LTE Drive Test - How to benefit from using a R&S®TSMW or R&S®TSME

Application Note

Products:

- R&S®TSMW
- R&S®TSME
- R&S®ROMES

This document describes the highlights of LTE scanning functionality of TSMW and TSME.
In an FAQ style, it explains briefly the background of LTE and leads to the important measurements that have to be done in a proper network roll-out.

Application Note

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12.2014-04

ROHDE&SCHWARZ

How a R&S®TSMW and R&S©TSME scanner bring special advantage in a LTE drive test system

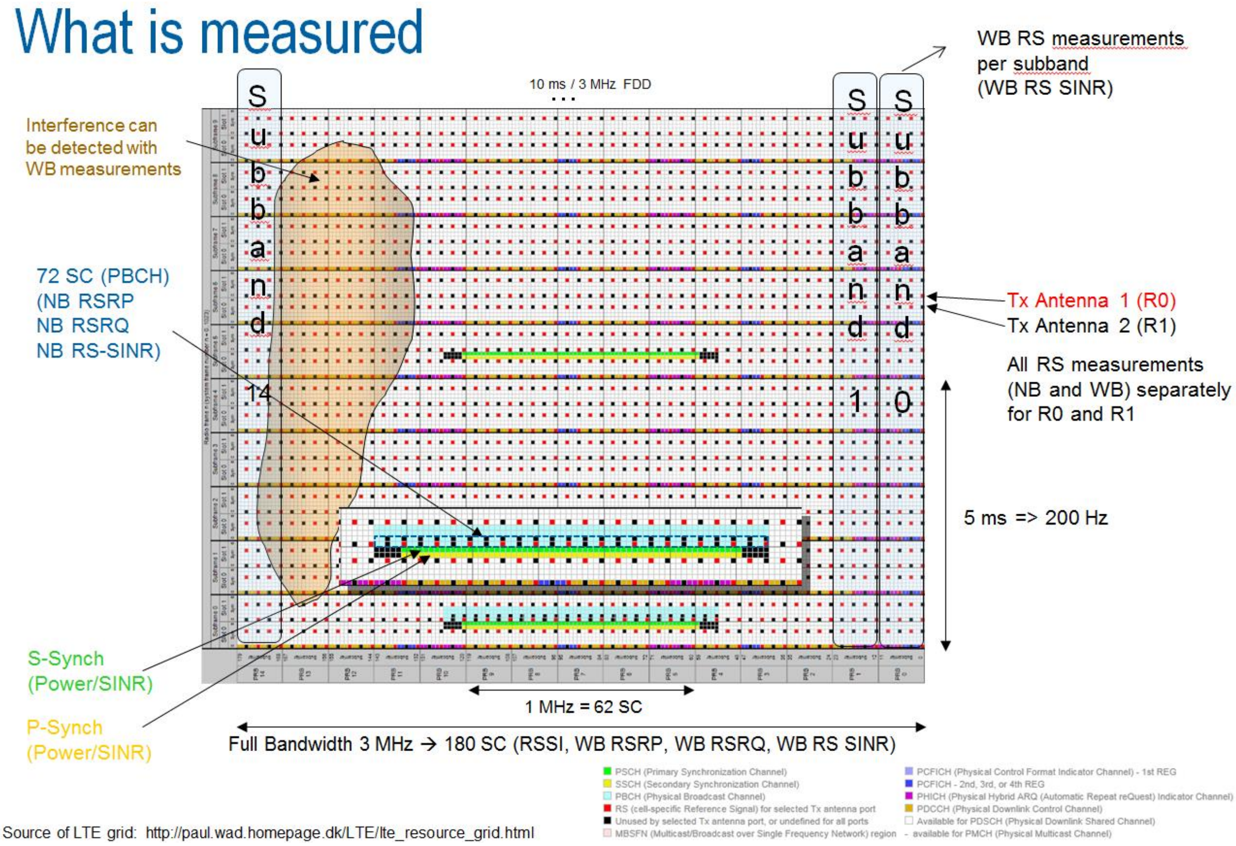
1.1 What can be measured with the scanner?

RSRP:	Power of the LTE Reference Signals spread over the full bandwidth and narrowband. A minimum of -20 dB SINR (of the S-Synch channel) is needed to detect RSRP/RSRQ
RSRQ:	Quality considering also RSSI and the number of used Resource Blocks (N) RSRQ = (N * RSRP) / RSSI measured over the same bandwidth Narrowband N = 62 Sub Carriers (6 Resource Blocks) Wideband N = full bandwidth (up to 100 Resource Blocks / 20 MHz)
RSSI:	Total power, includes interferences, power of other cells and traffic. It's measured over the full bandwidth
P_{tot}:	Is the narrowband RSSI that considers only Synch-Signal (62 Sub Carriers)
SINR:	Signal to Interference and Noise Ratio based on the Synch-Signal
RS-SINR:	SINR based on Reference Signals (narrowband and wideband).
ISI:	Channel Impulse Response (CIR) measurement shows mainly Multi-Path delays to detect Inter-Symbol-Interference (ISI)
Doppler:	The Doppler shift is measured relatively. It is based on the CIR measurement and can measure a shift of -100 to +100 Hz. This corresponds to a driving speed of approximately 160 km/h or 100 miles/h at 700 MHz.
CP:	The Cyclic Prefix is automatically detected by the scanner whether it’s the normal (7 symbols per slot) or the extended (6 symbols per slot)
CN:	Condition Number based on MIMO Matrix (see chapter 1.9, requires TSMW or TSME MIMO configuration)

