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1.0-20.0 GHz Multichannel Receiver

Part No. RM-1/20-16

Technical Description

St. Petersburg
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Contents

1. Introduction

The multichannel 1.0-20.0 GHz Receiver (below referred to as *Receiver*) is intended to be used with wideband down converters. The system down converter with receiver (Radiometer) can be used for plasma electron temperature measurements in Tokamaks. The fact is taken as a basis of the device that the intensity of the ECE 2nd harmonic is proportional to the electron plasma temperature in situations when the plasma can be considered as the black body for its own cyclotron radiation. The Radiometer is a super heterodyne receiver that picks up the plasma EC emission and produces 0…+10V analogue output signal proportional to the plasma emission power. The measurements are performed simultaneously in 16 frequency channels (i.e. radial points in the plasma) covering f heterodyne +20GHz band. Output signals are delivered in a form available to be stored in Tokamak data acquisition system.

2. Parameters and specifications

- Principle of functioning: super heterodyne receiver.
- Input frequency band 1.0 ÷ 20.0 GHz
- Output Video amplifier frequency band DC ÷ 1 MHz
- Number of output frequency channels 16
- Noise Figure 8-15 dB
- Total gain 20-25 dB
- Built-in attenuator in each channel 30.5 dB
- Attenuator step 0.5 dB
- Bandpass widths in individual channels 1.1875 GHz
- Maximum output voltage 0 - +10 V
- Input connector SMA
- Output connectors BNC
- Operating temperature +10°C…+40°C
- Power supply 220 V, 50 Hz

3. Design and principles of functioning

3.1 Block scheme of Receiver

The Receiver consists of 16 channels input power divider and 16 separated super heterodyne receivers. Block-scheme of the Radiometer is presented below:

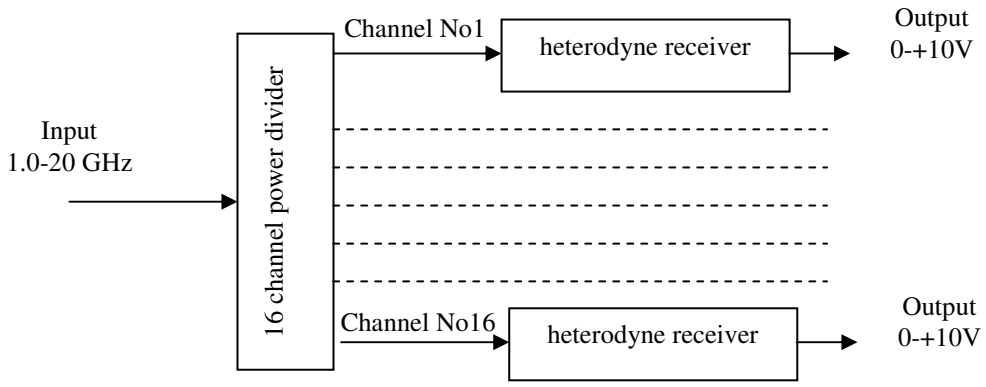


Fig. 1. Block-scheme of the Receiver.

3.2 Block scheme of super heterodyne receivers.

All the heterodyne receivers are constructed following the same scheme, which is depicted in Fig. 2.

