Application Note

will'tek

A new generation of wireless communications requires new test methods: Final testing a TD-SCDMA wireless device

boosting wireless efficiency

Abbreviations

ACLR	Adjacent Channel Leakage Power Ratio
BER	Bit Error Rate
BLER	Block Error Rate
DPCCH	Dedicated Physical Control Channel
EVM	Error Vector Magnitude
OBW	Occupied Bandwidth
PCDE	Peak Code Domain Error
PRBS	PseudoRandom Bit Sequence
RSL	Reference Sensitivity Level
SEM	Spectrum Emission Mask
TPC	Transmit Power Control
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
UE	User Equipment

This application note shows you which measurements should be taken into account in the final testing of TD-SCDMA mobile phones. These measurements are supported by the instruments of the 4400 Mobile Phone Tester Series and are usually performed as part of final and functional tests in manufacturing lines as well as after repair and alignment in service.

4400 Mobile Phone Tester Series

With the 4400 Mobile Phone Tester Series, Willtek offers one of the most cost-efficient solutions for manufacturing and high-level service of mobile phones. This instrument provides users in production and repair with a platform for all prevalent wireless technologies at hand. Testing solutions for GSM, GPRS, WCDMA and CDMA/AMPS terminals are as much available as for transmitter alignment of EDGE phones. The offering is complemented by options for audio measurements and battery current tests. The 4400 can be completely remote-controlled and allows users to shorten test times with parallel measurements and comprehensive automation capabilities. Fast switching between wireless standards is accomplished by the press of a button or a remote control command. Options for the TD-SCDMA (Time Division Synchronous Code Division Multiple Access) standard expand the testing spectrum. These support both manufacturers and service centres in testing wireless devices which are designed according to the TD-SCDMA standard. The non-call mode, that means testing without a call setup, allows measurements and alignment without signalling involved. The Call Mode Option extends the offering because it supports easy final testing of TD-SCDMA phones or user equipment (UE).

The TD-SCDMA Call Mode Option

The Willtek 4451 TD-SCDMA Call Mode Option includes the TD-SCDMA protocol, thus supporting the UTRAN Registration Area Update (URA) and the call setup procedure. This allows measurements under real-life conditions.

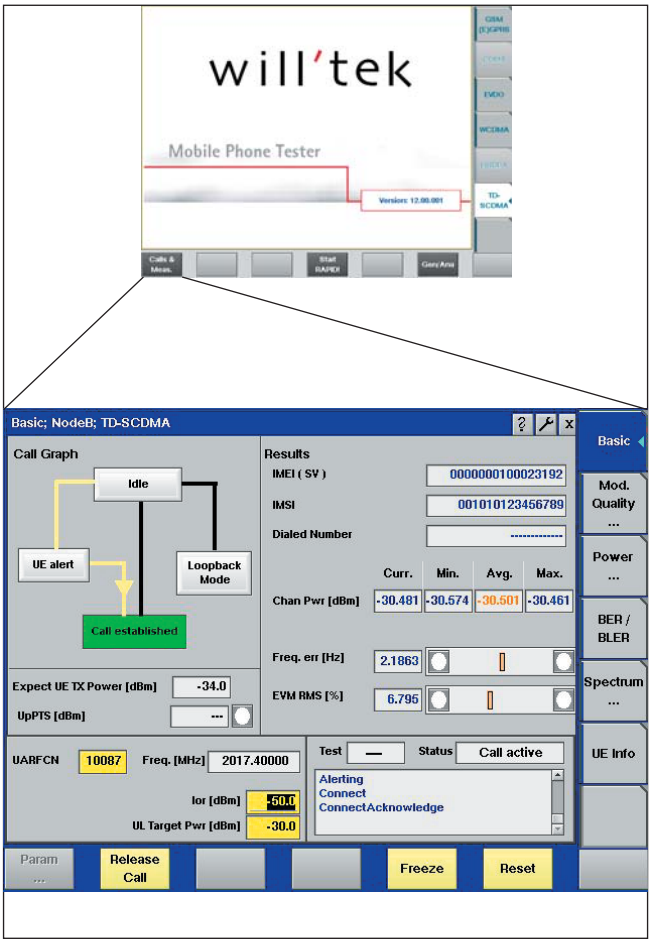


Figure 1: TD-SCDMA Basic Menu

Measurements that should be supported include:

