200mW FMCW Radar Front-End for Airport Ground Control Applications

NEW! Example of our radar-front end app: AVTIS (All-weather Volcano Topography Imaging Sensor) is a new research instrument designed to measure the size, shape and temperature of volcanic lava domes under virtually all weather conditions at St Andrews Millimetre Wave adnd High-Field ESR Group (visit their website)

94GHz 200mW Low-Noise FMCW Radar Front-end

This is a special low-noise high-power version of 94GHz FMCW radar front-end, that is designed for traffic control applications. The primary example of that application is airport ground control radar systems.

We propose the following variants of 200mW radar front-end shipment:
- with row analog output
- with row digital output
- with processed digital output (angle, distance and speed of a target)

Important: we advise our customers to purchase radar 200mW front-end with antenna to get them tuned as a whole unit. The reason for that is as following. Compare to 10mW version of the 94GHz FMCW radar front-end, this 200mW has a special circuitry design features to reduce noise factors. In according of that design, to reduce noise, the radar front end has to be adjusted with its antenna as the whole unit. Please read the following explanation which is illustrating these design features:

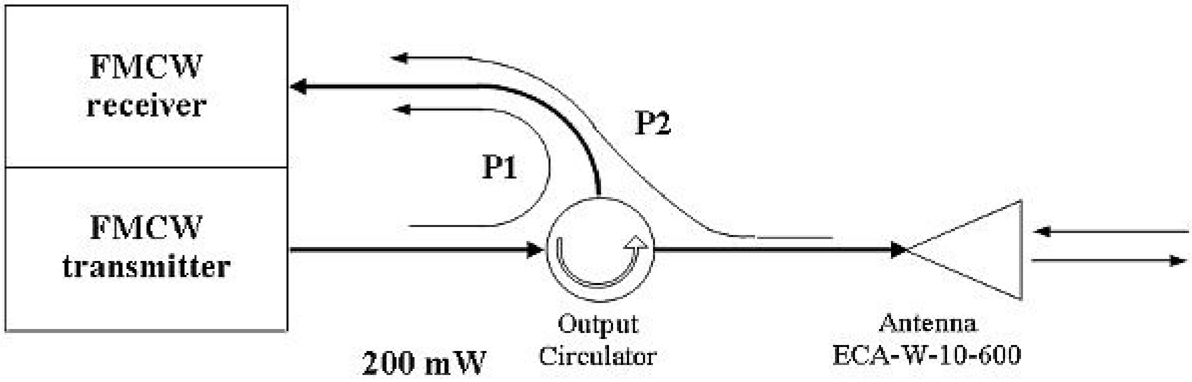

Fig. 1. General block schema of FMCW radar output

In this figure:
P1 – the power leakage through output circulator (isolation is approximately 30 dB);
P2 – the reflected power from the antenna (Antenna VSWR is less 1.13:1).

In general, the noise figure of receiver of FMCW radar front-end depends not only on receiver quality itself but also on amplitude noises of transmitter channel because transmitter power penetrates into the receiver. The penetrating power consists of two parts: the first one is a leakage of power through output circulator ports (path **P1** in the fig.1) and the second one is reflected power from antenna (**P2**).

The leakage of mm-wave power from transmitter to receiver leads to increasing of receiver noise figure and decrease its sensitivity. In any radar front-end module with the design similar to ELVA FMCW-94/200/200 the influence of leakage of transmitter power on noise figure gets considerable high when the transmitter power is more then approximately 10 mW. As experiments in ELVA lab shows - for 200 mW output power of FMCW-94/200/200 model the increasing of the noise figure can be from 13 dB to 25…30 dB. That's why it is necessary to make an attempt for counter-measure against the increasing of Noise figure.

The straightaway approach to decrease the leakage of transmitter power to receiver is to use output circulator with higher isolation and antenna with lower VSWR. But ELVA experience as producer of mm-wave components shows that it is very difficult task.

That's why ELVA proposed another approach: the problem can be solved by adding **P1** to **P2** signals in such way that an amplitude of total mm-wave signal to receiver does not increase but gets even less than **P1** and **P2**. It is possible to do using the fact that the **P1** and **P2** signals are vector values and the result depends on what phases **P1** and **P2** signals had when they were summarized.