	Narrowband	**Wideband**
Received power	Power Based on S-Sync (62 SC)	
	RSRP Based on RS in PBCH (72 SC)	WB-RSRP Based on RS (full bandwidth)
Quality	RSRQ Based on PBCH (72 SC)	WB-RSRQ Based on all received SC (full bandwidth)
SNR	SINR Based on S-Synch (62 SC) Based on P-Synch (62 SC)	

	RS-SINR Based on RS (72 SC)	WB-RS-SINR Based on RS (full bandwidth and per RB)
Total Power		RSSI Based on all received SC (full bandwidth)

In the following chart it is clarified, where in the LTE resource grind the measurements are taken:



In addition to the measurements listed in the above table, the scanners also deliver RS-SINR measurements per resource block. These are discussed in more detail in chapter 1.8.

1.2 Are TD-LTE and LTE FDD supported simultaneously?

Yes, the scanner supports TD-LTE and LTE FDD from day one. The scanner can scan both modes at the same time. Just add another channel or frequency and define whether it's TDD or FDD. All bands 33-43 are supported in one-box and can be scanned at the same time.

Other technologies can be measured at the same time as well! So for example, TD-LTE at 2.5 GHz can be scanned with FDD at 2.1 GHz at the same time.

1.3 How many cells can be detected?

The scanners have no limitation of number of cells that can be measured. The only limitation is the Dynamic Range (see chapter 1.10) or the general sensitivity of – 127 dBm (TSMW) for the power of the Synch-Channel.

ROMES is doing some filtering where the strongest signals are shown. That's why this approach is called TopN. The TopN can show 6 cells by default and can be extended to 32 cells.

The benefit here is, that the scanner is never missing any particular cell. It's scanning literally all 504 Physical Cell IDs in each measurement per frequency. In other words, once a new eNodeB is switched on, the scanners will show this cell immediately.

1.4 What is the difference between RSRP and S-Sync Power?

The scanners provide two different received power values.
First, the "Power" value that refers to the power of the Secondary Synch Signal (S-Sync).
Second the "RSRP", the average resource element power of the Reference Signals. .

The S-Sync is transmitted twice per LTE frame (every 5 ms) and allocates 62 sub carriers. The RSRP power is transmitted on one reference signal which allocates only 1 sub carrier. Reference Symbols are spread over the full bandwidth and depending on the configuration are transmitted much more often than the S-Sync.

The power of S-Sync is the accumulated power of on 62 sub carriers and is therefore 17.9 dB higher than the power the of S-Sync resource elements.

The power ratio between 62 sub-carriers and 1 sub-carrier = 10 * log10 (62) = 17.9 dB

This is important as the “Datasheet Sensitivity” of a Scanner can be 17.9 dB higher or lower. depending on how “Sensitivity” is defined (entire channel, or per sub-band). The sensitivity values in the TSMW data sheet gives sensitivity both in terms of SSYNC power and RSRP.

1.5 Why is the NB RSRQ value reported by the s different from the value reported by the UE and WB RSRQ value?

According to 3GPP RSRQ is defined as:
Reference Signal Received Quality (RSRQ) is defined as the ratio N×RSRP/(E-UTRA carrier RSSI), where N is the number of RB’s of the E-UTRA carrier RSSI measurement bandwidth. The measurements in the numerator and denominator shall be made over the same set of resource blocks.

The NB scanner delivers the RSRQ based on the 72 subcarriers of the PBCH. This corresponds to the RSRQ measured by the UE in those resource blocks that contain data for the UE.
So in an ideal interference and noise free environment the best RSRQ value of the PBCH in absence of fading effects is

(6*EPRE)/(72*EPRE) = 1/12 or -10,79 dB

with EPRE = eNodeB transmitted Energy per Ressource Element in mW for PBCH and reference signals.

A UE in idle mode or the Wideband scanner do the measurement on the complete reference signal.
In an ideal interference and noise free network in the absence of fading and traffic the RSRQ measured is (e.g. in a 20MHz system with 100 resource blocks and MIMO – using 4 resource elements per resource block for the reference signals R0 and R1):
(100*EPRE)/(100*4* EPRE) = 1/4 = -6.02 dB

So even under ideal conditions we expect to see a difference of up to 4,8 dB between the narrowband and the UE or wideband result respectively, depending on network load. In real fading conditions this difference can even be increased.

The NB scanner RSRQ measurement is based on the PBCH bandwidth, to provide a repeatable result, independent from the actual data traffic in the observed cell.

1.6 Why is the CINR the relevant value to assess the channel quality, and not RSRQ?

According to 3GPP RSRQ is defined as:
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This definition shows, that RSRQ depends on the data traffic in the observed cell. In practice however in absence of intersymbol interference, the quality of the channel and the ability of the receiver to decode the data does not depend on the data traffic from the own cell, but the data traffic from neighboring cells, causing interference.

As an example let's consider an eNodeB without neighbors, so without intercell interference. According to our calculations in the previous section the RSRQ in the cell without data traffic will be -6.02dB, while with data traffic increasing it will decrease down to -10.79 dB. So RSRQ shows a 4.8 dB variation although the actual capability of the receiver to decode the data has not changed.
Therefore RSRQ does not help to assess the channel quality.

CINR however provides an objective reference of the channel quality: the scanner decodes the signal, separates noise and interference (both intercell and intersymbol), and provides an accurate CINR value, independent of the traffic in the observed cell. The CINR value is an objective criteria to assess the channel quality.

