FM REBROADCASTING TRANSMITTER UTILIZING ICs

COPYRIGHT

by NIPPON HOSO KYOKAI (NHK)

EDITED

by NIPPON HOSO KYOKAI (NHK)

PRINTED

by JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

* * * * * * * * *

NHK CENTRAL TRAINING INSTITUTE

1-10-11, Kinuta, Setagaya-ku,

TOKYO 157, JAPAN

FM REBROADCASTING TRANSMITTER UTILIZING ICs

In the former FM rebroadcasting transmitters, transisterized circuits in form of units, were widely used. However, recently, in order to reduce the construction cost of establishing rebroadcasting stations, ICs are being positively used because of its low-power consumption, high reliability and compactness.

1. Principles of Design

1.1 To be used in the 76 - 90 MHz Frequency-range assigned to FM Broadcasting

(1) Receiver main unit to cover a wide-range of 76 - 90 MHz

(2) Transmitter main unit to cover a wide-range of 76 - 90 MHz

(3) 10 W power amplification unit to cover a wide-range of 76 - 90 MHz also

1.2 The number of necessary components and parts have been reduced, as much as possible to improve the reliability of the whole system.

(1) Lumped-constant intermediate frequency filters have been replaced to crystal filters.

(2) By adoption of ICs, the reliability of equipment has greatly increased.

1.3 Small in Size and Light in Weight

(1) Receiver unit consists of one unit measuring 35 x 170 x 180 mm.

(2) 1 W transmitter unit consists of one unit measuring 70 x 170 x 180 mm.

(3) 10 W power amplification unit consists of one unit

measuring 70 x 170 x 180 mm.

1.4 Low Cost

(1) As the size of device has become compact, it can be accomodated somewhere in the rack of existing TV rebroadcasting transmitters, which will result in reduction of construction cost.

(2) In case the FM rebroadcasting transmitter is located in TV rebroadcasting transmitter stations, the direct-current power supply could be used in common.

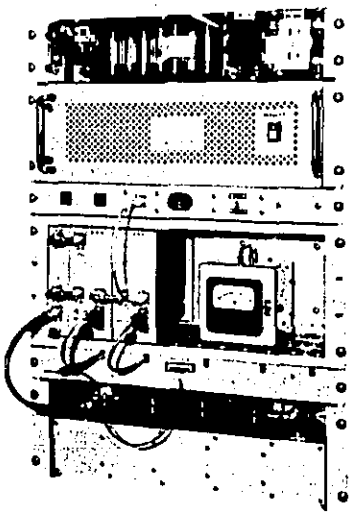
1.5 Others

(1) In order to eliminate the trouble of replacing lamps, red-light emitting diodes of long-life are used as indicator lamps for the squelch and output detection lamps.

(2) A shift-local system is adopted to stabilize the transmitting frequency, similarly to the conventional method in use.

2. FM Rebroadcasting Transmitter

The composition and line-up of FM 10 W rebroadcasting transmitter (one transmitter system) is shown in Fig. 1 and 2, respectively. The transmitter consists of an input-filter, receiver unit, 1 W transmitter unit, 10 W power amplification unit, harmonic filter, dummy-load switch and power supply unit etc.



Lightning arrester board
CVT rectifier (input AC)

Harmonic filter and dummy Load Switch
Receiver Unit
1W transmitter unit
10 W power amplification unit

Input filter

Fig. 1 Composition of 10W FM Rebroadcasting Transmitter (One Transmitter System)

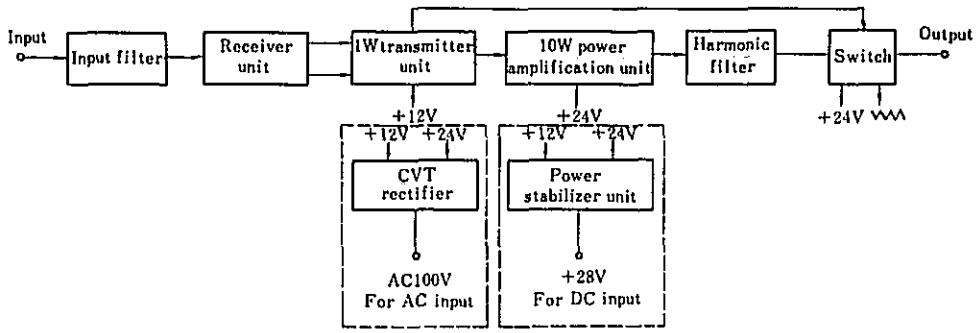


Fig. 2 Block Diagram of 10 W FM Rebroadcasting Transmitter (One Transmitter System)