Transmitter measurements

- minimum output power level
- maximum output power level
- transmit on/off time mask
- frequency error
- inner loop power control
- transmit modulation spectrum
- occupied bandwidth (OBW)
- adjacent channel leakage power ratio (ACLR)
- spectrum emission mask (SEM)
- modulation quality: error vector magnitude (EVM) and peak code domain error (PCDE)

Receiver measurements

- reference sensitivity level (RSL)
- maximum input power level

All these measurements are supported by the 4400 Mobile Phone Tester Series. For final testing the UE with the 4400, the 4479 Baseband Processing Hardware Option is a basic requirement. This technology-independent platform is the hardware basis for the TD-SCDMA tests, enabling future extensions of the standard to be implemented with a software upgrade.

Final testing the UE

Measuring setup

Apart from the hardware option mentioned above, the final test also requires a Test USIM to be installed in the UE. Hence the TD-SCDMA option for the 4400 Mobile Phone Tester Series consists of the following modules and components:

- 4479 Baseband Processing Hardware Option, order number M 248 690
- 4450 TD-SCDMA Non-Call Mode Option (signal generator and analyzer), order number M 897 255
- 4451 TD-SCDMA Call Mode Option, order number M 897 256
- 1103 USIM and GSM Test SIM Card, order number M 860 164

The TD-SCDMA Non-Call Mode Option is typically required for the alignment of the wireless device, but not necessary for final tests. This option provides for basic signal generator and analyzer functions.

Final testing with the 4451 TD-SCDMA Call Mode Option is supported with different measuring setup variants as follows:

Measuring setup 1:

4921 RF Shield and 4916 Antenna Coupler

Measuring setup 2:

Direct connection

Figure 2: Measuring setup variants for final testing the TD-SCDMA wireless terminal

Using the 4921 RF Shield minimises the impact of external interference on the measurements; the device may not only be interfered with but also negatively affect other test stations and even real networks. Without the RF Shield, nearby base stations may produce extreme repercussions and distortion in the measured signal. On the other hand, a connection simply involving the antenna coupler, without RF screening, helps minimise test times and increase throughput of wireless terminals. Both possibilities avoid the additional effort of various connectors with special plugs. However, using an antenna coupler without the RF Shield is not recommendable due to the above-mentioned impact of interference.

Final testing of the UE includes various measurements as already listed in the previous chapter.

Transmit power measurements

In any radio network based on CDMA, control of the transmit power is important as it affects the capacity of the radio cell. Generally, each transmitter adds to interference, so the capacity of the cell is affected even by calls in the neighbouring cells. A large capacity can only be assured if the transmit power of each wireless terminal is minimised to the extent that the signal strength just allows for the required quality of service.

Therefore power control is of great importance. There are two different ways to control transmit power: open loop power control during call setup and closed loop power control during an ongoing connection. The latter implies that the base station controls the UE transmit power by way of the TCP (Transmit Power Control) bits. The transmit power is defined over a dynamic range between P_{min} and P_{max}; the lower end is fixed for all wireless terminals at $P_{min, TD\text{-}SCDMA} = -49$ dBm. This compares to the minimum transmit power of GSM phones at $P_{min, GSM} =$ 0 dBm. The upper end is defined by the power class for the phone at hand. The ETSI specification requires a dynamic range, so measuring the minimum and maximum output power can be an important test parameter for the final test of a UE. With the 4400 the measurement can easily be carried out. Transmit power is controlled during an ongoing connection by way of the TPC bits, up or down in 1, 2 or 3 dB steps (Δ_{TPC}). This change must be applied in the time slot immediately following command reception. So in order to check inner loop power control, accurate measurement of the level change is required (see Fig. 3).

