

HA11123

FM/AM Radio Receiver System

Hitachi HA11123 is an IC system that has been developed for FM/AM radios and modular stereos. It has the following functions and features.

■ FUNCTIONS

FM

- IF Amp.
- Signal meter drive circuit
- AFC circuit
- FM demodulation signal amplification circuit

AM

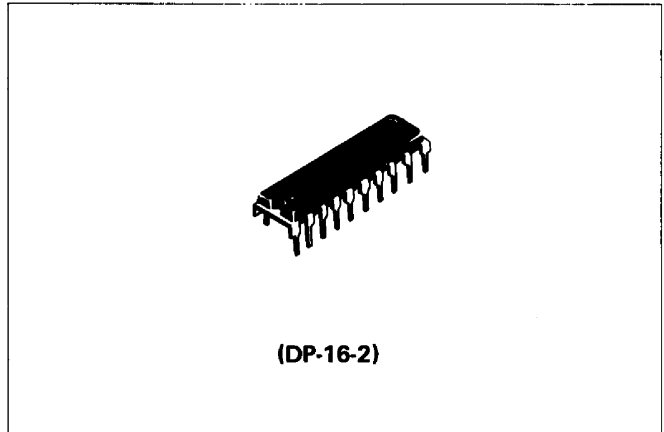
- Built-in transistor for converter
- IF Amp.
- AGC circuit

■ FEATURES

Since the FM IF Amp., detection circuit, signal meter circuit and AM converter, and IF Amp. are enclosed in one package, it is possible to save and to make the size smaller.

FM

- Utilizing a full balance direct current feedback type differential amplifying IF Amp. which gives rise to improved stability.
- Utilizing a quadrature type FM demodulation circuit with low distortion. (0.3% typ, when utilizing single tuning coil at 100% modulation)
- High sensitivity (Input limiting sensitivity 32dB μ)
- Large detection output (450 mVrms typ, at 100% mod.), freely changeable by the external resistor.
- High S/N (77dB typ.)
- High power source and voltage
- Lowest distortion point and highest output point correspond to S-curve middle point.
- Logarithmic linear signal meter (Dynamic range 50dB)



(DP-16-2)

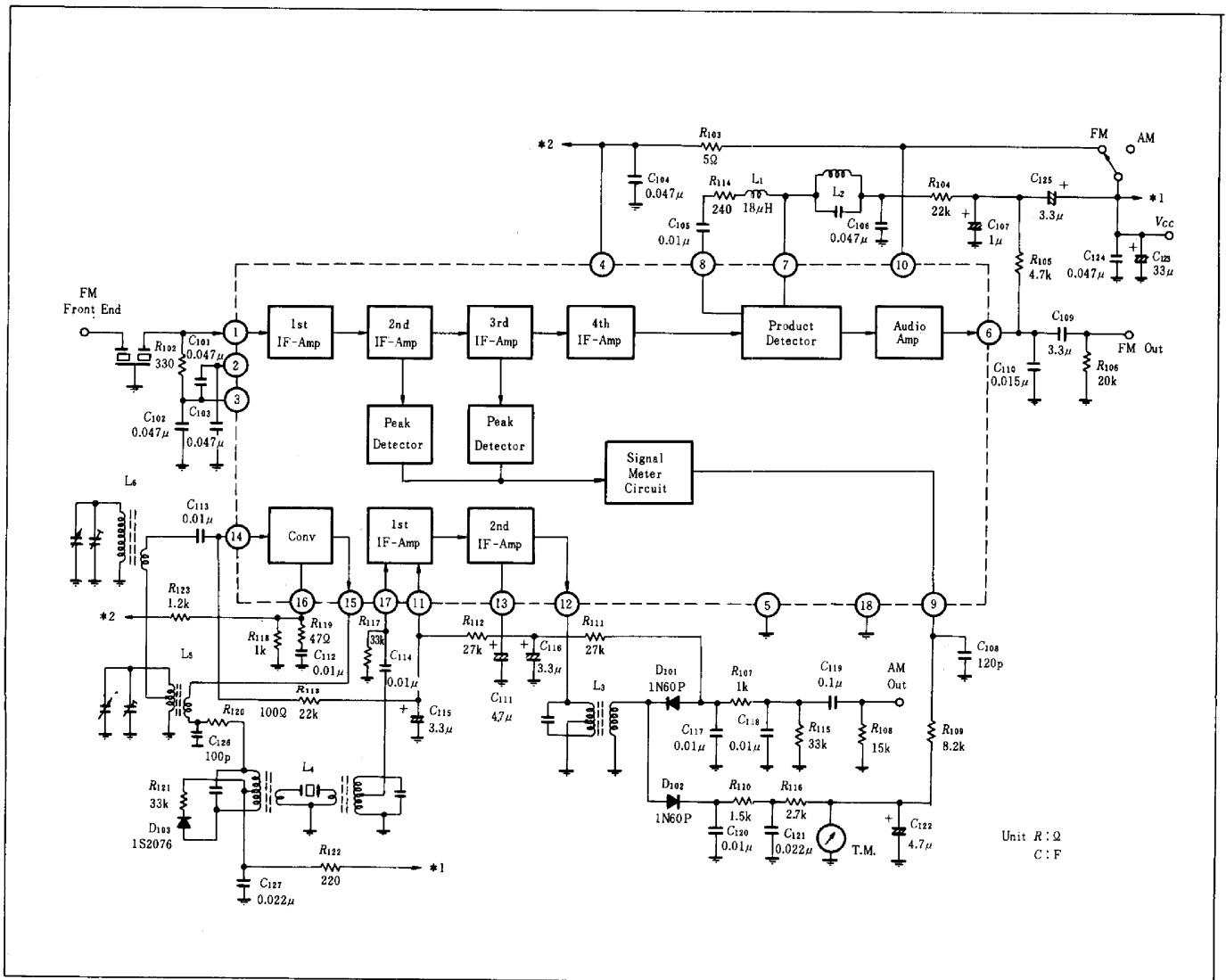
AM

- AM built-in converter
- High S/N (60dB at 100dB μ input)
- High AGC FOM (58dB)
- Low distortion (0.3% typ. 30% mod. at 74dB μ)

