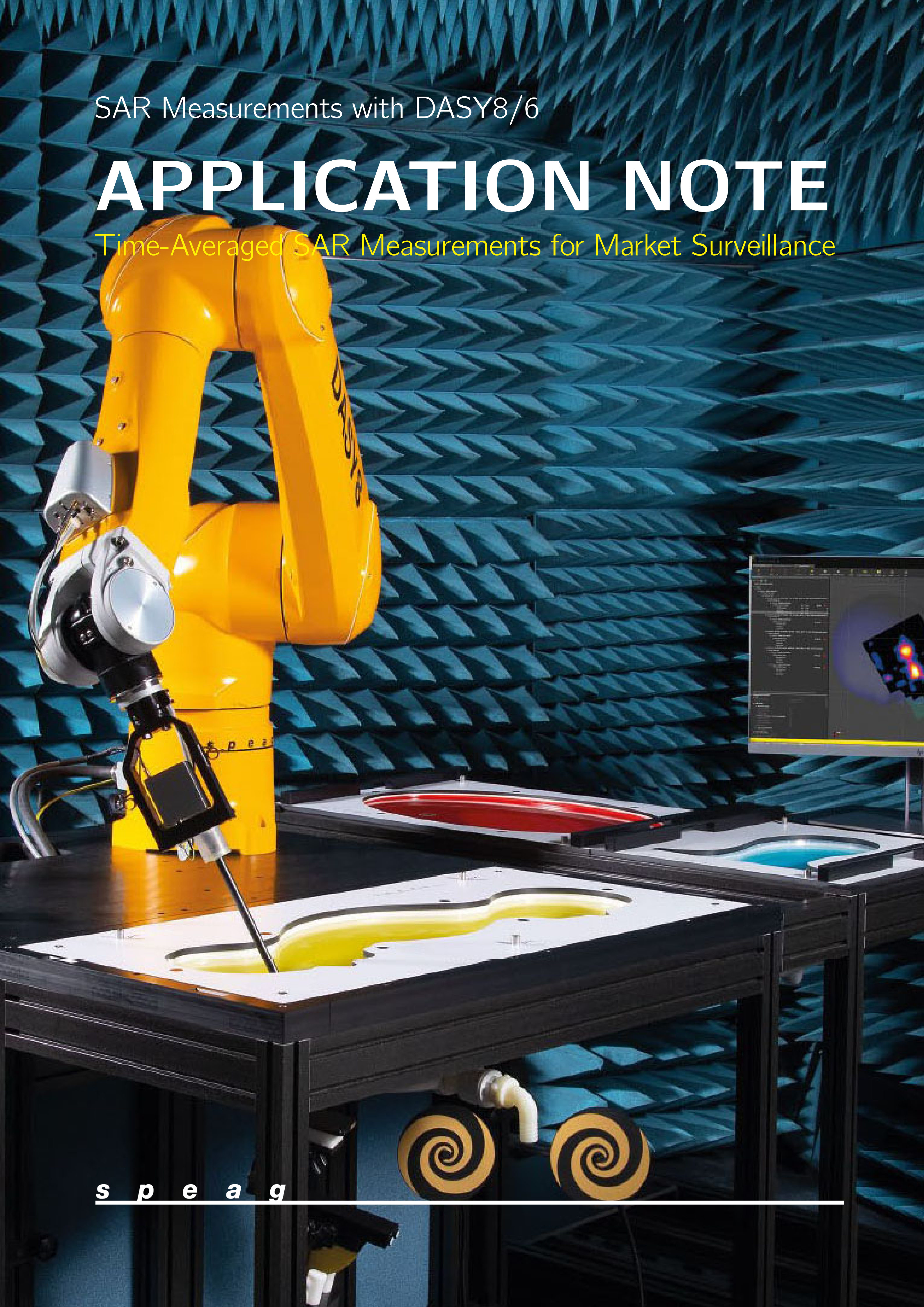
SAR Measurements with DASY8/6

APPLICATION NOTE

Time-Averaged SAR Measurements for Market Surveillance



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Contents

Time-Averaged SAR Measurements for Market Surveillance

1 Summary

This application note provides a workflow for time-averaged SAR measurements of commercial test samples without the use of manufacturer tools or specific test modes, e.g., in the context of market surveillance. Section 3 defines a simplified test procedure and the conditions under which it can be applied in DASY8/6 Module v16.0+. Section 4 demonstrates the complete workflow using the actual measurement results of a commercial test sample. This is followed by a discussion of the results and conclusions in Section 5.

Note 1: The base station simulator screenshots and instructions are based on Rohde & Schwarz ® CMW500 radio communication tester. The steps for other base station simulators are similar.

Note 2: The test procedure in case manufacturer tools are available is described in the DASY8/6 manual.

2 Time-Averaged SAR Introduction

The procedures in IEC/IEEE 62209-1528:2020 require test devices to maintain a fixed output power during SAR compliance measurements. Modern mobile devices implement dynamic power control and exposure time-averaging (DPC-ETA) to improve link quality while maintaining compliance with SAR limits. The concept of DPC-ETA has been introduced to enable SAR compliance control of wireless devices in real-time. In DPC-ETA, the RF power is recorded by the modem and time-averaged over a specified window duration. Device output power control is based on the linear SAR-to-power relationship established for a specific wireless operating mode and exposure condition. When the maximum time-averaged power is controlled by DPC-ETA, brief durations of higher instantaneous power may be applied while the maximum time-averaged SAR is not exceeded. DPC-ETA may lead to temporal fluctuations of the device output power / SAR during the test period. The methods for validating dynamic power control and dynamic exposure time-averaging algorithms used in wireless devices are described in IEC TR 63424-1. While DASY8/6 SAR measurement systems can accurately test the time-averaged SAR for DPC-ETA-enabled devices, the tests usually require manufacturer access/test modes to selectively enable or disable the DPC-ETA algorithm. That greatly complicates any independent testing scenarios (for example market surveillance). A solution for this market surveillance test problem is presented in this application note.