One of the possibilities it to use the following block-scheme:

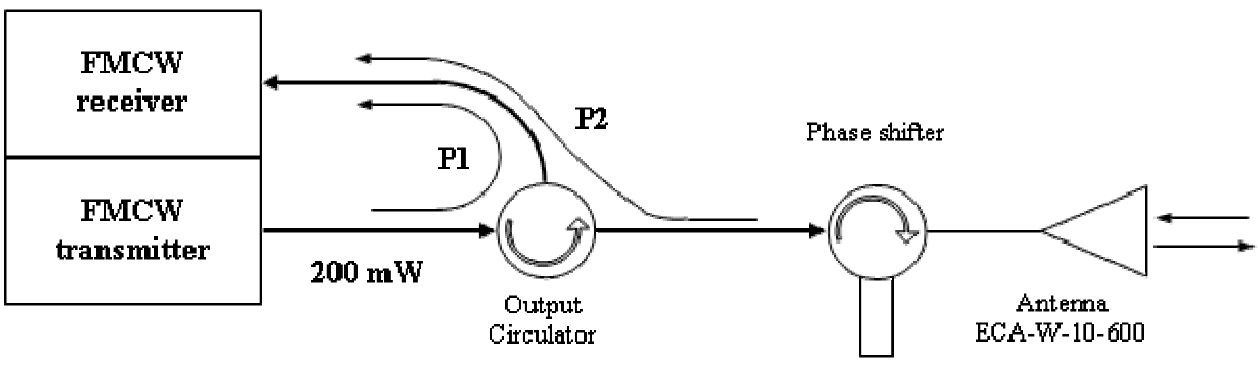

Fig. 2. ELVA-proposed block schema of FMCW radar output

In this figure:
P1 – the power leakage through output circulator (isolation is approximately 30 dB);
P2 – the reflection power from the "antenna + phase shifter" part.

Using the phase shifter it is possible to vary phase of the **P2** signal it to have a phase shifted at 180 deg relatively to **P1** signal. Thus, the amplitude of **P1+P2** sum will be less than the maximum of **P1** and **P2** signals. The best case is when amplitudes of **P1** and **P2** signals are equal. In this case their subtraction result gets significantly smaller than each of **P1** and **P2** signals.

It has to be noted that the output circulator leakage and antenna reflection are frequency depended values. So, the good subtraction of **P1** and **P2** signals is possible only within a narrow frequency band. To prove that, the experimental data were obtained for measurements of FMCW-10/94/200/200 radar module and ECA-W-10-600 antenna serial No.: 2020. The resulted plot is shown in fig.3 below.