1.7 Measurement speed counts – relevance of 200 Hz

Getting a high geographical density is of high interest. It allows a higher resolution of the drive test results even during driving. Especially once there is an interference scenario or a handover failure it is necessary to see what happened in a short period of time. A UE can't support a high update rate as it is limited in processing and battery power.
Furthermore, having high measurement rates brings up an insight of the fading conditions of the measured environment.

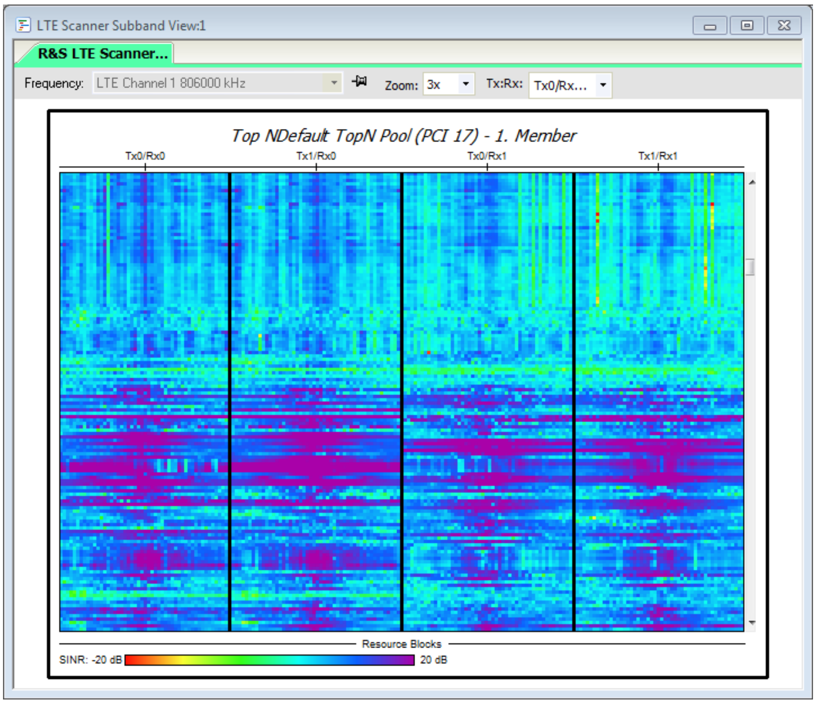
1.8 Narrowband vs. wideband measurements

The R&S LTE scanners support (since ROMES 4.65) narrowband and wideband measurements at the same time. How it can help to analyze different interference scenarios can be seen in the following overview. It differentiates between external interferences (not related to its own LTE network) and internal interferences (issues caused by wrong planning for example). For the latter one it needs to be clear if a TDD or a FDD network is in use.

External Interference		A) within central 1 MHz of LTE carrier (broadband interference e.g. Jammer)
		B) located in full bandwidth but not in central 1 MHz of LTE carrier (e.g. TV)
Internal Interference	Synchronous (e.g. TDD)	C) Physical Cell ID MOD3 identical but not equal (e.g. 3,6,9)
		D) Physical Cell ID MOD3 unequal (e.g. one site 1,2,3)
	Asynchronous (e.g. FDD)	E) other cases

Note: The Physical Cell ID can be 3,6,9 is seen as identical. The Physical Cell ID is hierarchically composed out of the Group ID and the Cell ID. The Cell ID is needed for the primary synchronization and the Group ID for the secondary synchronization. If the Physical Cell ID is 3,6,9 the Cell ID would be 0 in all the cases. The Group ID changes. Modulo 3 is the mathematical expression for this.
For more details on this, check the Rohde&Schwarz Application Note 1MA150

To identify external interference R&S ROMES displays Reference Signal SINR measurement per subband in this subband view:

