Millimeter-wave FMCW Radar Front-end

Features

- High accuracy
- On-line measurements
- High directivity with small antennas
- Digitized output information
- Portability
- Simple power supply
- Environmental safety
- Equipped with antennas by customer's choice

Applications

- Object location in construction and in survey measurements
- Precise distance measurements in dusty and/or humid atmosphere, at bad weather conditions
- Vehicle obstacle detection and collision warning in transport area
- Level sensing for loose/granular materials
- Robotic sensors

Specifications

- Continuos wave probing signal:
  operating frequency (typical) — 94 GHz
  output power — up to 200 mW
- Frequency sweep parameters (typical):
  sweep time (triangle waveform) — 2.5 ms min
  sweep bandwidth — 100 MHz min
  non-linearity — less than 0.25%
- Receiver:
  IF bandwidth — 5 MHz
  RF to IF total gain (from Circulator input to IF Amplifier output) — not less than 30 dB
  Noise figure — 20 dB
- Characteristics of antennas – provided as customer's options:

	#1	#2
Gain	30 dB	40 dB
Beam width	5.5°	1.5°
Side lobes	less than 25 dB	less than 25 dB
VSWR	less than 1.3	less than 1.3

Description

DOK & ELVA Ltd. offer a new version of Frequency Modulated Continuous Wave (FMCW) Radar front-end for a wide variety of applications. This is an OEM subsystem intended to be built in a customer facility.

Unlike most of FMCW radar products on the market based on the Gunn diode, the device uses active IMPATT frequency multiplier driven by microwave voltage controlled master oscillator (Fig 1). To meet the sensitivity and accuracy requirements, the frequency sweep of the transmitter (triangle waveform) is linearized, with the linearizer being implemented as an open-loop system. The advantage of this configuration is relatively high output power at low noise and good linearity.

The Radar operating frequency, 94 GHz, has been taken within the atmospheric low-loss window, 80 to 100 GHz. However, if desired, it can be any other in the range from 20 to 150 GHz.

The device described is a monostatic unit with a single antenna for both transmit and receive.

The frequency modulated signal reflected by the target enters the receiver via the Circulator (Fig. 2) and is mixed with the original transmitter signal in the Balanced Mixer. Intermediate Frequency (IF) at the Mixer output (i.e. average frequency of the interferention fringes) is proportional to the target distance, the sweep bandwidth, and inversely proportional to the sweep rise time. So, the distance information can be extracted from the IF signal after, for example, FFT processing.

The receiver part of the Radar ends in IF Amplifier. In the customer facility it should be followed with an Analogue-to-Digit Converter and a data acquisition system for further processing the output signal and storing the data obtained.

Noise factor of the receiver (Fig. 3) has been measured in a special experiment (Fig. 4) where the antenna was replaced with a calibrated diode noise generator. The noise level is seen to go down with the frequency that implies an improvement of the signal-to-noise ratio for long target distances.

Ideally, IF of the linearly swept signal reflected by a stationary target is a single sinusoidal harmonic. However, the frequency spectrum of the output Mixer signal is strongly dependent on the sweep linearity. The non-linearity introduces additional harmonics that results in spectrum widening and degradation. In worst cases the central fringe frequency can become "unseen" against noise background. Mentioned above special measures are taken in the Radar for improvement of the linearity and suppression of the noise. Examples of the IF spectra, obtained for different target distances at laboratory testing (Fig. 5), are shown on Figs. 6 in comparison with the spectrum calculated for 0.25% sweep non-linearity. One can see that the non-linearity less than 0.25% is obtained in the Radar.

The Radar front-end can be configured using one of two antennas (see Specifications) or no antenna at all according to the customer application.

Precise online determination of distances realized by means of the device can be used for object location in construction and in survey measurements, vehicle obstacle detection and collision warning in transport area, level sensing for loose/granular materials and in many other situations. Short wavelength (about 3 mm) makes high directivity (small target dimensions) achievable with small antennas suitable for portability and mounting convenience. Owing to low absorption for the frequency chosen, the radar can successfully operate in both indoor and outdoor facilities, in dusty and humid air, at bad weather conditions (e.g. mines, aerodromes etc.). Relatively high probing signal power in combination with the low noise figure of the receiver makes it possible to apply the Radar for distances of several hundreds meters long. The device is compact and has simple power supply system.