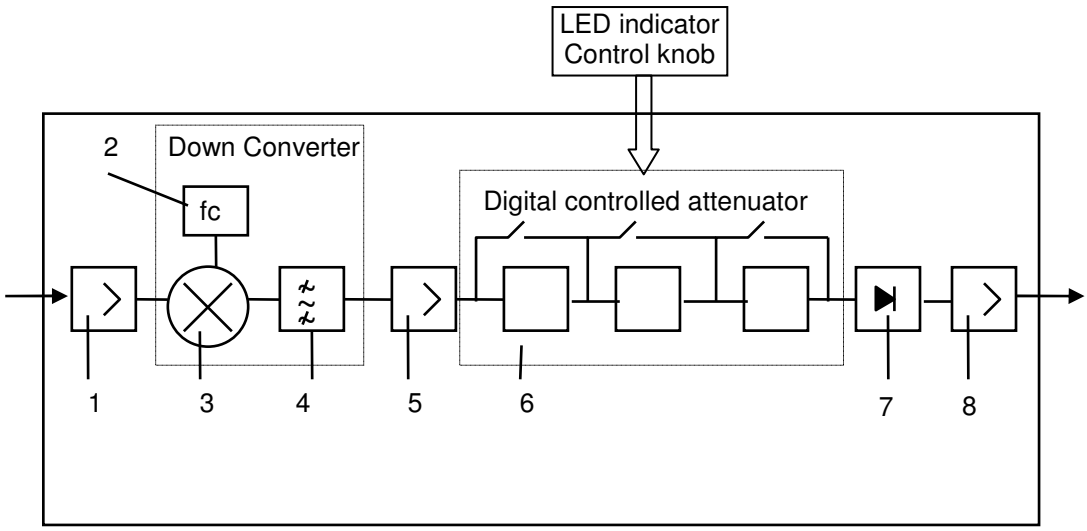


Fig. 2. Super heterodyne receiver.

Just at the entrance of the Module the signal is amplified with a bandpass amplifier (1, Fig. 2). Then the second frequency conversion is occurred that transforms the input signals within the frequency band of 1.0÷20 GHz into output signals with frequencies within a range from 0 to 0.59375 GHz. Balanced mixer (3, Fig. 2), local oscillator (2, Fig. 2) and low frequency bandpass filter (4, Fig. 2) are assembled into a double side band Down Converter unit.

Then the signal passes through another amplifier (5, Fig. 2) with gain factor of 25 dB depending on channel.

Detectors (7, Fig. 2) rectify the entering signals transforming them into output video signals. Conversion factor of the detectors varies around 100 mV/mW in different channels being linear vs the input power if the latter does not exceed 1 mW. Upper frequency limit of the detectors is not less than 10 MHz.

Digital controlled attenuator (6, Fig. 2) is provided in each channel to keep the power entering the detector below 1 mW thus ensuring the detector linearity. The attenuator is controlled with external microcontroller and allows to get 0.5 dB step. Every 2 sec microcontroller stories current setting of the attenuator and after switch off/on of the receiver refresh last set value.

The output Video amplifiers (8, Fig. 2) have about 100 times amplification factor and provide 0-+10V output in linear regime for video detector.

Central frequency, f_c, and the bandwidth, Δf, of individual channels of IF Blocks are presented in Tables 1.

Channel number	Central frequency, f_c, GHz	Frequency band width at level –20dB, Δf, GHz
16	1.59375	1.0000 - 2.1875
15	2.78125	2.1875 - 3.3750
14	3.96875	3.3750 - 4.5625
13	5.15625	4.5625 - 5.7500
12	6.34375	5.7500 - 6.9375
11	7.53125	6.9375 - 8.1250
10	8.71875	8.1250 - 9.3125
9	9.90625	9.3125 - 10.5000
8	11.09375	10.5000 - 11.6875
7	12.28125	11.6875 - 12.8750
6	13.46875	12.8750 - 14.0625
5	14.65625	14.0625 - 15.2500
4	15.84375	15.2500 - 16.4375
3	17.03125	16.4375 - 17.6250
2	18.21875	17.6250 - 18.8125
1	19.40625	18.8125 - 20.0000

3.3 Front panel and controls.

Front panel with control knobs are shown at Fig.3.

