USER MANUAL

LR-15: Radar-activated flashing beacons

TNSense Inc
info@tnsense.com

1 TABLE OF CONTENTS

2 NOW IT WORKS

2.1 THE RADAR AND SPEED MEASUREMENTS

LR-15 is a smart Doppler radar that constantly measures the speed of **approaching** "targets" (vehicles), separates up to 10 simultaneous targets with different speeds and individually tracks them. The radar measures the speed of each visible "target" approximately 10 times per second. The information about target includes the collection of all speed measurements during the period of time when a target is visible and the amount of reflected radar energy called RSSI (Reflected Signal Strength Indicator). The RSSI depends on the distance to the target and its shape and can be used to approximately estimate the size of the vehicle.

LR-15 can save traffic data on removable SD-Card in easy-to-process CSV files compatible with Microsoft Excel. These data files include:

- Individual real-time records with seconds resolution.
- The Average, Minimal and Maximal speed of each vehicle.
- Vehicles size / Radar cross section (maximal RSSI value).
- Speed variation (acceleration/deceleration).
- Speed Bins summary (configurable periods and bin's width).
- Power supply voltage (configurable periods).

Typical speed measurements accuracy is +/- 0.8 km/h (0.5 mph). The accuracy of identification of individual "target" may vary depending on traffic patterns and specifics of location. Under normal conditions, the identification error does not exceed +/- 8% of daily volume. For example, for 3,000 vehicles daily volume street, the radar can count from 2,760 to 3,240 targets. The error can be bigger or smaller for a shorter period of time.

2.2 DETECTION RANGE AND COVERAGE

The detection range of the radar depends on the size and shape of the "target". A midsize sedan is typically detected at the 100-120 meters range (330-400 ft). The range can be adjusted with configuration parameters such as the "Low RSSI" filter.

The radar beam is 24° in horizontal 12° in the vertical plane. The width of the beam at the distance is calculated using the following formula:

WIDTH = ANGLE * DISTANCE /57.26

The standard lane width in North America is 3.7m (12 ft). Therefore, the approximate coverage of the radar depending on the distance:

Distance		Beam Width		Lanes
m	ft	m	ft	
25	82	10	32	3
50	164	20	65	5
75	246	31	101	10
100	328	41	134	13
125	410	51	167	15
150	492	62	203	15

Table 1 Radar beam width vs distance.

2.3 FLASHING BEACONS AND AUXILIARY OUTPUT

LR-15 can be configured to activate a pair of flashing beacons and/or one auxiliary output when a measured speed of the closest or fastest "target" is equal or above an individual output's activation threshold and turned off when the speed exceeds the maximum threshold.

The pair of flashing beacons can be programmed to work in one of the following modes (flashing patters):

Time (ms)	Patterns													
	Beacon		**Eco-Beacon**		**3 + 3**		**4 + 4**		**Blocks**		**WWPS**		**Pulse 2 + 5**	
25	400		250		75		50		75		50		125	
50														
75														
100									75					
125							50					50		
150														
175					75				75					
200														
225							50				50		125	
250														
275														
300												50		
325					75		50			75				
350														
375														
400									75		50			
425		400		250		75		50						25
450														
475										75				25
500											50			
525								50						25
550														
575						75								25
600														
625								50						200
650														
675														
700														
725						75		50						
750														
775														
800														
Total	**400**	**400**	**250**	**250**	**225**	**225**	**200**	**200**	**300**	**300**	**200**	**200**	**250**	**300**
Grand Total	**800**		**500**		**450**		**400**		**600**		**400**		**750**	

Table 2 Beacons flashing patterns

Note: different flashing patterns have different beacons active time and therefore require different amounts of energy. For example, the simple Beacon pattern consumes twice more power (800 ms of activity) then 4 + 4 or WWPS patterns (400 ms of activity).

The default brightness of the beacons can be adjusted. The brightness is controlled with Pulse Width Modulation (PWM).

The axillary output does not depend on flash patterns and brightness settings. It provides a steady DC voltage when active.

Both beacons and the auxiliary output can be powered directly from the battery (typically 7.4V DC) or trough the internal 12V DC stabilizer. In this case, the output voltage does not depend on the type of the battery and the charge level. This is a customer configurable parameter.

2.4 LOCAL RADIO NETWORK (OPTIONAL*)

LR-15 can transmit real-time speed and RSSI together with additional parameters over the embedded 2.4GHz radio interface. This data is typically used by speed displays and wireless beacons in the same local radio network.

The local radio network is identified by one of the 16 available radio channels and the network ID code. All devices with the same radio channel number and the network ID can “hear” each other and “talk” to each other. The maximum communication distance is about 400 meters (1,300 ft) but it can be significantly reduced by buildings, trees branches, traffic signs and other obstacles in an urban environment.