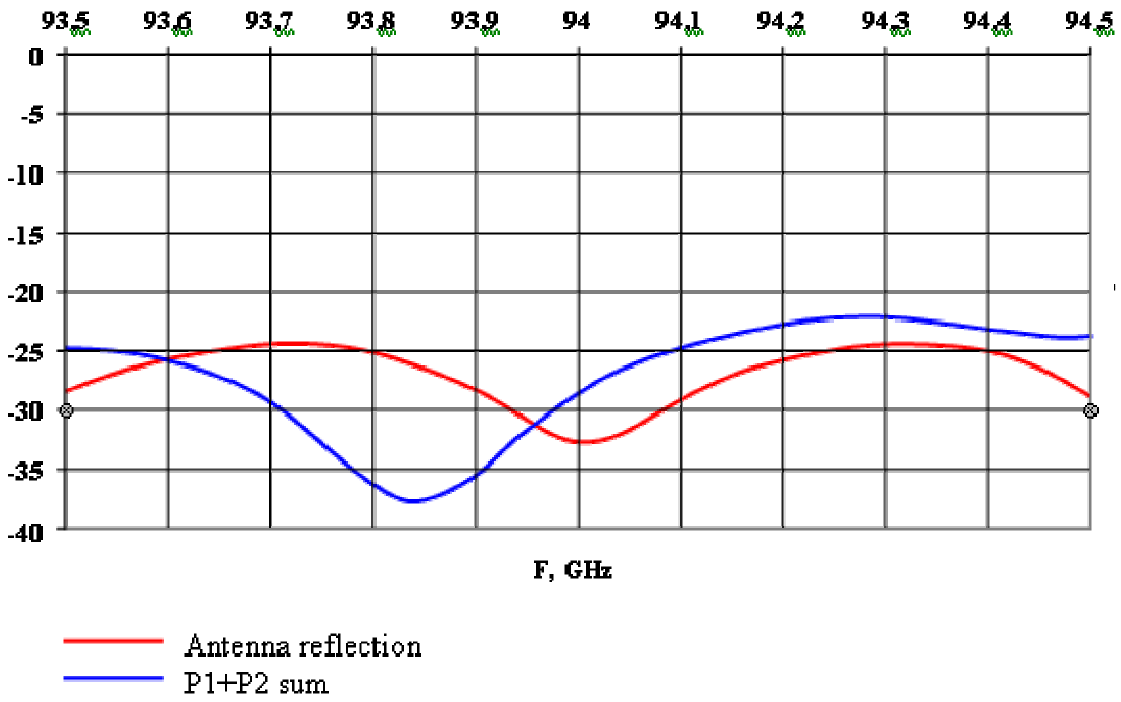

Fig. 3. Part of Transmitted power that penetrated into receiver

It can be seen that within 93.8-93.9 GHz frequency range (blue curve) total reflected power from transmitter to receiver is 35 dB less than output power of transmitter which is 200 mW. Noise figure of receiver is kept at approx 15 dB in this case. Antenna reflection power is at least 5 dB more (red curve).

There is circulator leakage as well. Without adjustment of phase of P2 signal the receiver Noise figure is at least 5 dB more, i.e. more then 20 dB.

Examples of pictures obtained with 200mW FMCW radar

These pictures were obtained from ELVA-1 building as examples of FMCW radar application for ground control.

Fig. 4. Photo of urban landscape around ELVA-1 office

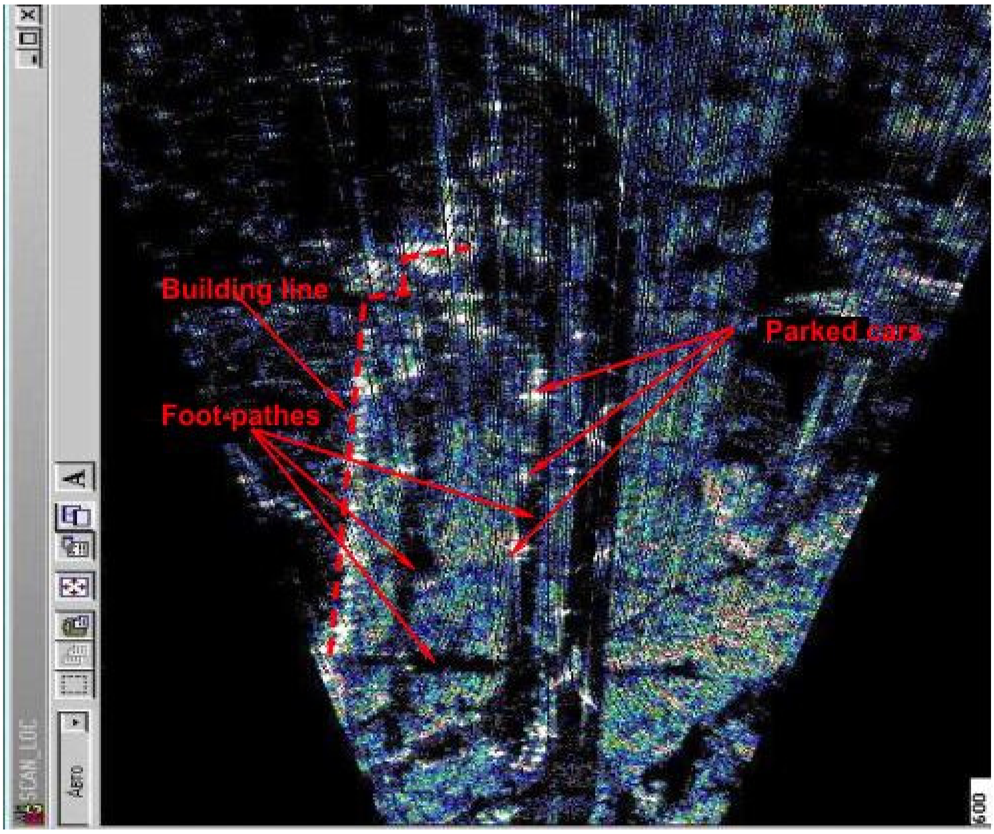

Fig. 5. Picture of the same place by 200mW FMCW radar