3 Test Procedure

The procedure used in DASY8/6 is described in IEC TR 63424-1's Section F.2.2 Single-point SAR method. It consists of two steps:

1. Disabling of the power control algorithm and forcing the device to operate at P_{limit}, followed by measurement of Area / Zoom Scan, resulting in $psSAR_{1g10gPlimit}$, which is the $psSAR_{1g10g}$ measured at P_{limit} of the wireless mode being tested, with a full SAR measurement according to IEC/IEEE 62209-1528:2020 and IEC 62209-3:2019 requirements. P_{limit} is the maximum time-averaged output power specified to ensure SAR compliance for the given DUT operating state.

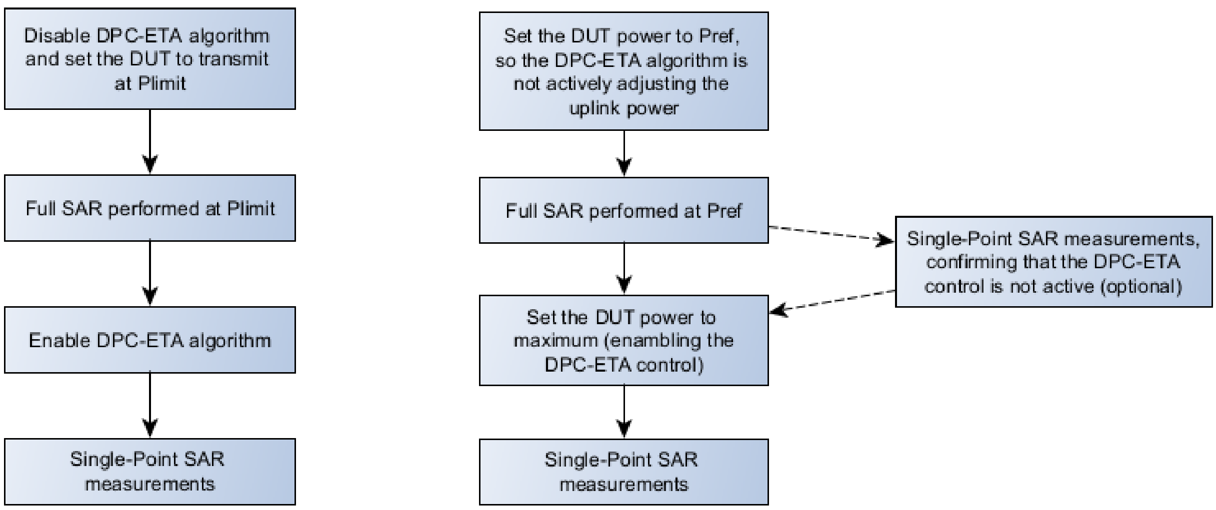
2. Enabling of the power control algorithm, followed by a Time-Averaged SAR scan , which performs single-point SAR measurements $pointSAR(t)$ at the peak SAR location identified during the Zoom scan. $pointSAR_{Plimit}$ is also measured at the same location at P_{limit} to scale the single-point SAR to $psSAR_{1g10g}$, using the following equation:

$$psSAR_{1g10g}(t) = \frac{pointSAR(t)}{pointSAR_{Plimit}} \times psSAR_{1g10Plimit} \tag{1.1}$$

Step 1 presents a significant limitation for independent testing - disabling the power control algorithm requires access to manufacturer tools. A small modification of this step can be done to overcome this limitation. The DPC-ETA algorithms will be actively adjusting the uplink power only at relatively high output power levels. Once the DUT output power is below a certain threshold, the transmission power and resulting SAR will stay constant. Lowering the output power from the DUT can therefore be used to prevent uplink power adjustments caused by the power control algorithm. This will allow a full SAR measurement in step 1, but performed at a power P_{ref} (lower than P_{limit}). $Plimit$ is then replaced with $Pref$ in Formula 1.1:

$$psSAR_{1g10g}(t) = \frac{pointSAR(t)}{pointSAR_{Pref}} \times psSAR_{1g10Pref} \tag{1.2}$$

Fig. 1.1 compares the original IEC TR 63424-1 procedure with the proposed modification.



(a) IEC TR 63424-1 Procedure (b) Modified Procedure

Figure 1.1: Workflow comparison

Here, P_{ref} should be carefully selected - too high values might trigger power control algorithm adjustments, and too low values might give SAR results close to the noise floor of the measurement system (DASY8/6 has an outstanding sensitivity of 10 mW/kg). P_{ref} should be set low enough, so DPC-ETA algorithms are not actively adjusting the uplink power, such as 13 dBm for example in the case of LTE and NR. If this level is resulting in SAR

values close to the noise floor of the measurement system, P_{ref} can be increased to a level at which the power control level is still not active. This can be confirmed with Single-Point SAR measurements (marked as optional in Fig. 1.1b). In cases when the user has no additional guidance about the choice of P_{ref}, this confirmation becomes more or less mandatory.
Note that the procedure described in this application note is valid only for a single radio configuration. If different channels, bands or communication systems are tested, the workflow described in Fig. 1.1b should be repeated for each new configuration.

3.1 Uplink Power Control

The uplink power control in 2G and 3G is relatively simple - the device is asked to transmit at a fixed level. Setting this level (in this case P_{ref}) in the base station simulator is a relatively easy task. The uplink power control in 4G and 5G is more flexible - instead of having fixed power levels, it uses the so-called TPC (Transmit Power Control) mechanism. In this algorithm, there are no fixed levels - instead, the base station is asking the UE to go up or down in steps of 1 dB. To test at a fixed power (which is not the maximum UE power), a parameter called P-Max (Max. Allowed Power) is used. It specifies the maximum allowed output power for the UE in the cell. The setting of the base station simulator is shown in Fig. 1.2. Here, the Active TPC setup is set to Max Power (asking the device to keep increasing its uplink power in 1 dB steps). The output power is limited by the P-Max value, effectively fixing the UE output power at P-Max.