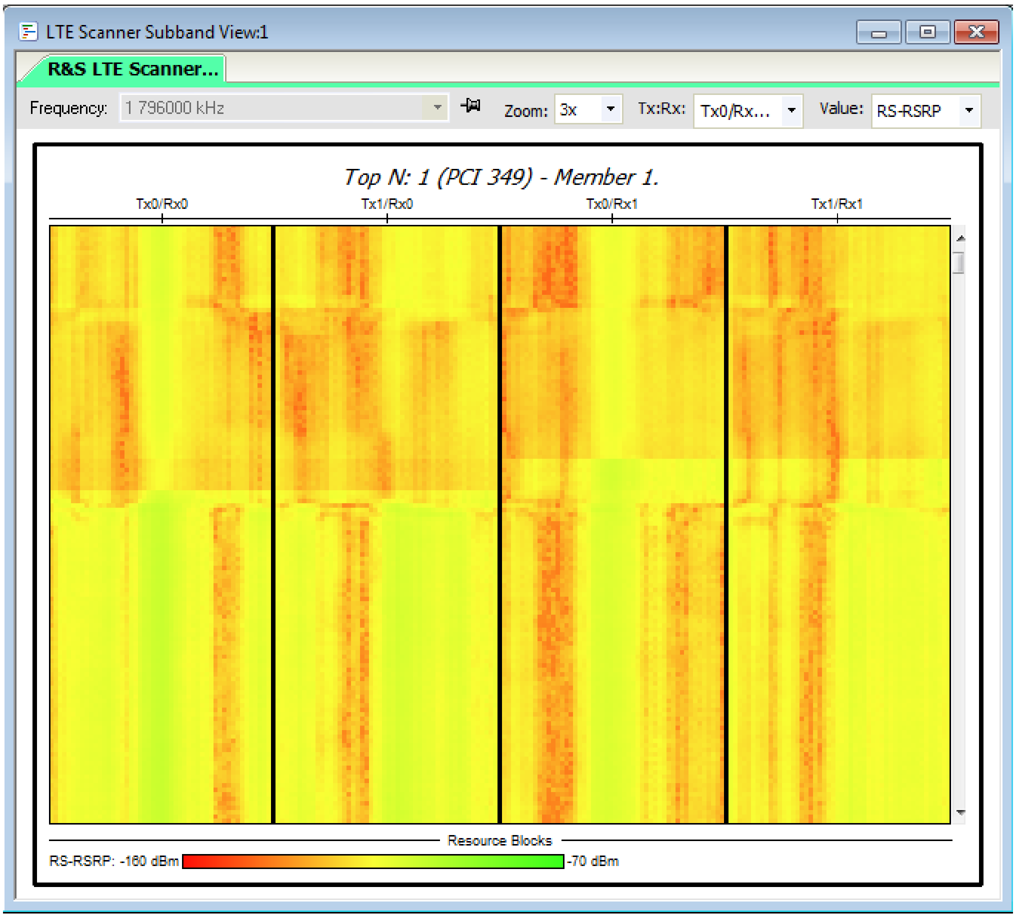


Tx0/Rx0: RS-SINR per RB of eNodeB TX port 0 (Reference signal R0) on TSMW frontend 0
Tx1/Rx0: RS-SINR per RB of eNodeB TX port 1 (Reference signal R1) on TSMW frontend 0
Tx0/Rx1: RS-SINR per RB of eNodeB TX port 0 (Reference signal R0) on TSMW frontend 1
Tx1/Rx1: RS-SINR per RB of eNodeB TX port 1 (Reference signal R1) on TSMW frontend 1

Using a single R&S©TSME (no MIMO configuration) will only provide Tx0/Rx0 and Tx1/Rx0 values.

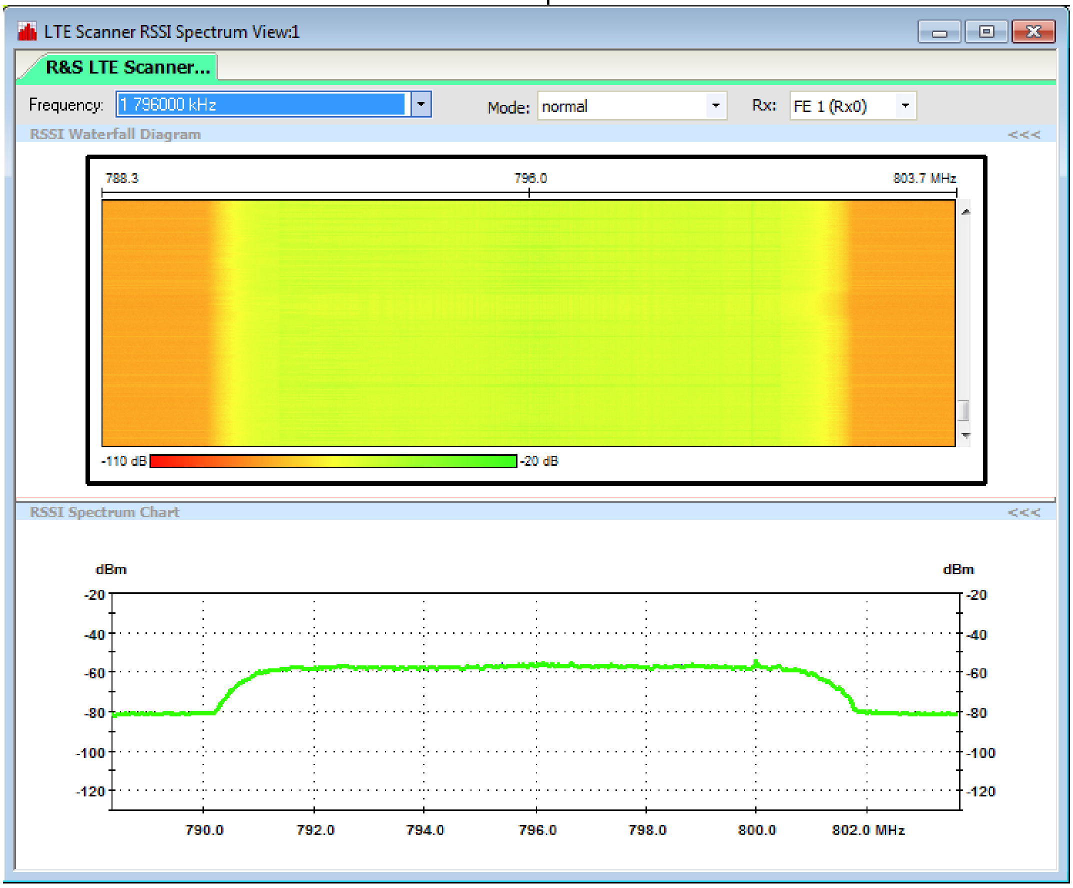
Each pixel corresponds to one resource block (horizontally) and one measurement in time vertically (waterfall diagram). Mouseover shows Timestamp, RS-SINR value per RB, Frequency of RB, RB index.
External interferers will show as vertical lines in the waterfall diagram. Using an interference hunting receiver like the R&S PR100 the owner of the spectrum can find the location of the interfering source.

