Application Note 1106

Code-selective measurements with the SRM-3006

Using the LTE-TDD option

With firmware release 1.5.0, the SRM 3006 can also demodulate TDD mode LTE signals. This article provides an overview and describes the main differences with FDD mode.

Figure 1: Narda SRM-3006

Contents

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1 The LTE E-UTRA frequency bands

LTE stands for **L**ong **T**erm **E**volution. This is the fourth generation of mobile telecommunications networks, called 4G for short. The specification process for LTE began in around 2004, and it took another five years or so until the first LTE networks came on line between 2008 and 2010. LTE is now operational almost everywhere in the world, and has already developed further to LTE Advanced, or 4.5G. It is likely that LTE will also play an important part in the coming decades, particularly in connection with the fifth generation mobile telecommunications standard (5G).

The LTE frequencies are based on the E-UTRA specification, which stipulates frequency bands between 700 MHz and 3700 MHz. (E-UTRA band 46 is actually at 5200 MHz, but is not used according to information available when this article was written.) Some E-UTRA bands are listed in Table 1 along with their frequency and duplex information.

E-UTRA band	Frequency band [MHz]	Frequency range [MHz]		Duplex mode
1	2100	UL: 1920 – 1980	DL: 2110 – 2170	FDD
3	1800	UL: 1850 – 1910	DL: 1930 – 1990	FDD
7	2600	UL: 2500 – 2570	DL: 2620 – 2690	FDD
12	700	UL: 699 – 716	DL: 729 – 746	FDD
30	2300	UL: 2305 – 2315	DL: 2350 – 2360	FDD
33	2100	1900 – 1920		TDD
38	2600	2570 – 2620		TDD
40	2300	2300 – 2400		TDD
42	3500	3400 – 3600		TDD
44	700	703 – 803		TDD
65	2100	UL: 1920 – 2010	DL: 2110 – 2200	FDD

Table 1: E-UTRA / LTE frequency bands (UL: uplink, DL: downlink) and duplex modes (as of April 2017)

Table 1 makes it clear that some frequency bands definitely overlap. This basically means an increase in spectrum management, particularly in frontier regions, and there is a risk of interference. For example, bands 12 and 44 have spectral components in common, as do bands 30 and 40. Table 1 also shows that each LTE frequency band is allotted one of two specific duplex modes: either frequency division duplex (FDD) or time division duplex (TDD). (A look at all the E-UTRA bands shows that bands 1 through 32 and 65 through 71 only allow FDD, while bands 33 through 46 only allow TDD.) The duplex mode describes the dimension in which the uplink and downlink are separated from each other. This is described in detail below.

At the time this article was published, the majority of LTE networks worldwide used FDD mode. According to the Global Mobile Suppliers Association (GSA) there were 95 LTE TDD networks in 54 countries worldwide in operation at the end of January 2017. At that time, there were 32 network providers operating both LTE FDD and TDD networks. TDD networks are frequently found in China and India, but also in Canada, the USA, and some African countries, particularly Ghana and Nigeria. LTE in Europe mainly uses FDD mode, but TDD networks do exist in Belgium, Finland, Ireland, Italy, The Netherlands, Sweden, Slovakia, Spain, and Russia.

2 The LTE duplex modes

The duplex mode in cellular mobile telecommunications systems such as 2G, 3G and 4G refers to the way communication between the handset and the base station takes place, that is, how the uplink and downlink are separated from each other. In 2G as well as in 3G and most of the 4G frequency bands (see Table 1) a specific frequency range is reserved for the uplink (i.e. the wireless signal from the handset to the base station). At the same time, a different exclusive frequency range is used for the downlink (from base station to handset). The two communications channels are thus separated by their frequencies, and this is therefore called frequency division duplex mode.
LTE stipulates TDD bands as well as FDD bands. TDD means that the two communications channels are separated from each other in time rather than in frequency. The uplink and downlink operate on the same frequency, but alternate with each other in a strictly controlled manner. This is illustrated in Figure 1.