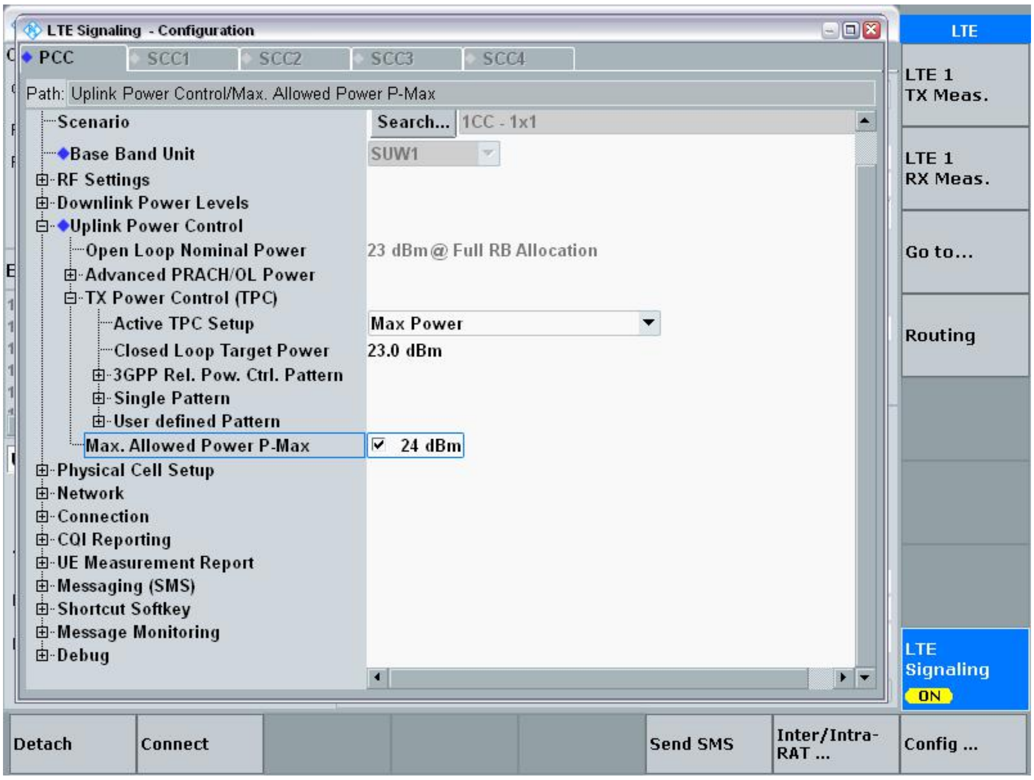


Figure 1.2: Maximum Allowed Power P-Max setting in the BSS

3.2 Test Sequences

The procedure described in this application note is using a fixed maximum uplink power when evaluating the DPC-ETA algorithm. If desired, different test sequences closer to real-life deployment scenarios can be used instead of this fixed output power setting (for example, sequences with random uplink power changes, simulated fading, etc.). This can be achieved by running external scripts controlling the BSS and is out of the scope of this application note.

3.3 Clearing the DPC-ETA averaging buffers

The DPC-ETA algorithm is continuously monitoring and controlling the TX power over the defined averaging window. To reset the algorithm, the UE power should be set to a low level (for example, 0 dBm) for a duration at least as long as the time-averaging window (for example, 360 s, 100 s or 60 s). The corresponding setting is shown in Fig. 1.3.

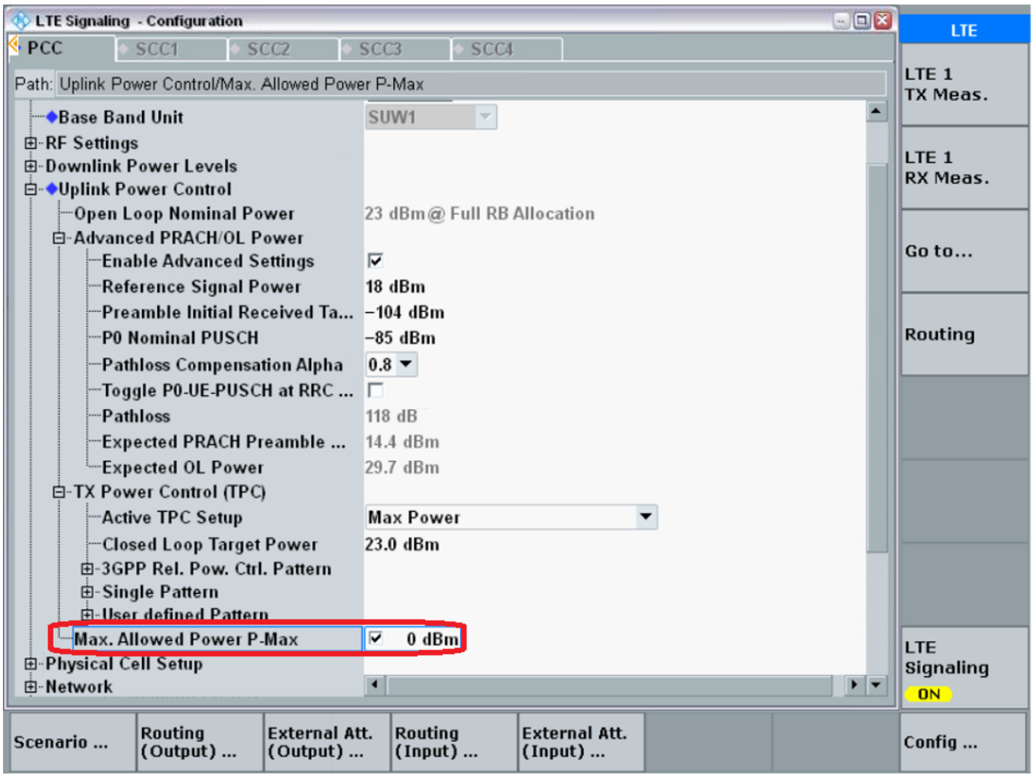


Figure 1.3: Setting P-Max to 0dBm in order to clear the DPC-ETA buffer

3.4 Additional Considerations

- The procedure is not applicable for devices that utilizing transmit antenna diversity or MIMO for the uplink direction. In such cases, the cSAR3D vector array system can be used. It captures the entire SAR distribution in intervals of 0.3s. This information is used to automatically calculate psSAR or Volume Time-Averaged SAR as described in section F.2.4 in IEC TR 63424-1.
- The phone designs are constantly evolving and the DPC-ETA algorithms nowadays are not only using the uplink power as an input, but also information from one or multiple sensors inside the device. These can be inputs from proximity sensors, motion sensors, user settings (WiFi tethering via hotspot mode), selected audio mode (headset vs. hands-free operation) etc. For example, some phones will trigger time-averaging only when they are close to the body (proximity sensor triggered) and in hotspot mode (selected in the phone settings). Some phones might also use Mobile Country Code (MCC) and Mobile Network Code (MCC) as another input - see Appendix 2 for details on this.

