User Guide

SmartCart FCC test software

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1 Introduction

SmartCart is a portable LTE eNodeB that is used for testing new installations of SmartSky's service on aircraft. It shares a common codebase with the SmartSky ground network eNodeBs including the non-standard customisations of LTE to support the air-to-ground service. A USRP is used as the radio transceiver and the emissions of this transceiver are put through an FCC approvals process.

The SmartCart FCC test software drives the radio in a way that is representative of normal operation of SmartCart. It differs in the following ways:

- The eNodeB will transmit continuously and without needing a UE to talk to
- A normal LTE link has varying amounts of information in the control and data regions according to the data transferred, together with broadcast information and other overheads. The test software used a fixed data pattern and a fixed allocations so that measurements are repeatable and non-time-varying.
- The test software is intentionally a worst case as far as RF emissions are concerned. It can fully populate the on-air spectrum which may only occur transiently in normal operation.

2 Referenced documents

Reference	Title	Issued by
Reference 1. P4417-UG-016	SmartCart Installation Guide	CC

Table 1 - Referenced documents

3 Installing the software

The SmartCart FCC test software is part of the normal SmartCart installation. Either start with an already installed SmartCart or with reference to the installation manual (Reference 1 - P4417-UG-016):

- In section 4 "SmartCart Base station installation" follow steps 4.1 through 4.5 to install the software
- A login is needed to drive the software:
  - This can be on the keyboard/monitor/console used for installation (step 9 of section 4.4 sets the password)
  - This can be via SSH (see section 4.6) but it is recommended to use a different SSH key if the SmartCart is to be used by a test house or other non-SmartSky personnel
- Sections 4.7 eNodeB commissioning and 4.8 VPN commissioning are not required

Once SmartCart base station has been installed please stop and disable the normal SmartCart services by logging in and running:

```
smartcart@smartcart:~$ sudo systemctl stop enodeb
smartcart@smartcart:~$ sudo systemctl disable enodeb
smartcart@smartcart:~$ sudo systemctl stop diagnostics
smartcart@smartcart:~$ sudo systemctl disable diagnostics
```

then reboot the SmartCart base station.

4 Running the software

The software is controlled by a script that will print its help text if called with no arguments:

```
usage: enodeb_test.py [-h] --bandwidth BANDWIDTH --allocation ALLOCATION --modulation MODULATION [--gain
GAIN] [--dev]
enodeb test-app runner script
optional arguments:
  -h, --help            show this help message and exit
  --bandwidth BANDWIDTH
                        Bandwidth [5|10]
  --allocation ALLOCATION
                        Allocation [full|low|mid|high]
  --modulation MODULATION
                        Modulation [qpsk|qam16|qam64]
  --gain GAIN           Gain (default: 90)
  --dev                 Enable development options
```

Note the following about the parameters:

- SmartCart uses an LTE cell with a nominal bandwidth of 5 MHz (an occupied bandwidth of 4.5 MHz); selecting 5 MHz also configured the lowest channel centre frequency of 2448.2 MHz.
  - Testing can be performed with a 10 MHz nominal (9 MHz occupied) bandwidth and this uses a channel centre frequency of 2450.7 MHz
- A `full` allocation will occupy the entire LTE bandwidth and results in the highest average transmitted power output. Otherwise the allocation occupies the minimum bandwidth possible that is consistent with the 500kHz minimum bandwidth limit in the FCC rules. `low` will place this allocation at the low frequency edge of the LTE channel bandwidth, `high` at the high frequency edge and `mid` in approximately the centre.
- SmartCart may use any of QPSK, QAM16 or QAM64 in normal operation. For FCC approvals select the worst case (based on measurements).
- The gain should be set to at least the highest used in SmartCart i.e. 90.