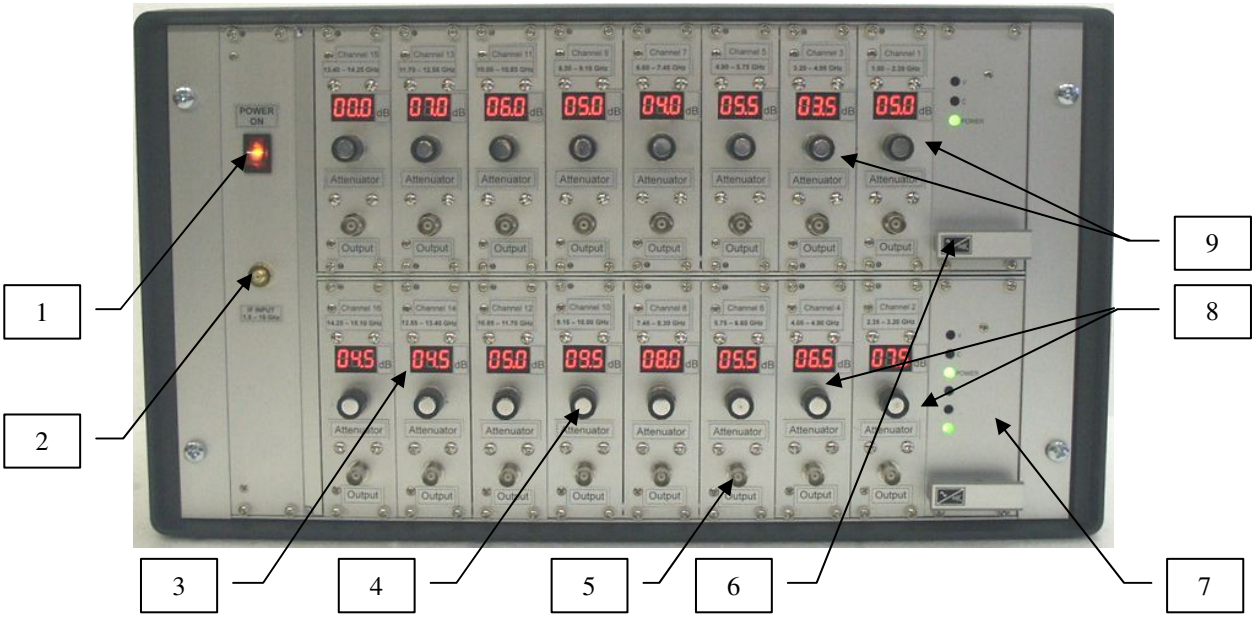


Fig. 3. Front panel and control knobs.

1- Power switch with indicator
2- Input 1.0-20 GHz, SMA connector
3- LED Indicator of built-in attenuator
4- Control knob of built-in attenuator
5- Output of heterodyne receiver, BNC connector
6- Power supply module +5 DCV
7- Power supply module +/-12 DCV
8- Line Channels No. 2, 4, 6,…16
9- Line Channels No. 1, 3, 5….15

3.4 Rear panel.

Rear panel of the receiver is shown at Fig.4.