4 Measurements in DASY8/6

This section demonstrates a measurement of a commercially available phone (DUT) using DASY8/6 v16.0.0.68 in the following test configuration:

	Band	Ch.	Freq. (MHz)	BW (MHz)	RBs	RB Pos.	Modulation	Position	Spacer (mm)	Details
LTE	2	18900	1880	20	50%	high	QPSK	bottom	10	hotspot on

A new DASY8/6 project is created. This includes a Fast Area Scan and a Zoom Scan, followed by a Time-Averaged Scan, anchored to the peak location identified in the Zoom Scan. For better visualization, the averaging duration in this example is set to 300 s as shown in Fig.1.4. The tested DUT uses an averaging window of 100 s, which means that we will see 3 averaging periods in the results.

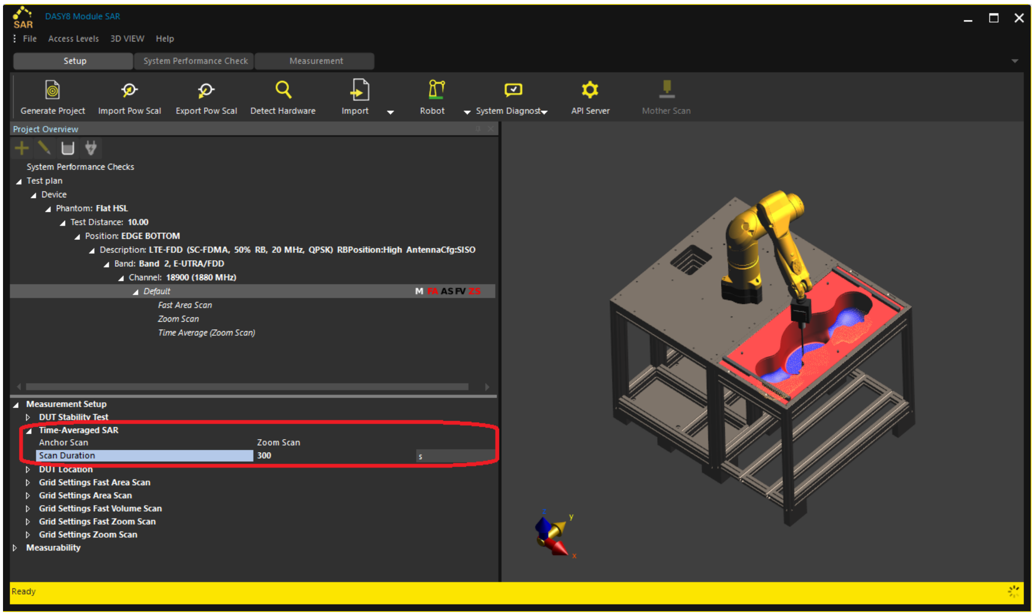
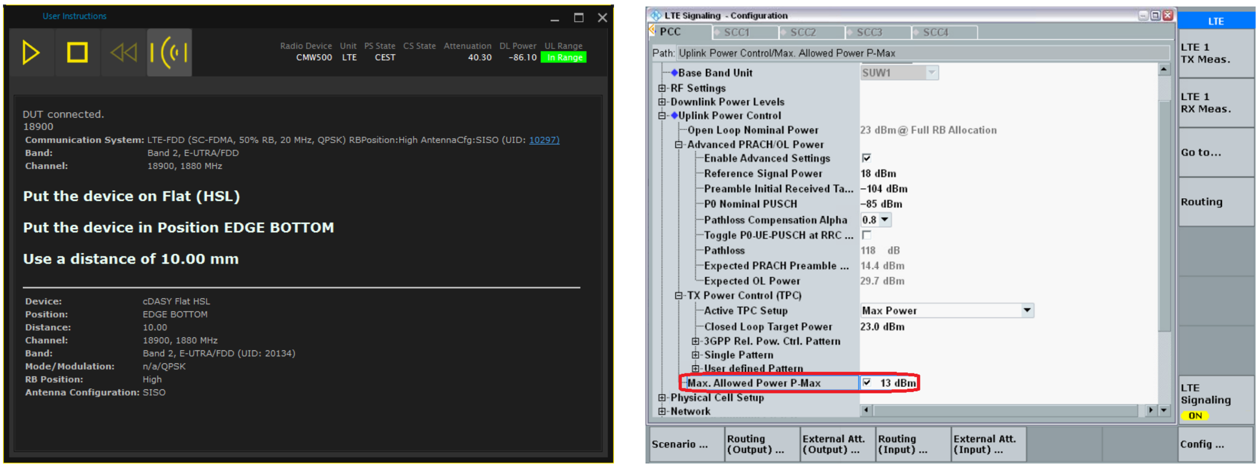


Figure 1.4: Time-Averaged Scan settings

DASY8/6 controls the base station simulator to set up the call and adjust the path loss. Before proceeding with the actual Area / Zoom Scan, the DUT output power is set to P_{ref} of 13 dBm, by manually adjusting the 'Max. Allowed Power P-Max' as shown in Fig. 1.5b below. This step is performed after DASY8/6 prompts the user to place the device in the right position via the User Instruction as shown in Fig. 1.5a.



(a) User Instruction window showing an established call (b) Setting the maximum allowed UE power to 13 dBm

Figure 1.5: Reducing the uplink power of the DUT before proceeding with the Area/Zoom scan

The DPC-ETA control stops actively adjusting the uplink power when this is lowered to P_{ref}. Once the Area and Zoom scans are finished, DASY8/6 asks the user to activate the power monitoring algorithm with the dialogue box shown in Fig. 1.6.