2.1 Input Filter

The ratings and principle performances of the input-filter are shown in Table 1 and the circuit diagram of input filter is shown in Fig. 3. The input-filter consists of 5-stage helical coaxial resonators, and a coupling coil is provided in the input and output terminal. The inner coils are coupled by means of window-connection method.

The input filter is mounted in a standard size rack. The height of the filter unit is about 15cm, which is about half of the height required for conventional ones, however, the insertion loss has increased by approx. 2 dB.

Table 1 Ratings and Performances of Input-filter

Item		Rating Performances
Frequency		Specified frequency between 76-90 MHz
Impedance		50 Ω ; VSWR less than 1.2
Selectivity	Band-width (-3 dB)	More than 360 kHz
	±600 kHz	More than 40 dB
	±1 MHz	More than 60 dB
Insertion loss		Less than 5 dB

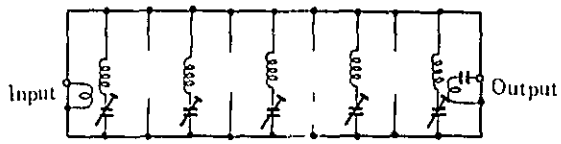


Fig. 3 Circuit of Input Filter

2.2 Receiver Unit

The ratings and performances of the receiver unit are given in Table 2, and the block diagram is shown in Fig. 4.

(1) Receiver main unit

The receiver main unit can correspond to any frequency, within the frequency range of 76 to 90 MHz, without any adjustment.

The gain of the high-requency amplification circuit is about 30 dB, and its output is fed into the mixer circuit through a band-pass filter. The 2-multiplied output of

local oscillation frquency, entering the mixer circuit is "reception frequency - 10.7 MHz."

The 10.7 MHz intermediate frequency output of the mixer enters through a filter and intermediate frequency amplification stage and becomes an output power of 106 dB, at 50 ohms, impedance.

The output-power of the crystal oscillator is further amplified at the original oscillation frequency amplification circuit, and becomes an oscillation output of 114 dB.

Then, this output is applied to the 1W transmitter unit and becomes the local oscillation frequency of the shift-local.

Table 2 Ratings and Principle Performances of Receiver Unit

Item		Rating · Performances
Input	Frequency Impedance Level	Specified frequency between 76-90 MHz 50 Ω 40-70 dBμ(terminated)
Output	Frequency Impedance Level	10.7 MHz 50 Ω 106 dBμ (terminated)
Original oscil output	Frequency Impedance Level	(Reception freq - 10.7 MHz)/2 50 Ω 114 dBμ (terminated)
Noise index		Less than 6 dB
Intermediate frequency selectivity	- 1.5 dB attenuation ±400 kHz ±600 kHz	More than 300 kHz More than 25 dB More than 40 dB
Power source		+12V, less than 0.2A

(2) Receiver local oscillation unit (cassette unit)

The frequencies to be received are determined by the receiver local oscillator. The oscillation frequency is

set by "Reception frequency - 10.7 MHz" x 1/2.

2.3 1 W Transmitter Unit

The ratings and performances of the transmitter unit are showr in Table 3. The block diagram is indicated in Fig. 5. As for input signals, the intermediate frequency of receiver unit and the original oscillation frequency are applied.

The shift-local system for stabilization of the transmission frequency, shown in Fig. 6 is utilizing the branched output of the receiver local oscillation frequency, as a part of the oscillation frequency of the transmitter unit. The fluctuation of the receiver local oscillation frequency will be cancelled out at the transmitter unit, and will not become the cause of frequency fluctuation.