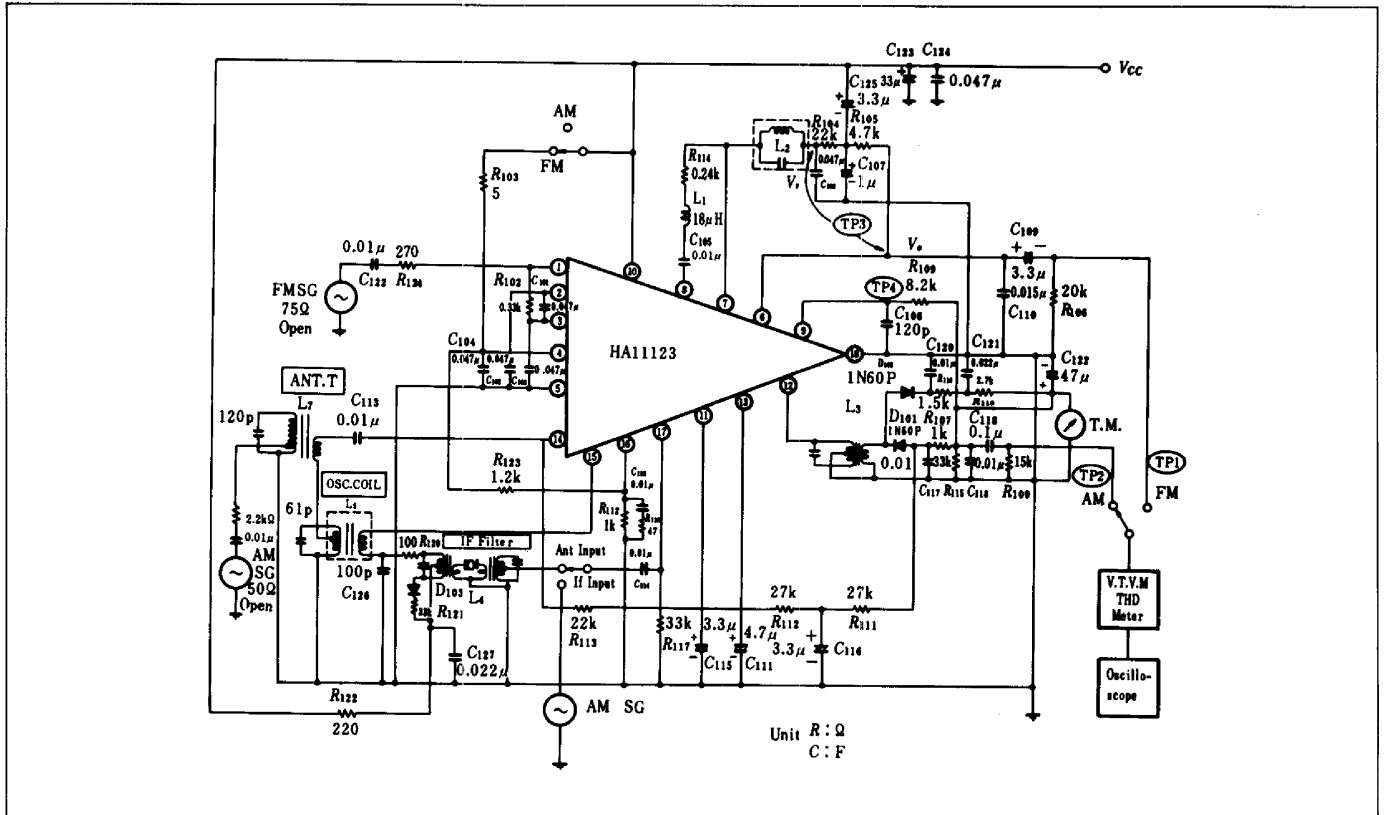
HA11123

Item	Symbol	Test Conditions	min	typ	max	Unit
Quiescent Current	I_0	$V_{CC} = 5.5V$, FM, without AM input	—	25.4	40	mA
Recovered AF voltage	e_{11} 01		285	450	600	mVrms
Total Harmonic Distortion	T. H. D		—	0.3	1.0	%
Limiting sensitivity -3dB	$V_{in(11m)}$	Input level at the point where the output decreases by -3dB from the output for the input level 106dB μ .	—	32	37.5	dB
Signal-to-Noise Ratio	(S/N) ₁	Output level at no modulation for the output for the input level 106dB μ , (400Hz, 100% mod)	67	77	—	dB
AM Rejection Ratio	AMR ₁	Input level 106dB μ , FM 400Hz, 100% mod, AM1kHz, 30% mod	35	55	—	dB
Signal Meter Output	V_{M1}	Input 106dB, pin 9 voltage	1.34	1.60	1.86	V
Max. Sensitivity	S_{RF1}	Antenna transformer level where the recovered AF voltage is 10mV.	—	30	36	dB
Total Harmonic Distortion	T. H. D		—	0.3	2.0	%
Recovered AF Voltage	e_{03}		65	100	130	mVrms

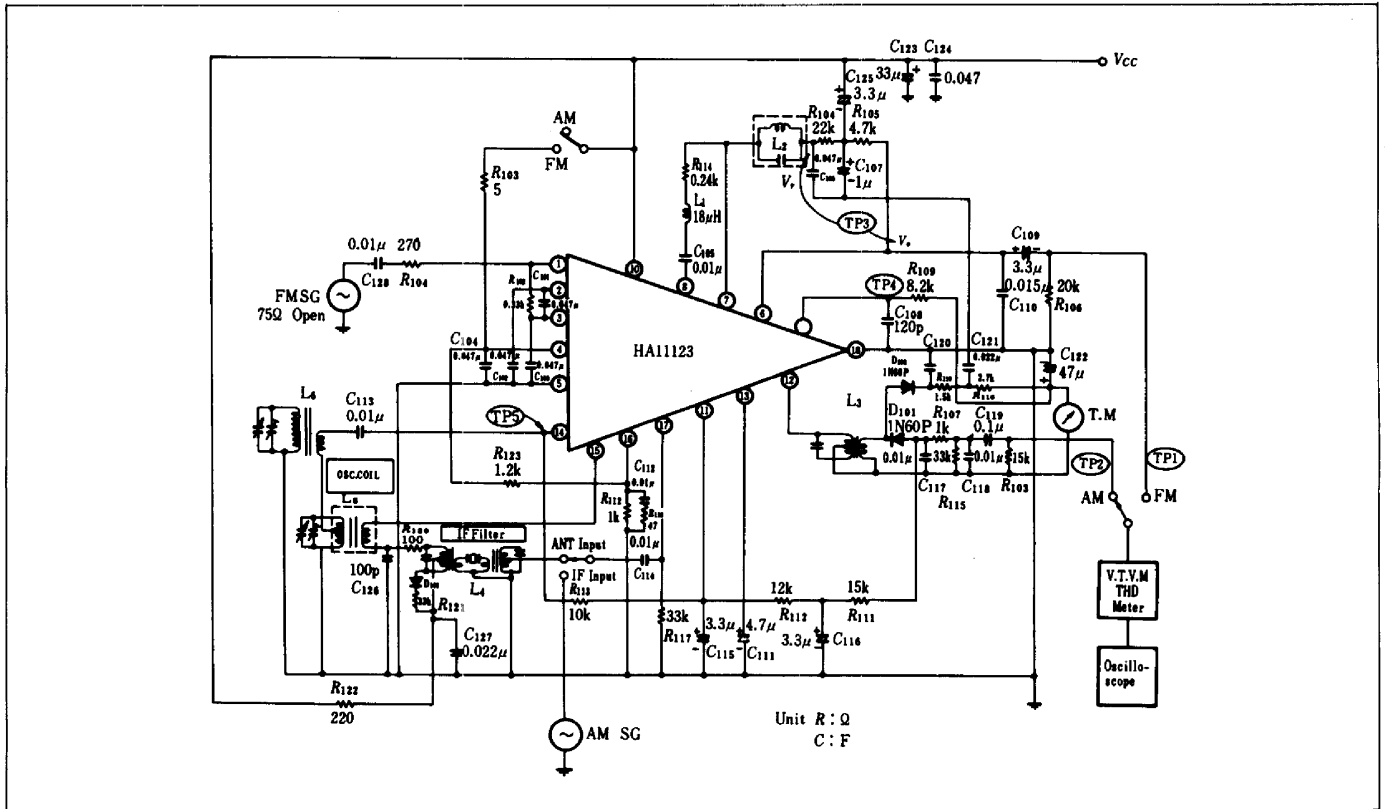
■ BLOCK DIAGRAM



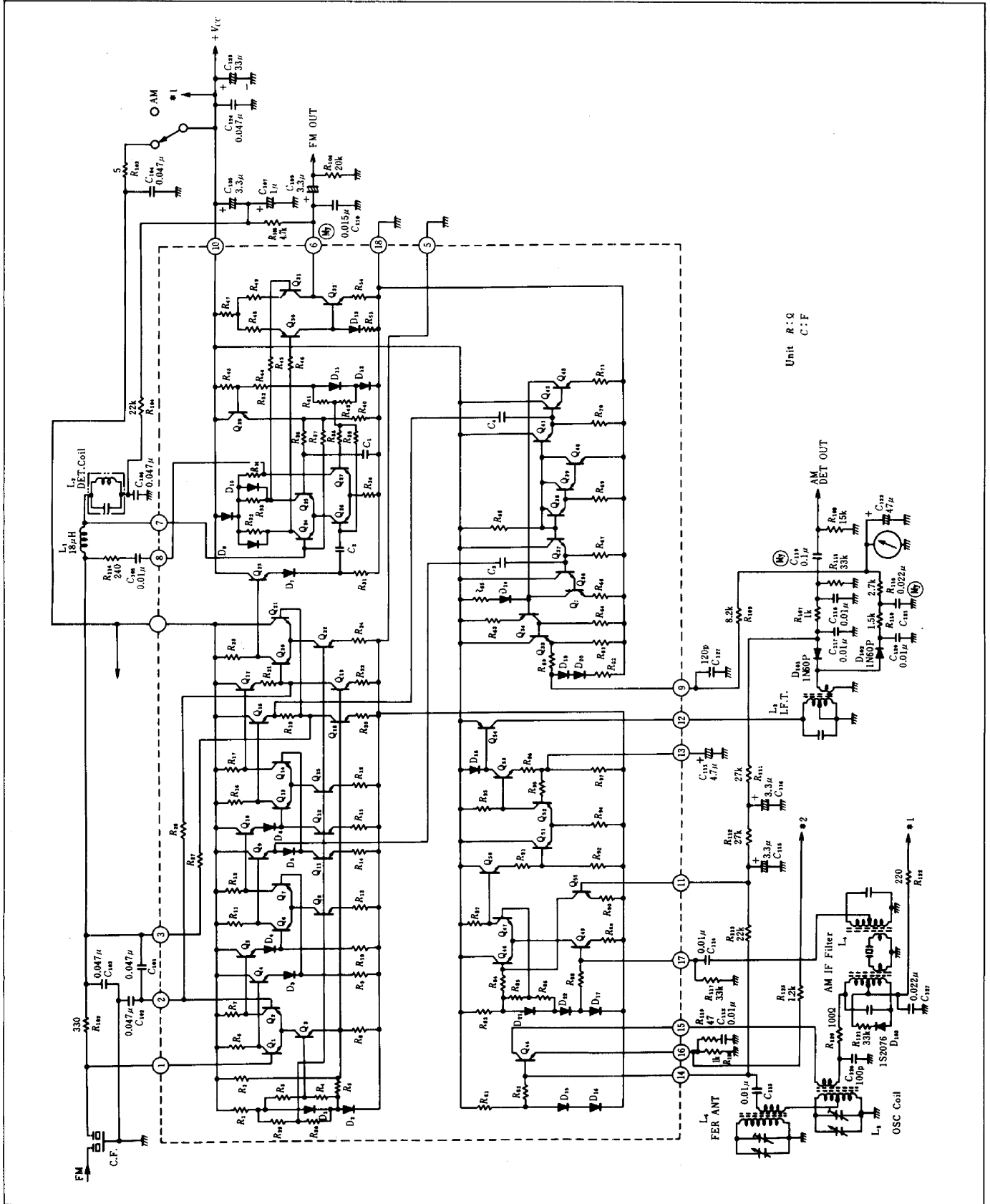
1. AM SECTION OF ANTENNA TRANSFORMER INPUT



2. AM SECTION'S IF INPUT OF FERRITE BAR ANTENNA INPUT



■ CIRCUIT SCHEMATIC AND TYPICAL APPLICATION CIRCUIT



■ EXPLANATION OF OPERATIONS

FM Section is constructed by a 4-stage direct coupled full balance direct current feedback type IF differential amplifier that is provided with a limiter, quadrature type FM demodulator, FM demodulation signal amplifier and signal meter drive circuit; and AM Section is constructed by a converter, 3-stage direct coupled IF amplifier, and an AGC circuit.