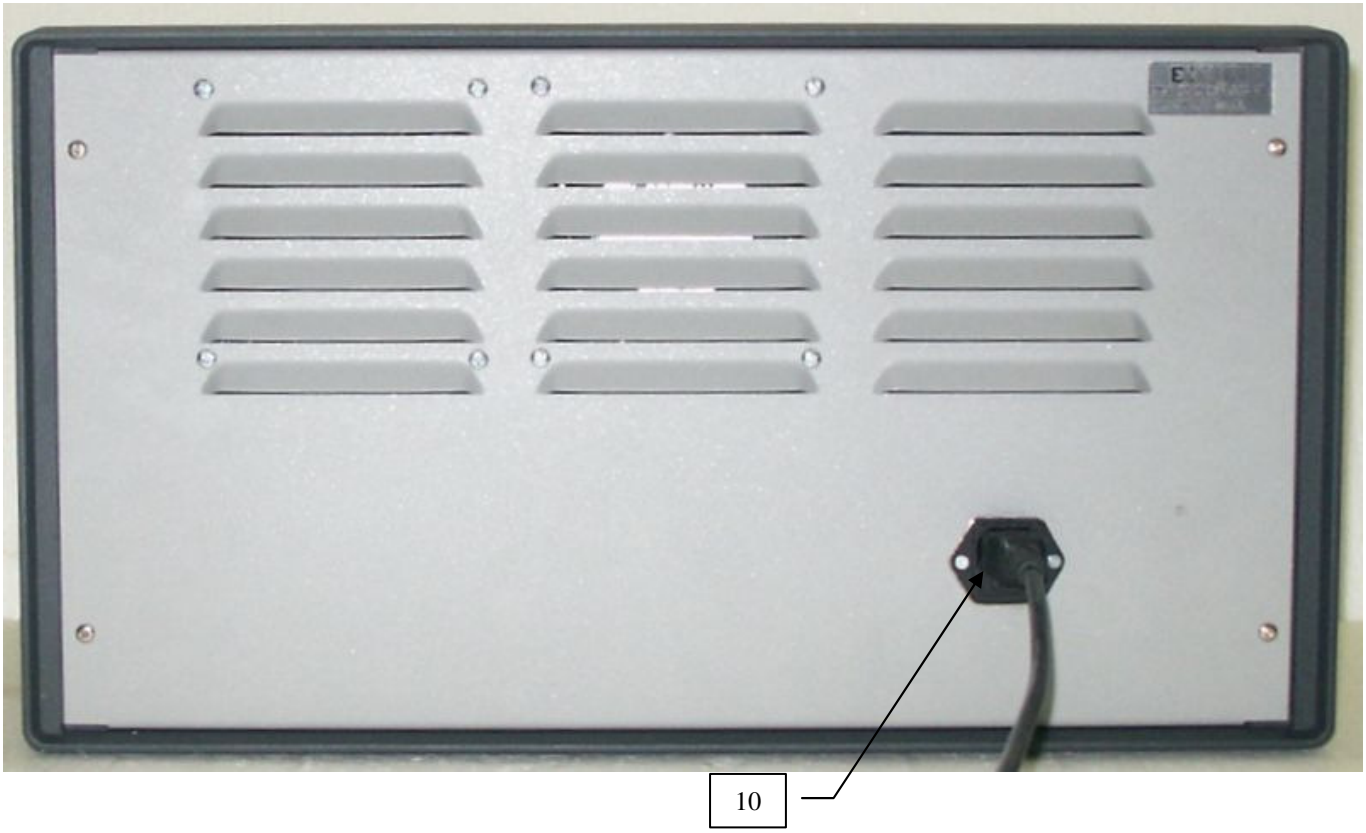
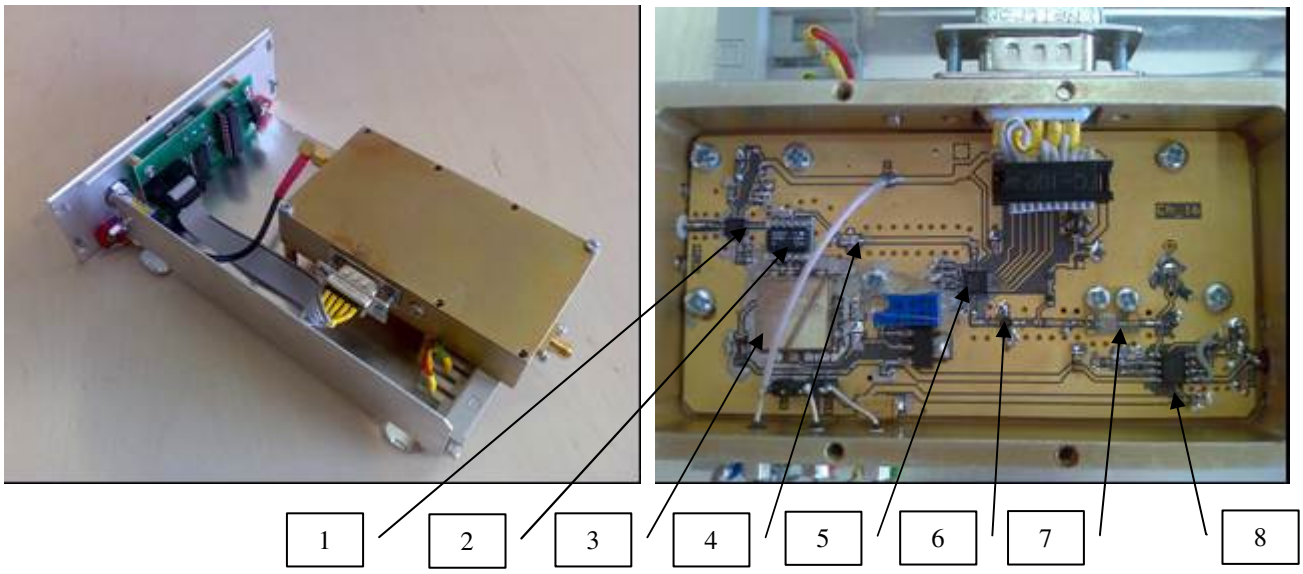


Fig. 4. Rear panel.