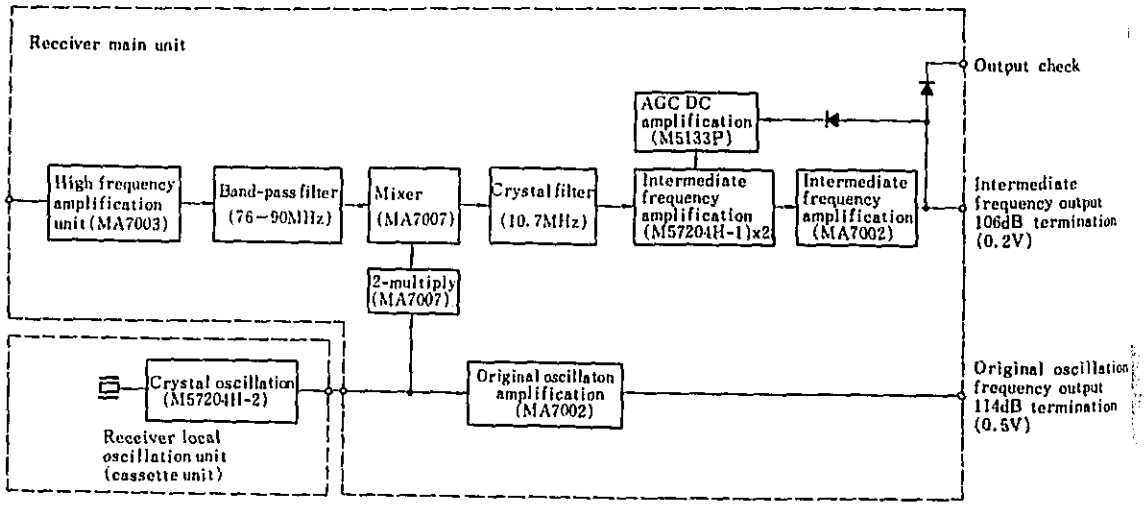


Fig. 4 Block Diagram of Receiver Unit

Table 3 Ratings and Principle Performances of 1W Transmitter Unit

Item		Rating.Performances
Input	Frequency Impedance Level	10.7 MHz 50 Ω 106 dBμ (terminated)
Original oscillation input	Frequency Impedance Level	(Reception freq. -10.7 MHz) 50 Ω 114 dBμ (terminated)
Output	Frequency Impedance Level	Specified frequency between 76-90MHz 50 Ω 1 - 1.2 W
Intermediate frequency selectivity	-1.5dB atennuation ±400 kHz ±600 kHz	 More than 300 kHz More than 25 dB More than 40 dB
Band-Pass filter selectivity	Band-width (-3 dB) ±600 kHz ±1 MHz	 400 kHz More than 20 dB More than 30 dB
Output-level adjustment range		More than rated value +1 dB-0.5 dB
Spurious		Under rated imput/output, less than - 65 dB, excluding harmonics
Power source		+12V less than 0.7 A

