C-Band Active Reflector
For Radar Calibration

XY-Sensing Ltd.

Contents

1 Overview

The C-band active reflector is a device designed to emulate a radar target with a significantly larger radar cross-section than the actual dimensions of the device. Assuming the radar operates within the frequency range of the device, the incident probing signal is received, amplified and radiated back towards the radar. Hereby, the reflected power is significantly higher than the power absorbed by the device's antenna. That is equivalent to increasing a radar cross-section.
Furthermore, a modulation is introduced to the re-radiated signal, allowing the Doppler-processing radars for distinguishing the echo of the reflector from the ground clutter.
The device is battery-powered, hence it does not require any external power source, if charged beforehand.

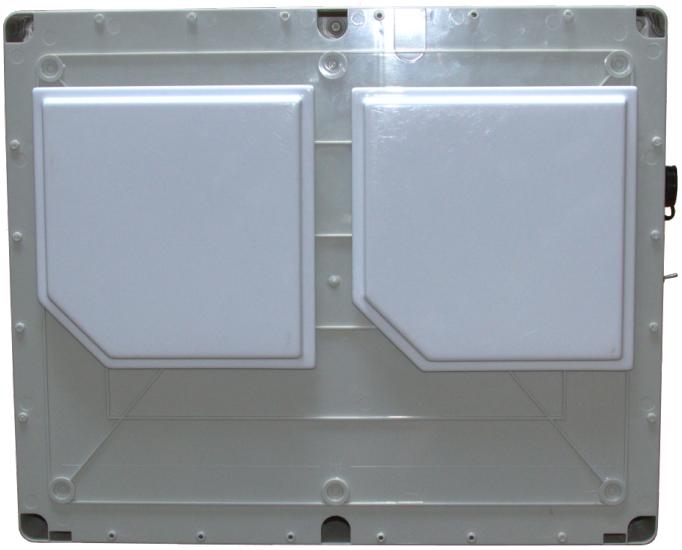

Figure 1: Device frontal view

2 Specifications

All the following parameters are guarantied by design.

Parameter	Condition	Min.	Typ.	Max.	Units
Radar cross-section	f = 5.5 GHz		28		dBsm
Frequency range		4.9		6	GHz
3-dB beamwidth	Horizontal Vertical		18 18		° °
Modulation frequency	Hi mode Low mode		1 100		kHz Hz
Battery capacity			5600		mAh
Operating current			160		mA
Charge current				800	mA
Charger voltage			5		V
Height			390		mm
Width			480		mm
Length	 With assembly clamp		145 245		mm mm
Weight			3.35		kg

Table 1: Device specifications

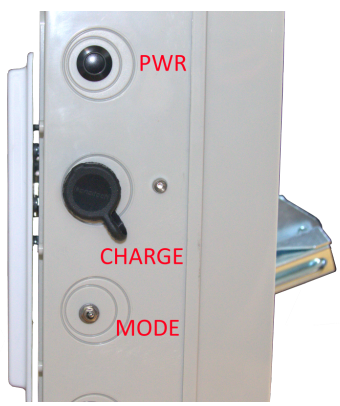

Figure 2: Device side view

3 Typical usage

3.1 Basic operation

The device is powered from an internal battery, which may be charged before use. This eliminates the necessity of providing any external power supply during measurements in the field. For charging the device an ordinary 5 V USB charger may be used. The charging port (CHARGE) should be connected to the charger by an USB cable causing a red diode to start flashing. As the charge process completes the diode stops flashing and illuminates continuously. Assuming mostly discharged battery every 1 minute of charging allows for approximately 5

