	Countermeasures for AMR, during FM weak electric field	Decrease of detection output	Poor AMR	
R_{124}	560	Output direct direct load resistor of transistor Q27 in IC	Poor stability of IF, decrease in detection output	Poor AMR	
C_{101}	Trimmer capacity	For removal of antenna stage trucking	———	———	
C_{102}	0.0047μ	Coupling	———	———	
C_{103}	0.0022μ	Coupling	Low sensitivity	Tracking can not be removed, selection characteristics are poor	
C_{105}	4.7μ	Bypass	———	Low sensitivity	
C_{106}	100p	Coupling tracking	Tracking can not be removed		
C_{107}	Trimmer capacity	Removal of RF stago tracking	———	———	
C_{108}	0.0047μ	By-pass	Easy occurrence of abnormal oscillation	Low sensitivity, suspension of oscillation	
C_{109}	0.0022μ	Coupling	Low sensitivity	Suspension of oscillation	
C_{110}	0.022μ	By-pass		Signal is fed back, poor distortion factor	
C_{111}	0.022μ	By-pass		Signal is fed back, poor distortion factor	
C_{112}	Trimmer capacity	Removal of covering	———	———	
C_{113}	180p	Local oscillation stage correction capacity	Covering is unable to be removed	Covering is unable to be removed	
C_{114}	5p	Coupling	Poor (AM) selection characteristics	Low sensitivity	
C_{115}	22μ	Determination of constant at AGC	Slow AGC response speed	Signal appears on AGC line poor distortion	
C_{116}	0.033μ	For smoothing (455kHz)	Larger attenuation level at 4kHz	455kHz leaks into the audio section	
C_{117}	0.015μ	Same as above	Larger attenuation level at 4kHz	455kHz leaks into the audio section	
C_{118}	0.015μ	De-emphasis constant determination			

(to be continued)

Parts No.	Recommended Value	Purpose	Influence		Remorks
			Larger than recommended valus	Smaller than recommended value	
C_{119}	1μ	Coupling		Low sensitivity, poor distortion	
C_{120}	0.047μ	By-pass	Easy occurrance of abnormal oscillation	Easy occurrance of abnormal oscillation	
C_{121}	0.047μ	By-pass	Easy occurrance of abnormal oscillation	Easy occurrance of abnormal oscillation	
C_{122}	200p	By-pass	Poor AM suppression	Poor AM suppression	
C_{123}	0.033μ	De-coupling		Unstable FM IF system	
C_{124}	33μ	De-coupling		Easy reception of ham influence	
C_{125}	500p	De-coupling		Easy to become unstable	
C_{126}	1μ	By-pass	Easy reception of signal from power source	Easy reception of signal from power source	
C_{127}	3.3μ	By-pass			
L_{101}	6.8μH	FM signal cut-off	AM tracking can not be removed, decrease in AM sensitivity	Decrease in FM sensitivity	
L_{102}		Antenna tuning	———	———	
L_{103}		RF tuning	———	———	System is integrate and interlocked
L_{106}		Oscillation tuning	———	———	
L_{104}	Oscillation transformer	Phase inversion, feedback	———	———	
L_{105}	Padding coil		Covering can not be removed	Covering can not be removed	
L_{107}	AM IFT	Provides AM selection level	———	———	
L_{108}	AM IFT	Provides AM selection level	———	———	
L_{109}	AM IFT	Provides AM selection level	———	———	
L_{110}	18μH	Phase shift (10.7MHz)	———	———	
L_{111}	10.7MHz Tuning coil	Phase shift (10.7MHz)	———	———	

■ SPECIAL COMPONENTS SPECIFICATIONS

Item No.	Parts Name		Circuit Symbol	Specification	Remarks
1	Push button tuner (5 buttons)	Antenna (Ⅱ) coil	L_{102}	Inductance 180μH (1MHz) Unloaded Q>50	Maker: Tuner Shoji Model No.: P000-N309-1
		RF coil	L_{103}	Inductance 170μH (1MHz) Unloaded Q>50	
		Oscillation coil	L_{106}	Inductance 27μH (1MHz) Unloaded Q>50	
2	Antenna coil (Ⅰ)		L_{101}	Inductance 6.8μH	
3	Padding coil		L_{105}	Inductance 6.8μH	
4	IFT for AM (Ⅰ), (Ⅱ)		L_{107} L_{108}	 1 − 2 45 (T) 2 − 3 96 (T) 4 − 6 10 (T) C_T 180 (pF)	Toko Model No.: 7MCS-1022GN
5	IFT for AM (Ⅲ)		L_{109}	 1 − 2 48 (T) 2 − 3 93 (T) C_T 180 (pF)	Toko Model No.: TMCS-1021GN
6	Phase shift coil (FM)		L_{110}	18μH	Toko Model No.: 144HZ-180JH
7	FM Detection coil		L_{111}	 1 − 3 11 (T) C_T 82 (pF)	Toko Model No.: 119ACS-10089AO
8	Trimmer condenser		C_{101}	MAX 100pF	Shinmei Denki Model No.: L-1P1
9	Oscillation coil for AM		L_{104}	 1 − 2 7 (T) 2 − 3 67 (T) 4 − 6 24 (T)	Toko Model No.: 7BRS-1119GN

■ PC-BOARD LAYOUT PATTERN