Figure captions

Fig. 1. Generator of the transmitted signal: 1 – Voltage Controlled Master Oscillator; 2 – Transistor Power Amplifier of the microwave signal; 3 – IMPATT Active Frequency Multiplier (×13); 4 – IMPATT Injection-Locked Amplifier of the mm-wave probing signal.

Fig. 2. Block diagram of the Radar.

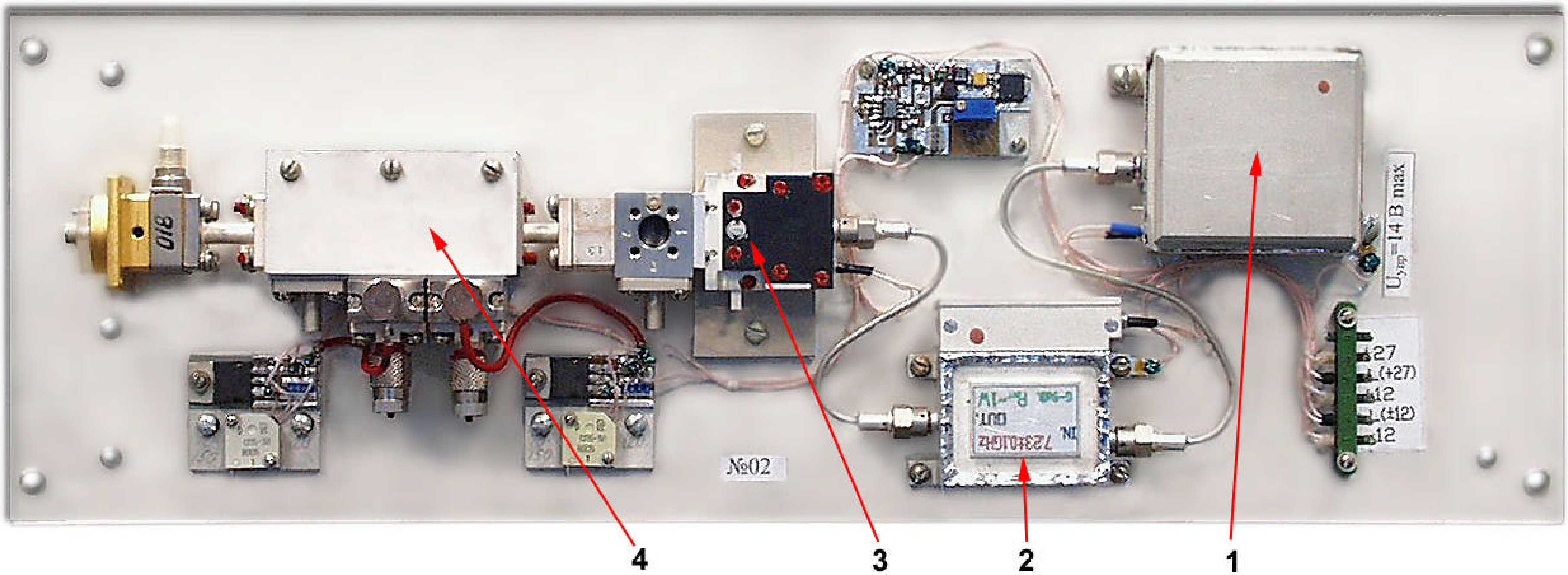
Fig. 3. Receiver noise figure.

Fig. 4. Block diagram of the experiment on receiver noise measuring.

Fig. 5. The Radar during testing in the DOK laboratory.

Fig. 6. Obtained in the test experiments frequency spectra of the reflected signal are compared with the spectrum calculated for 0.25% sweep non-linearity (yellow line).

Fig. 7. Block Diagram of the Linearity measurements.



