# 使用R&S®TS-EMF便携式系统测量LTE信号的电磁场强度EMF

R&S®TS-EMF是一套便携式环境电磁场测量系统。多年来，它已成功地广泛使用在政府部门和测量服务提供商；同时，它也在不断发展以跟上技术的步伐；一个系统软件在随时更新，以便对LTE移动无线电网络中使用的信号进行测量。

## Well suited for LTE

The tried-and-tested R&S®TS-EMF portable system for EMF measurements (FIG 1) is used to verify compliance with applicable limits. It covers all relevant measurement methods. This includes, for example, the GSM, WLAN and WiMAX™ radio standards as well as decoding of the CPICH in WCDMA. The system measures all signals from the broadcast to the mobile radio and radar ranges and sums them up. It also performs extrapolations to determine the maximum utilization of mobile radio systems, for example.

The LTE mobile radio networks that are currently set up in many countries are making it necessary to take this new mobile radio standard into account as part of EMF measurements. Accordingly, the R&S®TS-EMF portable system has been expanded to include LTE-specific functions based on the latest research in this sector.

## LTE signal structure

LTE uses an OFDMA signal with a bandwidth of up to 20 MHz and made up of a number of subcarriers that are 15 kHz wide. In addition, it has a timing structure with a frame length of 10 ms consisting of 10 subframes and a symbol length of 71 µs.

In the band center, this signal contains 1080 kHz wide signaling in addition to the user data. The P-SCH and S-SCH channels (also known as S-Sync and P-Sync) are encoded individually per base station and are transmitted with constant power so that, analogous to decoding of the CPICH, an individual correlation between the emission and the base station is obtained. The same applies to the reference symbols which are distributed over the entire spectrum (FIG 2).


图1　对LTE信号进行精确的EMF电磁场强度测量：R&S® TS-EMF便携式系统，带有R&S® TSEMF-B2全向天线和R&S®TSMW通用无线网络分析仪

All other channels, including the user data, are not encoded. Accordingly, adjacent base stations coordinate the allocation of timeslots and frequency channels with flexible timing. This is a distinction compared to WCDMA where all channels are encoded. In addition, different modulation types are possible per time and frequency block in LTE.

**Spectrum of an LTE signal**

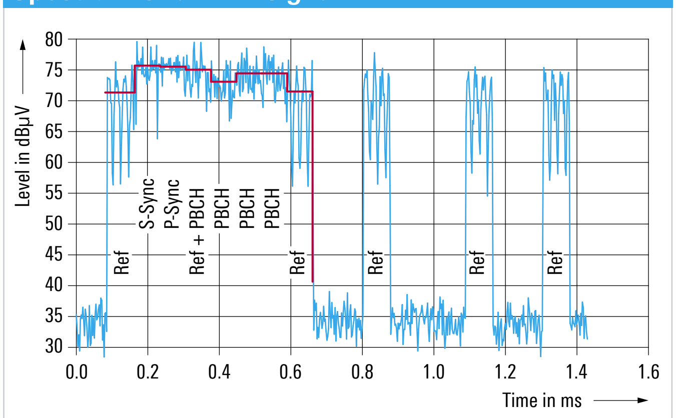


FIG 2 LTE signaling without user data.

**Frequency-selective measurement**

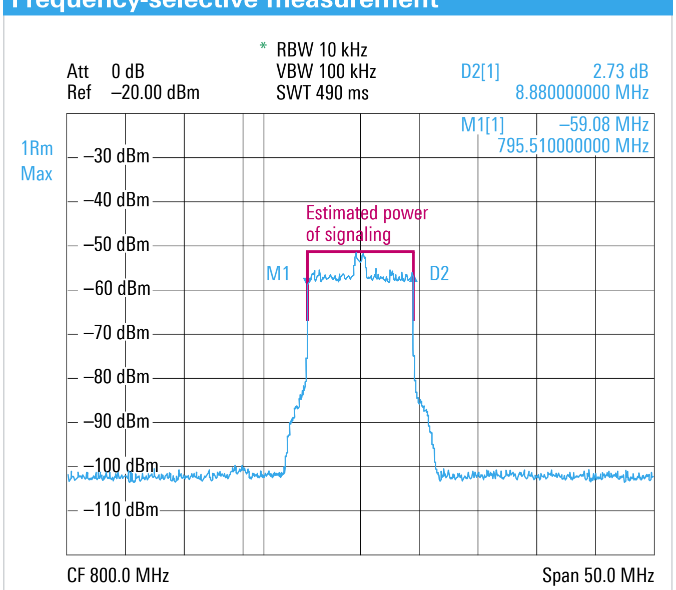


FIG 3 Frequency-selective measurement on an LTE signal without user data.

## Frequency-selective measurement

The R&S®TS-EMF does not require any expansions to perform frequency-selective measurements on LTE signals. Such measurements determine the instantaneous total field strength generated by all surrounding base stations (FIG 3). Due to the high crest factor, the RMS detector must be used. However, because of the signal's timing structure, the dwell time per measurement point must be optimally adapted to the symbol rate in order to avoid undervaluation or overvaluation. The test system provides diverse measurement capabilities:

- Average power versus signal bandwidth
  This measurement shows the fluctuations that occur due to varying network utilization. Since the reference channels are distributed across the entire frequency range, the signal bandwidth can also be determined in this manner.
- Field strength due to signaling in band center
  Since the signaling level and the reference symbol level can be set independently, extrapolation requires appropriate specifications from the network operator.

