NEW PASSIVE RADIOMETRIC CHANNEL DESIGNED FOR INTEGRATION WITH WEATHER RADAR PROTOTYPE AND MEASUREMENT RESULT INVESTIGATIONS

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ABSTRACT

Previous attempts to integrate microwave radiometer into weather radar were unsuccessful due to unsolvable technical incompatibilities. The best way was to employ non-simultaneous measurements, when radiometer worked in gaps between radar pulses. Still, high waveguide tract dampening, remained a setback for quality data.

Advance in semiconductor technology presented a whole new range of cheap tiny apparatus, including microwave receivers. Thus it became possible to build small microwave radiometer that would fit into radar antenna focus, allowing to exclude extra dampening. Shifting central frequency and using orthogonal polarization allowed to exclude high power radar pulse jamming.

Presented prototype, slightly improved by now, allows to measure cloud liquid water continuously during radar sounding and precisely in the same beam direction. Several sets of such scans were made. Results show that described passive channel design proves to be quite operational. Further research is being conducted.

I INTRODUCTION

Previously MGO presented first prototype of passive radiometric channel designed for integration with weather radar [1].

Weather radars are commonly used worldwide for detection of dangerous weather phenomena, such as thunderstorms, hail, heavy rains etc. It can also detect cloud border and follow cloud masses movement. On the other hand, passive microwave radiometers are used much the same, but to measure total atmospheric water vapor quantities and total cloud liquid water. Using these two instruments combined by integrating MW radiometer into WR would significantly improve radar capabilities for short-term forecast and now-casting [2].

Several attempts to integrate MW radiometer into WR receiver were performed, which proved the validity of combined measurements theory. But also a variety of difficulties were discovered, that complicated practical use of these measurements.

Advancements in receiver production technologies allowed the use of smaller radiometers, solving problems mentioned above.

II INTEGRATION PRINCIPLES FOR MRL-5 WR

MRL-5 weather radar is widely used in ex-USSR countries (about 40 radars operational) as well as in some European, Asian and others. It uses 4.5 m parabolic dish and operates at λ_1 = 10 cm and λ_2 = 3 cm.

Basic integration principles were described in [3]. MW radiometer is placed into antenna focus, alongside MRL's irradiator, in it's waveguide “radio shadow” (fig. 1). Thus, WR antenna shading by radiometer is excluded. It produces another problem: MWR and WR polar patterns become not aligned dimensionally. But, according to theoretical estimations and experimental research this difference is 2˚ at azimuth plane (fig. 2).