There are two types of messages which can be transmitted by LR-15:

- Raw data – includes current speed and RSSI of the closest or fastest vehicle.
- Smart sign data – includes the current speed of the closest or fastest vehicle together with smart display parameters.

Note: Active radio transceiver and radio communication require additional power. It is recommended to turn off the transceiver when the LR-15 is installed as a stand-alone device.

2.5 COMMUNICATION PORTS

LR-15 has two types of communication ports which can be used to set the parameters of the device and download files from the internal Micro SD card (if inserted):

- The micro USB port (FTDI COM-over-USB device).
- Optional 20-pin DIP format module (Bluetooth, Wi-Fi or Cellular modem).

When connected to a computer LR-15 is identified as a serial port (COM port). The default port speed is 115,200 bps.

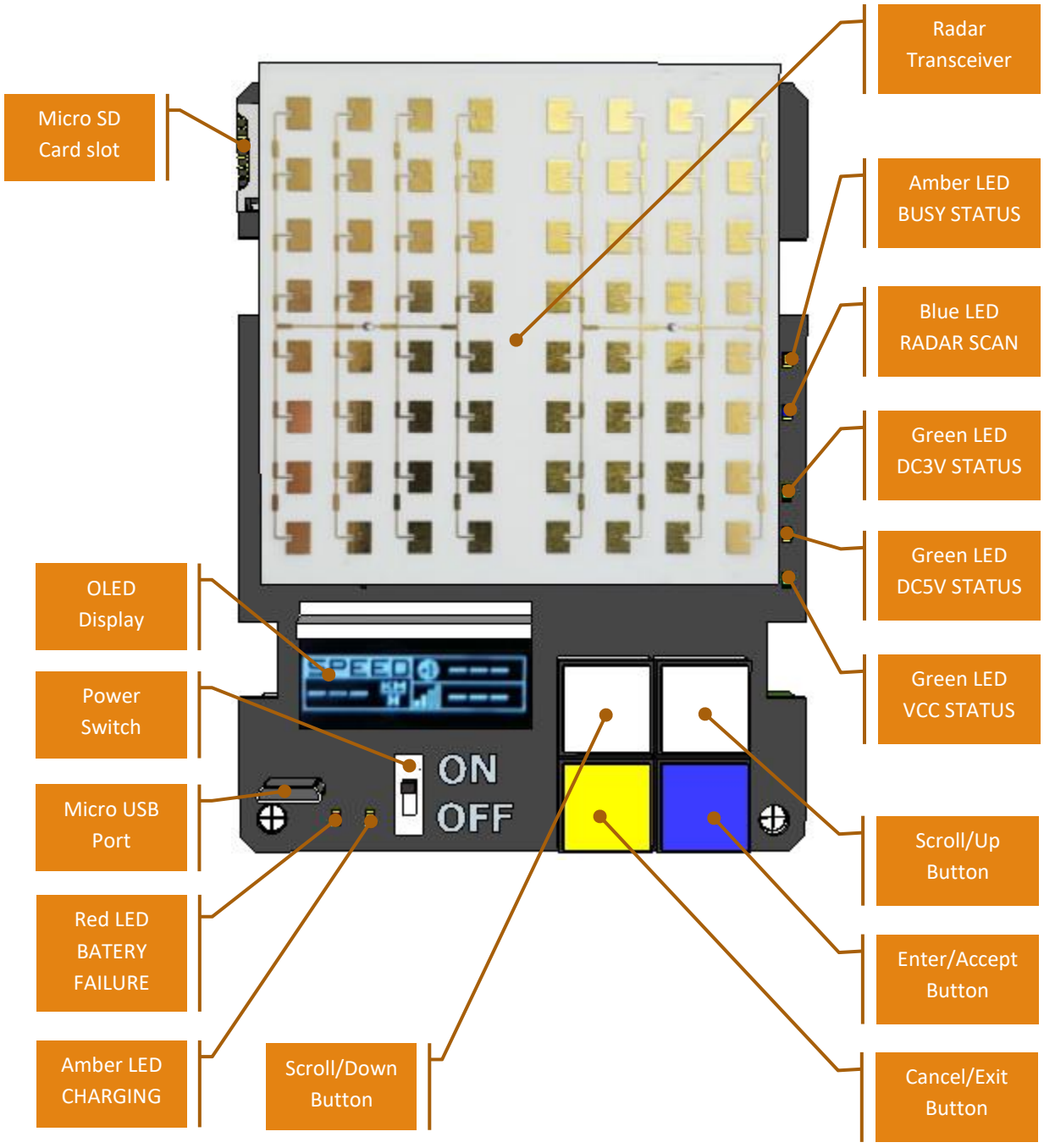
Note: The Micro USB port cannot be used to recharge the internal battery however it can provide enough power to operate the unit even without an internal battery. In this case, the beacons may be disabled.