1. FM OPERATIONS

Full Balance Direct Current Feedback Type IF Differential Amplifier

The intermediate frequency (IF) signal whose frequency has been changed by the front-end passes through the IF filter, etc. and is inputted to pin 1. The signal is amplified about 70dB by the 4-stage full balance direct current feedback type differential amplifier.

The FM IF amplifier of the IC avoids the amplification of the input offset of the first stage differential amplifiers (Q_1 and Q_2), and feeds back the direct current from the third stage to the first stage at the full balance so that the amplifiers of all stages can limit the amplitude of the input signal symmetrically.

A low noise transistor is used for the first stage amplifier the noise level at the weak electric field of an ordinary FM receiver that is constructed by the IC may depend upon the noise level of the front end alone. Moreover, it is also designed so that it may have a sufficient amplification function for the supply voltage.

Quadrature Type FM Demodulator

The IF signal that is impressed with pin 1 is amplified approximately to 70dB by the direct current feedback type differential amplifier, and is inputted to the quadrature type FM demodulator for demodulation that is constructed by Q_{24} to Q_{27} . Namely, the direct current I_0 of the differential amplifier R_{34} constructed by Q_{26} and Q_{27} is switched by the IF signal inputted to Q_{26} , and moreover, this signal is also switched by the differential amplifier that is constructed by Q_{24} and Q_{25} . The signal switching Q_{24} and Q_{25} picks out from pin 8 the signal that has been switched by Q_{26} and Q_{27} . It is the input IF signal which coincides with the tuning frequency f_0 of the detection coil and is phase shifted by about $\pi/2$ by the tuning impedance of coil L_1 and detection coil L_2 . Fig. 1(a) shows the current wave form of Q_{26} , (b) and (c) are the operational wave forms provided by the switching of Q_{24} and Q_{25} , (d) and (e) are the collector current wave forms of Q_{25} and Q_{26} when the input IF signal f_i coincides with the tuning frequency f_0 of the detection coil L_2 . The angle of current flow is 1/4 cycle, and the average current is $I_0/4$ respectively. Next, in case the input IF signal f_i slips off from the tuning frequency f_0 of the detection coil L_2 , Q_{24} and Q_{25} are driven by the signal whose phase is shifted only to phase θ according to the characteristics of the frequency slip Δ of the single tuning circuit constructing the detection coil L_2 vs the phase slip θ . Thus, the switching operations are indicated by the broken lines in (b) and (c) of Fig. 1, and the

flow angle of the collector current of Q_{24} and Q_{25} increases only by θ more than 1/4 cycle on one hand and decrease only by θ on the other hand as indicated by (f) and (e). Accordingly, the average electrical current changes in proportion to θ with $I_0/4$ as its center, thereby demodulating the FM signal.

Here, the diodes, D_9 and D_{10} , works as a limiter to conduct sufficient oscillation control operations.

FM Demodulation Signal Amplifying Circuits

The circuit which is constructed by Q_{30} , Q_{31} , D_{13} , and Q_{32} changes only when the input intermediate frequency signal frequency f_i slips from the tuning frequency f_0 of the detection coil L_2 , is the FM demodulation signal amplifying circuit, which outputs from pin 6 the electric current proportionate to the voltage of R_{32} and R_{33} of the negative related phase. Namely, when $f_i = f_0$, as is clearly shown by (d) and (e) of Fig. 1, the average electric current is $I_0/4$, the voltage at both ends of R_{32} and R_{33} becomes the same, and the supply current of Q_{31} and the absorption current of Q_{32} become the same. Therefore, the electric current is not supplied to the load resistance R_{105} from pin 6. However, in the case of $f_i \neq f_0$, the flow angle of the electric current changes responding to the synchronous slippage, the electric current, mutually, decreases by the negative phase relationship, and the electric current of Q_{30} and Q_{31} changes differentially. As the result, only the increase of the supply current of Q_{31} corresponds to the decrease of the absorption current of Q_{31} .

Accordingly, the change of the electric current flowing to the load resistance R_{105} doubles that of the electric current of Q_{31} or Q_{32} . Since Q_{31} and Q_{32} become the current supply type that the collectors are connected to each other for the sake of providing a normal transistor amplifier, it is necessary to connect them to the voltage source through the load resistance R_{105} .

For the IC the internal voltage is utilized. Namely, the emitter voltage of the base bias source Q_{29} of the differential amplifier consisting of Q_{24} and Q_{25} is impressed from pin 7 to pin 6 through the coil L_1 for phase shifting, detection coil L_2 , resistance R_{104} and load resistance R_{105} . Since this construction becomes a feedback type amplifier, the offset voltage of Q_{24} and Q_{25} are not amplified very much, and the direct current operating voltage is fixed at the voltage of pin 7 voltage. Since, for the alternating current (AC), the contact points of R_{104} and R_{105} have been connected at C_{125} and C_{107} , the feedback will not operate and the demodulation signal voltage is decided depending on the value. Fig. 2 indicates the demodulation signal voltage, in contrast to the size of the load resistance R_{105} . The S-curve of pin 6 DC varies with the voltage of pin 7 mainly, but since the feedback is performed, different from the conventional FM demodulator, the inclination of this S-curve's DC does not always correspond to the demodulation FM sensitivity and it is designed to be smaller than the demodulation sensitivity.

However, the S-curve of this DC can be changed by the value of R_{104} . Fig. 3 indicates the direct current voltage at the time of 100 kHz detuning for R_{104} .

Then, since the IC is designed so that the best distortion factor may correspond to the center of the S-curve, the optimum AFC operations are possible.

Namely, when the input IF signal frequency f_i corresponds to the tuning frequency f_0 of the detection coil L_2 , and if the operations of Q_{24} and Q_{25} and the switching operations of Q_{26} and Q_{27} are exactly the phase shift difference of $\pi/2$ as indicated by (a), (b), and (c) of Fig. 1, then the average values of the collector currents of both Q_{24} and Q_{25} become $I_0/4$ and the current does not flow in or out of pin 6. Therefore, it almost corresponds to the voltage of pin 7, namely, the center of the S-curve. However, since the phase shift difference determined by the phase shifting coil L_1 and the tuning impedance of the detection coil L_2 does not become $\pi/2$ exactly, it is necessary to correct it. For HA11123, the resistance R_{114} is supplemented to correct it by the output capacity of pin 8, and the inductance of the phase shifting coil L_1 , etc. Therefore, the best distortion points almost corresponds to the center of the S-curve. When the voltage of pin

7, namely, the voltage of C_{104} and the S-curve voltage of pin 6 are used to perform the AFC operations, even if the AFC operations are turned ON and OFF at the tuning point, there will be no jumping in the frequency.

Signal Meter Drive Circuit

For the signal meter drive circuit, pin 9 supplies the signal meter drive voltage which increases almost logarithmic lineally in contrast to the broader input signal level by adding the signals of the stage 2 of the differential amplifier and of the stage 3 of the full balance direct current feedback type differential amplifier rectified respectively.

As is widely known, since the internal resistance and capacity of IC generally disperse, the meter voltage also disperses. However, this IC is designed to have a dispersion of $\pm 10\%$ in the oscillation conversion of the signal meter (200 μ A full scale, 1.2 k Ω) when the value of R_{109} represents 8.2 k Ω .

Causion for S-Curve Observations

In case the S-curve is observed by sweep generator, be sure to connect the capacity of 3.3 μ F in parallel to C_{106} , so as to prevent the reception of the sweep frequency of sweep generator.