The Wideband measurement also shows how frequency selective the transmission over the LTE wideband channel is. Here we can see the RSRP value displayed per resource block:



Within the LTE carrier we can see differences in received power of 20dBm or more between resource blocks.

The wideband measurements also include a spectrum measurement of the LTE carrier:



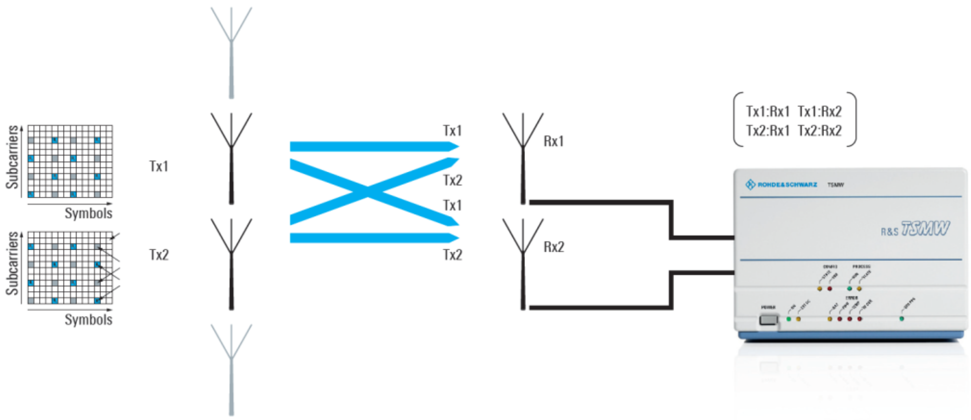
Three spectra are measured at the same time:

- Normal: continuous measurement (FDD, and TDD UL and TDD DL included in the spectrum)
- TDD DL: spectrum is measured over TDD downlink subframes only
- TDD UL: spectrum is measured over TDD uplink subframes only

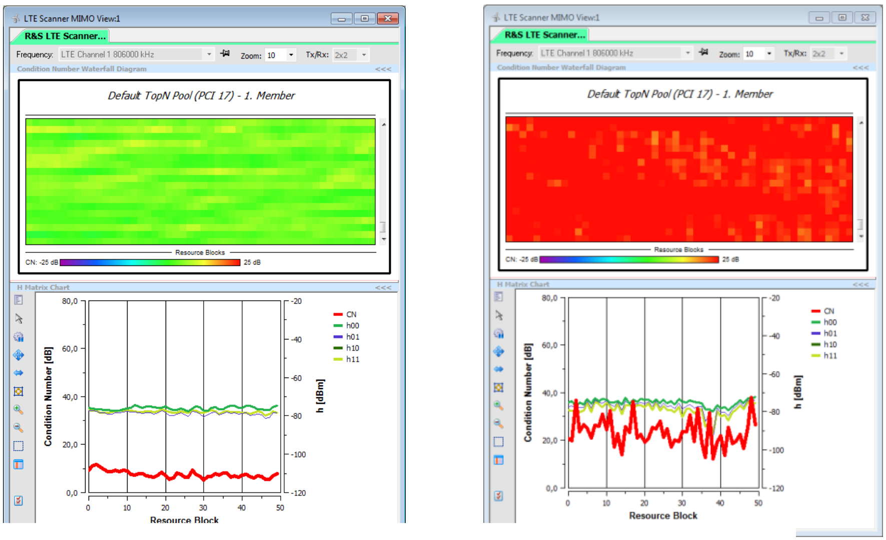
In addition to the subband Reference Signal SINR measurement this spectrum measurement can be used to detect interference. In particular the TD LTE uplink spectrum will show interference clearly, when no UEs are close to the scanner.

1.9 How MIMO-specific measurements with TSMW bring benefit

To understand the gain in performance of MIMO it’s important to understand the MIMO channel. The R&S®TSMW can help with its R&S®TSMW-K30 MIMO option to measure the details under real field conditions.
All of the MIMO specific measurements are based on the full bandwidth and can be applied for 4x2 and 2x2 MIMO Systems. The output is basically the Channel Matrix with complex values, meaning amplitude and phase. This measurement needs to be done by each terminal using MIMO. Out of the channel matrix a so-called Singular-Value-Decomposition is calculated. The results are called Singular Values and is been used to get the Condition Number (CN). The condition number qualifies the channel whether it’s “ill-conditioned” (MIMO not applicable) or “well-conditioned” (MIMO usable). In a case with CN < 10 dB, this “well-conditioned” channel matrix would be useful when recovering the data streams. If the CN would be >15 dB it can be expected that data recovery would be very sensitive to noise.

