RF Lecture Series
Modulation Fundamentals
Introduction to TD-SCDMA

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1. Introduction

TD-SCDMA, or Time Division-Synchronous Code Division Multiple Access, is a 3G mobile telecommunications standard, being developed initially for People's Republic of China. It has been adopted by ITU and by 3GPP as part of UMTS Release 4, and is hence becoming a global standard.

At the point of writing, this standard is relatively new. This paper intends to provide the basis of demodulating TD-SCDMA waveform for a successful EVM testing. It will first discuss the basics of the TD-SCDMA modulation to give the reader an idea of how the waveforms are created before dwelling on the mechanics of demodulating the signal.

2. TD-SCDMA Overview

TD-SCDMA combines an advanced TDMA (Time Domain Multiple Access) / TDD (Time Domain Duplex) system with an adaptive CDMA component operating in a synchronous mode. The TDD scheme allows dynamically adjusting the number of timeslots used for downlink and uplink, the system can more easily accommodate asymmetric traffic with different data rate requirements on downlink and uplink. Also, using the same carrier frequency for uplink and downlink means that the channel conditions are the same in both directions, and the base station can deduce the downlink channel information from uplink channel estimates.

The TD-SCDMA standard is currently utilized in China and uses a variety of frequency bands between 1785 MHz and 2220 MHz. For wireless local loop, it can be deployed using the frequency band between 1900 MHz and1920 MHz. Voice data are transmitted at 8 kbps. Possible data rates for switch circuit services such as video are 12.2, 64, 144, 384 and 2048 kbps. Packet data rate transmissions are either 9.6, 64, 144, 384 and 2048 kbps.
The data bits are spread with the CDMA channelization code into spread bits (chips). The chip rate of TD-SCDMA is 1.28Mcps.

TDMA uses a 5 ms frame for repetitive transmissions. This frame is subdivided into 7 time slots, which can be flexibly assigned to either several users or to a single user who may require multiple time slots. Each carrier consists of the uplink and downlink which share the same 1.6 MHz carrier frequency band with the seven timeslots per frame and 16 codes per timeslot. (Figure 1)

A Basic Resource Unit (RU) for TD-SCDMA is defined by frequency, timeslot (TS) and code channel with spreading factor.

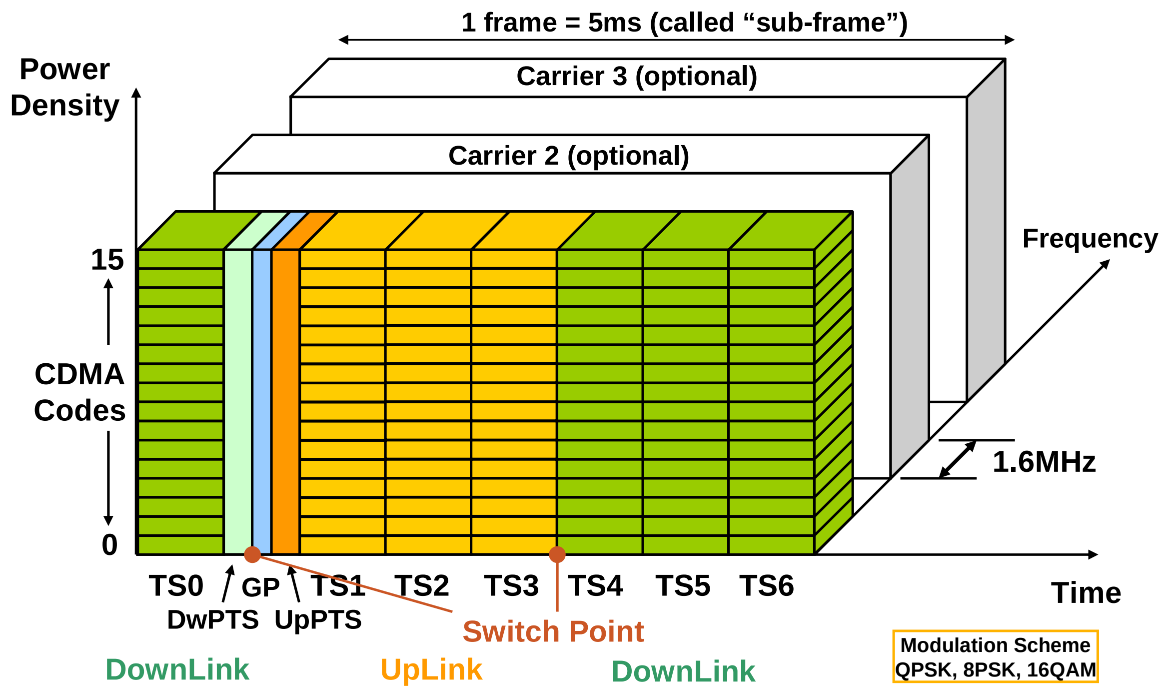

Figure 1. TD-SCDMA Resource Structure

Physical channels take on a four-layer structure of super frame, radio frames, subframes and time slots/codes. The radio frame has a duration of 10 ms and is subdivided into 2 subframes of 5 ms each, and each sub-frame is then subdivided into 7 time slots (TS) and 3 special time slots.