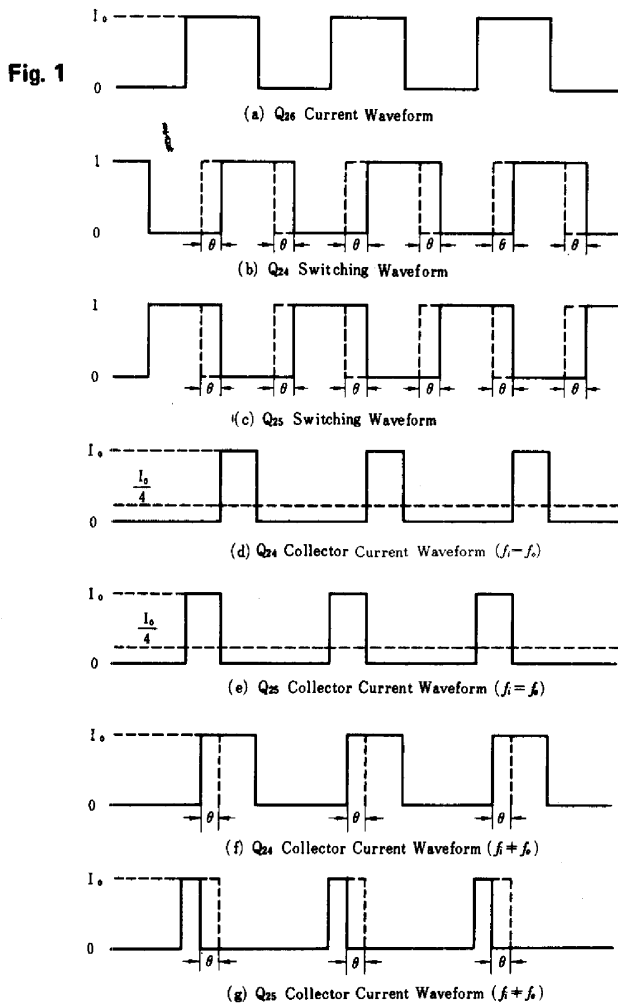


Fig. 1

Fig. 2 R_{105} VS. FM Det. Output Voltage (C_{01})

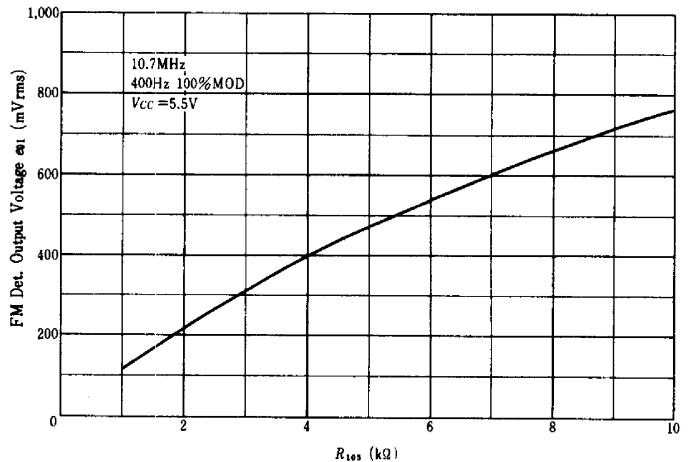
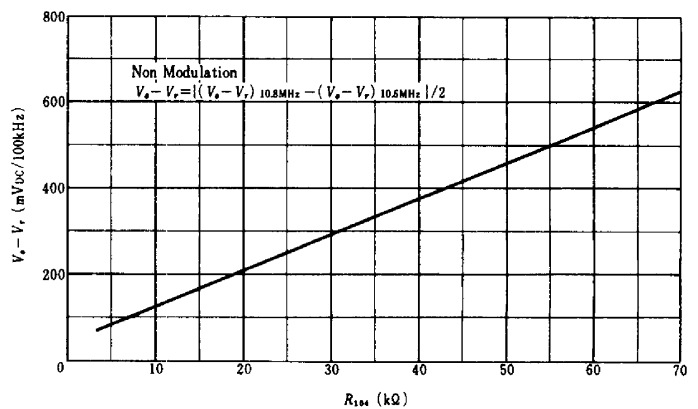


Fig. 3 R_{104} VS. FM Det. DC Output Voltage ($V_0 - V_r$)



2. AM OPERATIONS

Transistors for Converter

The IC has a built-in low noise transistor for the converter. At the base of the transistor, a bias is applied and it can be used also as a self-converter or as a mere mixer with the terminals being made up by the collector, emitter and base.

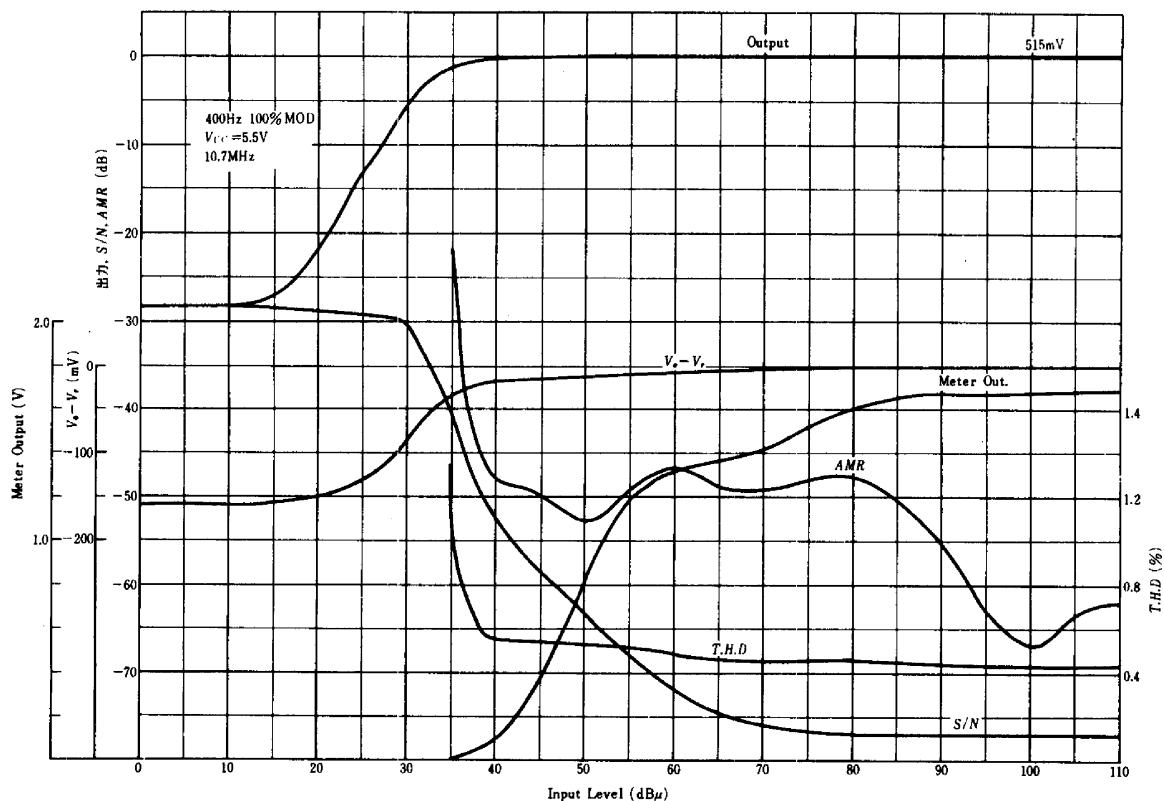
Third Stage Direct Coupled IF Amplifier

The intermediate frequency signal that has converted the frequency is inputted to pin 17. The input signal is amplified on the two-stage level by the Cascode Amp. of Q_{49} and Q_{47} and by the differential amplifiers of Q_{51} and Q_{52} . The output of Q_{52} is amplified by the emitter ground amplifier of Q_{53} and so that a sufficient amplitude may be obtained to drive the detection circuit. The intermediate frequency transformer is connected to pin 12, and it is detected by the external detection circuit (D_{101}). At the anode side of the diode D_{101} , the IF signal is bypassed by C_{117} , and the demodulation signal and synthesized signal of the direct current voltage cor-

responding to the demodulation signal are obtained. The demodulation signal for this synthesized signal is bypassed by a filter that is constructed by R_{111} , C_{116} , R_{112} , and R_{115} , and only the negative direct voltage is added to pin 11 as the AGC control signal after being split into R_{113} , R_{112} , and R_{111} . Since the signal outputted to the anode of the diode D_{101} is small at the time of a weak input, the negative direct current voltage is also small. The electric potential of pin 11 is provided charge electricity to Q_{55} and Q_{46} . Accordingly, as the input becomes larger, the electric potential of pin 11 falls, and Q_{46} starts conduction. As the result, the current that is flowing to Q_{47} decreases, and the gain of the Cascode Amp. constructed by Q_{49} and Q_{47} drops.