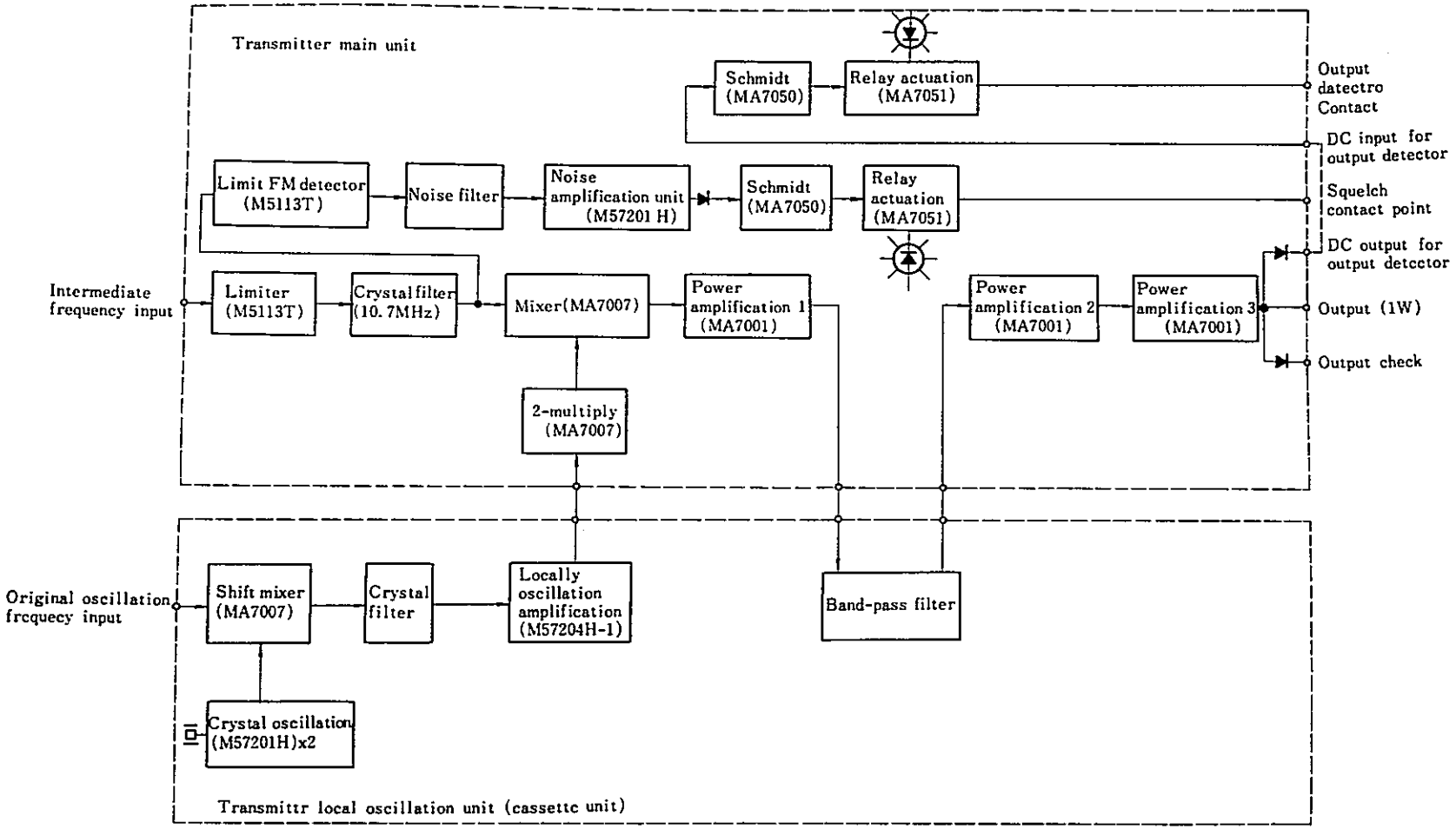


Fig. 5 Block Diagram of 1W Transmitter Unit

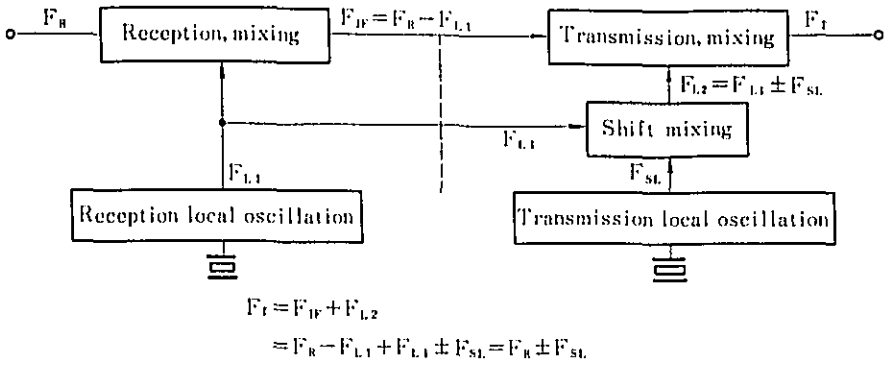


Fig. 6 Principle of Shift-local System

The only cause of frequency fluctuation of the transmitting frequency, is the deviation of multiplication-shift in the local crystal oscillator frequency of transmitter unit. The local oscillation frequency of the crystal oscillator is expressed by "reception frequency-transmitting frequency" x 1/2.