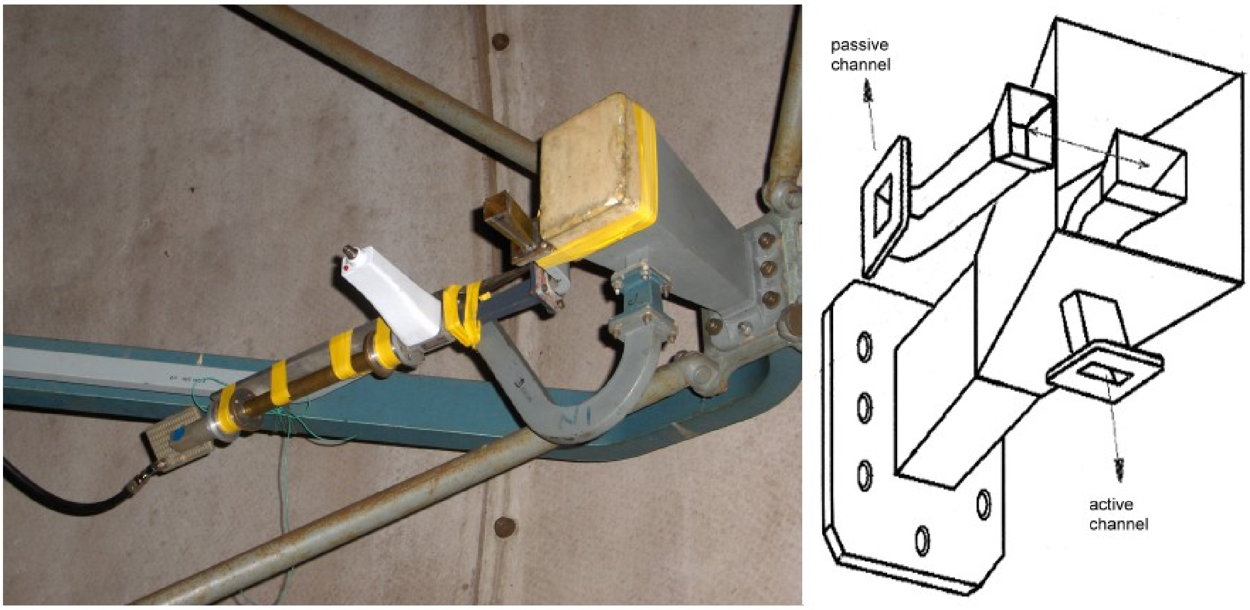

Figure 1. MW radiometer placement

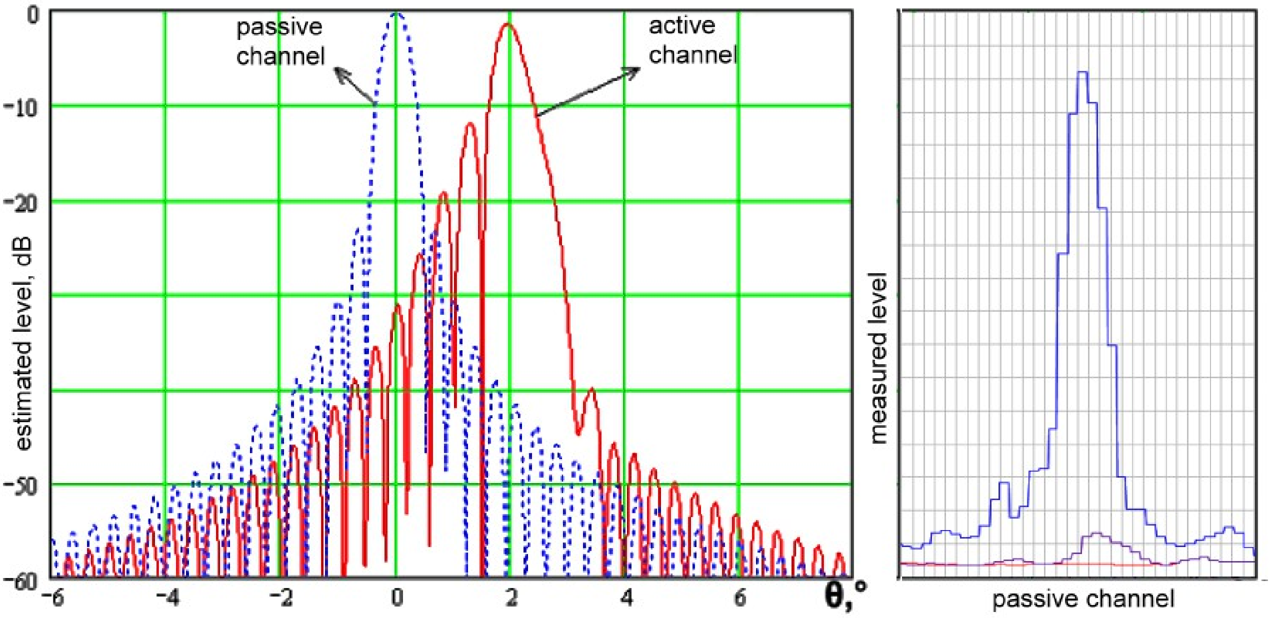

Figure 2. Estimated polar pattern and measured one

III MW RADIOMETER PROTOTYPE DESIGN

MW radiometer is using standard satellite television converter (low-noise block, LNB) as a receiver. It operates at one of two bands: 10.7-11.7 GHz or 11.7-12.7 GHz and can also use horizontal or vertical polarization. LNBs also have the “colfet” effect [4], emit low temperature noise [5]. That property is used in MWR “self-control” function. There is also a detector, amplifier and data collection and control system (fig. 3).