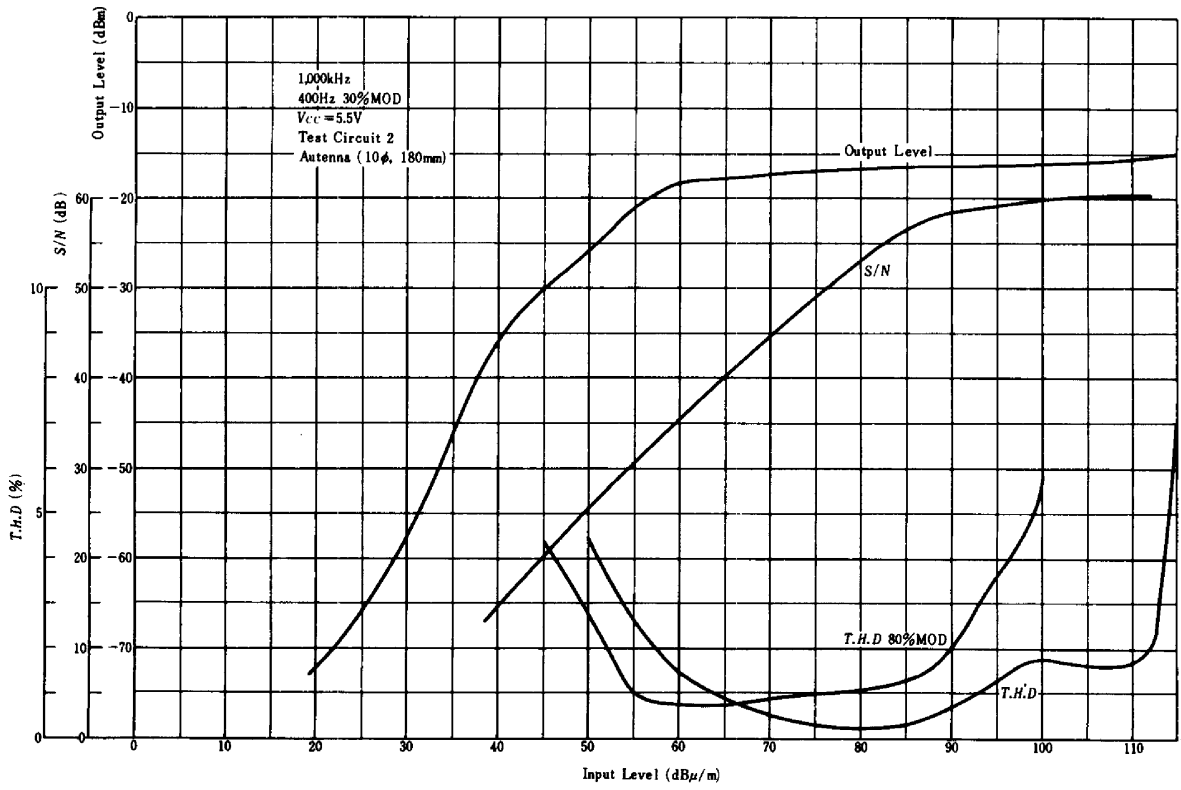
The AGC circuit that is constructed by Q_{46} , Q_{47} and Q_{49} is very strong with strong input as compared with the conventional reverse type AGC circuit, and the maximum permissible input (input level whose distortion factor is 5%) is 104dB (400Hz at 30% mod.) at the IF input level.

FM CHARACTERISTICS VS. INPUT LEVEL

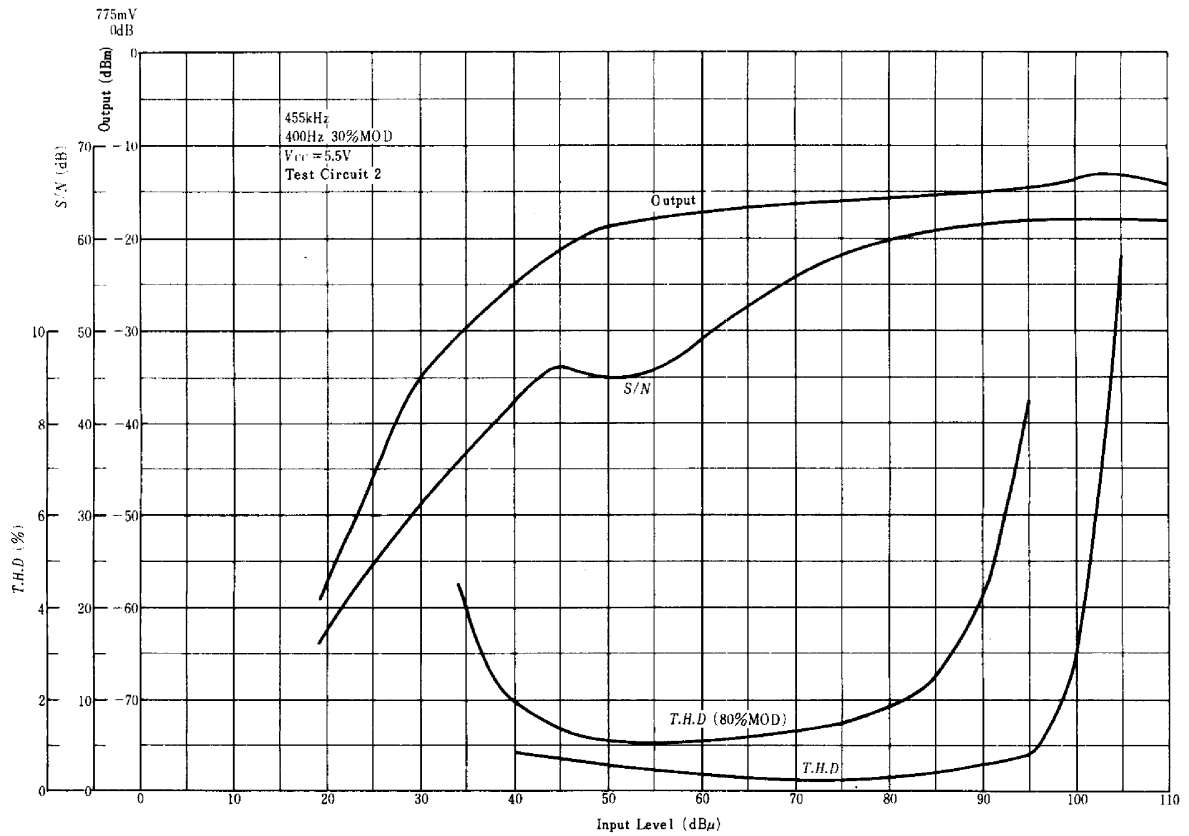


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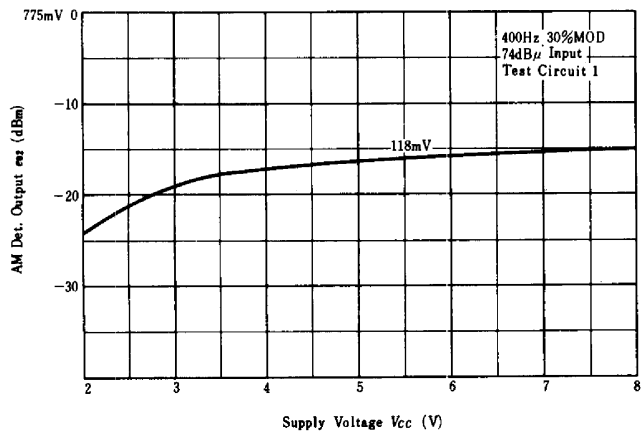
AM CHARACTERISTICS VS. INPUT LEVEL (Antenna Input)