10- Power plug 220 ACV with built-in fuse 2A.

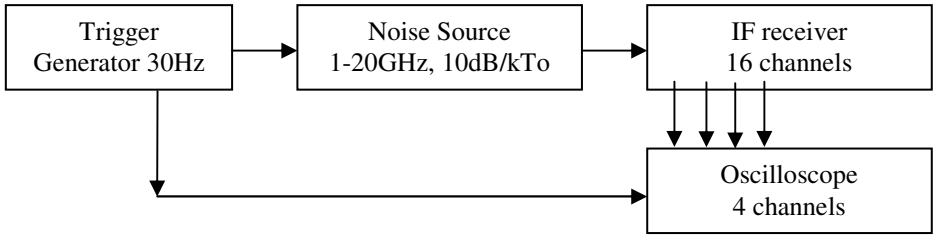
3.5 Plug-in module.



1. Input LNA
2. Balanced Mixer
3. Local oscillator
4. BPF
5. Digital attenuator
6. IF LNA
7. Video Detector
8. Video Amplifier

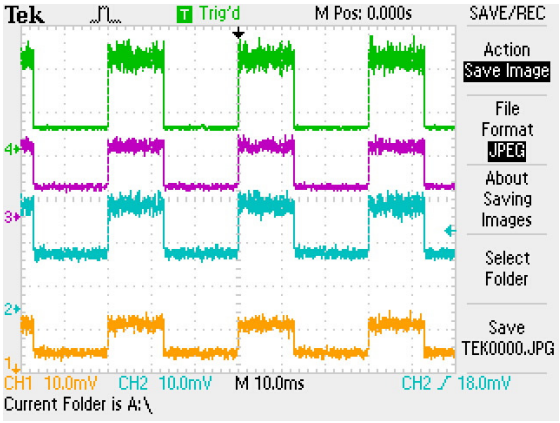
4. Calibration.