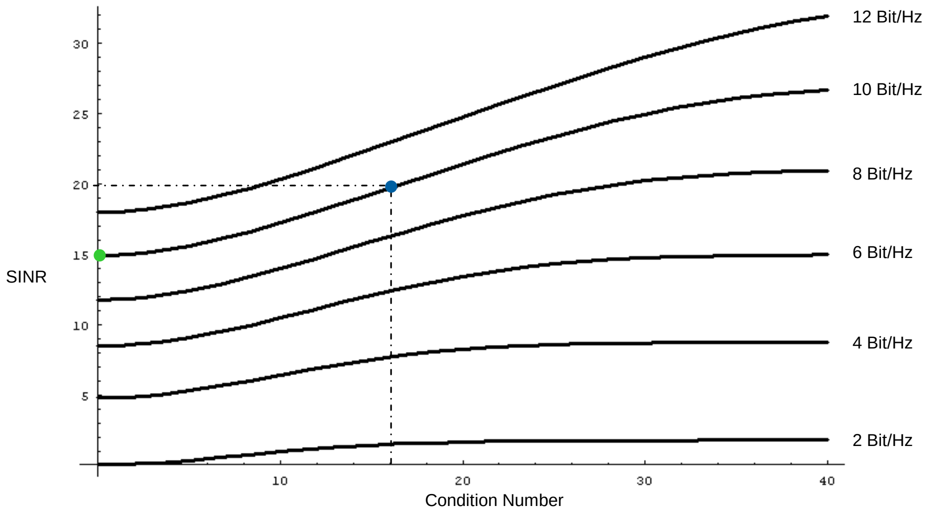


	H Matrix	Singular Values	Condition Number
well conditioned	$\begin{pmatrix} 0.9 & \boxed{0.2} \\ \boxed{0.15} & 0.8 \end{pmatrix} \rightarrow$	$\begin{pmatrix} 1.0323 \\ 0.6683 \end{pmatrix} \rightarrow$	1.54 (3.77 dB)
ill conditioned	$\begin{pmatrix} 0.9 & \boxed{0.8} \\ \boxed{0.65} & 0.8 \end{pmatrix} \rightarrow$	$\begin{pmatrix} 1.5800 \\ 0.1266 \end{pmatrix} \rightarrow$	12.48 (21.92 dB)



“well-conditioned” and “ill-conditioned” field data

R&S®ROMES provides the Condition Number per resource block along the full applied bandwidth for each found cell. So it can be seen what spectral area is “ill-conditioned” and may not allow MIMO or may reduce MIMO performance. Using the internal GPS provides further information of the position of the measurement.



1)

As said, a low Condition Number (CN) represents good conditions for MIMO. But the full MIMO performance also depends on the SINR of the signal. So the system performance of a system with CN=0 dB and SINR=15 dB would be equal to a system with CN=15 dB and SINR=20 dB[1]. Bottom-line, the performance of a MIMO system depends on the Signal-to-Noise-Ratio and also on the Condition Number. To understand throughput issues, both values need to be considered.

Getting the CN and the SINR per Resource Block (per sub-band) brings a better understanding of the whole LTE-MIMO channel. Interferences, fading, multipath, antenna correlation and noise can be the reasons to degrade MIMO performance. The R&S®TSMW is an independent test solution.

In the TopN view ROMES also displays the linear average of the CN over all resource blocks.

The TSMW outputs the complex H- matrix per resource block, with complex coefficients in sqrt(mW).

$$\boldsymbol{H} = \begin{pmatrix} \boldsymbol{h_{00}} & \boldsymbol{h_{01}} \\ \boldsymbol{h_{10}} & \boldsymbol{h_{11}} \end{pmatrix}$$

From the matrix, the RSRP per transmit path per RB can be calculated:

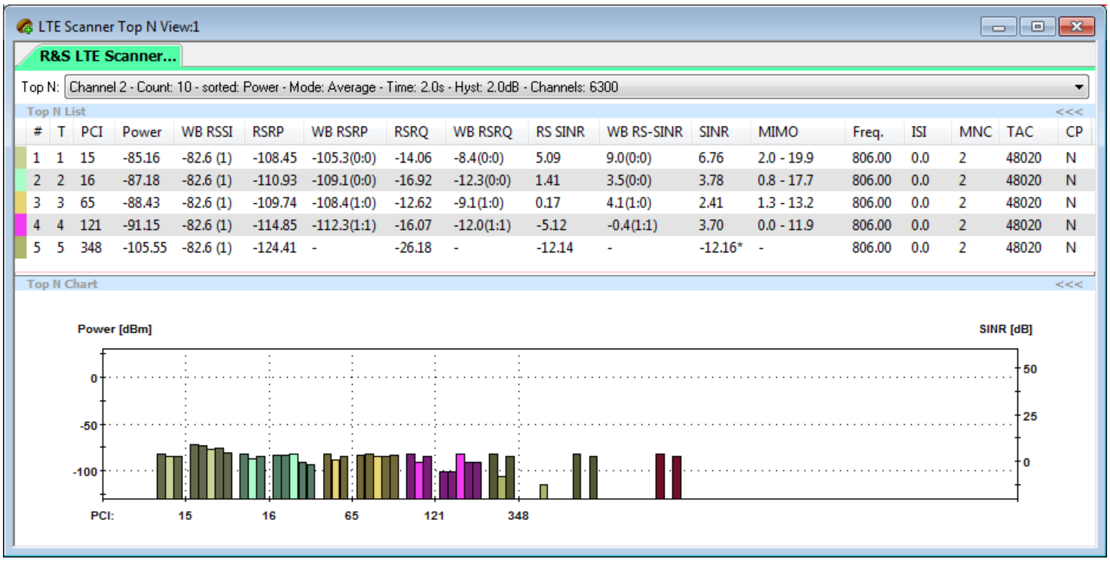
eNodeB TX port	RX port	RSRP [mW]
TX0	RX0	$\lvert h_{00}\rvert^2$
TX0	RX1	$\lvert h_{01}\rvert^2$
TX1	RX0	$\lvert h_{10}\rvert^2$
TX1	RX1	$\lvert h_{11}\rvert^2$

[1] After the ideal MIMO Channel Capacity, Gerad J. Foschini *"On limits of wireless communications in a fading environment when using multiple antennas"*

1.10 Dynamic range matters – 20 dB make the difference

The level range is set by the strongest detected signal. But how low of a signal can be detected in the presence of a strong signal? This is the dynamic range of a scanner.