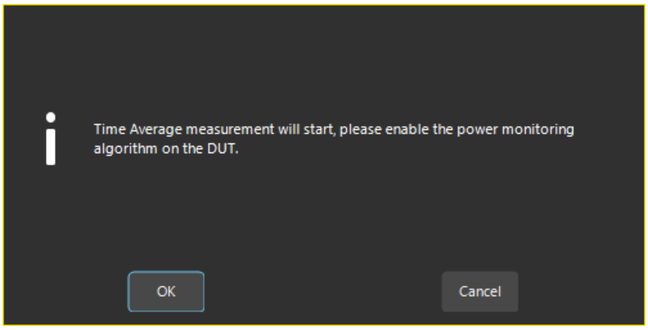


Figure 1.6: DASY8/6 dialog box asking the user to enable the power monitoring algorithm

At this point, optional single-point SAR measurements shown in Fig. 1.7 can be performed to confirm that the DPC-ETA algorithm is not controlling the output power. Here, we use the option to repeat the Time-Averaged scan multiple times. Therefore, the first run is used for the output power stability confirmation (the uplink power is kept at 13 dBm). The second run is used for the actual DPC-ETA measurement (the uplink power is increased to its maximum, which activates the DPC-ETA control).
Note that it is important to perform the Time-Averaged scan directly after the Zoom scan. If the Time-Averaged Scan is performed at a later occasion, this will trigger a new reference measurement, resulting in wrong overall result.
Another critical item is the positioning of the DUT - once the Fast Area/Zoom scan have started, the device should not be moved until all steps are completed. Re-positioning the device after the Zoom scan is performed, will mean that the reference measurement used for scaling the time-sweep results is not valid anymore, resulting in a wrong result. This should not present a difficulty to the test lab, since uplink power modifications are done over the air.

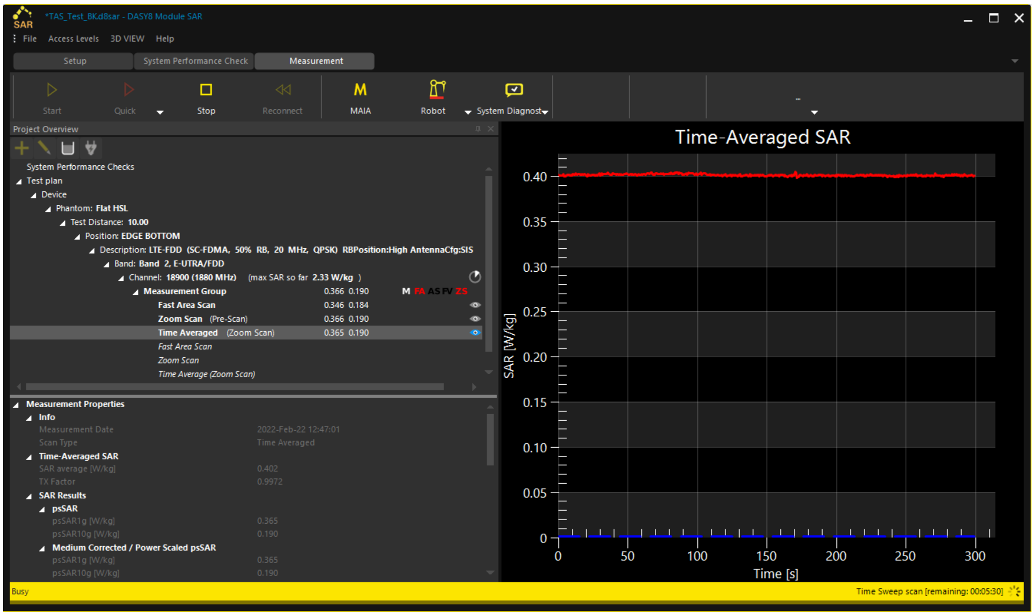
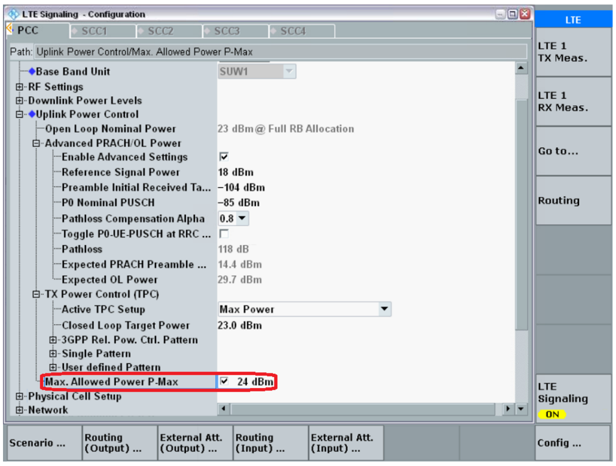
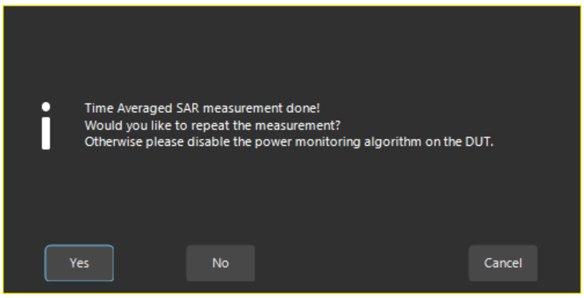


Figure 1.7: Optional single-point SAR measurements confirming that the output power of the phone is stable - the DPC-ETA algorithm is not controlling it

Next, the maximum allowed power is set to 24 dBm (or 1 dB above the maximum allowed uplink power) manually from the BSS screen - the corresponding settings are shown in Fig. 1.8a. Optionally, before doing it, the P-Max can be set to 0 dBm for one time-averaging period to clear the DPC-ETA buffer - as described in Section 3.3. A Time-Averaged scan is started afterwards.



(a) Setting the maximum allowed UE power to 24 dBm



(b) DASY8/6 dialog window asking to repeat the Time-Averaged measurements (with the DPC-ETA control on)

Figure 1.8: Steps for enabling DPC-ETA control.

The DPC-ETA control can be monitored in real-time while the measurement is running, using the Multimeter View - shown in Fig. 1.9.