2.6 INPUT POWER AND BATTERIES

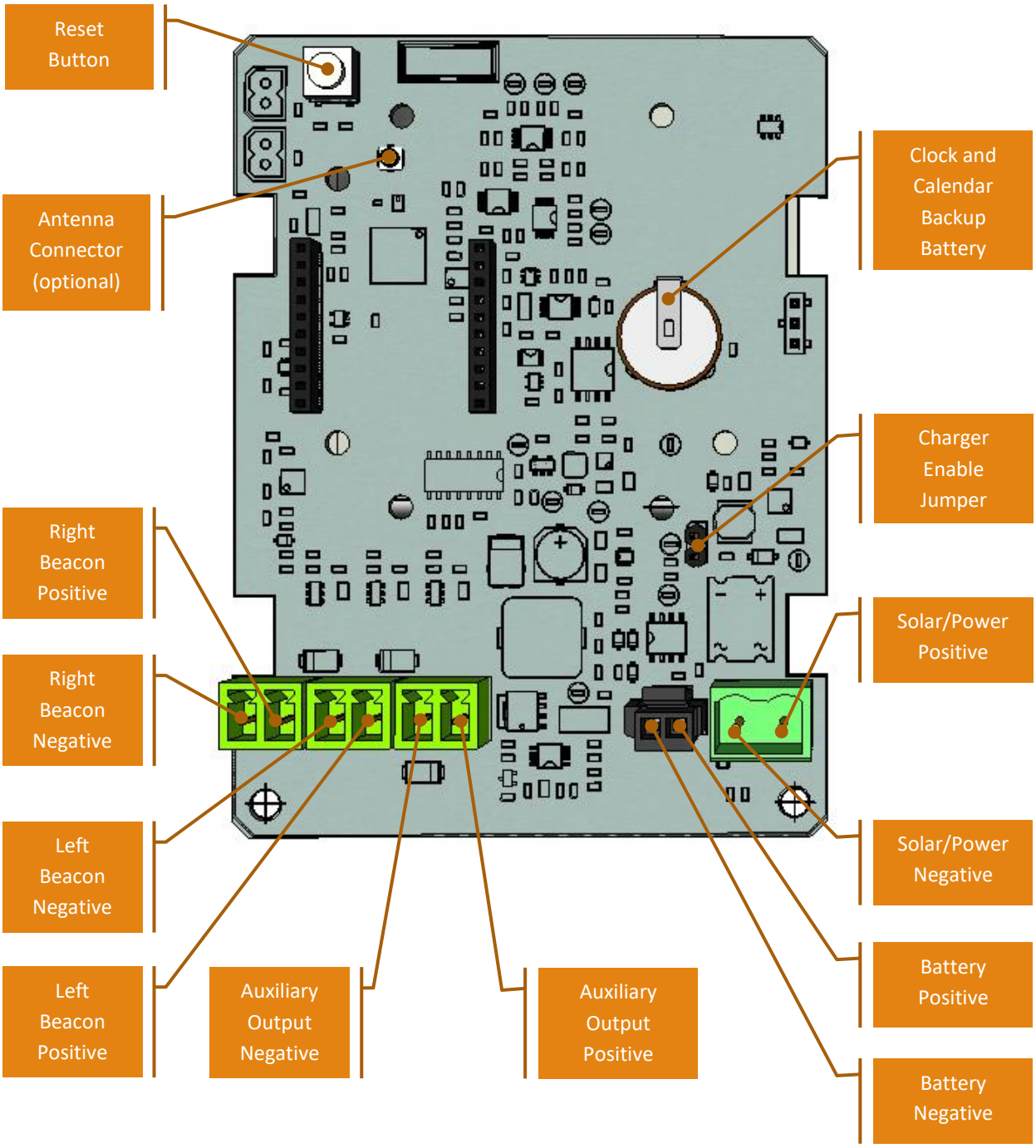
LR-15 is powered with a 2 x 4 cells 7.4 Volt lithium-ion batteries pack. The battery is automatically recharged by the connected solar panel or option AC 120V.240V power supply unit. The LR-15 has embedded the Maximum Power Point Tracking (MPPT) charging unit specially tuned for 7.4V lithium-ion batteries packs.