The frequency-band allocated to FM broadcasting is from 76 to 90 MHz, and the minimum channel spacing is 0.6 MHz. Therefore, if the number of multiplication of the local oscillator is twice, it will become 0.3 to 7 MHz. Even in this case, the deviation will be within 100 Hz and there will be no trouble arising in maintenance, with regard to multi-stage relaying.

(1) 1 W transmitter main unit

The transmitter main unit consists of limiter unit of intermediate frequency amplifier, mixer unit of the transmitter conversion unit, 1W power amplification unit, squelch unit and output-detector unit.

The 2-muli multiplied local oscillator frequency output applied to the frequency mixer unit is "reception frequency - 10.7 MHz." This mixer unit will correspond to any output frequency within the range of 76 - 90 MHz,

as well as to the 1 W power amplification circuit.
The squelch circuit will FM-detect the output of the intermediate limiter-stage and, amplify the noise component in the neighbour of 150 kHz of the detected output and, rectify it to operate the relay. In other words, it is a noise-detector type squelch. In case the carrier of the master station is off the air, it will connect the dummy load to the transmitter output to prevent radiation of noise. In case of the two transmitters system, it will be used as a switching signal, to switch over between the two transmitters.
The output detector circuit will operate when the output power of the 1 W power amplification circuit becomes -6 dB. The DC input to operate the output detector circuit will be taken from the 1 W stage, in case of the 1 W rebroadcasting transmitter and from the 10 W stage in case of the 10 W rebroadcasting transmitter.
The output detector circuit-contact will detect the abnormality of the power amplification units, in case of the two transmitter system, and provide a signal to switchover between the two transmitters.
The operation of the squelch output-detector is provided by a emission diode, which has a long life.

(2) Transmitter local oscillation unit (cassette unit)
The local oscillation unit of the transmitter determines the frequency to transmit, within the frequency range of 76 - 90 MHz. The local oscillator unit of the transmitter consists of a mixer circuit to shift and combine the original oscillation frequency of the receiver unit and a transmitter crystal oscillation frequency, and a band-

pass filter inserted in the converted frequency circuit of the transmitter.

As the output of the shift-combiner and transmitter crystal generates spurious signals, a narrow band-pass crystal filter is used to supress the spurious interference.

2.4 A Circuit Preventing Generation of Spurious Signals

(1) Transmitter Mixer Circuit

It is generally preferable to eliminate spurious by putting a resonance circuit in the input and output of the mixer stage. A balanced type mixer stage had been adopted to reduce generation of spurious caused by wide-band operation.

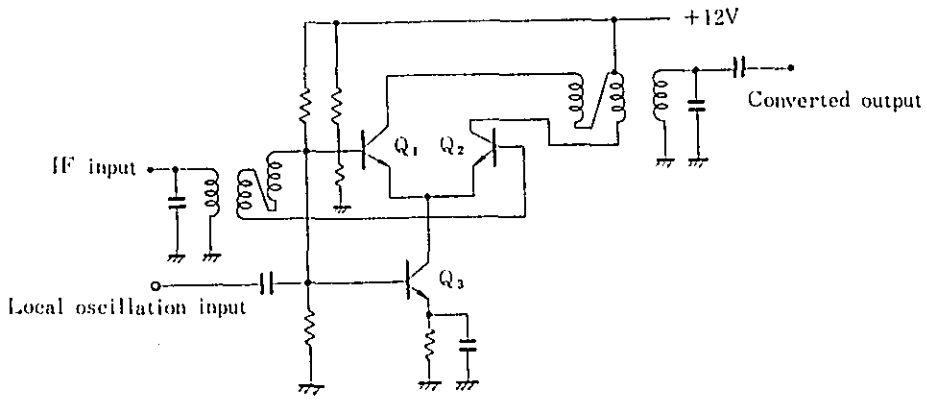


Fig. 7 Diagram of Transmitter Mixer

Fig. 7 indicates the transmitter mixer circuit. The IF input enters the base of Q_1 and Q_2 of the balanced type IC circuit, in push-pull, and leaves the collector in push-pull. The local oscillation input enters the base Q_3 and it is amplified. Then, it is fed to the emitter of Q_1 and Q_2 in phase and, no output of local oscillation will appear as output. Actually, spurious appears in the output signal, to a degree of -4 to -6 dB, but as it will be saturated in

the following stage amplifier, there will be no fear in increase of spurious radiation. This spurious signal will be completely removed by the band-pass filter located in the transmitter cassete unit.