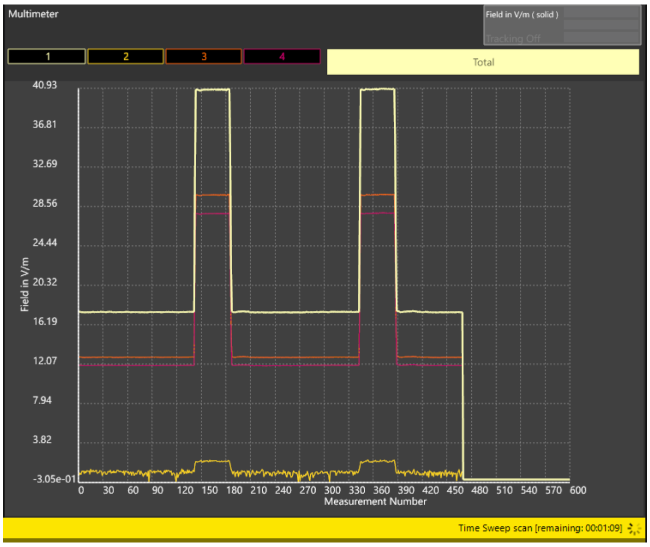


Figure 1.9: Multimeter view, visualizing the DPC-ETA control in real-time.

The Time-Averaged scan results are shown in Fig. 1.10. They are summarized in table 1.1 below.

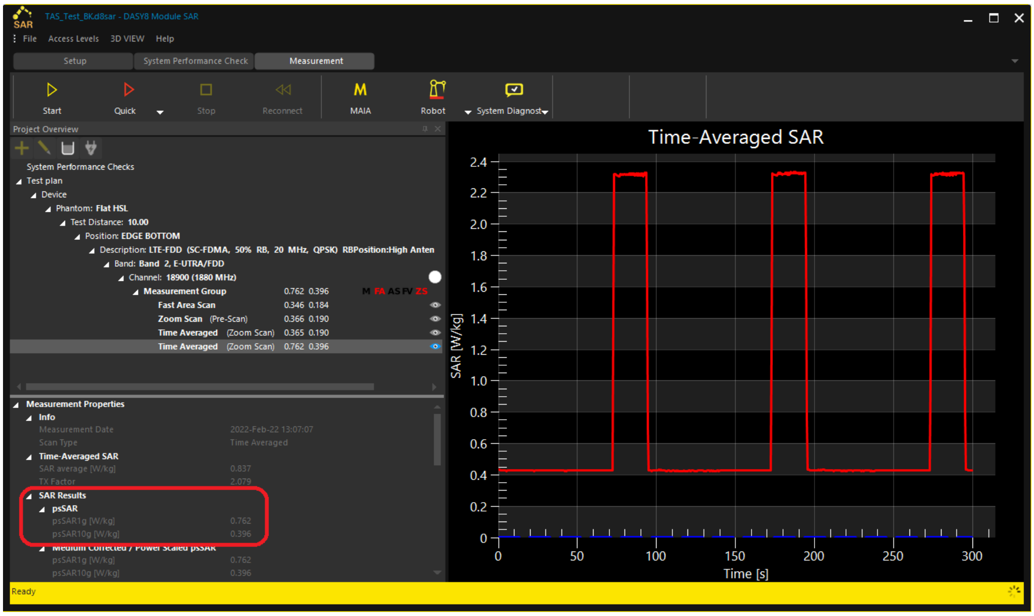


Figure 1.10: DASY8/6 Time-Averaged scan results.

Test Case	Freq. (MHz)	SAR Zoom Scan @ 13 dBm (W/kg)		Time-Averaged SAR @ 24 dBm (W/kg)	
		1g	10g	1g	10g
LTE, 20 MHz, 50% RB, QPSK	1880	0.366	0.190	0.762	0.396

Table 1.1: DASY8 TAS Results

DASY8/6 calculates the Time-Averaged SAR over the duration of the whole measurement. If different averaging intervals are required, the raw data can be exported in .csv format and post-processed in external programs like Excel, etc. This can be done by right-clicking on the Time-Averaged SAR node and selecting Export, as shown in Fig. 1.11.

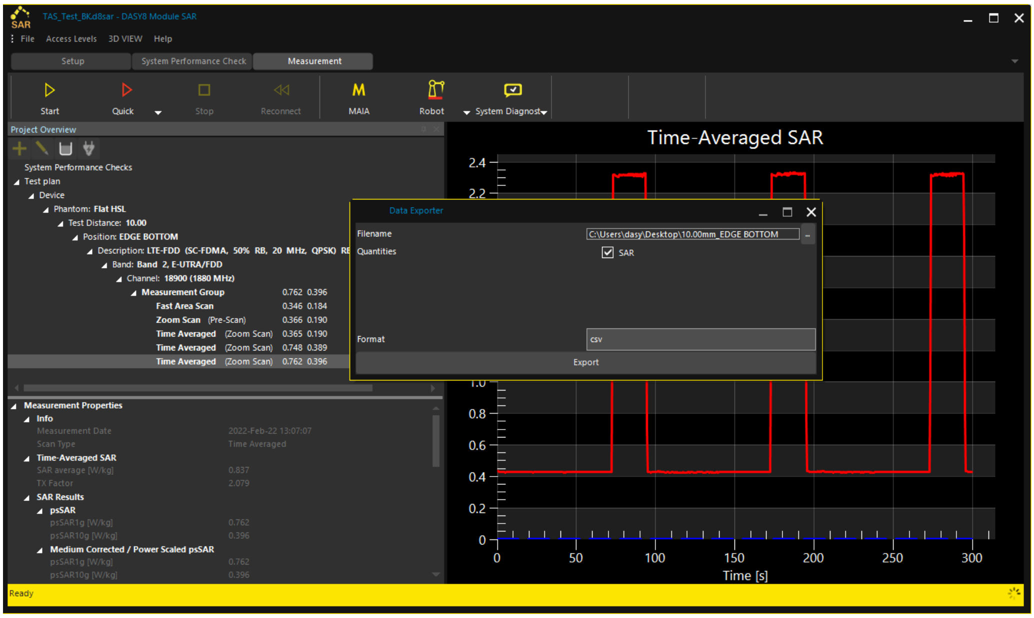


Figure 1.11: Time-Averaged SAR export in .csv format.