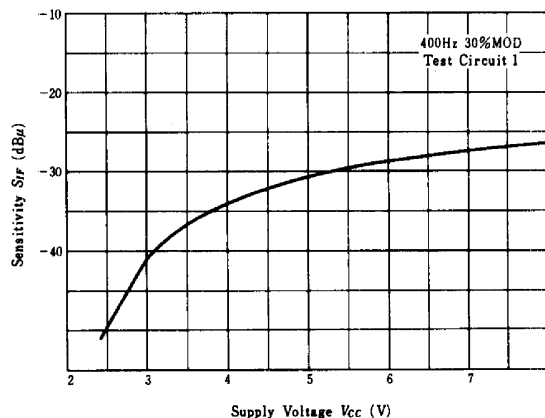
AM CHARACTERISTICS VS. IF INPUT LEVEL



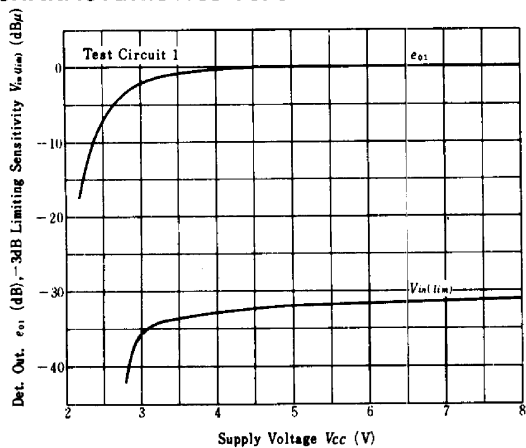
AM DETECTION OUT. VS. SUPPLY VOLTAGE



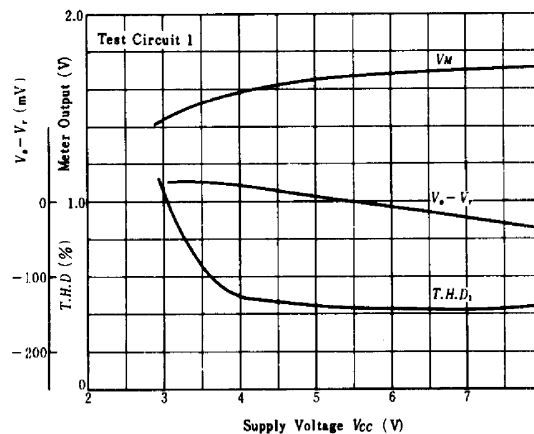
AM IF SENSITIVITY VS. SUPPLY VOLTAGE



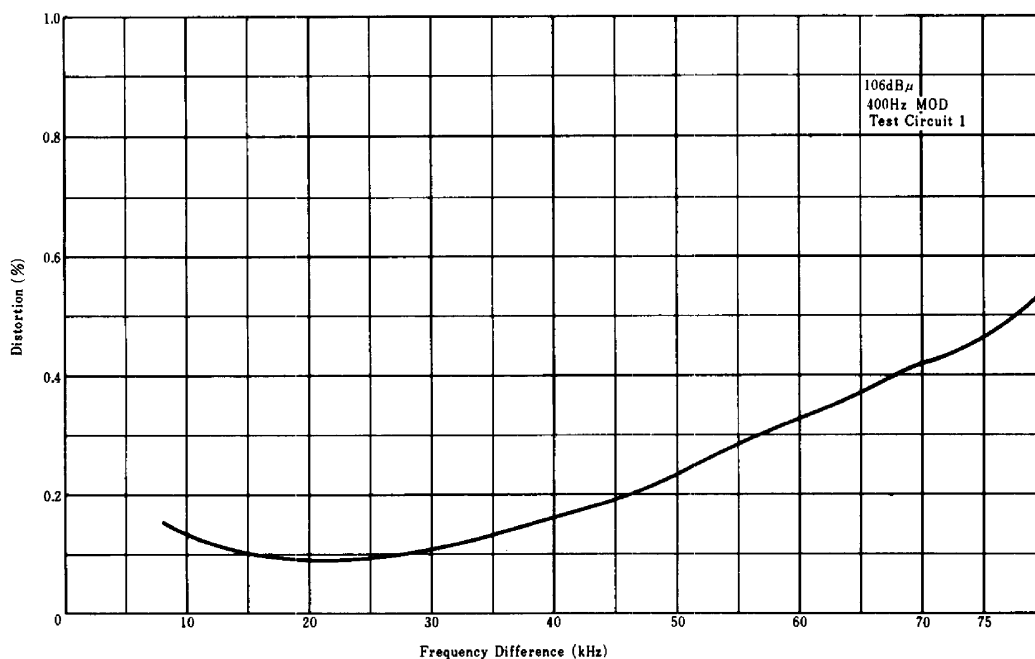
FM CHARACTERISTICS VS. SUPPLY VOLTAGE 1)



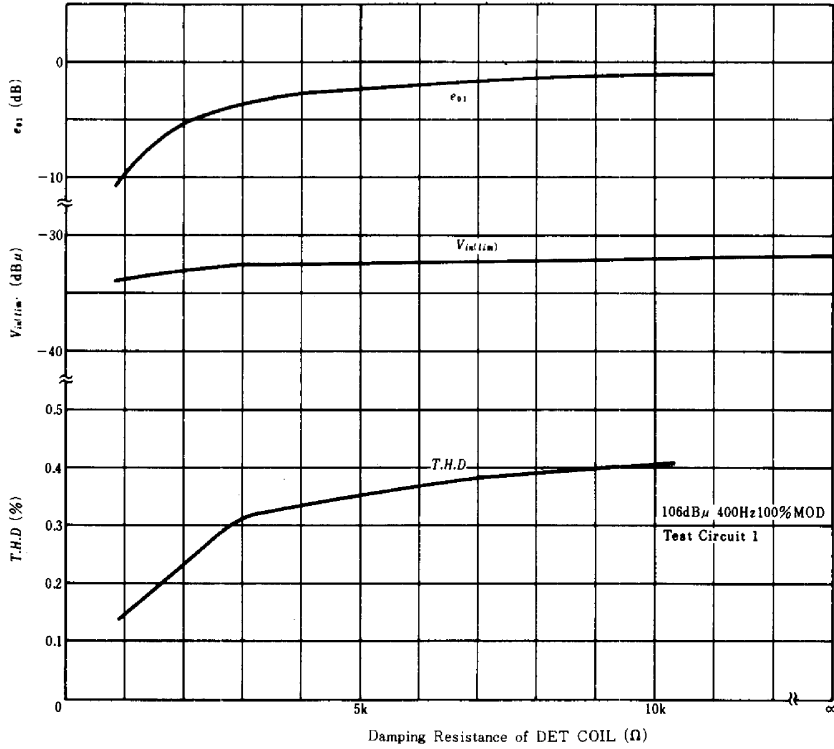
FM CHARACTERISTICS VS. SUPPLY VOLTAGE (2)



DISTORTION VS. FREQUENCY DIFFERENCE

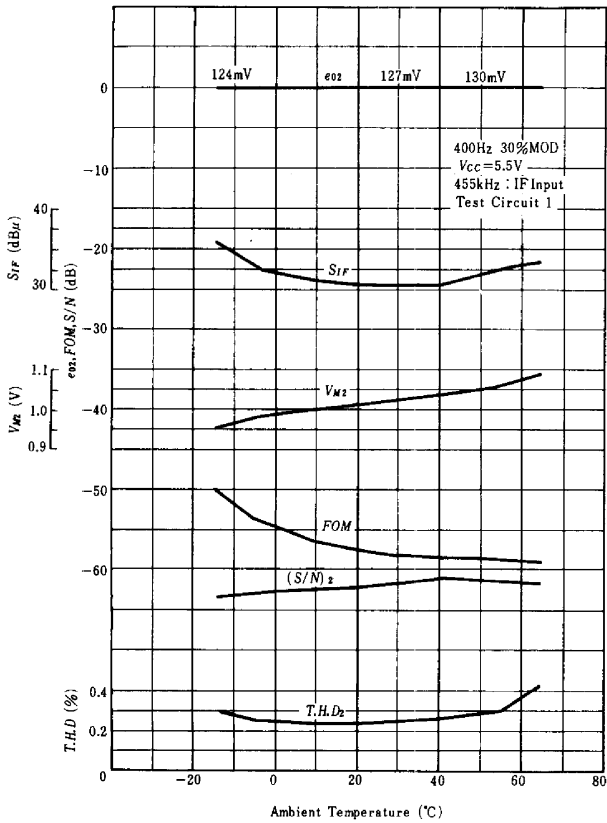


FM CHARACTERISTICS VS. DAMPING RESISTANCE OF FM DET. COIL

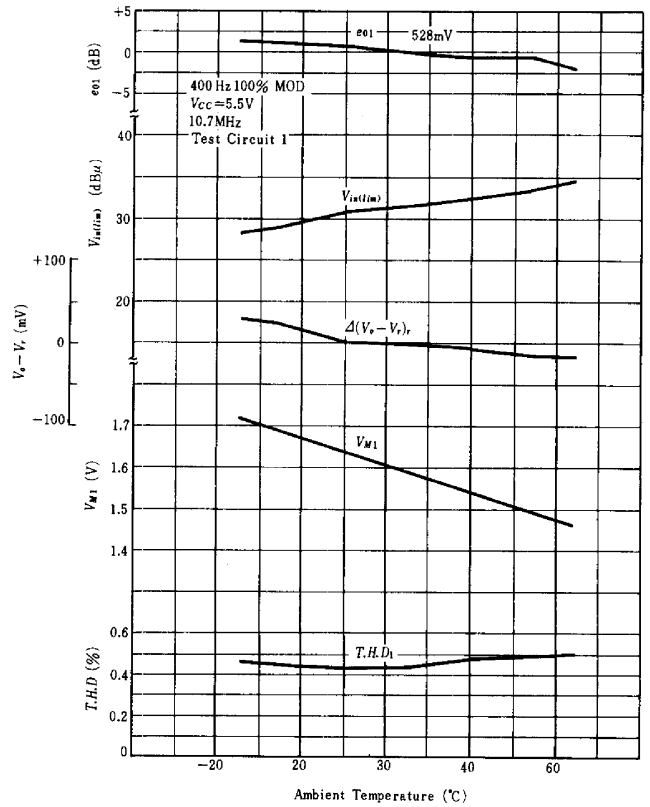


Note: Damping resistance is defined as parallel resistance to FM DET COIL (L_2).