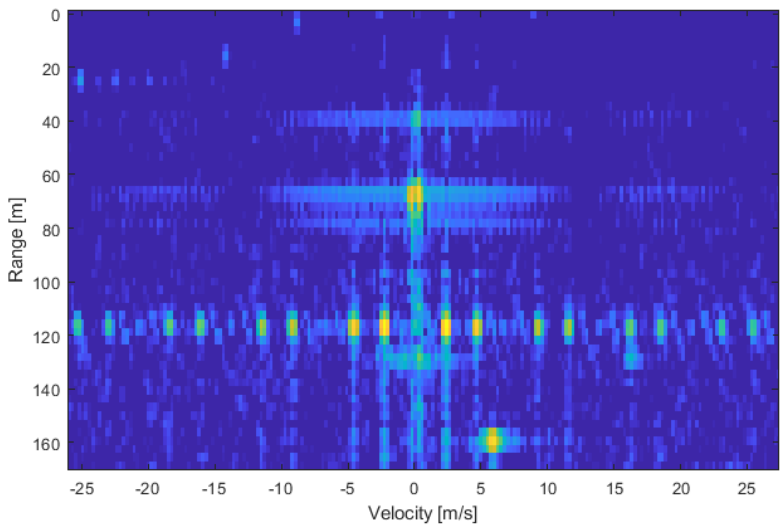

Figure 3: Range Doppler map with an echo of the device visible

minutes of operation. As the charging process progresses, however, the charging current decreases. That said, fully charging the battery, allowing for over 30 hours of device operation may take more than 7 hours.
The device may be activated by pressing the PWR switch. Illuminated green light indicates the device operation. In the active state the device emulates an object with a modulated radar cross-section. The modulation allows the Doppler-processing radars to separate the echo of the reflector from the ground clutter. Echo of the reflector produces a characteristic pattern on a Range-Doppler map, visible in Figure 3 slightly before 120 meters. At the boresight, the reflector exhibits the peak radar cross-section of 31 dBsm (1260 m^2). Due to the modulation the average radar cross-section is lower, approximately 28 dBsm. Modulation frequency may be changed using the MODE switch. When the lever is deflected upwards, the high modulation frequency is selected. Otherwise the lower frequency is set.
Important note: The device should not be operated when the charger is plugged in.

3.2 Exemplary radar calibration procedure

The primary purpose of the active radar reflector is calibration of radar systems, i.e. measurement and elimination of range and angle indication systematic errors. This is achieved by placing the reflector in a known location and measuring it's range and angular position. Repeating these steps allows for acquisition of the measurement errors data and determining correction coefficients. In order

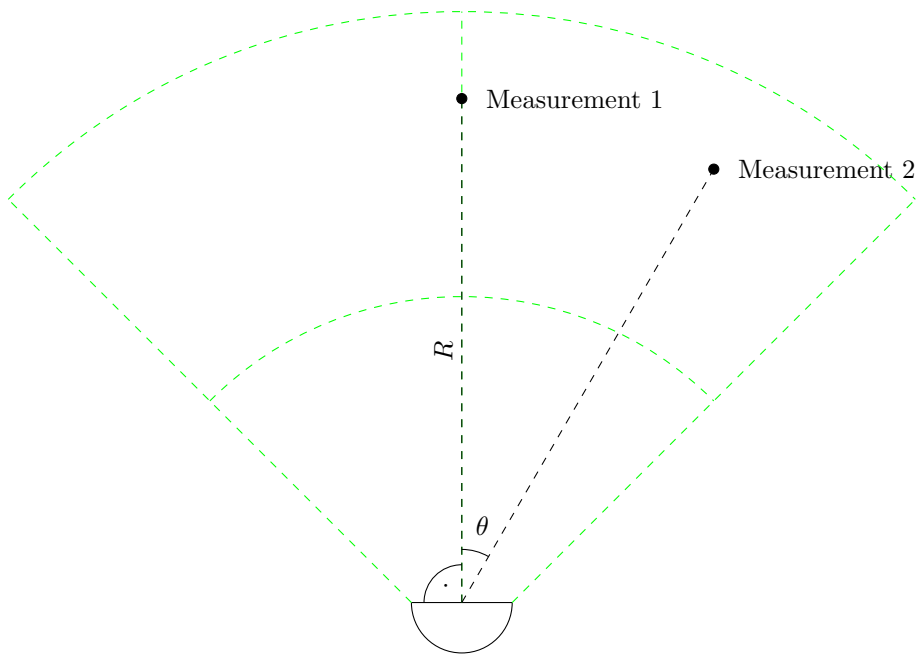

Figure 4: Measurements for radar calibration

to improve precision, using a tripod or placing the device on a mast is highly recommended. An assembly clamp is included for this purpose.
A dual-antenna radar for range and azimuth estimation may serve as an example. Parameters contributing to the azimuth error may be determined by performing two measurements (as shown in Figure 4), first with the reflector directly at the boresight of the radar at a range of R and second with a known angle-off the boresight θ. The former allows for direct phase misalignment correction. The latter enables offsetting for inaccurate evaluation of the distance between the antennas.
Considering the range measurement, the primary source of errors, i.e. a nonzero length of the cables, may be evaluated through recording also the range estimate for both channels obtained in the first measurement. Introducing an offset to the range indication may eliminate the error.