5 Conclusion

DASY8/6 Module v16.0+ can be used to evaluate the Time-Averaged SAR of commercial samples for market surveillance. A simplified procedure for this evaluation was presented in this application note, along with the results of an actual measurement of a commercial sample. The simplified procedure consists of measuring the reference SAR value of the device at a lower power level (P_{ref}), at which the DPC-ETA algorithms are not actively adjusting the uplink power.

Measurements on a commercial sample show that the simplified procedure gives consistent results, enabling DPC-ETA evaluations without the need of manufacturer tools.

Appendices

1 Path Loss Estimation in the BSS

The goal of the path loss estimation is to have enough dynamic range for the time-averaging SAR measurement, otherwise, a call might be dropped when the DUT uplink power is changed. Note that the absolute accuracy of the path loss in this estimation is not a concern as long as the DUT TX power can follow the requests from the call box.
Note that the path loss estimation is performed automatically in DASY if the BSS is selected - this section describes the steps in case the BSS is used separately from DASY8/6. In both cases, the path loss estimation should be performed when the DUT is positioned next to the phantom in the position which will be tested - changing the position with respect to the phantom will change the losses too.

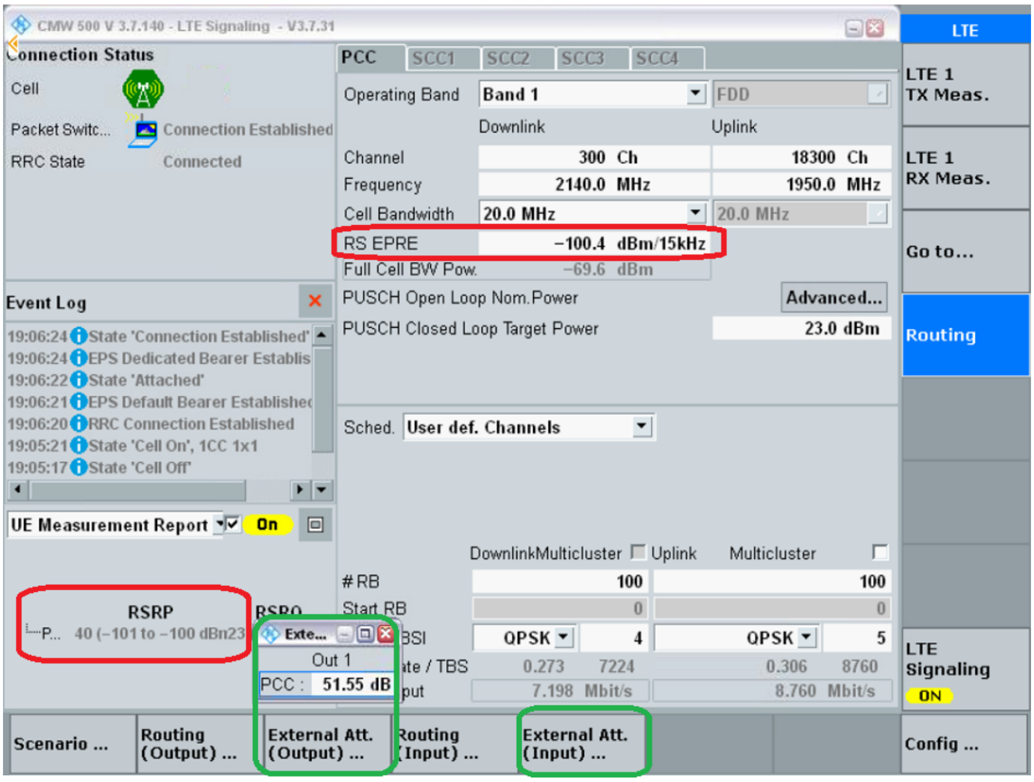


Figure 12: Loss Estimation in Rohde & Schwarz CMW500

The following steps explain how to perform manually a path loss estimation in LTE using CMW500. The procedure is similar for other base station simulators and protocols.

1. Enable UE Measurement Report after establishing a call to the DUT.

2. Adjust the External Attenuation input/output (marked in green) in Fig. 12) until RSRP and RS EPRE match closely. The match doesn't have to be exact. Here, the input and output attenuation can be kept equal, assuming that the uplink and downlink losses are more or less the same.

3. Optionally, a quick sanity check can be performed by running an LTE TX Measurement from the Multi Evaluations tab (Fig. 13. The TX power should be close to the requested TX power - in this case, the maximum power the DUT.