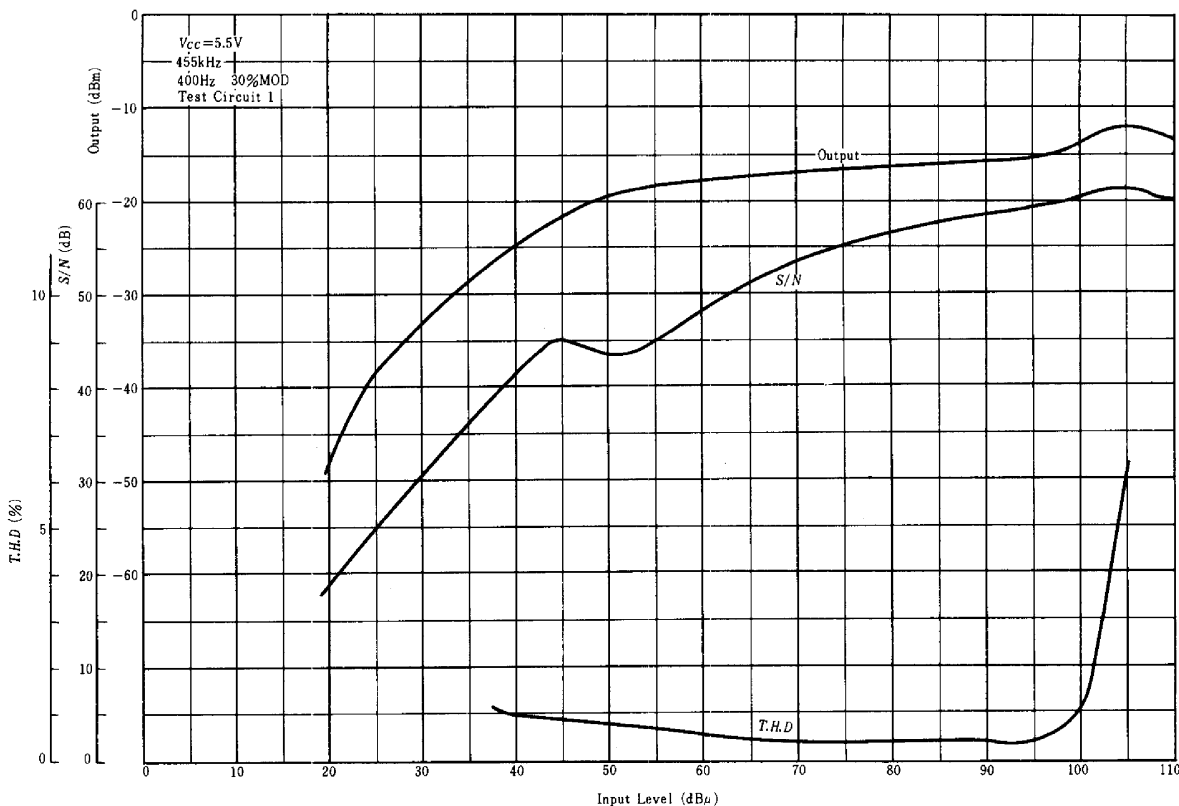
AM CHARACTERISTICS VS. AMBIENT TEMPERATURE



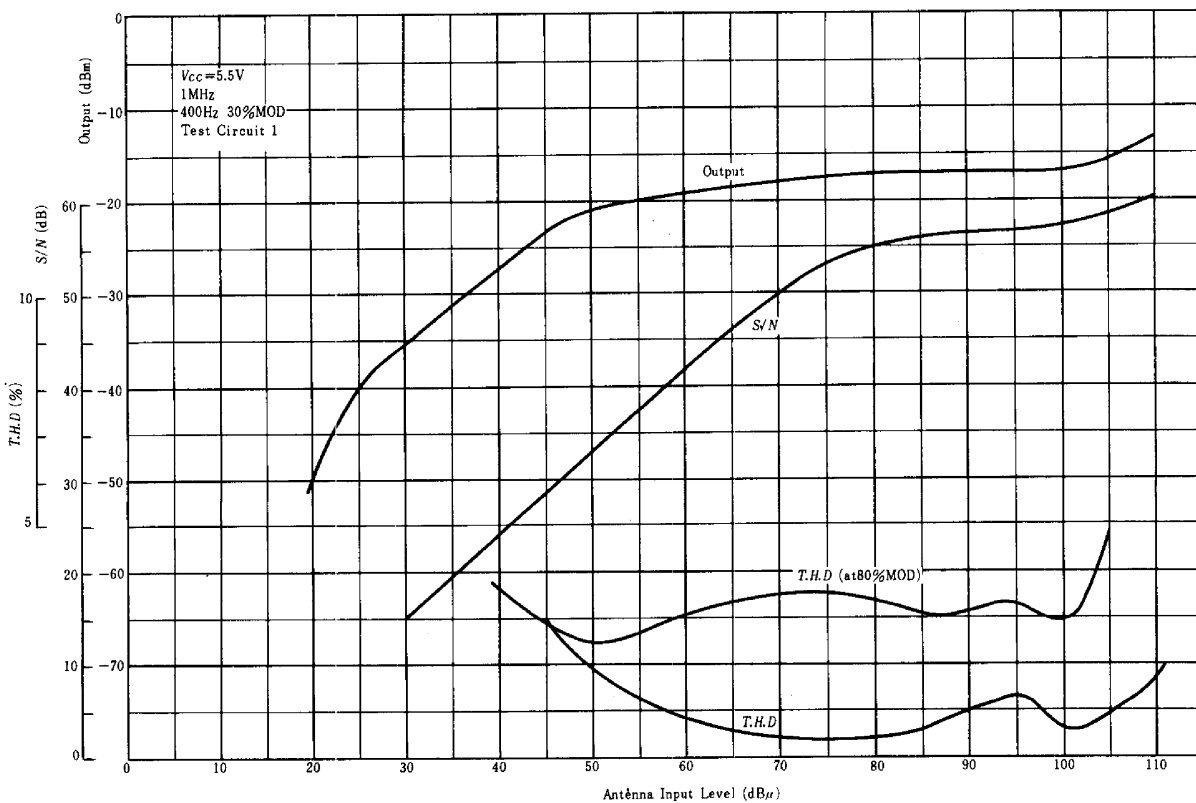
FM CHARACTERISTICS VS. AMBIENT TEMPERATURE



AM IF INPUT CHARACTERISTICS VS. INPUT LEVEL



AM ANTENNA INPUT CHARACTERISTICS



EXTERNAL COMPONENTS LIST

1. RESISTANCE

Parts No.	Recommended Value	Purpose	Influence		Remarks
			Smaller than recommended value	Larger than recommended value	
R ₁₀₂	330Ω	Intermediate freq. filter matching with impedance	—	—	
R ₁₀₃	5Ω	Power source decoupling	Deterioration of decouple effect	Deterioration of decreased voltage characteristics	
R ₁₀₄	22kΩ	Determination of the size of AFC voltage	Smaller AFC voltage	Larger AFC voltage	
R ₁₀₅	4.7kΩ	Determination of detection voltage	Smaller detection voltage	Larger detection voltage	
R ₁₀₆	20kΩ	FM output resistance	—	—	
R ₁₀₇	1kΩ	Composition of C ₁₁₈ and LPF	Deterioration of leakage of carrier	Smaller detection output	
R ₁₀₈	15kΩ	AM output resistance	—	—	
R ₁₀₉	8.2kΩ	Signal meter power source adjustment	Meter current increases	Meter current decreases	Determination of optimum value by meter used
R ₁₁₀	1.5kΩ	Composition of C ₁₂₁ and LPF	Deterioration of distortion factor	Meter current decreases	
R ₁₁₁	27kΩ	Smoothing C ₁₁₆ and AGC voltage	Quicker AGC response	Deterioration in AGC response	Note : The maximum sensitivity deteriorates when all the values becomes small.
R ₁₁₂	27kΩ	Smoothing C ₁₁₅ and AGC voltage	Quicker AGC response	Deterioration in AGC response	
R ₁₁₃	22kΩ	AGC bias supply	Deterioration in AGC response	Quicker AGC response	
R ₁₁₄	240Ω	For phase shifting correction	—	—	Determination of the optimum value by detection coil used.
R ₁₁₅	33kΩ	For D ₁₀₁ bypass adjustment	Decrease in output	Deterioration of distortion	
R ₁₁₆	2.7kΩ	Adjustment of signal meter current	Increase in meter current	Decrease in meter current	
R ₁₁₇	33kΩ	For gain dispersion range reduction	Deterioration of gain	Increase of dispersion gain	
R ₁₁₈	1kΩ	Converter, emitter resistance	Deterioration of S/N	Deterioration of gain	
R ₁₁₉	47Ω	Determination of converter gain	Larger converter gain	Deterioration of converter gain	
R ₁₂₀	100Ω	Prevention of oscillation	Deterioration of stability	Deterioration of gain	
R ₁₂₁	33kΩ	Composition of D ₁₀₃ and AGC converter	Deterioration of distortion factor	Deterioration of distortion factor	
R ₁₂₂	220Ω	Power source decoupling	Deterioration of decouple effect	Deterioration of decreased voltage	
R ₁₂₃	1.2kΩ	For converter ON/OFF	—	—	

Note : The measuring circuits 1 and 2 can be selected respectively, as the AGC constants (R₁₁₁, R₁₁₂, R₁₁₃).