For frequency-selective measurement of LTE signals, the latest R&S®TS-EMF software version (RFEX v6.1.30) has been expanded to include test packages with predefined parameters for LTE. This makes it very convenient to measure LTE signals, especially in combination with the R&S®TSEMF-B2 isotropic antenna that covers all LTE bands with its frequency range from 700 MHz to 6 GHz.

Frequency-selective measurements can only determine the total value for all surrounding base stations. It is not possible to correlate the results with individual base stations. Like in WCDMA, it is necessary to apply large safety factors when extrapolating to the maximum system utilization. On the one hand, this is due to the fact that, depending on the base station settings, user data can cover the signaling, making the measurement result a function of the traffic. On the other hand, multiple input multiple output (MIMO) technology is used in LTE. Here, user data is transmitted via up to four antennas while the signaling is sometimes transmitted only via one antenna. Accordingly, the other propagation paths are not taken into account for the signaling. A third issue is that the LTE standard allows transmission of signals to individual user equipment with a level that is up to 3 dB higher.

## Code-selective measurement

For WCDMA, it was already shown that precise extrapolation to the maximum utilization and correlation of the emission with a base station are possible only by decoding the signal. The situation is comparable with LTE. Precise extrapolation is based on the signaling field strength or alternatively on the reference symbols. However, detailed base station parameters are needed such as the number of channels or the factor $\rho_B$ that represents the ratio of the signal levels. These signal

Packet: LTE Test

| Cell ID | Frequency [MHz] | Field Strength E [V/m] | Field Level [dBµV/m] | Limit L [V/m] | Exposure Ratio ER E² / L² | ER * 1000 [‰] | Power Density [µW/cm²] |
|---|---|---|---|---|---|---|---|
| 255 | 796.0000 | 0.0755 | 97.5593 | 38.7999 | 0.0000 | 0.0038 | 0.0015 |
| 3 | 806.0000 | 0.1412 | 102.9984 | 39.0429 | 0.0000 | 0.0131 | 0.0053 |
| | Total Exposure Ratios | | | | 0.0000 | 0.0169 | 0.0068 |
| | Total Field Strength (RMS) | | 0.1601 V/m | | | | |
| | Max. Single Value: | | 0.1412 V/m | | | | |

| Cell ID | S-SyncChanPow [V/m] | P-SyncChanPow [V/m] | CenterRSRP [V/m] | AntMaskRSRP |
|---|---|---|---|---|
| 255 | 0.075502746 | 0.075502746 | 0.007763598 | 1 |
| 3 | 0.141389867 | 0.141389867 | 0.014613444 | 1 |

| | |
|---|---|
| Antenna: | Tri-axis probe |
| Cable: | 0 m Cable |
| Limit Line: | ICNIRP |
| Extrapolation factor: | 0 dB |

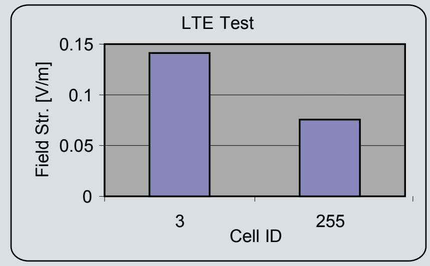


FIG 4 Example of a test report for LTE decoding.

| | LTE | WCDMA (UMTS) | GSM |
|---|---|---|---|
| **Modulation method** | OFDMA | CDMA | FDD-TDMA |
| **Distinction between base stations** | code | code | frequency |
| **Signaling** | symbols in specified timeslots in band center | CPICH, constant amplitude | BCCH, constant timing |
| **Signaling power** | variable with respect to max. power (typ. ≤ ±3 dB) | variable, typ. 10 % of max. power | BCCH always full power |
| **Influence of user data** | power on additional subcarriers and / or timeslots | boosting of signal with additional power | traffic channels on different frequency channels |
| **Measurement method** | decoding of six inner resource blocks: P-SCH, S-SCH, reference symbols and cell information | decoding of CPICH | power level of BCCH, no decoding |
| **Extrapolation to max. power** | level of reference symbols extrapolated to full bandwidth | max. power / CPICH power | max. number of TCHs |
| **MIMO** | yes | no | no |

FIG 5 Measurement methods in LTE, WCDMA and GSM.

parameters are automatically determined during decoding. In the area of MIMO, the measurement makes it possible to determine by how many antennas the received reference signal was transmitted, allowing an exact extrapolation.

These code-selective measurements are supported by the R&S®TS-EMF portable test system in conjunction with the R&S®TSMW universal radio network analyzer and the R&S®TSEMF-K21 and R&S®TSMW-K29 options. The high measurement speed supports all relevant measurement methods including stirring, dot matrix and averaging versus time. Accordingly, the tried-and-tested WCDMA measurement method has been expanded to cover LTE. The system can output a detailed test report at the press of a button (FIG 4).

## 总结

R&S®TS-EMF是第一款支持LTE-FDD信号频率选择性和代码选择性测量的EMF测试系统。当频率选择性测量确定来自所有周围基站的瞬时总发射时，代码选择性测量使得发射与单个基站相关并且精确外推到最大利用率。使用这种来自WCDMA应用且经验证的方法，可避免高估或低估EMF，以提供具有必要精度的真实评估。

图5比较了不同移动无线电标准的测量方法

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