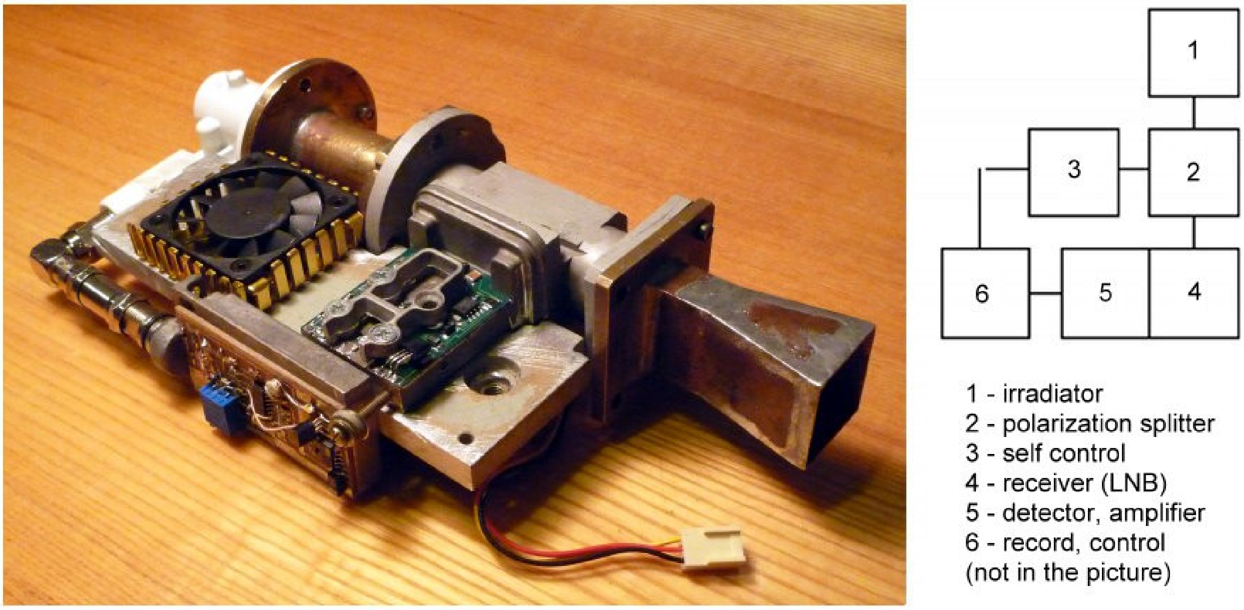

Figure 3. MWR prototype

Data collection and control system consists of:

- a power unit with relay-switchable outputs to control radiometer operation modes;
- multichannel ADC with analog outputs to set radiometer operation modes;
- single-board computer (SBC) to record and process data and control modes.

Low frequency unit, power unit, SBC and ADC are placed behind the dish to ensure electromagnetic safety from radar sounding pulse. The data is transferred to the operating console through coll-rings (fig. 4).