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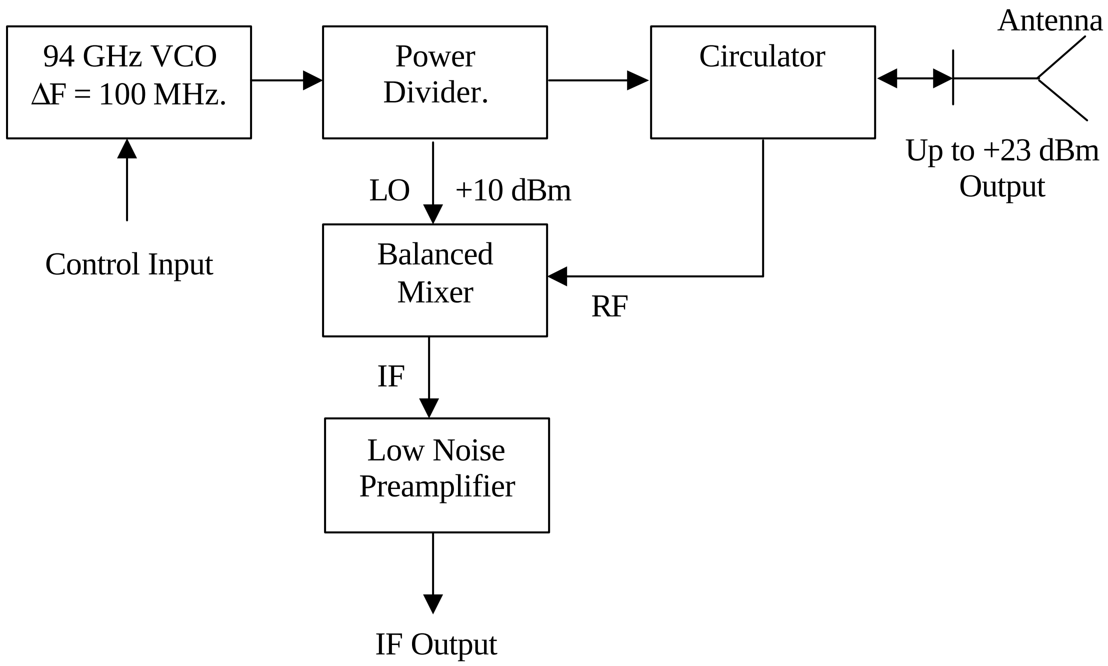


Fig. 2. Block diagram of the Radar Front-end.