(2) 2-multiplication circuit

The 2-multiplication circuit of the local oscillator will also become the cause of spurious generation. In the C class multiplier, the strength of second harmonics is about 6 dB lower in strength than that of the fundamental frequency. In order to decrease the spurious generation over the whole band, a high class band-pass filter will be necessary. Therefore, in this rebroadcasting transmitter, a 2-multiplication method employing the full-wave rectification system was adopted.

In this system, the even-order harmonic output, such as the second, fourth, will only be generating theoretically, and the odd-order output, such as the fundamental, the third, fifth will not be generating.

The circuit is shown in Fig. 8, the ICs, same as the ones in the transmitter mixer stage are used, and the output is a double resonance circuit, obtaining a spurious output ratio, more than about-35 dB, for the odd-order harmonics and about-25 dB for the even-order harmonics.

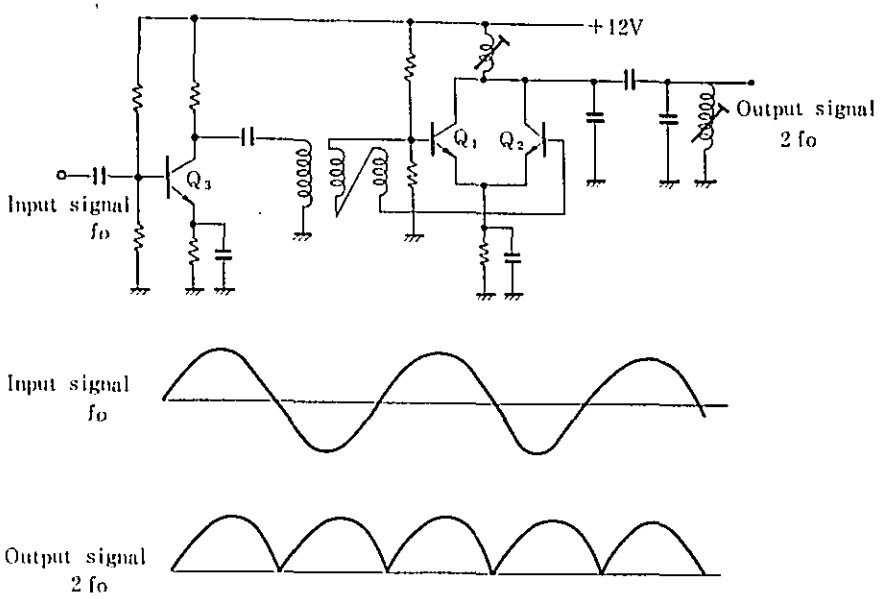


Fig. 8 2-multiplier Circuit

(3) Shif-mixer output circuit

As a spurious of "original oscillation ±0.3 - 7 MHz" generates in the output of the shift-mixer, it is eliminated by a narrow-band crystal filter.

The selectivity of the filter is ±150 kHz, having an attenuation characteristic of more than 60 dB and the spurious of the output of mixer stage is suppressed more than 60 dB.

2.5 10 W Power Amplification Circuit

In case of the 1 W rebroadcasting transmitter, the harmonic filter is inserted between the output of the 1W transmitter unit and the antenna circuit.

In case of the 10 W rebroadcasting transmitter, a 10 W power amplification unit is added between the 1 W transmitter unit and the harmonic filter. The power amplification unit is of the transistorized type and the major ratings and performances are shown in Table 4. The block diagram is given in Fig. 9.

As the power amplification unit is of wide-band amplification covering the frequency range of 76 - 90 MHz, it can be used for any other transmitter station, just as the receiver unit and 1 W transmitter unit can be used.

The harmonic spurious inherent to wide-band amplification will be eliminated by the filter explained in the following section.