If the dynamic range is small: a strong signal will block out weaker signals
If the dynamic range is high: weaker signals can be seen if a strong signal is present.



A scanner dynamic range of 20 dB is outstanding. It allows to detect signals that are 20 dB weaker than the total power (P_{tot}) at one frequency.

The benefit in a high dynamic is obvious. The scanner can detect more signals, as the power of weak signals can still be high enough to cause interference.

1.11 What benefit is behind Broadcast Message Decoding

Each eNodeB is transmitting Broadcast Messages at any time. They include additional information (see box below) to support the UE with environmental details. The so called System Information Blocks (SIB) containing the broadcast messages are transmitted in the Physical Broadcast Channel PBCH.

The knowledge of these network parameters provides a better picture of the eNodeB relations, positions and configurations. Those details are very helpful to indentify an interfering cell or for more in depth analysis like Handover Analysis or Neighborhood Analysis.

The full SIB message decoding brings also a benefit in using the Base Station Position Estimation feature. That allows the user to get a cell data base in by just driving around with the TSMW or TSME and ROMES.

MIB	System Bandwidth
SIB1	Cell ID, MCC, MNC, TAC, SIB Mapping
SIB2	Radio Resource Configuration, Preamble Power Ramping, Inter SubFrameHopping, UL Power Control, UL CP Length, UL EARFCN
SIB3	Cell Reselection Info, Intra Freq Cell Reselection
SIB4	Intra Frequency Neighbors (same frequency)
SIB5	Inter Frequency Neighbors (different frequency)
SIB6	WCDMA Neighbors
SIB7	GSM Neighbors
SIB8	CDMA2000 EVDO Neighbors

1.12 What happens if two different LTE Cells have the same Physical Cell ID?

The physical cell ID is the cell specific number that can be related to the Scrambling Code in WCDMA or to the PN code in CDMA2000. There are 504 different IDs available. It is beneficial to separate the same IDs far apart to reduce possible irritations.

Sometimes the same physical cell ID is transmitted by neighbor cells. In case of FDD (asynchronous network) the scanner can detect the two different cells, as the time of arrival is analyzed as well. The case of TDD (synchronous network) the signals will overlay completely so that this occurrence can not be recognized.

1.13 Multi-Technology – which configurations are possible?

	TSMW/TSME support	BCH / SIB Message Demodulation
GSM	✓	✓
WCDMA	✓	✓
CDMA2000	✓	✓
1xEVDO (Rel.0/Rev.A/Rev.B)	✓	✓
WiMAX 802.16e	✓	✓
TD-LTE	✓	✓
LTE FDD	✓	✓
TETRA	✓	✓
TD-SCDMA	✓	✓
RF Powerscan	✓	N/A

All above measurement can be performed in parallel.

The TSMW has two receivers built-in. Both can be used in a manner that speeds up the scanning process even more. Seeing that the signal scanning is a constant measurement job and the BCH demodulation is an occasional job, it is beneficial to separate those jobs each to one receiver.

That means in other words, LTE scanning is done on RX1 and the demodulation of LTE BCH messages is done on RX2. Especially in the case of using multiple technologies it increases the measurement speed strongly.

Technologies (simultaneously)	BCH demodulation	Performance with 2nd receiver compared to one
GSM, UMTS	All	3.3x
	Off	2.2x
GSM, UMTS, LTE	All	5.6x

	Off	4.7x
GSM, UMTS, LTE, TETRA	All	4.2x
	Off	2.9x

1.14 Which LTE Bands can be covered by the scanner?

The following LTE bands are supported by the TSMW and TSME (same HW for all bands):