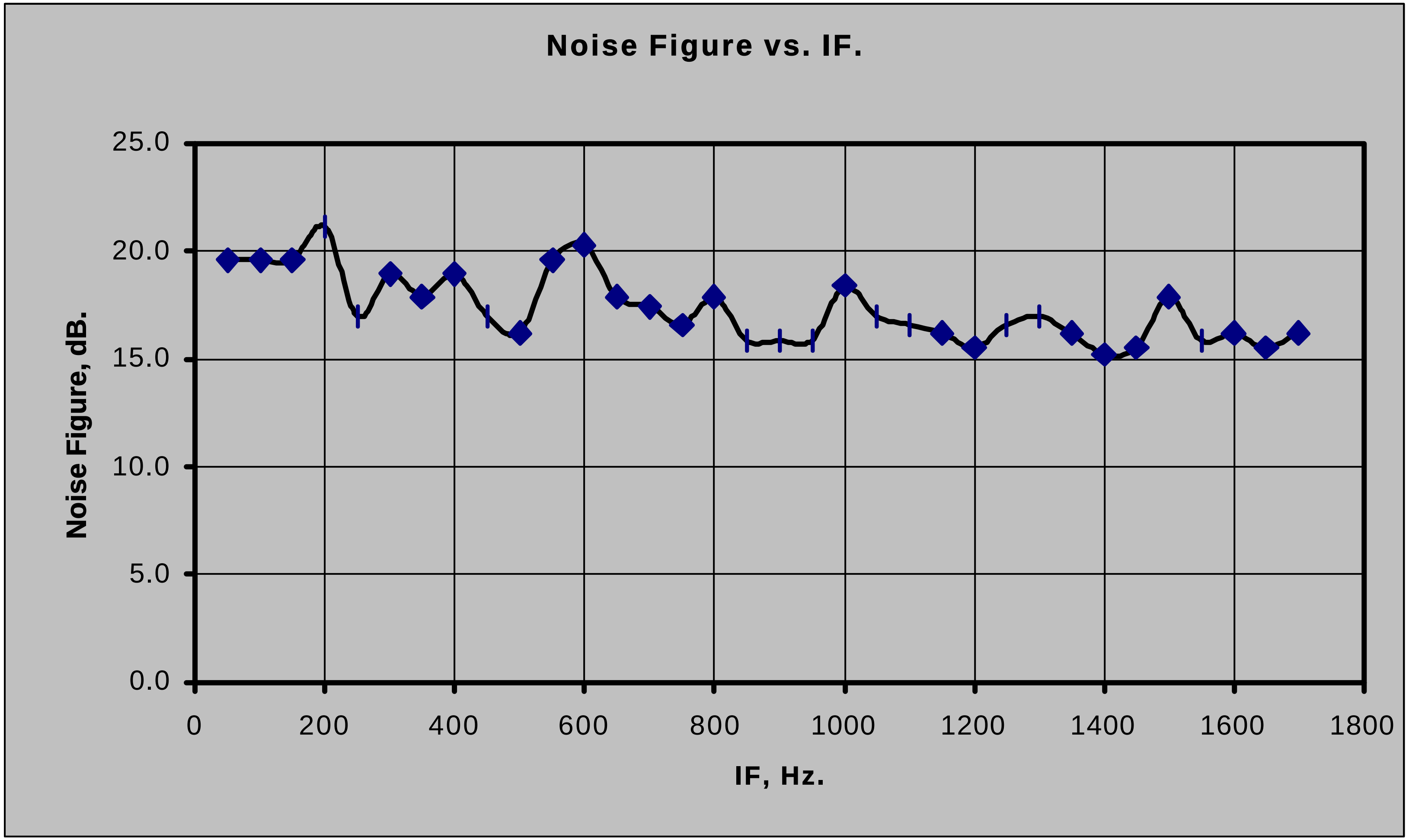
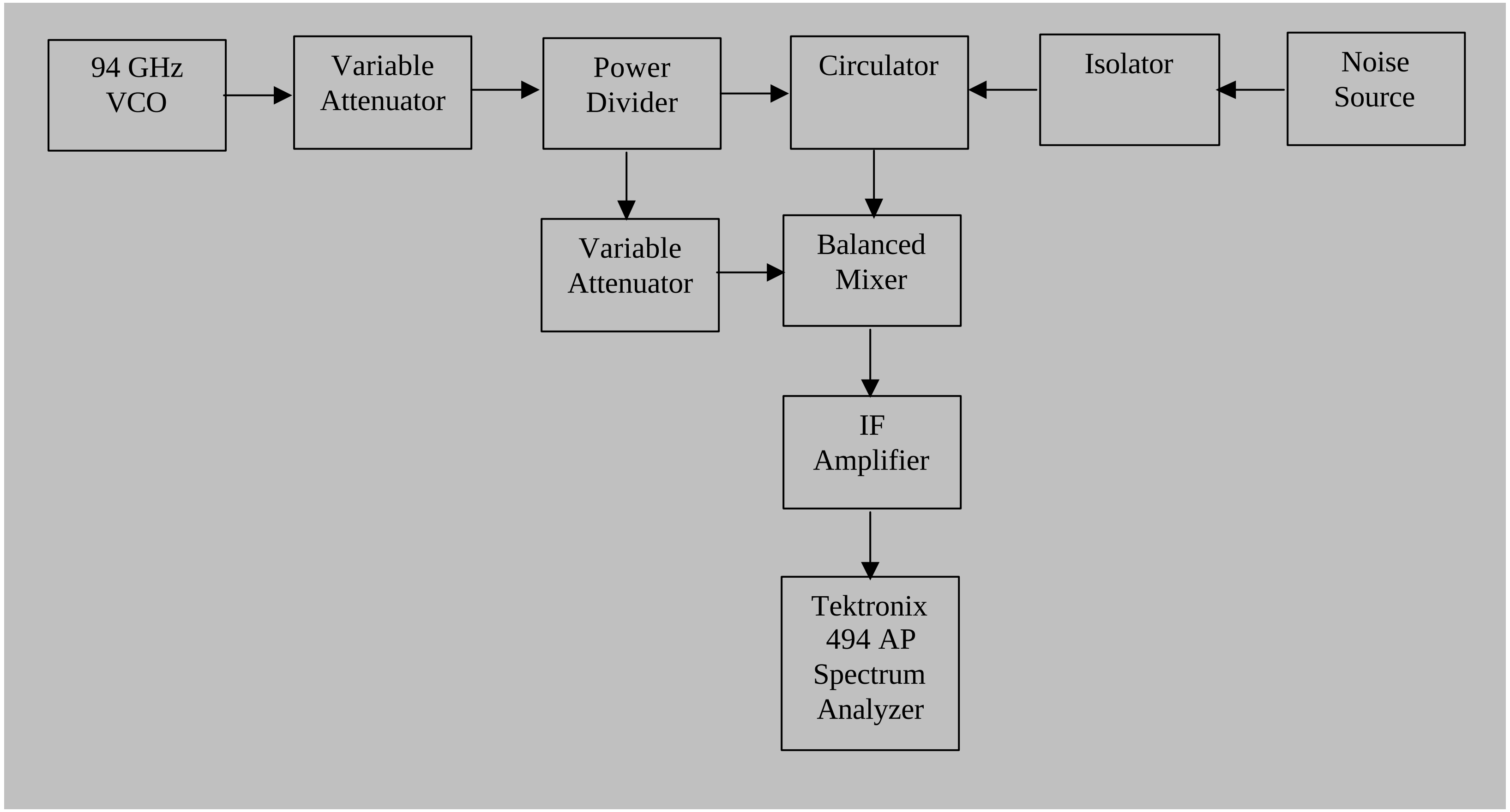