Run the script with the relevant parameters e.g.:

```
$ sudo python3 /usr/local/bin/enodeb_test.py --bandwidth 5 --allocation full --modulation qam16
[INFO] [UHD] linux; GNU C++ version 9.3.0; Boost_107100; UHD_3.15.0.0-0-unknown
[INFO] [B200] Detected Device: B200
[INFO] [B200] Operating over USB 3.
[INFO] [B200] Detecting internal GPSDO....
[INFO] [GPS] Found an internal GPSDO: GPSTCXO, Firmware Rev 0.929b
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Setting master clock rate selection to 'automatic'.
[INFO] [B200] Asking for clock rate 16.000000 MHz...
[INFO] [B200] Actually got clock rate 16.000000 MHz.
Running: /usr/local/bin/pdsch_enodeb -a 'clock=gpsdo,serial=31ED0F9' -S -F -c 25 -g 90 -p 25 -f
2448200000 -N 13 -O 0 -m 14
Opening RF device...
Available RF device list: UHD  zmq
Trying to open RF device 'UHD'
[INFO] [UHD] linux; GNU C++ version 9.3.0; Boost_107100; UHD_3.15.0.0-0-unknown
[INFO] [LOGGING] Fastpath logging disabled at runtime.
Opening USRP channels=1, args: serial=31ED0F9,type=b200,master_clock_rate=23.04e6
[INFO] [UHD RF] RF UHD Generic instance constructed
[INFO] [B200] Detected Device: B200
[INFO] [B200] Operating over USB 3.
[INFO] [B200] Detecting internal GPSDO....
[INFO] [GPS] Found an internal GPSDO: GPSTCXO, Firmware Rev 0.929b
[INFO] [B200] Initialize CODEC control...
[INFO] [B200] Initialize Radio control...
[INFO] [B200] Performing register loopback test...
[INFO] [B200] Register loopback test passed
[INFO] [B200] Asking for clock rate 23.040000 MHz...
[INFO] [B200] Actually got clock rate 23.040000 MHz.
Setting USRP time to 1664180657.000000s
[INFO] [MULTI_USRP]     1) catch time transition at pps edge
[INFO] [MULTI_USRP]     2) set times next pps (synchronously)
/builds/p4417/lte-stack/CC-srsLTE/lib/src/phy/rf/rf_uhd_imp.cc:822: Could not lock reference clock
source. Sensor: gps_locked=false

RF device 'UHD' successfully opened
Setting sampling rate 5.76 MHz
Set TX gain: 89.8 dB
Set TX freq: 2448.20 MHz
 - Resource Allocation Type:            Type 0
   + Resource Block Group Size:         2
   + RBG Bitmap:                        0x1fff
 - HARQ process:                        0
 - TPC command for PUCCH:               --
 - Transport blocks swapped:            false
 - Transport block 0 enabled:           true
   + Modulation and coding scheme index:        14
   + New data indicator:                        No
   + Redundancy version:                        0
 - Transport block 1 enabled:           false
```

The eNodeB will run continuously and measurements can be made. See Appendix A for example performance.

To stop the application press Ctrl-C:

```
^CSIGINT received. Exiting...
Done
```

The application can be restarted – no need to reboot the SmartCart base-station.

5 Restoring normal operation

At the end of FCC testing reinstall SmartCart base station by following installation manual (Reference 1 - P4417-UG-016) including the eNodeB commissioning and VPN steps.

Appendix A

Figure 1 shows the typical performance of the USRP connected to an LTE analyser. Figure 2 and Figure 3 show the extent to which the resource grid is full for 5 MHz and 10 MHz allocations. Figure 4 shows the allocation detail and relative power of PDCCH vs PDSCH for 5MHz. The figures are not corrected for cable loss – the signal power at gain of 90 should be around 2 dBm and RSTP around -25 dBm.