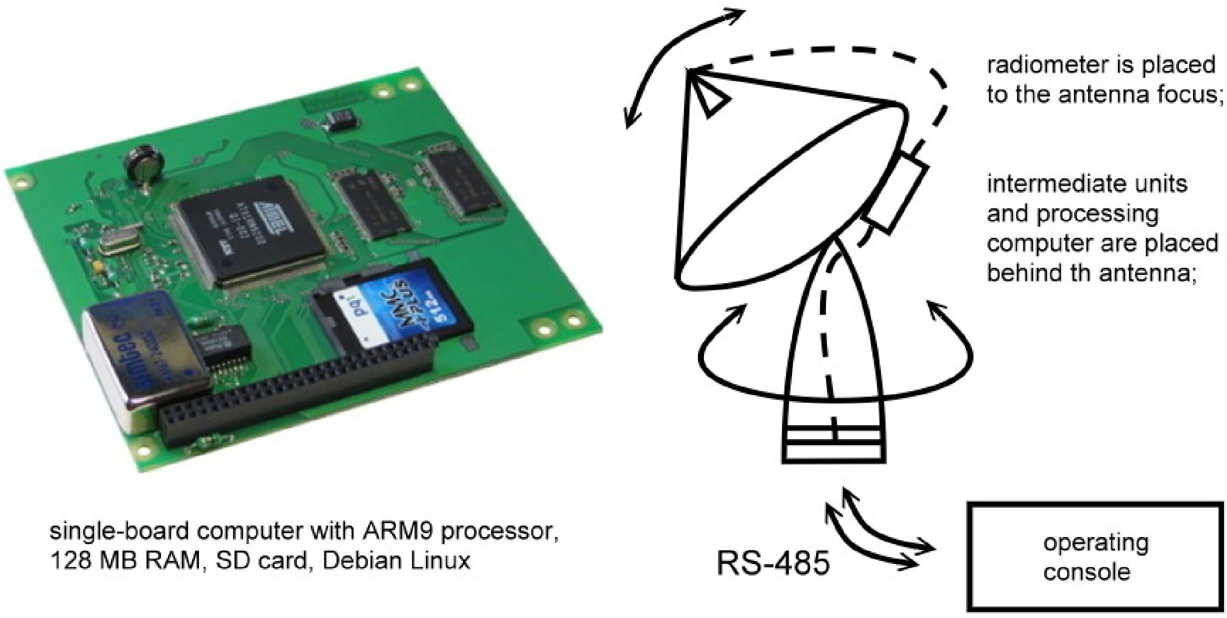

Figure 4. Passive channel elements on weather radar

IV PASSIVE CHANNEL PRELIMINARY TESTS

Passive channel has a built-in self-control system. There are two predefined temperature levels. This is a way to control that radiometer is operational and to control possible signal drifts during measurements. The system was tested with wide-aperture low-temperature emitter at liquid nitrogen temperature (fig. 5, left).

Second most important test was to determine whether the high power radar sounding pulse will jam radiometer input (fig. 5, right).

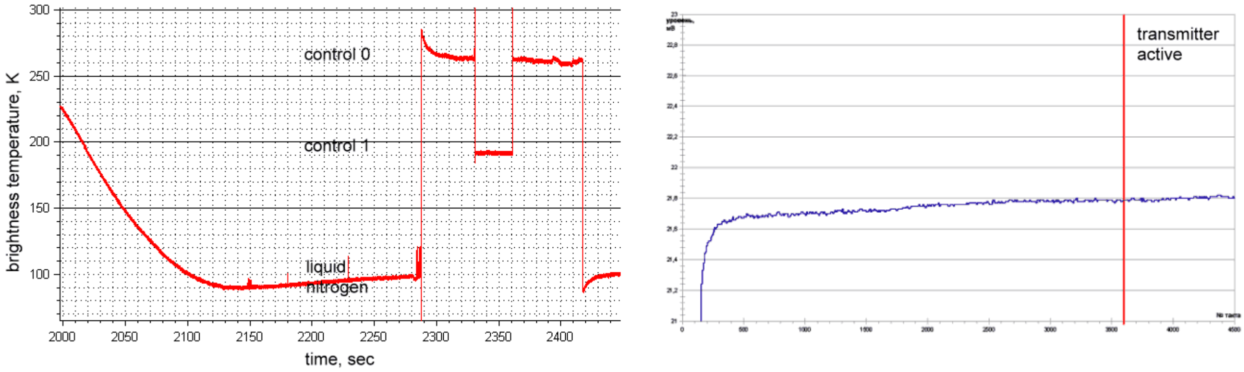

Figure 5. Self-control system test and radar transmitter test

Evidently, there is no change in radiometer signal level at the moment when radar starts to transmit its sounding pulse.

V COMBINED AUTOMATED OPERATION MEASUREMENT

Typical MRL-5 working cycle consists of 18 scans for different elevation angles at 6 azimuthal rotations per minute. Passive channel data control system starts automatically with WR. It records radiometer data and antenna elevation and azimuth angles from radar selsyns. Afterwards, radiometer data can be synchronized with radar data by these angles (fig. 6).