3 DEVICE OVERVIEW

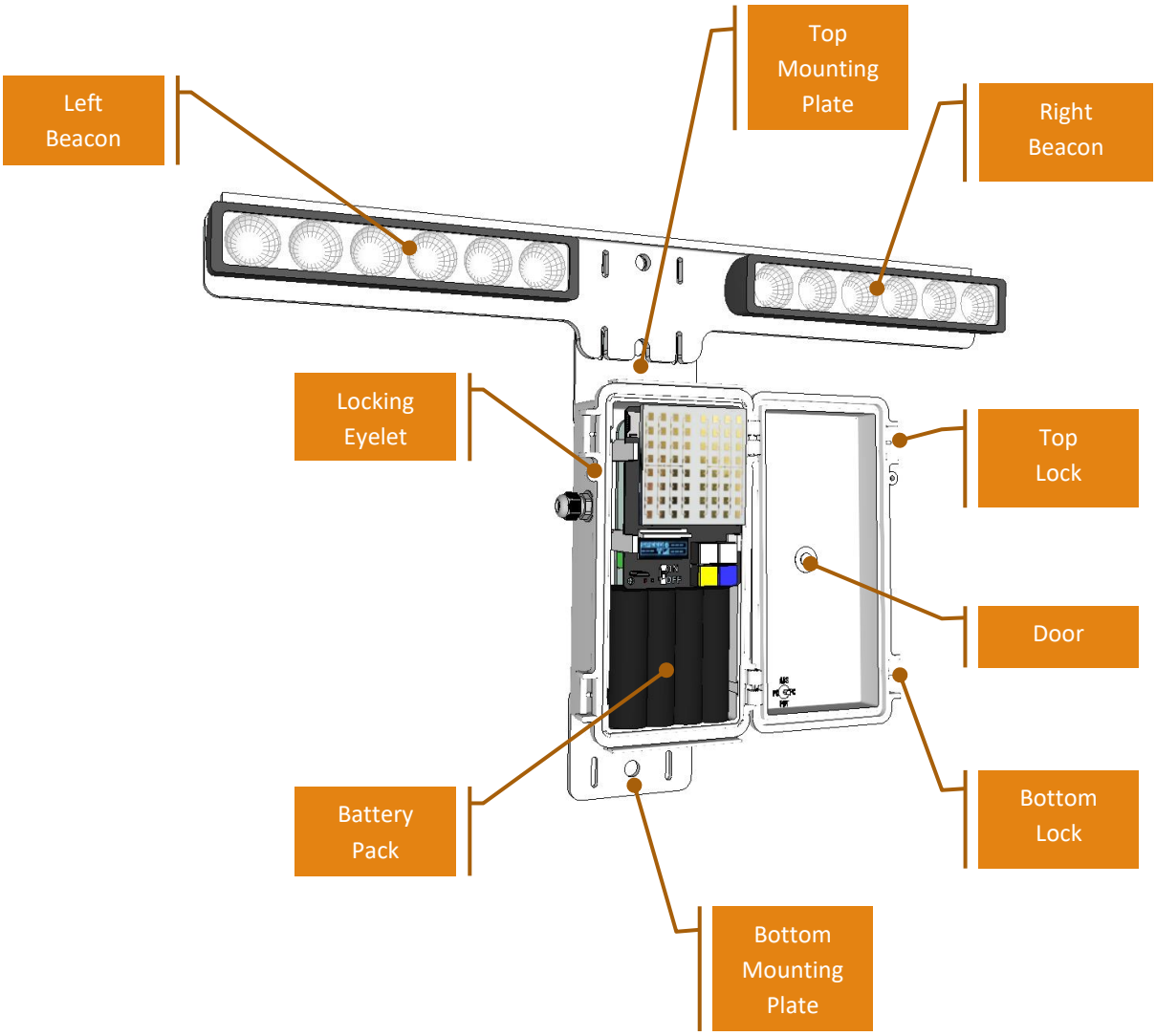
3.1 RADAR FRONT VIEW



3.2 RADAR BACK VIEW



3.3 DEVICE ENCLOSURE (SAFE-T OPTION)



4 CONFIGURATION AND DIAGNOSTICS

4.1 MENU NAVIGATION

LR-15 has the following three levels of the menu:

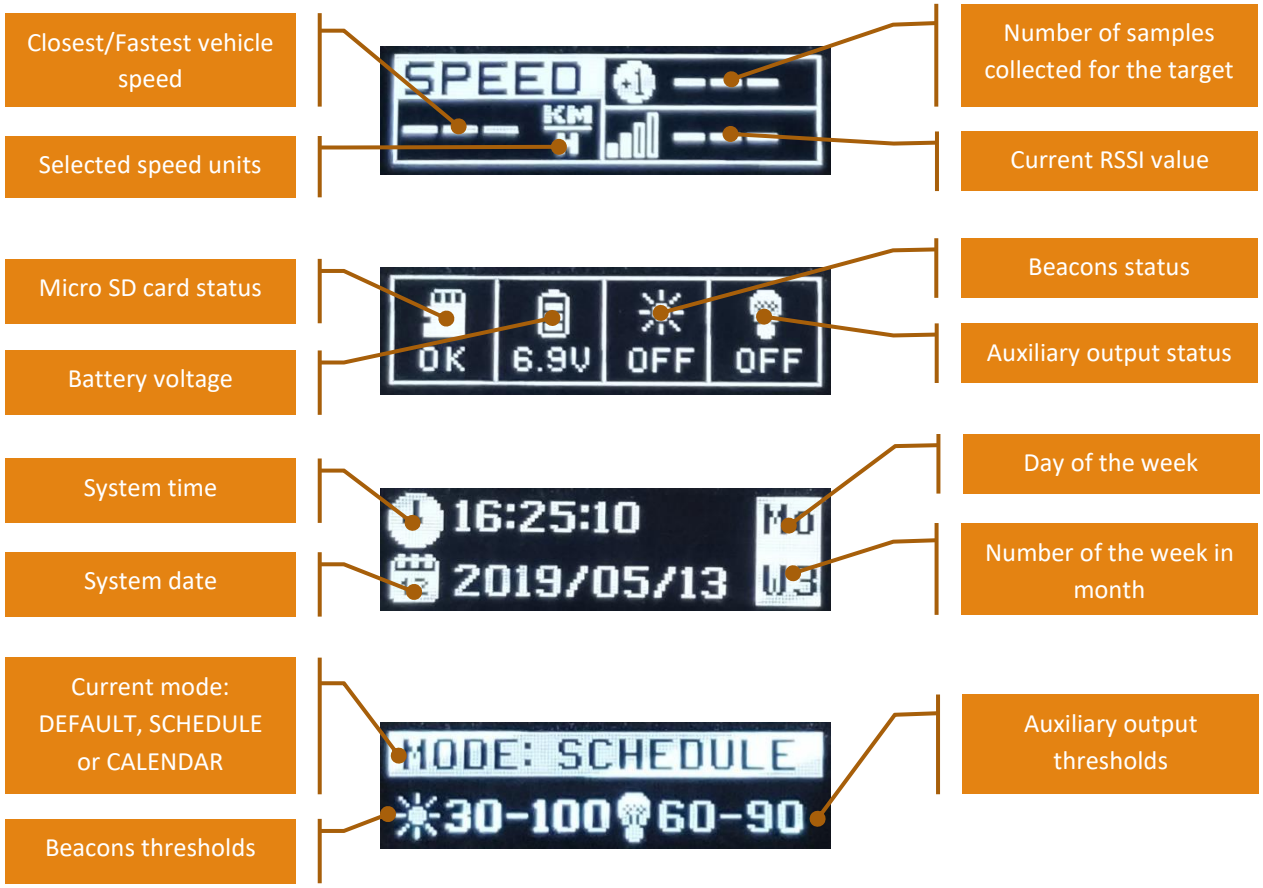
1. System status screens.
2. Group of parameters (icons).
3. Individual parameters of a selected group.

Use “Enter” (Blue) and “Cancel” (Yellow) buttons to navigate between levels and “Up” / “Down” (White) buttons to scroll items of the selected levels.

By default, the OLED display is turned off. Press the “Enter” button to activate the OLED display. The current status page will be displayed. The display will turn off automatically after a period of inactivity (no buttons pressed). You can turn the OLED screen off manually by pressing the “Cancel” button when one of the system status screens is selected.

4.2 SYSTEM STATUS SCREENS

Various diagnostics information can be verified using system status screens. Buttons “Left” and “Right” can be used to navigate between status screens:



4.3 CONFIGURATION PARAMETERS OF PARAMETERS

All system settings and parameters can be modified by a customer through the system menu. Parameters are assembled into the following groups:

- Speed thresholds for beacons and auxiliary output.
- Beacons flashing parameters and power settings.
- Traffic statistic recording parameters.
- Real-Time Clock settings.
- Advances system settings.
- Finetuning radar parameters.

Press the “Enter” (Blue) to access the selected group of parameters or “Up” / “Down” (White) buttons to select the required group. You can choose to exit this to the diagnostics menu by pressing the “Esc” (Yellow) button.

When a group of parameters is selected you can navigate between each individual parameter using “Up” / “Down” (White) buttons to review or change them.

Press the “Enter” (Blue) button when the parameter is displayed to change the value. Use “Up” / “Down” (White) buttons to edit the value and press the “Enter” button again to accept the new value. You can press the “Esc” (Yellow) button to cancel all changes.

4.3.1 BEACONS AND AUX ACTIVATION THRESHOLD’S

- **STROBE-ON** – activate beacons when currently measured speed is above this threshold.
- **STROBE-OFF** – turn off beacons when currently measured speed is above this threshold.
- **AUX-ON** – activate auxiliary when currently measured speed is above this threshold.
- **AUX-OFF** – turn off the auxiliary output when the currently measured speed is above this threshold.

4.3.2 BEACON PATTERNS AND POWER SETTINGS

- **FLASH MODE** – beacons flashing patterns (see 2.3).
- **BRIGHTNESS** – default beacon’s brightness in the percentage of maximum.
- **12V OUTPUT** – outputs voltage adjusted to 12V (enabled/disabled). If DISABLED, both beacons and the auxiliary output will be powered with the power supply voltage.