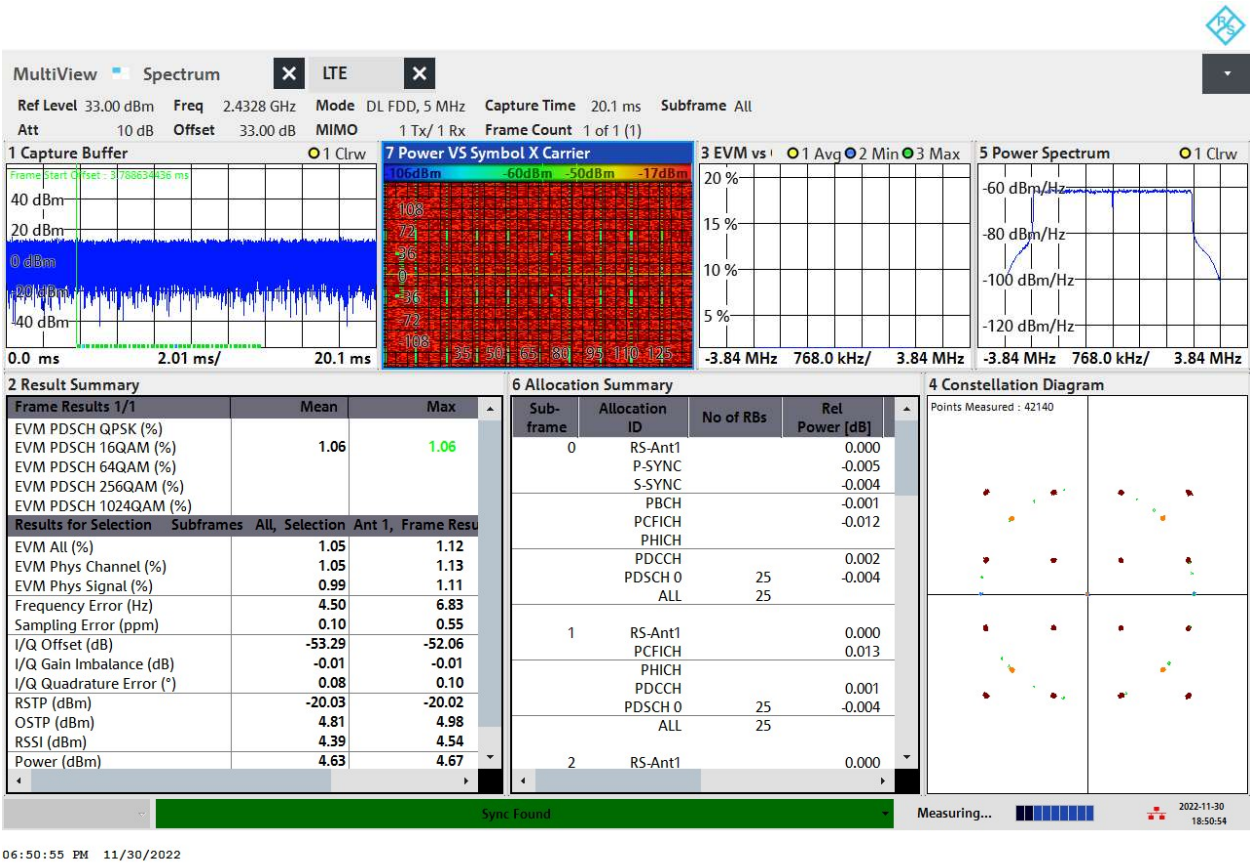

Figure 1 LTE summary with full allocation

06:49:56 PM 11/30/2022

Figure 2 Power vs resource element 5 MHz

06:49:04 PM 11/30/2022

Figure 3 Power vs resource element 10 MHz

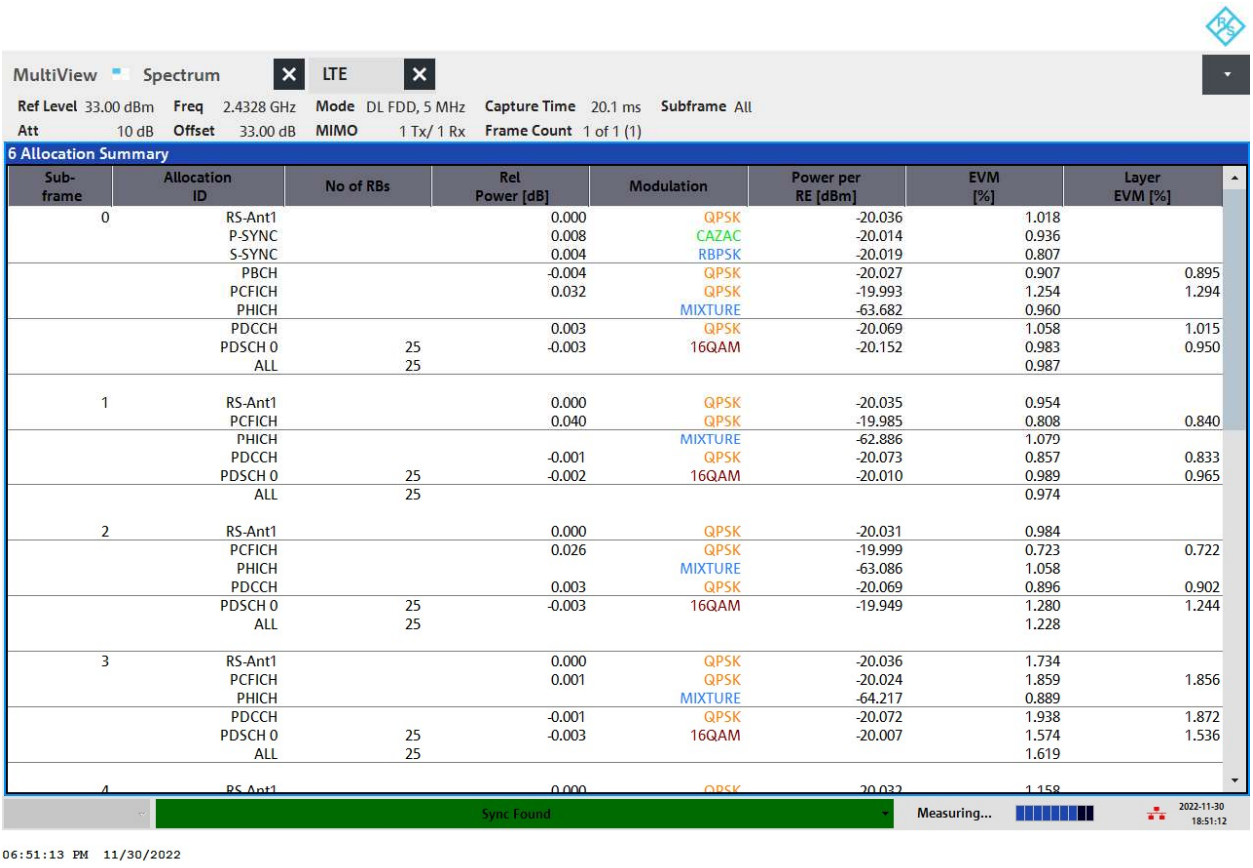

Figure 4 Allocation summary and relative powers at 5MHz

FCC Compliance Statement

Changes or modifications not expressly approved by SmartSky Networks could void the user's authority to operate the equipment.

Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

This equipment complies with FCC radiation exposure limits set forth for an uncontrolled environment. This equipment shall be installed and operated with a minimum distance of 20cm between the radiator and any part of your body.