Fig.3. Receiver noise figure.



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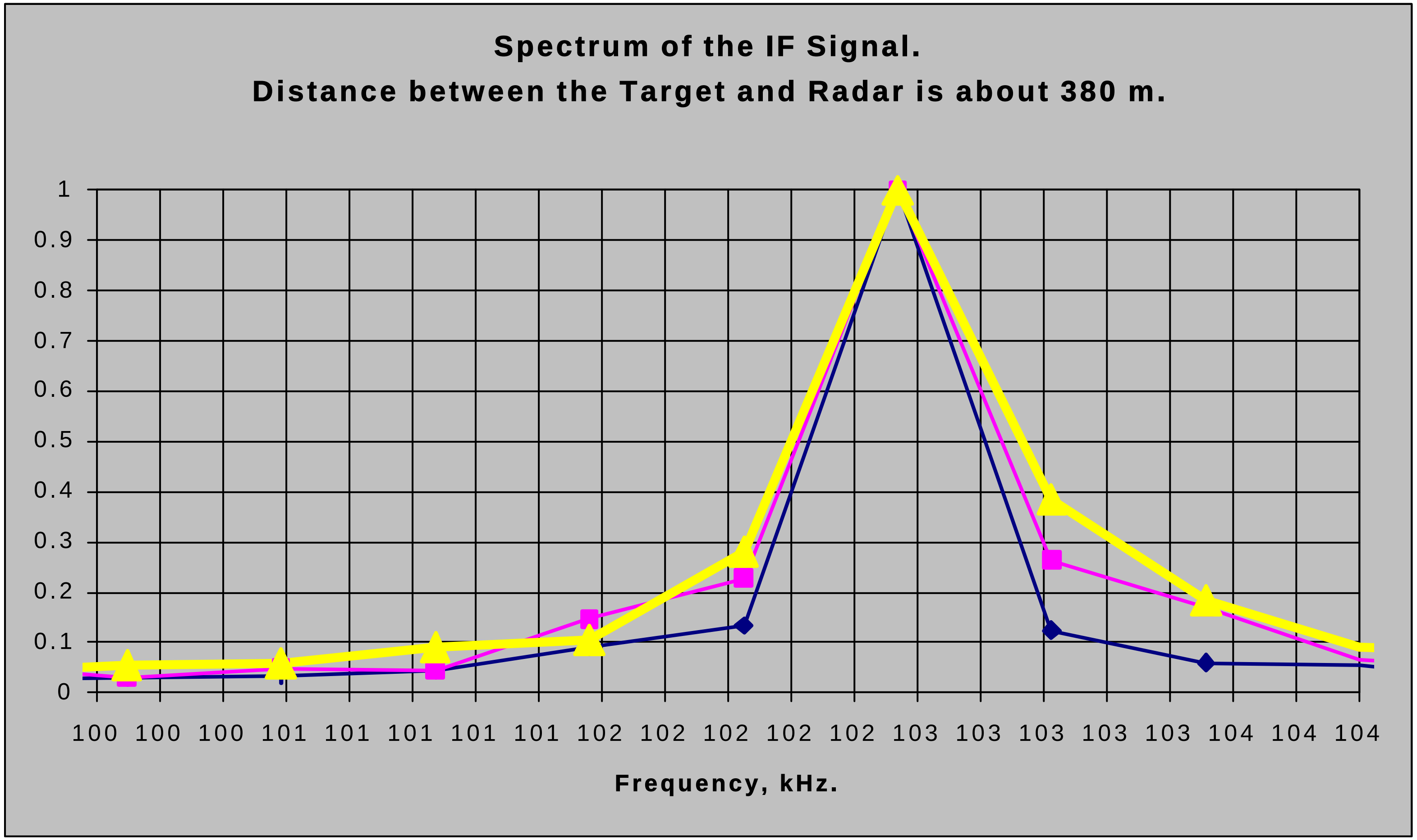