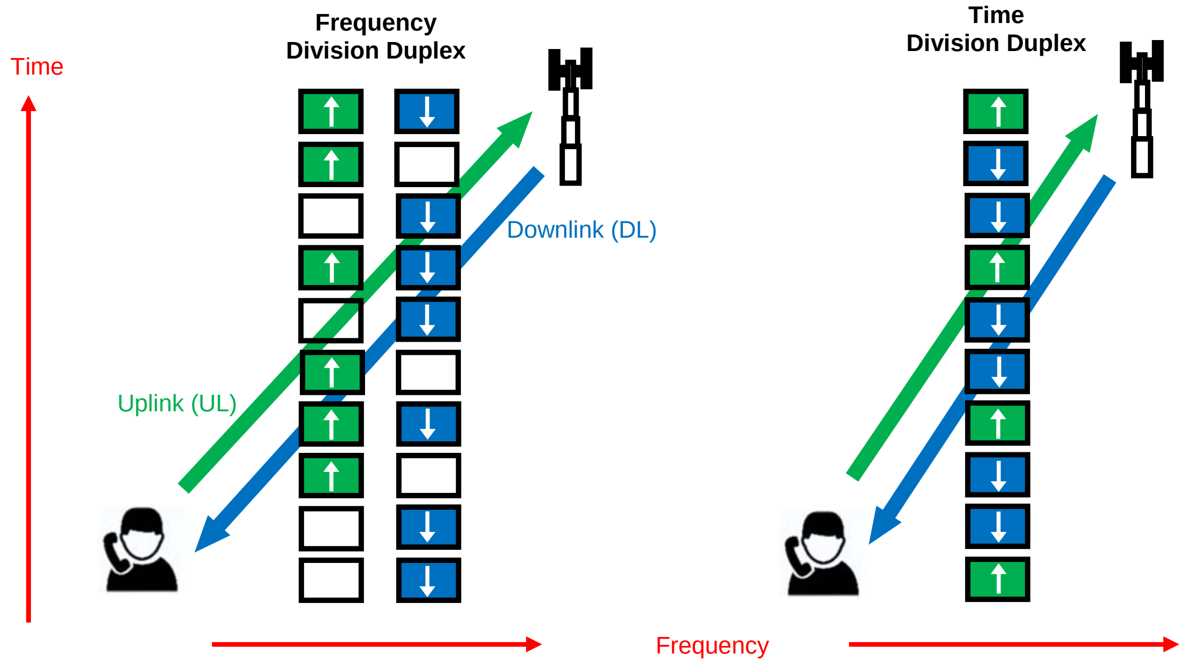

Figure 2: The difference between FDD (left) and TDD (right)

The diagram of FDD on the left of Figure 1 makes it clear that the uplink and downlink operate on two different frequencies or bands, but can operate simultaneously. It is important to remember that this simultaneous operation is not random, but follows a specific protocol depending on the mobile communications standard being used. It should also be noted that some of the available timeslots can be empty, depending on the volume of data traffic (blank boxes in the diagram).
TDD is shown on the right in Figure 1. This clearly shows that only one frequency band is used, and the uplink and downlink signals must alternate with each other as a consequence. The uplink and downlink must never be allocated the same resources (i.e. number of timeslots). On the contrary, the downlink is typically given more resources, as the handset will generally download more data than it uploads. This is indicated by the larger number of blue DL boxes in

Figure 2. A protocol is also required for this, to ensure that the uplink and downlink in TDD alternate without conflicts. Such a protocol is likely to be quite complex for a modern communication technology like LTE. It can be illustrated simply as being like a conversation between two persons using a simple walkie-talkie link operating on one frequency. When one person is talking, the other is listening, and vice versa. The two persons take turns to talk. If they both try to talk at the same time, a conflict occurs and communication becomes unintelligible. If the first person has more to say than the second, they would require more resources, just like the TDD downlink in Figure 1.

3 LTE-TDD uplink and downlink configurations

As explained in section 2, LTE-TDD is subject to a specific protocol. Among other things, this determines the resources / number of timeslots that are to be allocated to the uplink and downlink within a given time period. This is referred to as the uplink / downlink configuration of a TDD network. Seven configurations, numbered 0 to 6, are defined for LTE-TDD, as shown in Figure 3. These allocate more resources to either the downlink or the uplink, as appropriate.

Uplink / downlink-configuration	**Sub frame number**									
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
0	DL	SSF	UL	UL	UL	DL	SSF	UL	UL	UL
1	DL	SSF	UL	UL	DL	DL	SSF	UL	UL	DL
2	DL	SSF	UL	DL	DL	DL	SSF	UL	DL	DL
3	DL	SSF	UL	UL	UL	DL	DL	DL	DL	DL
4	DL	SSF	UL	UL	DL	DL	DL	DL	DL	DL
5	DL	SSF	UL	DL	DL	DL	DL	DL	DL	DL
6	DL	SSF	UL	UL	UL	DL	SSF	UL	UL	DL

Figure 3: LTE-TDD uplink and downlink configurations

However, as Figure 2 focuses on the LTE standard, the term used is sub frames rather than resources or timeslots. A sub frame has a duration of one millisecond according to the specification. Ten sub frames make up a so-called radio frame, which is the largest unit in the LTE frame structure. A sub frame can be used for either the downlink (DL) or the uplink (UL), as shown in Figure 2. A sub frame can also function as a special sub frame (SSF). The special sub frame has various functions: It contains pilot signals for the uplink and the downlink, and a large part of the special sub frame is allocated as so-called guard time. As with many other communications systems, no signals are transmitted during the guard time. This serves to provide immunity to the negative effects caused by multipath propagation.