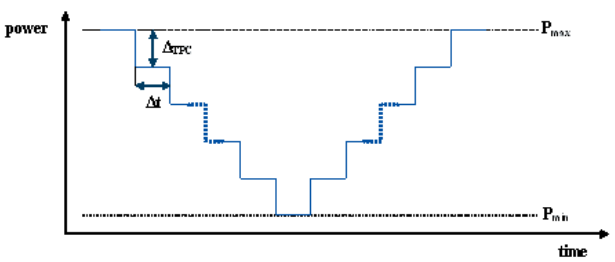


Figure 3: Inner Loop Power Control

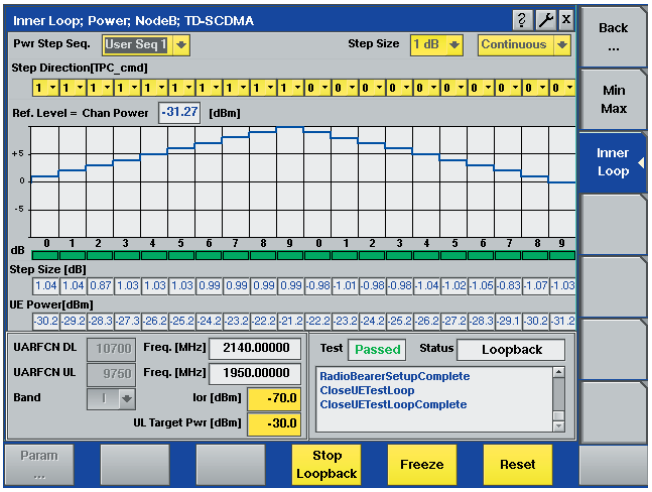


Figure 4: Inner Loop Power Control menu

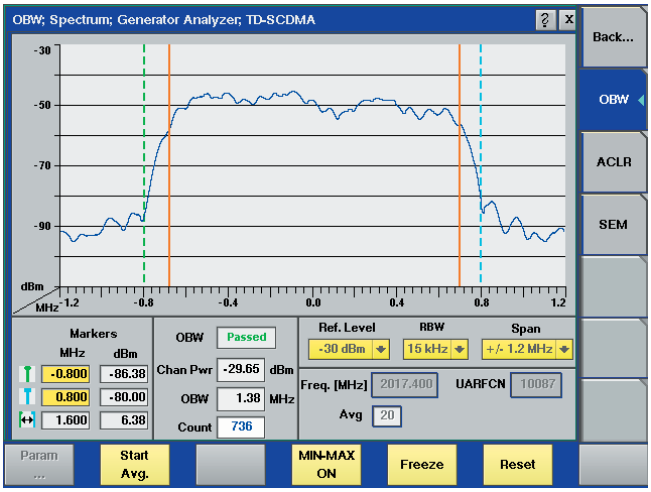


Figure 6: Occupied Bandwidth (OBW)

Transmit On/Off mask

TD-SCDMA is a time division multiple access standard, where multiple phones share the same frequency resource. In addition to codes, the different phones are also using different timeslots which are allocated by the network. In order to ensure that phones in consecutive time slots do not interfere with each other, the standard has defined an on/off time mask which needs to be verified during the final test. Figure 5 shows the screenshot of such a measurement.