4.3.3 TRAFFIC STATISTIC RECORDING PARAMETERS

- **SPEED-FROM** – speed bins settings: the unit will record speed bins beginning from the selected speed
- **SPEED-TO** – speed bins settings: the unit will record speed bins up to the selected speed.
- **BIN-WIDTH** – speed bins settings: width of speed in (in selected speed units)
- **PERIOD** – speed bins settings: write speed bins record to file with this interval.
- **TARGETS LOG** – record raw daily logs of vehicles with all parameters (enabled/disabled). This is the most detailed form of information.

- **SPEED BINS** – record monthly speed bins files (enabled/disabled).
- **POWER LOG** – record monthly log files of battery voltage (enabled/disabled).
- **OUTBOUND** – record the same set of files (excluding power log) for outbound vehicles (enabled/disabled).

4.3.4 DATE AND TIME SETTINGS

- **SYS TIME** – set time for the internal real-time clock.
- **SYS DATE** – set the current date for the internal calendar.

4.3.5 ADVANCED SETTINGS

- **SPEED UNITS** – system speed units (*KM/H* – kilometers per hour or *MPH* – miles per hour).
- **DEMO MODE** – demo mode (activate/disactivate).
- **DISP TRAFFIC** – traffic direction used as "displayed" speed (*Inbound*/*Outbound*). This speed will be used in outputs (beacons and auxiliary) thresholds.
- **DISP SELECT** – algorithm of speed selections for cases when more than one vehicle is detected (*CLOSEST* or *FASTEST*)
- **SLEEP CYCLE** – number of sleep system cycles that are used when no traffic is detected. Increasing this parameter helps save battery power but reduces the time of reaction.

4.3.6 RADAR SETTINGS

- **LOWEST SPEED** – lowest speed filter set in RSU – radar speed unit. (1RSU = 0,82 km/h). All speeds below this limit will be rejected.
- **RSSI FILTER** – lowest signal level filter is used to reject ambient "noises". (RSSI – Reflected Signal Strength Indicator). A lower value will increase the detection range but may result in false detections caused by small moving objects such as leaves, branches, heavy rain or snow etc.
- **RSSI DELTA** – minimal difference between RSSI levels of two separate vehicles (targets) which will result in the creation of two records. This value can be reduced in a case when the radar undercounts vehicles (counts multiple vehicles as one).
- **SPEED DELTA** – minimal difference between detected speeds which will be considered as a separate vehicle (in RSU – radar speed unit). This value can be reduced in a case when the radar undercounts vehicles (counts multiple vehicles as one).
- **STAT CONFIRM** – minimal number of samples for each vehicle to confirm the validity of a statistics record (samples). This value can be reduced in a case when the radar undercounts vehicles (counts multiple vehicles as one).
- **SIGNAL LOST** – number of system cycles that did not return a vehicle speed to consider a vehicle as passed (disappeared).
- **TARG.CONFIRM** – a minimal number of consecutive samples to confirm the "target" as valid.
- **AMP. FACTOR** – factor of the radar signal amplification, times: *x1, x2, x5, x10, x20, x50, x100*.

5 DATA FILES

5.1 FOLDERS STRUCTURE

Data files are recorded on the inserted Micro SD card. The controller automatically detects the presence of the SD card and manages the proper structure of folders and files.

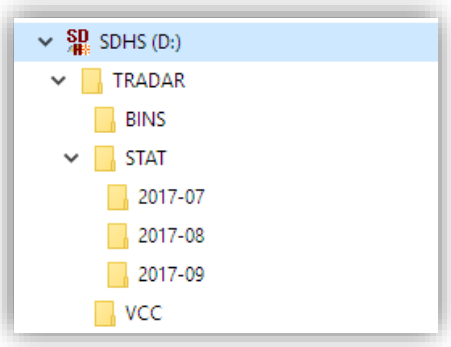


FIG.1: EXAMPLE OF THE FOLDERS STRUCTURE ON SD CARD.

The controller will automatically create the **"TRADAR"** folder if was not previously created and will be used as a root folder for all other folders and files created during the operation.

The data collection option is active by default on all of TNSense radar-based devices. The data collection will begin when the SD card is inserted into a device at paused when it is removed.

All data is recorded in standard Comma-Separated-Values (CSV) files. The comma (,) symbol is used as a delimiter and values are placed between two quotes (") symbols.