4 Using the SRM 3006 LTE-TDD option

It is now also possible to demodulate LTE TDD signals on the SRM 3006 with firmware release 1.5.0. Sections 1 to 3 above have described how LTE TDD functions differently to LTE FDD and how it therefore needs different treatment in the SRM. The main distinction between the FDD option and the TDD option is that the particular uplink / downlink configuration can be set additionally in the TDD option.

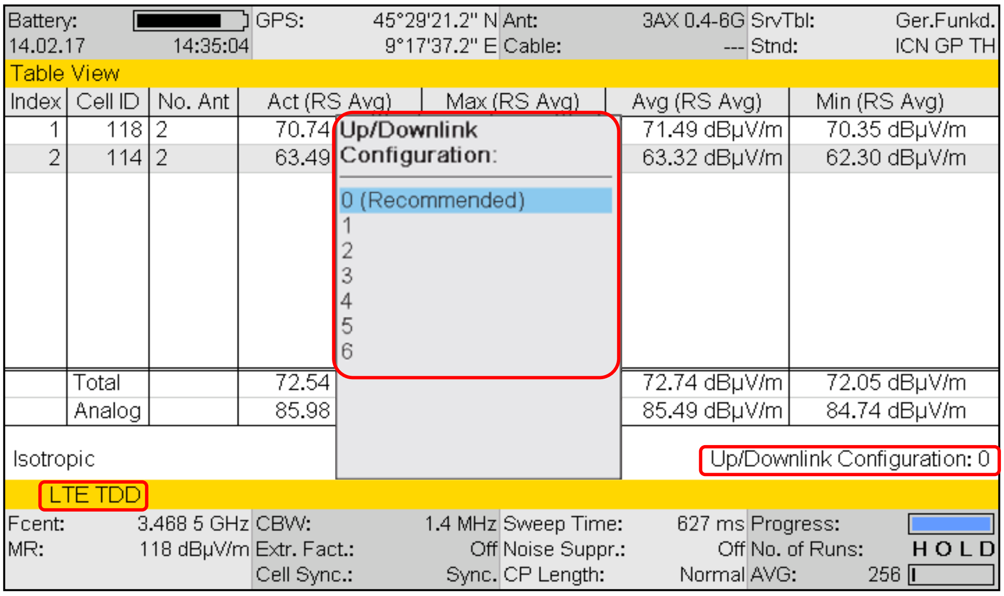

Figure 4: LTE TDD option in the SRM 3006 with uplink / downlink configuration selection

If the uplink / downlink configuration being used in an LTE TDD network is definitely known, this can be set appropriately during a measurement with the SRM 3006, as illustrated in Figure 3. The SRM benefits from a slightly reduced measurement uncertainty if the correct configuration is set. If a setting is chosen that does not correspond to the actual uplink / downlink configuration, the risk of over- or under evaluation increases significantly. The configuration setting “0 (Recommended)” is an exception to this. This setting can be used universally for all network configurations. When set to “0”, the SRM focuses on sub frames 0 and 5 and also on the reliable downlink components in the special sub frames (i.e. sub frames 1 and 6). These four sub frames always carry downlink signals, regardless of the uplink / downlink configuration, as is shown clearly in Figure 3 and by the explanation of SSF given above. The configuration setting “0 (Recommended)” should therefore be used as the standard setting, and should also be used if the actual uplink / downlink configuration is not definitely known.

Remember that the SRM can also demodulate TDD signals when the setting “0 (Recommended)” is chosen, even when this does not correspond to the actual configuration of the network. If the actual configuration is set, this will merely achieve a slight improvement in the measurement uncertainty. If a configuration other than “0 (Recommended)” is set and this does not correspond to the actual configuration of the network, then the measurement uncertainty will be significantly degraded and even the basic demodulation function will no longer be assured!

5 Further literature

This article describes the LTE-TDD option in the SRM 3006. Further information about LTE as well as UMTS can be found on the Internet at: www.narda-sts.com/de/selektiv-emf/srm-3006
As well as chapter 12.6 “LTE-TDD” in the SRM 3006 operating manual, the following three documents available from the Narda STS website are of particular interest:

- Immission measurements in the vicinity of LTE base stations (Part 1: Fundamentals)
  Application Note AN 1062

- Immission measurements in the vicinity of LTE base stations (Part 2: Measurement methods)
  Application Note AN 1064

- Using UMTS mode
  Technical Note 10

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