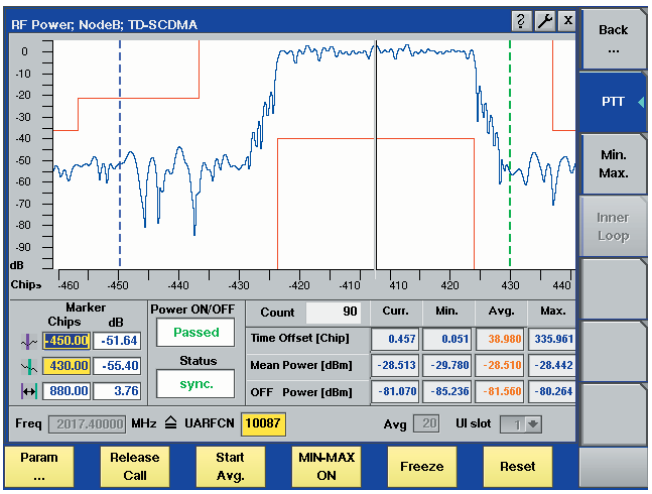


Figure 5: Transmit On/Off menu

Frequency spectrum

Spectrum measurements for TD-SCDMA include that of the occupied bandwidth (OBW). 99% of the entire power should be spread within a range of no more than 1.6 MHz around the carrier frequency. In the example measurement in Fig. 6, the occupied bandwidth is 1.38 MHz.

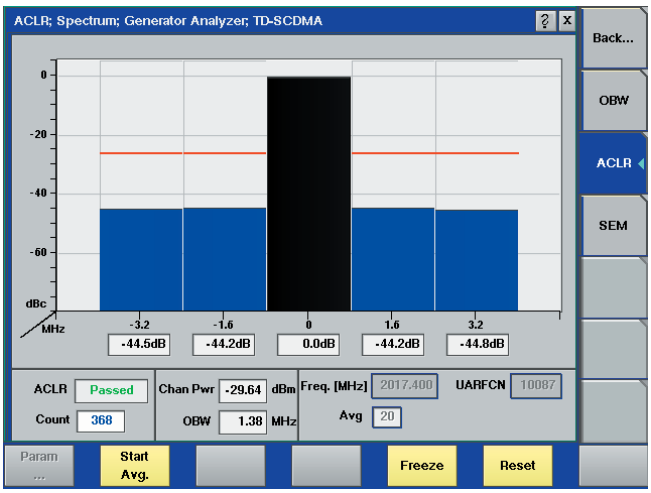


Figure 7: Adjacent Channel Leakage Power Ratio (ACLR)

Also included in the group of spectrum measurements is the adjacent channel leakage power ratio (ACLR). This measurement determines the ratio of the spectral power in the neighbouring channels to the power in the allocated channel. The limits should not be exceeded to avoid interference with neighbouring channels. ETSI specifications require that the measurement be taken with the UE transmitting at maximum transmit power, which in terms depends on which of the four power classes the phone belongs to. The 4400, however, allows this measurement to be performed at any transmit power level. In the measurement in Fig. 7, the transmit power is –29.64 dBm.

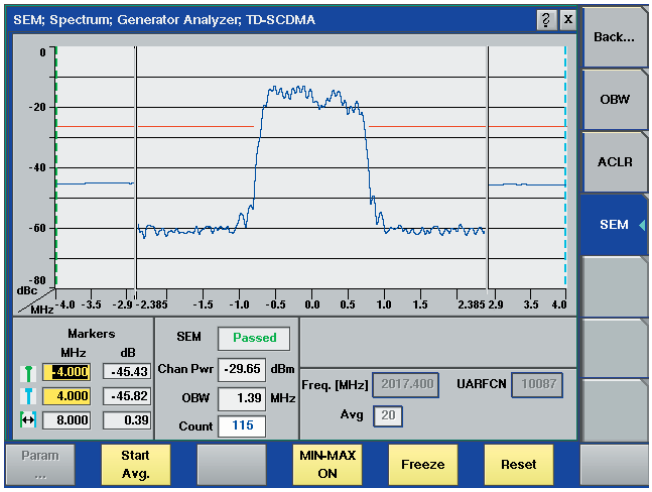


Figure 8: Spectrum Emission Mask (SEM)

In the spectrum emission mask (SEM), the signal spectrum outside the allocated channel is measured. The resulting display is split into two parts. In a spacing between 0.8 and 1.8 MHz from the carrier frequency, the signal is measured at a resolution bandwidth of 30 kHz. A 1 MHz filter is used above 1.8 MHz up to 4.0 MHz from the carrier. The specification gives upper limits depending on the frequency; these limits are pre-programmed and marked red on the 4400 display as shown in Fig. 8.