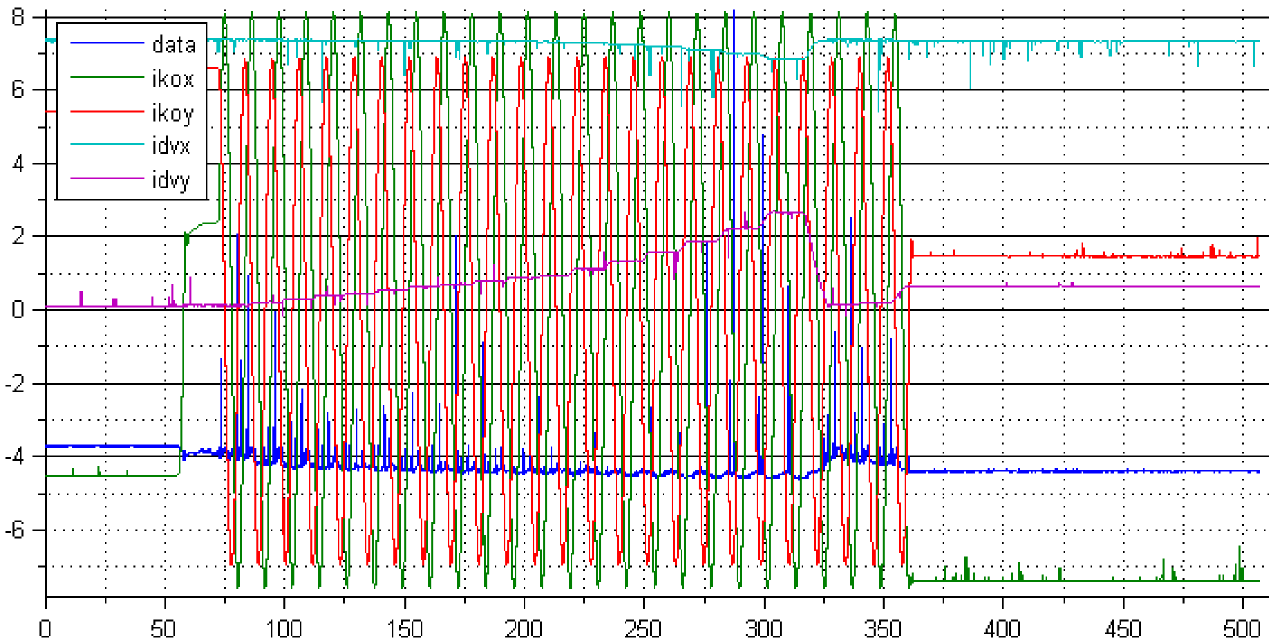

Figure 6. Sample of typical passive channel working cycle

To compare difference in weather conditions three observation days (10/31, 11/15 and 11/18 2011) were selected. On the chart (fig. 7) one full turn (360°) at elevation 10.53° is plotted.

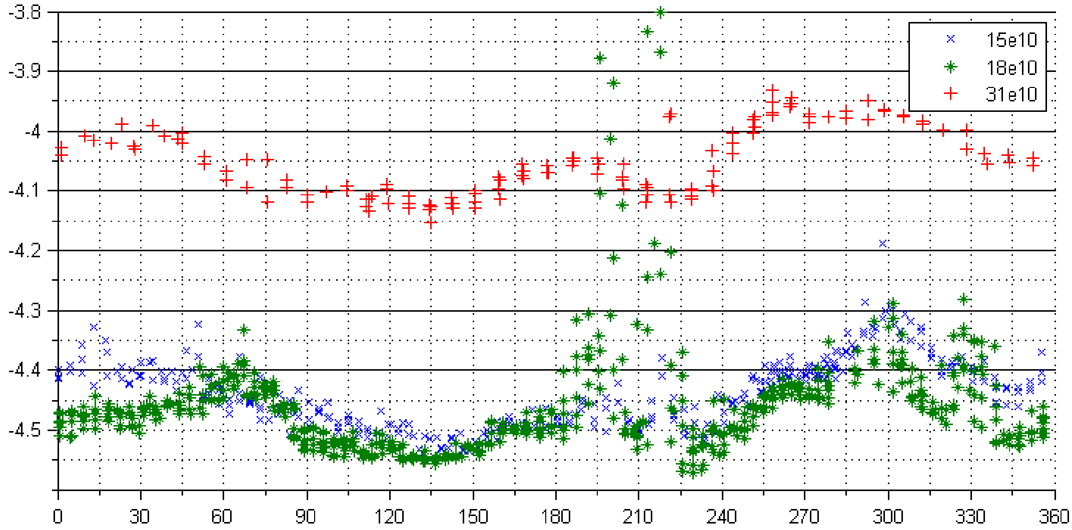

Figure 7. Different weather conditions comparison

VI ANALYSIS AND CONCLUSIONS

As seen from the chart (fig. 7), the course of radiometer signal is rather uneven, though the weather conditions were rather fair. This could be due to underlying surface exposure.

Another clear obstacle is around 210 azimuth. This one appears on all scans regardless of weather conditions. It has very high brightness temperatures (about 1000 K) and is visible on elevations up to 12º. This object is still unknown and considered to be some natural target (or clutter target).

Although it is useful for initial research purposes (like measuring passive channel polar pattern) it makes impossible to measure distant objects in its direction.

Also there is a certain drift, that could appear due to receiver's temperature instability. Thus it is essential to equip radiometer with thermal stabilization system.

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