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Real-time Rain Monitoring with DVB-S Signal analysis

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1) Context

In recent years, **flash flood events** seems increase all over the world. To cope with such events a nowcasting service would be worth to validate weather alerts and to give civil protection offices timely information on the precipitation.

A rain monitoring sensor unit based on the measurement of the **attenuation of the microwave signal** in the Ku band used by most of the commercial **DVB satellites** will be employed to that purpose.

In particular, the proposed system – named *SRS Smart Rainfall System* - is able to estimate **the rain rate in real time** by inverting the propagation model [1].

2a) Description of approach

In order to illustrate the working principle of the considered technique, let us consider a receiving (RX) antenna located at a position $\mathbf{r}_{RX}$ (Fig. 1).

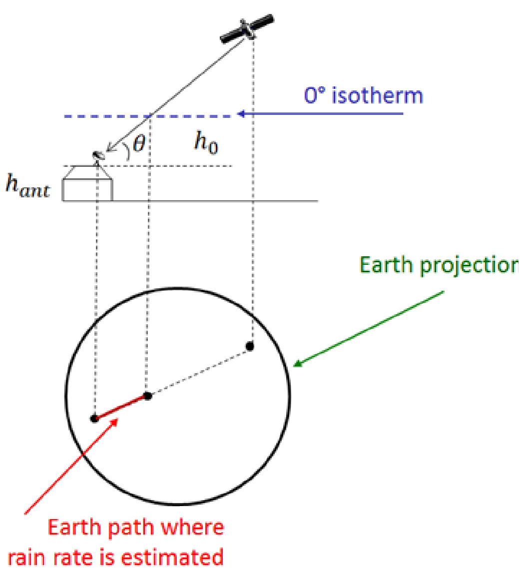

Figure 1. Rain estimation approach.

The antenna receives a plane-wave EM signal transmitted by a commercial satellite.

Since the wave propagation is affected by the precipitation during its path, by using the ITU model described in [2], the precipitation rate can be expressed as

$$R = \sqrt[a_p]{\frac{10\log(P_o/P)}{b_p l}}$$

where $P \propto |\mathbf{E}(\dot{\mathbf{r}}_{Rx})|^2$ is the power available at the output of the antenna (being $\mathbf{E}(\mathbf{r}_{Rx})$ the electric field impinging on the antenna) [3], P_o is the clear sky power at the output of the antenna, b_p and a_p are empirical parameters derived from the ITU model [2], and $l = H \ / \ sin\vartheta$, being H the elevation of the 0 °C isotherm at the given latitude and ϑ the elevation angle of the RX antenna (Fig. 1).

2b) Description of the sensing module

As first validation tests, experiments aimed at verifying the operation and effectiveness of the sensor, have been carried out in the laboratories of the University of Genoa – DITEN. The block diagram of the **sensor module** is drawn in Fig. 2.

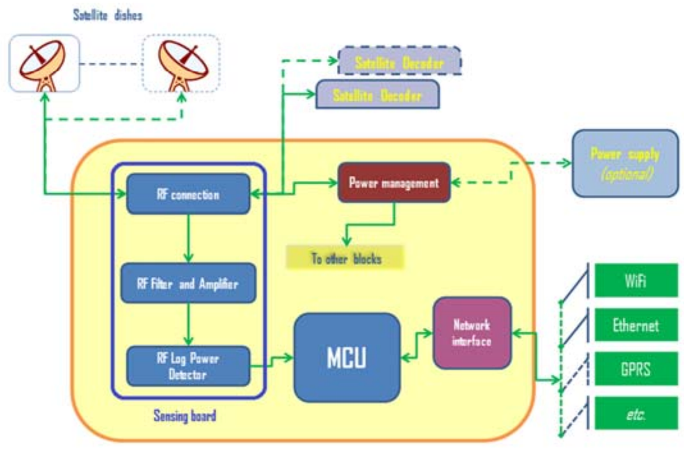

Figure 2. Block diagram of the sensor module: the detection of the incoming power intensity is performed by the "sensing board" on the left.

It exploits the information contained in the **power level of the signal** at the output of an **LNB** (Low Noise Block converter), commonly used in the receiving chain of a consumer DVB-S set.

For our purposes, it is worth using a low-cost Universal LNB. In such a case, the down-converted signal on the descending cable contains (in the band 915 MHz – 2150 MHz) one of the four possible bands which correspond to two different polarizations – vertical and horizontal – and, in the case of the Ku-band, two different frequency bands – lower and upper.

A proper circuitry detects the level of the signal as a voltage obtained with a **logarithmic detector** (Fig. 2). Such a value provides an **estimation of the rain intensity** averaged along the path, and is transmitted on either a wired or a wireless link to a collection center, for recording and monitoring. A detail of the sensing board is depicted in Fig. 3.

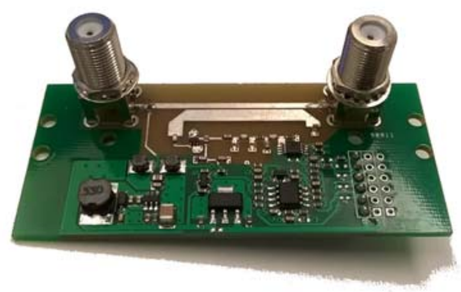

Figure 3. Sensing board: the two F connectors provide connectivity towards the decoder (left) and to the LNB (right).

3) Experimental results and conclusions

To test our approach an experiment was carried on using an antenna pointed towards the Eutelsat 13° E constellation. From our location (i.e. latitude: 44.40° N - longitude: 8.95° E) the direction corresponds to an azimuth of 174.2° with an elevation of 38.7°. The **signal** recorded on November 13, 2013 is depicted as a **dotted line** in Fig. 4,. The **dashed line** corresponds to the **clear sky** voltage level. In Fig. 5 the comparison with a rain gauge over an interval of 8 hours is reported.

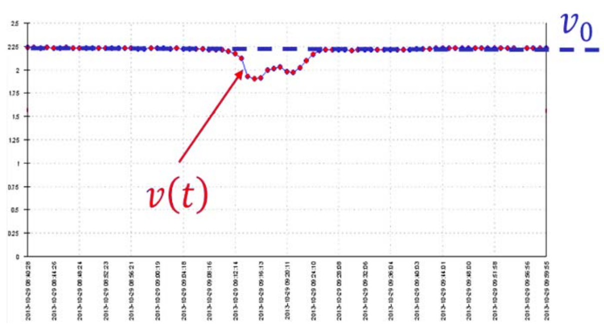

Figure 4. Signal decrease due to rainfall in an interval of 100 minutes (one point per minute). The scale on the left is in Volts.

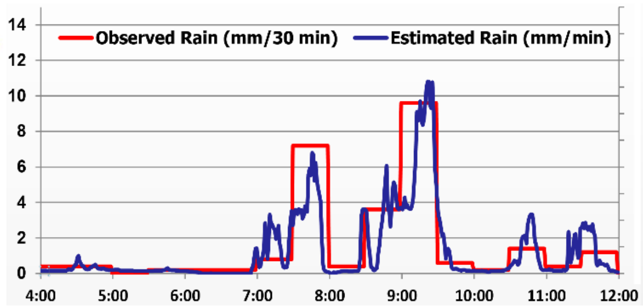

Figure 5. Comparison with rain gauge: the blue line is the SRS estimation, while the red histograms corresponds to the rain gauge measurements.

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