5.2 SPEED BINS

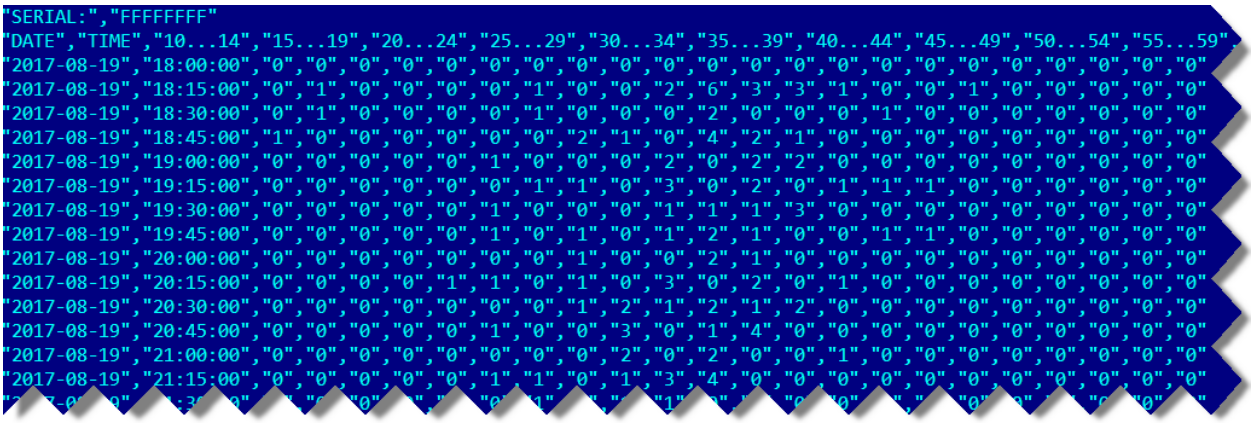
The "Speed Bins" files are created in the **"BINS"** sub-folder. A new file will be created for each month. The name of the file has the following format:

BYYYY-MM.csv

Where:

- YYYY – four digits year
- MM – two digits month of the year number with leading zero

The speed bins files contain periodically recorded vehicles counters for each speed preprogrammed "bin". The whole range of recorded speed and the "width" of the speed bins are set via the onboard user interface and/or through the TNSense's "Radar Toolkit" software.



```
"SERIAL:","FFFFFFFF"
"DATE","TIME","10...14","15...19","20...24","25...29","30...34","35...39","40...44","45...49","50...54","55...59"
"2017-08-19","18:00:00","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0","0"
"2017-08-19","18:15:00","0","1","0","0","0","0","1","0","0","2","6","3","3","1","0","0","1","0","0","0","0","0"
"2017-08-19","18:30:00","0","1","0","0","0","0","1","0","0","0","2","0","0","0","1","0","0","0","0","0","0","0"
"2017-08-19","18:45:00","1","0","0","0","0","0","0","2","1","0","4","2","1","0","0","0","0","0","0","0","0","0"
"2017-08-19","19:00:00","0","0","0","0","0","1","0","0","0","2","0","2","2","0","0","0","0","0","0","0","0","0"
"2017-08-19","19:15:00","0","0","0","0","0","0","0","1","1","0","3","0","2","0","1","1","1","1","0","0","0","0","0","0"
"2017-08-19","19:30:00","0","0","0","0","0","0","1","0","0","0","1","1","1","3","0","0","0","0","0","0","0","0","0","0"
"2017-08-19","19:45:00","0","0","0","0","0","0","1","0","1","0","1","2","1","0","0","1","1","1","0","0","0","0","0","0"
"2017-08-19","20:00:00","0","0","0","0","0","0","0","0","1","0","0","2","1","0","0","0","0","0","0","0","0","0","0","0"
"2017-08-19","20:15:00","0","0","0","0","0","1","1","0","1","0","3","0","2","0","1","0","0","0","0","0","0","0","0","0"
"2017-08-19","20:30:00","0","0","0","0","0","0","0","0","1","2","1","2","1","2","0","0","0","0","0","0","0","0","0","0"
"2017-08-19","20:45:00","0","0","0","0","0","0","1","0","0","3","0","1","4","0","0","0","0","0","0","0","0","0","0","0"
"2017-08-19","21:00:00","0","0","0","0","0","0","0","0","0","2","0","2","0","0","1","0","0","0","0","0","0","0","0","0"
"2017-08-19","21:15:00","0","0","0","0","0","0","1","0","1","0","1","3","4","0","0","0","0","0","0","0","0","0","0","0"
```

The first two lines of the file contain the serial number of the device which was used to collect the information and the columns header.