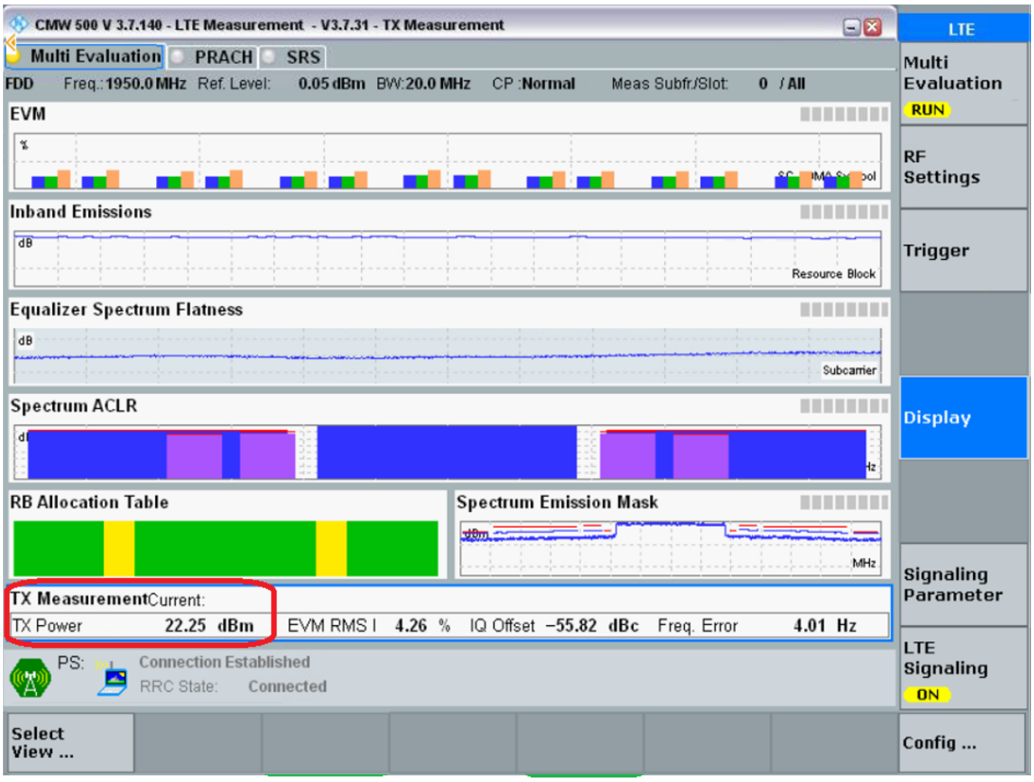


Figure 13: Confirmation of the estimated path loss in TX

The procedure described in this application note is based on Open Loop Power Control with Active TPC Setup set to Max Power (referred to "All Bits Up" too). Since Open Loop is used, the results are not so sensitive to operator movement or small changes in the measurement environment.

2 MCC and MNC considerations

The default values for MCC = 001 (Mobile Country Code) and MNC = 01 (Mobile Network Code) used in the BSS automation are corresponding to Test PLMN (Public Land Mobile Network). Some DPC-ETA implementations will have different behaviour (for example different averaging window duration) based on the MNC/MCC values. To enable testing for the different combinations, these parameters are exposed in the BSS automation, as shown in Fig. 14. When the BSS automation is used, these are automatically set in the tester.

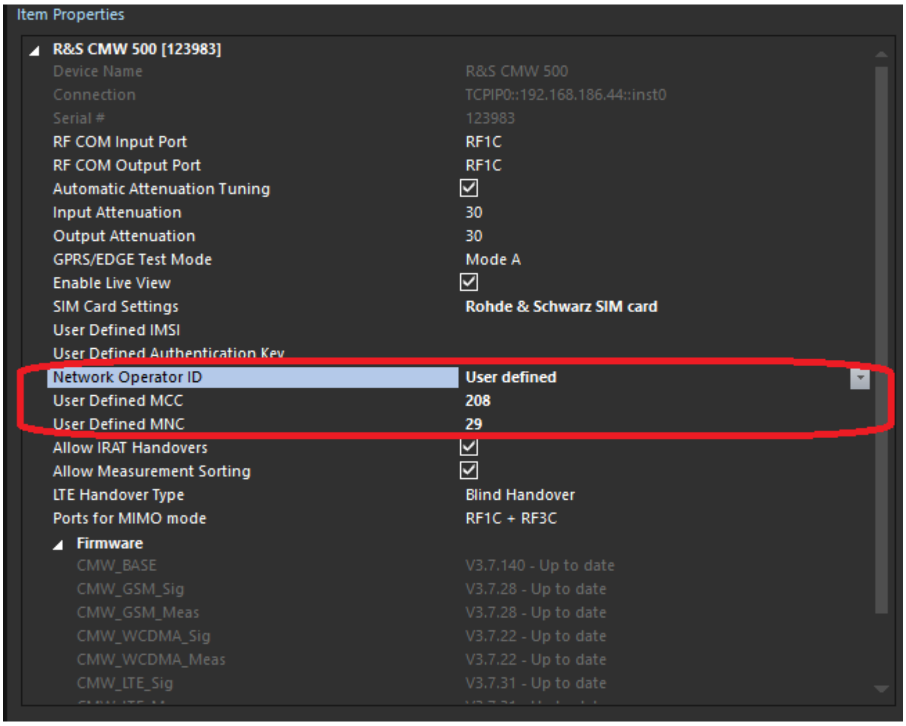


Figure 14: MCC/MNC settings in DASY8/6

These parameters can be edited manually directly in the BSS if the automation in DASY8/6 is not used. The corresponding fields are shown in Fig. 15.

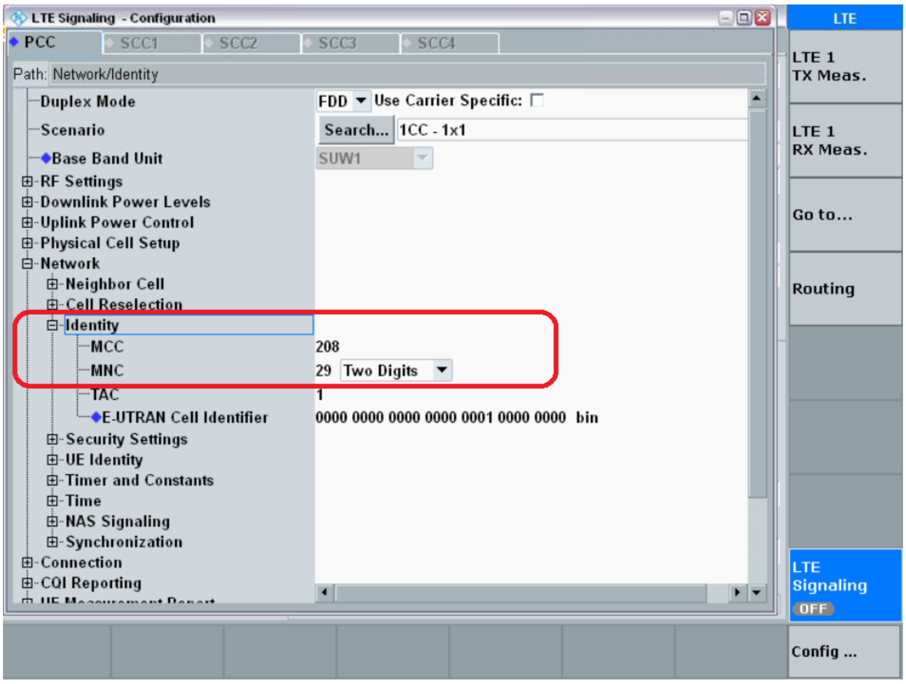


Figure 15: MCC/MNC settings in Rohde & Schwarz CMW500