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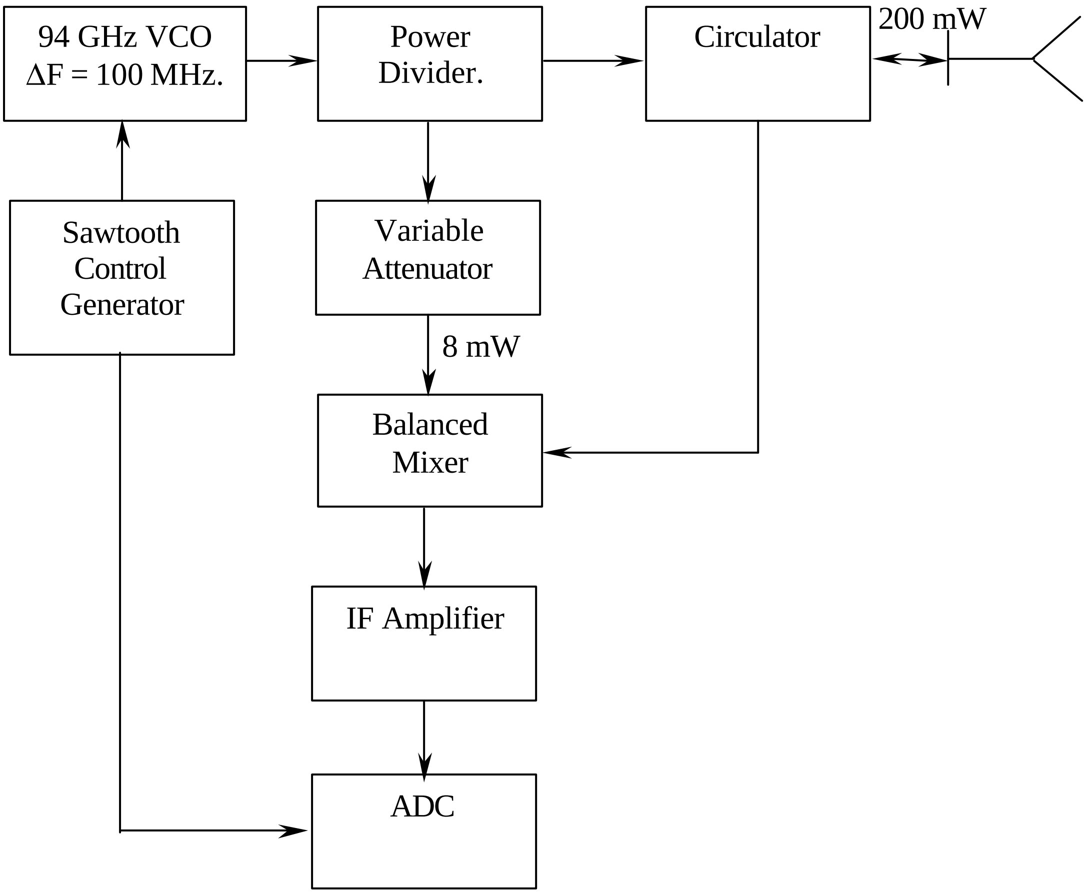

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