Table 4 Ratings and Principle Performances of 10 W Power Amplification Unit

Item		Rating · Performances
Input	Frequency Impedance Level	76 - 90 MHz 50 Ω 1 W ±1 dB
Output	Frequency Impedance Level	76 - 90 MHz 50 Ω 10 W
Band performance		Less than ±0.5 dB in range of 76 - 90 MHz
Output level adjustment range		Rating +1 dB, morethan -0.5 dB
Spurious		With respect to the fundamental wave of rated input/output, not more than -10 dB for second harmonic, -15 dB for third harmonic, -20 dB for fourth harmonic, respectively.
Output for output-detection		DC +2.3 - 5.8 V 10 k Ω load
Power source		DC +24 V less than 1.3 A

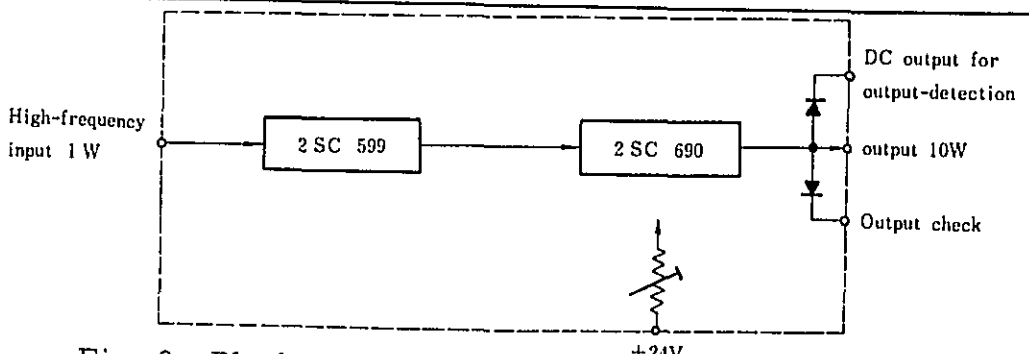


Fig. 9 Block Diagram of 10 W Power Amplification Unit

2.6 Harmonic Filter

The harmonic filter, as shown in Fig. 10, is a low-pass filter. It attenuates the generation of harmonics of the FM frequency-band of 76 - 90 MHz, which will be higher than 152 MHz, by an amount of 80 - 100 dB.

As the main purpose of the low-pass filter is to eliminate the harmonics of the power amplification circuit, the adjacent spurious generated at the modulation circuit are devised to be eliminated by the reception unit and 1 W transmitter unit.

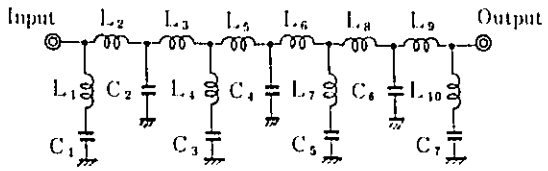


Fig. 10 Circuit of the Output Filter

In case the transmitting frequency and receiving frequency are very near, the radiated power of transmitter will often be fed back to the receiver antenna and become the cause of oscillation. To prevent this, the necessary D/U value is set and the amount of feed-back to the receiver unit is limited, and a notch filter with frequency corresponding to the reception frequency, is inserted between the 10 W amplifier output stage and output filter, to avoid feed-back. The notch filter is inserted in case the difference of frequency is within 1 MHz.

2.7 Power Supply Unit

The power consumption of the receiver and transmitter unit is about 0.7 A at 12V, and that of the 10 W power amplification unit and ancillary unit it is about 1.3 A at 24 V. There are two methods for supplying power.

One is to branch "DC +24 ~ +28V" from the constant voltage

rectifier of existing TV rebroadcasting transmitters and after passing through the power supply stabilizer, it is supplied to the equipment.

The other one is to use a CVT constant voltage rectifier, to draw out the necessary DC source from AC 100 V power lines. The CVT rectifier source is the same type used for TV rebroadcasting transmitters.

3. Adjustment and Maintenance

The way of adjustment and maintenance are the same as the transistorized rebroadcasting transmitters in use. However, attention should be paid to the fact that DC is superposed on the receiver output and the 1 W transmitter input. To measure the high-frequency, it will be necessary to use a DC disconnecter. In the former 2-transmitter system, the squelch was set to operate when the open-end level of the input filter was 30 dB, but in case of the one transmitter system, the open-end input level is set to 27 dB, because there will be no distribution loss existing. The value mentioned above is a condition when a resistor attenuator is not inserted in the input side but when an attenuater is inserted, this value should be added.