Modulation quality

The quality of the TD-SCDMA signal can be determined with the error vector magnitude (EVM) and the peak code domain error (PCDE). The error vector can be represented in the I/Q diagram of the TD-SCDMA signal, where amplitude and phase can be assessed (Fig. 9). The modulation error is supplied by the difference between the measured and the calculated ideal modulation vector, and evaluated for each symbol. Quality assessment is simplified by regarding the RMS-averaged EVM only. This parameter describes the modulation quality of the complete signal. Figure 9 shows the constellation display, i.e. the representation in the I/Q plane of the signal transmitted by the mobile phone.

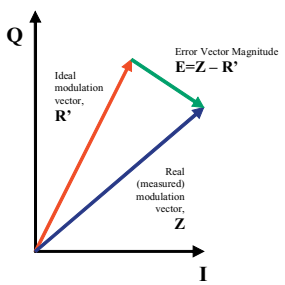


Figure 9: Error vector magnitude

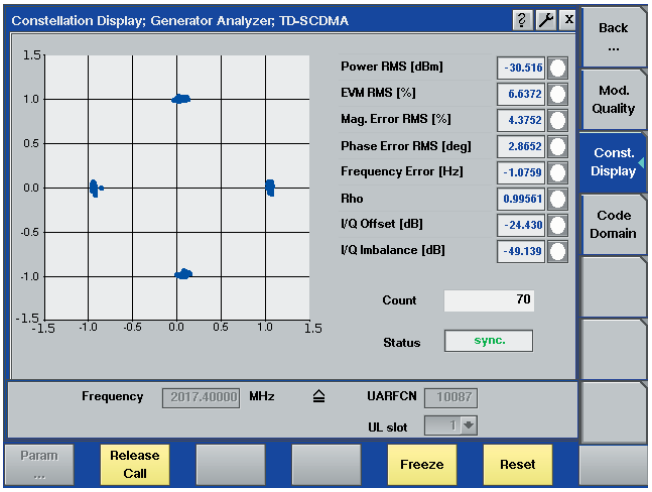


Figure 10: Constellation Display menu

Another way of assessing modulation quality is reviewing the signal in the code domain. The entire transmit power is split into the individual code channels characterising the CDMA system; the distribution on code channels plays an important role in this type of evaluation. For each code channel, the test instrument displays the channel power relative to the entire power. Unallocated code channels do not transport data but only noise which can be considered as crosstalk. Code channel crosstalk is caused when the real-life transmitter injects additional noise into other channels so that orthogonality is affected or lost. The code channel most interfered with and the power injected are of high interest. The ratio between each unallocated code channel and the power in the allocated code channel is calculated, giving the code domain error (CDE); the largest one is considered as the peak code domain error (PCDE). It is important to evaluate this error over a longer period of time as it varies. Figure 12 shows an example of the peak code domain error on the 4400.