5.3 TARGETS LOG

The daily "Targets Log" files are created in the **"STAT"** sub-folder. A new subfolder will be created for each month in the **"STAT"** folder and the new file will be created every day when at least one target is detected. The name of the monthly sub-folder and daily file has the following format:

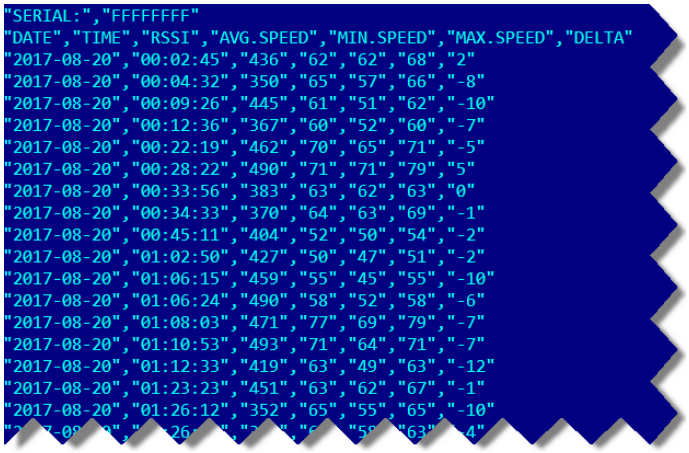
YYYY-MM\MM-DD.csv

Where:

- YYYY – four digits year
- MM – two digits month of the year number with leading zero
- DD – two digits day of the month with leading zero

The log contains an individual, a time-stamped record for each passed target. The record information includes the following fields:

- "DATE" – the date of the record.
- "TIME" – the time when the record was created (after the vehicle passed).
- "RSSI" – maximum rate if RF reflection which is proportional to the vehicle size (no units).
- "AVG.SPEED" – average speed during the target observation period (in selected speed units).
- "MIN.SPEED" – the minimal speed of the target (in selected speed units).
- "MAX.SPEED" – the maximal speed of the target (in selected speed units).
- "DELTA" – acceleration (positive) or deceleration (negative) during the observation period.



```
"SERIAL:","FFFFFFFF"
"DATE","TIME","RSSI","AVG.SPEED","MIN.SPEED","MAX.SPEED","DELTA"
"2017-08-20","00:02:45","436","62","62","68","2"
"2017-08-20","00:04:32","350","65","57","66","-8"
"2017-08-20","00:09:26","445","61","51","62","-10"
"2017-08-20","00:12:36","367","60","52","60","-7"
"2017-08-20","00:22:19","462","70","65","71","-5"
"2017-08-20","00:28:22","490","71","71","79","5"
"2017-08-20","00:33:56","383","63","62","63","0"
"2017-08-20","00:34:33","370","64","63","69","-1"
"2017-08-20","00:45:11","404","52","50","54","-2"
"2017-08-20","01:02:50","427","50","47","51","-2"
"2017-08-20","01:06:15","459","55","45","55","-10"
"2017-08-20","01:06:24","490","58","52","58","-6"
"2017-08-20","01:08:03","471","77","69","79","-7"
"2017-08-20","01:10:53","493","71","64","71","-7"
"2017-08-20","01:12:33","419","63","49","63","-12"
"2017-08-20","01:23:23","451","63","62","67","-1"
"2017-08-20","01:26:12","352","65","55","65","-10"
```

The first two lines of the file contain the serial number of the device which was used to collect the information and the columns header.

5.4 BATTERY VOLTAGE AND RESETS LOG

The controller can periodically record the battery voltage. This information can be useful for calculating the expected autonomy of the system when it is used in AC rechargeable mode or to adjust the position of the solar panel.

The monthly log files are created in the “VCC” sub-folder. A new file will be created for each month. The name of the file has the following format:

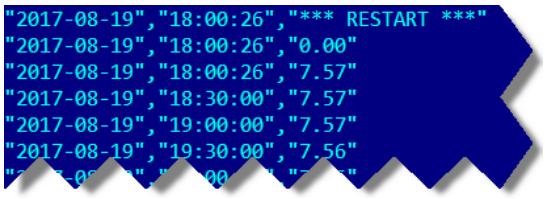
VYYYY-MM.csv

Where:

- YYYY – four digits year
- MM – two digits month of the year number with leading zero

The log contains individual, time-stamped periodic records. The record information includes the following fields:

- "DATE" – the date of the record.
- "TIME" – the time when the record was created (after the vehicle passed).
- "VCC" – the battery voltage at this moment (in Volts).



```
"2017-08-19","18:00:26","*** RESTART ***"
"2017-08-19","18:00:26","0.00"
"2017-08-19","18:00:26","7.57"
"2017-08-19","18:30:00","7.57"
"2017-08-19","19:00:00","7.57"
"2017-08-19","19:30:00","7.56"
```

During the boot routine, the controller creates a time-stamped record with the “*** RESTART ***” message.

6 ISED REGULATORY STATEMENT

This device complies with Industry Canada license-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

CAN ICES-3 (B)/NMB-3(B)

This digital apparatus does not exceed the Class B limits for radio noise emissions from digital apparatus set out in the interference-causing equipment standard entitled: "Digital Apparatus," ICES-003 of the Canadian Department of Communications.

Cet appareil numérique ne dépasse pas les limites de classe « B » pour les émissions de bruit radioélectrique par un appareil numérique énoncées dans la norme relative au matériel brouilleur, intitulée « Appareils numériques », NMB-003 du ministère canadien des communications.