EUTRA operating band	Uplink (UL) operating band BS: receive UE: transmit	Downlink (DL) operating band BS: transmit UE: receive	Duplex mode
1	1920 MHz to 1980 MHz	2110 MHz to 2170 MHz	FDD
2	1850 MHz to 1910 MHz	1930 MHz to 1990 MHz	FDD
3	1710 MHz to 1785 MHz	1805 MHz to 1880 MHz	FDD
4	1710 MHz to 1755 MHz	2110 MHz to 2155 MHz	FDD
5	824 MHz to 849 MHz	869 MHz to 894 MHz	FDD
6	830 MHz to 840 MHz	875 MHz to 885 MHz	FDD
7	2500 MHz to 2570 MHz	2620 MHz to 2690 MHz	FDD
8	880 MHz to 915 MHz	925 MHz to 960 MHz	FDD
9	1749.9 MHz to 1784.9 MHz	1844.9 MHz to 1879.9 MHz	FDD
10	1710 MHz to 1770 MHz	2110 MHz to 2170 MHz	FDD
11	1427.9 MHz to 1447.9 MHz	1475.9 MHz to 1495.9 MHz	FDD
12	699 MHz to 716 MHz	729 MHz to 746 MHz	FDD
13	777 MHz to 787 MHz	746 MHz to 756 MHz	FDD
14	788 MHz to 798 MHz	758 MHz to 768 MHz	FDD
15	Reserved	Reserved	FDD
16	Reserved	Reserved	FDD
17	704 MHz to 716 MHz	734 MHz to 746 MHz	FDD
18	815 MHz to 830 MHz	860 MHz to 875 MHz	FDD
19	830 MHz to 845 MHz	875 MHz to 890 MHz	FDD
20	832 MHz to 862 MHz	791 MHz to 821 MHz	FDD
21	1447.9 MHz to 1462.9 MHz	1495.9 MHz to 1510.9 MHz	FDD
22	3410 MHz to 3490 MHz	3510 MHz to 3590 MHz	FDD
23	2000 MHz to 2020 MHz	2180 MHz to 2200 MHz	FDD
24	1626.5 MHz to 1660.5 MHz	1525 MHz to 1559 MHz	FDD
25	1850 MHz to 1915 MHz	1930 MHz to 1995 MHz	FDD
26	814 MHz to 849 MHz	859 MHz to 894 MHz	FDD
27	807 MHz to 824 MHz	852 MHz to 869 MHz	FDD
28	703 MHz to 748 MHz	758 MHz to 803 MHz	FDD
29	–	717 MHz to 728 MHz	FDD (CA only)
30	2305 MHzto 2315 MHz	2350 MHz to 2360 MHz	FDD
31	452.5 MHz to 457.5 MHz	462.5 MHz to 467.5 MHz	FDD
...			
33	1900 MHz to 1920 MHz	1900 MHz to 1920 MHz	TDD
34	2010 MHz to 2025 MHz	2010 MHz to 2025 MHz	TDD
35	1850 MHz to 1910 MHz	1850 MHz to 1910 MHz	TDD
36	1930 MHz to 1990 MHz	1930 MHz to 1990 MHz	TDD
37	1910 MHz to 1930 MHz	1910 MHz to 1930 MHz	TDD
38	2570 MHz to 2620 MHz	2570 MHz to 2620 MHz	TDD
39	1880 MHz to 1920 MHz	1880 MHz to 1920 MHz	TDD
40	2300 MHz to 2400 MHz	2300 MHz to 2400 MHz	TDD
41	2496 MHz to 2690 MHz	2496 MHz to 2690 MHz	TDD
42	3400 MHz to 3600 MHz	3400 MHz to 3600 MHz	TDD
43	3600 MHz to 3800 MHz	3600 MHz to 3800 MHz	TDD
44	703 MHz to 803 MHz	703 MHz to 803 MHz	TDD

In addition the scanners support all LTE implementations outside 3GPP standardized bands within their supported frequency range (TSMW: 30MHz to 6 GHz, TSME 350 MHz to 4.4GHz).

1.15 Indoor Measurements – GPS required?

The scanners have a built-in GPS. The SuperSense technology even allows a position fix with very poor GPS satellite signals. In some cases this even works indoor, like in shopping malls with a thin metal roof.

The scanners **can** use the GPS for the synchronization but they do **not need** a GPS to get measurements. When no GPS is available, the instruments are able to use technology related Synch Channels for their own synchronization.

2 Why is an Ethernet connection of benefit with the R&S®TSMW?

2.1 Performance

The capabilities of the scanner equipment are affecting the required bandwidth of the data link to a PC. The more functions are running in parallel, the more bandwidth is needed.

TSMW and TSME offer a wide set of features like multi technology measurements (up to 8 concurrent), spectrum scanning or SIB demodulation (demodulation of broadcast messages). The TSMW has built in a second receiver so that even more features can be realized. It can be used for additional technologies or for LTE-MIMO measurements that would require twice the bandwidth.
Also the scanning performance affects the required bandwidth tremendously. The TSMW scanner hardware for example is able to deliver outstanding scanning speeds like in LTE with 200 measurements per second or in UMTS with 200 measurements per second.

A USB connection would provide only a data rate of up to 20 MB/s on average. A Gigabit Ethernet connection would perform up to 80 MB/s easily. That is 4x faster than USB.

2.2 Device Handling

The device handling should be as easy as possible. That is one target of the design of Rohde & Schwarz drive test scanners.
To get them connected with the drive test software on the PC, no drivers are needed. Just define a fixed local IP address like 192.168.0.5 for the PC and the scanners will work. No concerns about the driver versions.

The Ethernet connection has some advantages e.g. over USB: When connecting any device to a USB port for the first time, a new virtual COM port is assigned. This port remains even if the device is no longer used. This ends up in having numerous COM ports impacting the Windows system stability. The user needs to take care of these unused COM ports or make sure to connect each device to the same COM port every time.
LAN does not care about historical connections.

Finally, an Ethernet based scanner equipment does not block any USB ports on laptops that are required for USB devices (such as test phones) doing quality measurements.

2.3 Mechanical usage

The Ethernet connection provides a reliable mechanically stable fixture of the connection. A USB cable can get disconnected in a typical drive test setup in a car during testing. Furthermore the LED and the icons on the taskbar are indicating the status of the connection. So you will never miss the correct connection.

3 Good to know

3.1.1 IP Address

The TSMW and TSME require a static IP address that uses 192.168.0.x and sub-net mask is 255.255.255.0 at the PC.

Change the settings in Windows 7 at Start -> Control -> Panel –> Network and Internet -> Network and Sharing Center

Click on "LAN" connection Properties – Networking Tab -> Internet Protocol Version 4 (TCP/IPv4) -> change IP address to the above mentioned number

Full explanation of "how to change IP address" please click here

The default IP address of the TSMW and the TSME is 192.168.0.2

3.1.2 GPS

The scanners have an internal GPS. But no GPS signal is needed for synchronization! GPS data is tunneled through the LAN connection and does not require any other cable connection.

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

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