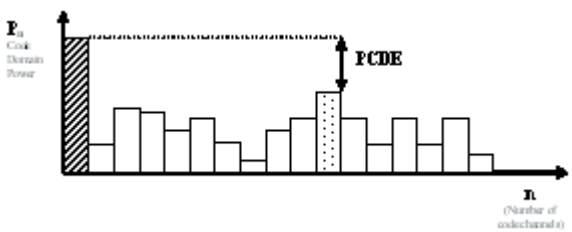


Figure 11: Peak code domain error

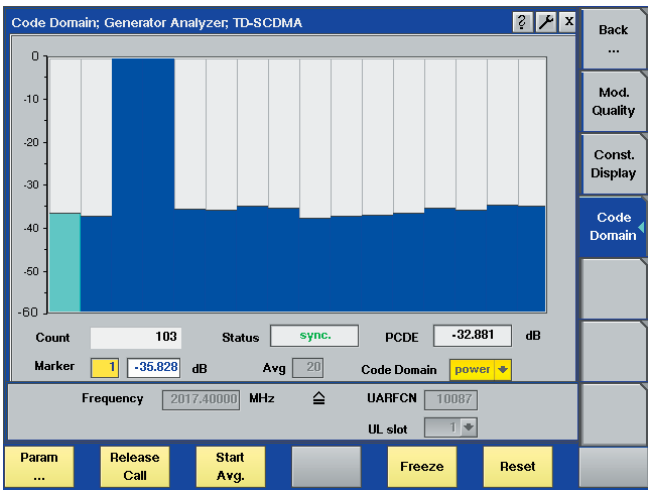


Figure 12: PCDE measurement on the 4400

The frequency error describes the difference between the used and the assigned carrier frequency. The actual frequency may deviate by a maximum of 1 ppm from the frequency assigned by the base station.

Receiver measurements

Bit error and block error measurements (BER, BLER) help to assess the receiver of digital transmission systems. The 4400 transmitter provides defined test sequences to the user equipment's receiver; these are pseudo-random bit sequences (PRBS). The transmitted are compared with the received bits (BER) or data blocks, and thus the error rate is determined. The reference sensitivity level (RSL) describes the lowest receive power at which the bit error rate does not exceed 0.1%. This value can of course be determined for high levels as well, but not all manufacturers specify this as a part of the final test. The standard requires bit error rates below 0.1% for a range from –107.3 dBm to –25 dBm.

Summary

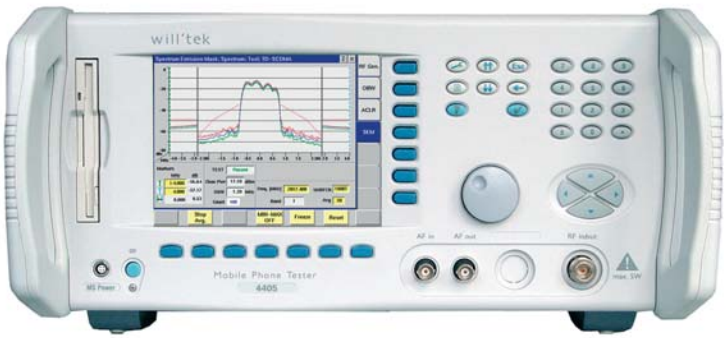
For the final test of TD-SCDMA wireless terminals, the following measurements are recommended with the limits listed in the table below.

Transmitter measurements

	Power class, value	Tolerance (dB)		
Maximum output power	1, +30 dBm	+1.7	-3.7	Depends on the power class of the User Equipment (UE)
	2, +24 dBm	+1.7	-3.7	
	3, +21 dBm	+1.7	-3.7	
	4, +10 dBm	+2.7	-2.7	
Frequency error	Maximum: ±1 ppm			For additional information see ETSI specification TS 134 121
Inner loop power control	1 dB step: ±0.5 dB 2 dB step: ±1.0 dB 3 dB step: ±1.5 dB			
Minimum output power	Less than –49 dBm			
Transmit On/Off mask	See Figure 5.4.4.2.1 in TS 134 122			
Occupied bandwidth	No more than 1.6 MHz			
Spectrum emission mask	f in MHz	Minimum requirement for Band I, II, III		
	0.8 to 1.8[1)]	See TS 134 122 Chapter 5.5.2		
	1.8 to 2.4[1)]			
	2.4 to 4.0[2)]	–49.0 dBc		
	[1)] 30 kHz measurement bandwidth [2)] 1 MHz measurement bandwidth			
Adjacent channel leakage power ratio ACLR	Power class	UE channel	ACLR limit	
	2, 3	+1.6 or –1.6 MHz	32.2 dB	
	2, 3	+3.2 or –3.2 MHz	42.2 dB	
Error vector magnitude	Does not exceed 17.5% for specified parameters			Parameters: Output power > –20 dBm Power step size = 1 dB
Peak code domain error	Does not exceed –20 dB for spreading factor 16 (SF 4)			

Receiver measurements

Reference sensitivity level	Operating band	I_{or}	
	I, II, III	–107.3 dBm/MHz	



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