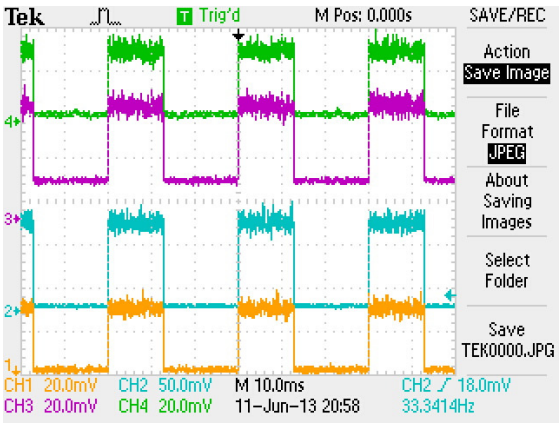
4.1 Test setup

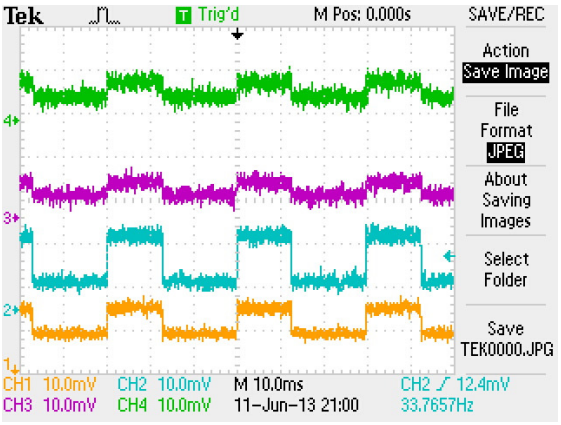


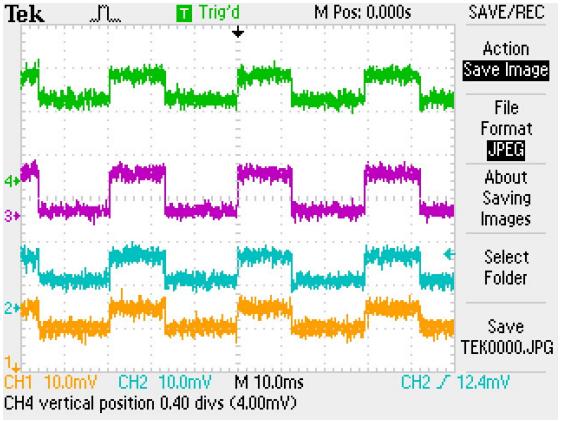
4.2 Test results.

A) Built-in attenuators set at 0dB



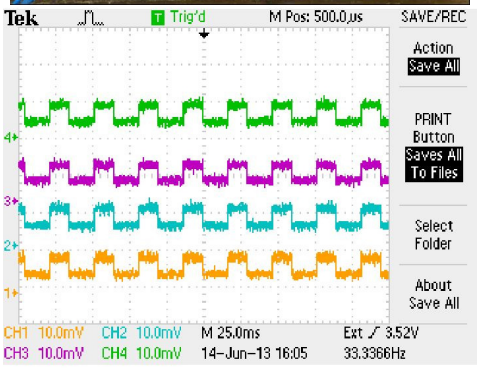


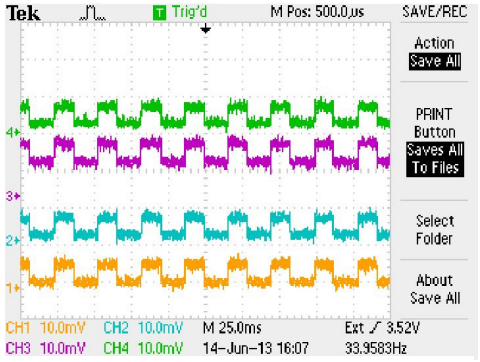


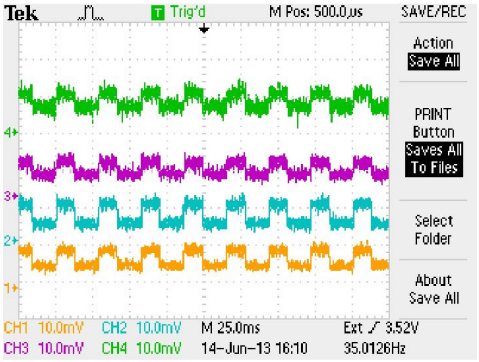


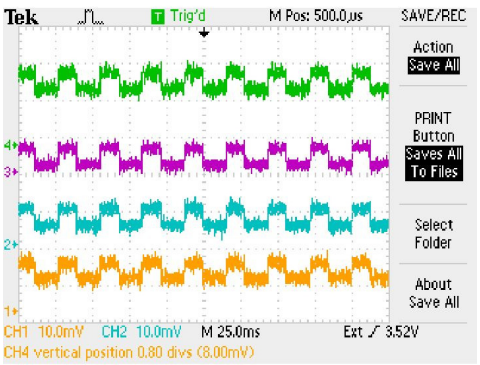
Channel No / Attenuator, dB
1 / 0
2 / 0
3 / 0
4 / 0
5 / 0
6 / 0
7 / 0
8 / 0
9 / 0
10 / 0
11 / 0
12 / 0
13 / 0
14 / 0
15 / 0
16 / 0

B) Built-in attenuators are adjusted for equal signal in each channel









Channel No / Attenuator, dB
1 / 6.5
2 / 3.0
3 / 6.5
4 / 12.5
5 / 7.5
6 / 14.5
7 / 8.5
8 / 7.5
9 / 1.5
10 / 3.0
11 / 0.0
12 / 0.0
13 / 0.5
14 / 0.1
15 / 0.25
16 / 0.1