The main difference between two is that the maximum sensitivity (input level at detection output=10mV) for the measuring circuit is about 4dB better than that for the measuring circuit 2, but T.H.D. becomes worse at the demodulation of 80%.

2. CONDENSER

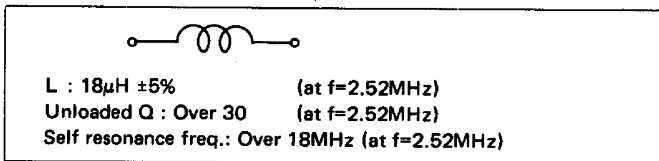
Parts No.	Recommended Value (Unit μF)	Purpose	Influence		Remarks
			Smaller than recommended value	Larger than recommended value	
C ₁₀₁	0.047	Bypass condenser	Deterioration of stability	—	
C ₁₀₂	0.047	Bypass condenser	Deterioration of stability	—	
C ₁₀₃	0.047	Bypass condenser	Deterioration of stability	—	
C ₁₀₄	0.047	Decoupling	Deterioration of decouple effect	—	
C ₁₀₅	0.010	Coupling	—	—	
C ₁₀₆	0.047	Bypass condenser	—	—	Note 1
C ₁₀₇	1	C ₁₂₅ and hum removal	—	—	Note 2
C ₁₀₈	0.00012	Bypass condenser	—	Deterioration of AMR	
C ₁₀₉	3.3	FM output coupling	—	—	50 sec. deemphasis
C ₁₁₀	0.015	Determination of R ₁₀₃ and deemphasis	—	—	
C ₁₁₁	4.7	Bypass condenser	Decrease in gain	—	
C ₁₁₂	0.01	Bypass condenser	—	—	
C ₁₁₃	0.01	AM input coupling	—	—	
C ₁₁₄	0.01	AM IF coupling	—	—	
C ₁₁₅	3.3	Smoothing AGC voltage	Deterioration of distortion in lower limits	Deterioration of AGC response	
C ₁₁₆	3.3	Smoothing AGC voltage	Deterioration of distortion in lower limits	Deterioration of AGC response	
C ₁₁₇	0.01	Smoothing condenser	Deterioration of Distortion	—	
C ₁₁₈	0.01	Smoothing condenser	Deterioration of distortion	—	
C ₁₁₉	0.10	Determination of R ₁₀₈ and AM output coupling f characteristics	Deterioration of f characteristics in lower limits	Large output in lower limit	
C ₁₂₀	0.01	Smoothing condenser	—	—	
C ₁₂₁	0.022	Smoothing condenser	—	—	
C ₁₂₂	47	Meter output audio bypass	Meter oscillates by audio signal	Large meter constant	
C ₁₂₃	33	Power source decoupling	Meter oscillates by audio signal	Large meter constant	
C ₁₂₄	0.047	Power source decoupling	Deterioration of decouple effect	—	
C ₁₂₅	3.3	C ₁₀₇ and hum removal	—	—	
C ₁₂₆	0.0001	Prevention of oscillation	Unstable	—	Note 2
C ₁₂₇	0.022	Power source decoupling	Deterioration of decouple effect	—	

- Note : 1. When observing the S-curve, make the voltage 3.3 μF .
Use about 500pF for extremely strong AM input countermeasures that intermix at the time of FM.
2. C₁₀₇ and C₁₂₅ are the circuits to remove the hum which superposes to the power source.

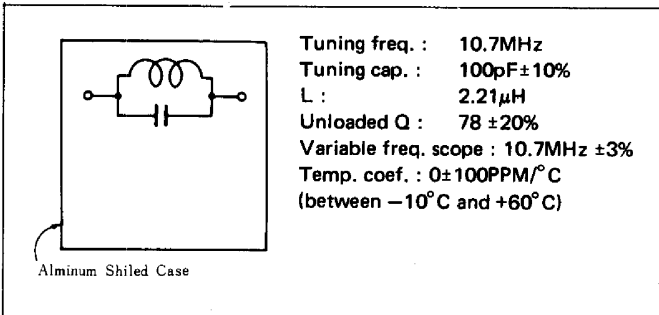
3. COIL, DIODE

Parts No.	Recommended Value	Purpose	Influence		Remarks
			Smaller than Recommended value	Larger than Recommended value	
D101	IN60P	For AM signal detection			
D102	IN60P	For AM meter output detection			
D103	IS2076	For AGC converter			
L1		See the attached paper.			
L2					
L3					
L4					
L5					
L6					
L7					

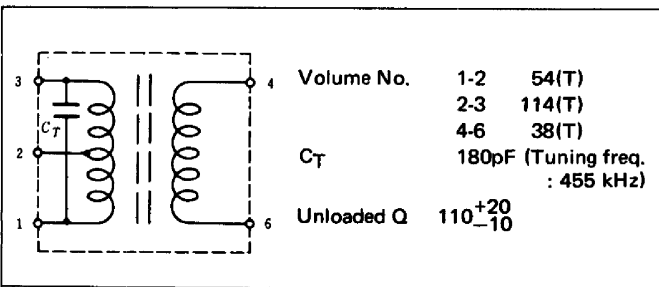
L₁ : COIL FOR PHASE SHIFTER
(Equivalent to Toko 144LZ-180K)



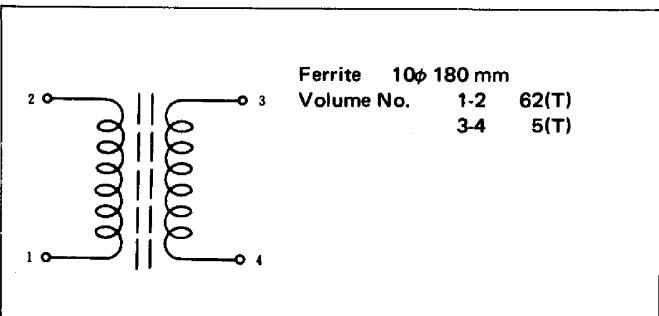
L₂ : COIL FOR DETECTION
(Equivalent to Toko MV4FLC-20000AG)



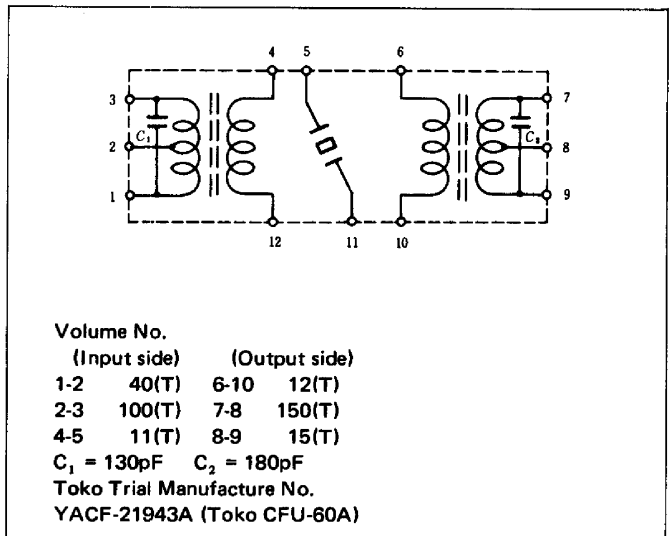
L₃ : DETECTION COIL FOR AM (Toko RMC-4256AAM)



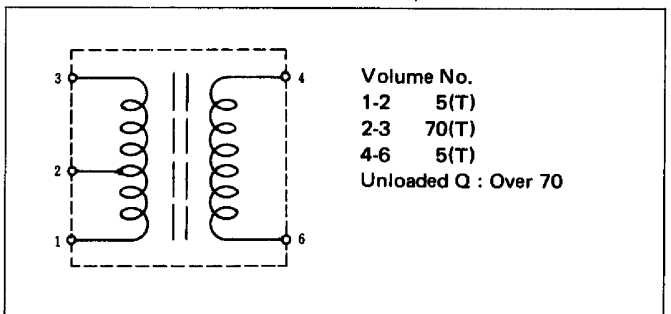
L₆ FERRITE BAR ANTENNA FOR AM



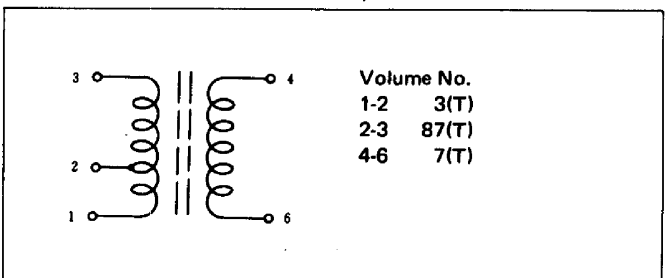
L₄ IF TRANSFORMER FOR AM
(Equivalent to Toko CFU-089)



L₅ OSCILLATION COIL FOR AM
(Toko Trial Manufacture No. RWR 42110N)



L₇ ANTENNA TRANSFORMER FOR AM
(Toko Manufacture No. RMN-41749N)



PC-BOARD LAYOUT PATTERN