The 7 timeslots are 675 µs duration or 6400 chips each and can be allocated to different Resource Units (RU) for different users. The 3 special times slots are DwPTS (downlink pilot timeslot) which occupies 96 chips , GP (the main guard period) occupies 96 chips and UpPTS (uplink pilot timeslot) uses 160 chips. See Figure 2 for an illustration.

The downlink pilot timeslot consist of 32 chips of guard period followed by 64 sync chips for downlink synchronization. The uplink pilot timeslot is used for uplink initial synchronization, random access, and measurement for adjacent cell when handoff. It consists of 160 chips: 128 for SYNC, 32 for GP.

The assignment of the time slots in a subframe is as follows. TS0 is always assigned as the downlink direction. TS1 is always allocated as uplink. In each subframe, there are two switching points that separate the uplink and the downlink. The first switching point is always at the GP, The second switching point can occur anywhere between the end of TS1 and the end of TS6. It is this second switching point that determines the traffic nature of a particular subframe, that is, symmetric or asymmetric. In asymmetric mode, at least one uplink timeslot (TS0) and one downlink timeslot (TS1) must be allocated for traffic.

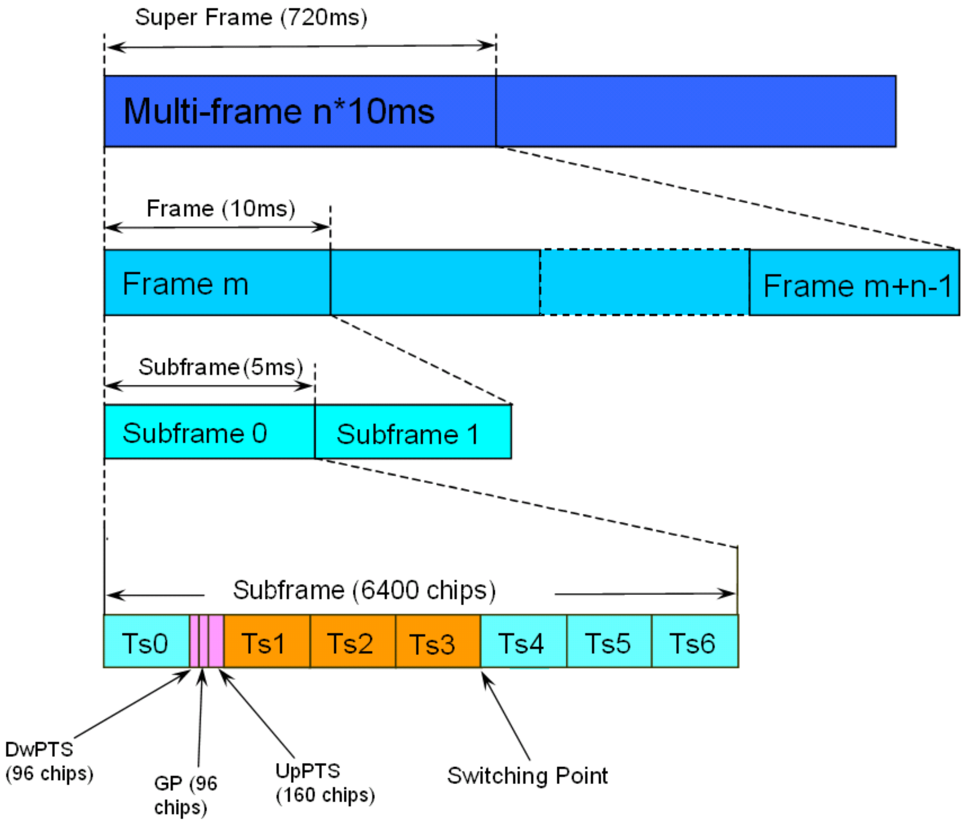

Figure 2. TD-SCDMA Frame Structure

The timeslot consist of two data symbol fields, a midamble of 144 chips and a guard period of 16 chips. The data fields of the burst type are 704 chips long. The data bits in the burst are modulated and spread by the spreading factor of 1, 2, 4, 8, or 16 in the uplink and with the spreading factors 1 or 16 in the downlink. The guard period is 16 chips long.

The modulation scheme can be either QPSK or 8PSK. In HSDPA (High-Speed Downlink Packet Access) mode, 16QAM is used.

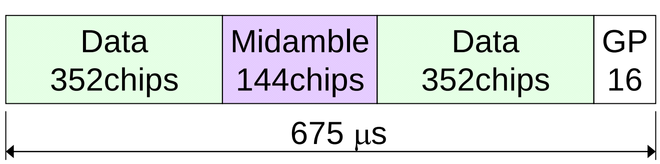

Figure 3. Timeslot Burst Structure

3. Composite EVM

TD-SCDMA uses QPSK, 8PSK or 16QAM, for which the ideal symbol points always map onto specific locations (4, 8 or 16 points) in the I/Q plane. However, when a time slot contains the signal of more than one code channels, the constellation diagram does not look like any of these single traditional formats, but rather it appears as a combination of them as shown in Figure 4. In this simplified diagram, each code channel uses QPSK to modulate the spread signal (chips) and all signals are added to generate the signal to be transmitted. The final constellation becomes the composite of all code channels' constellations.

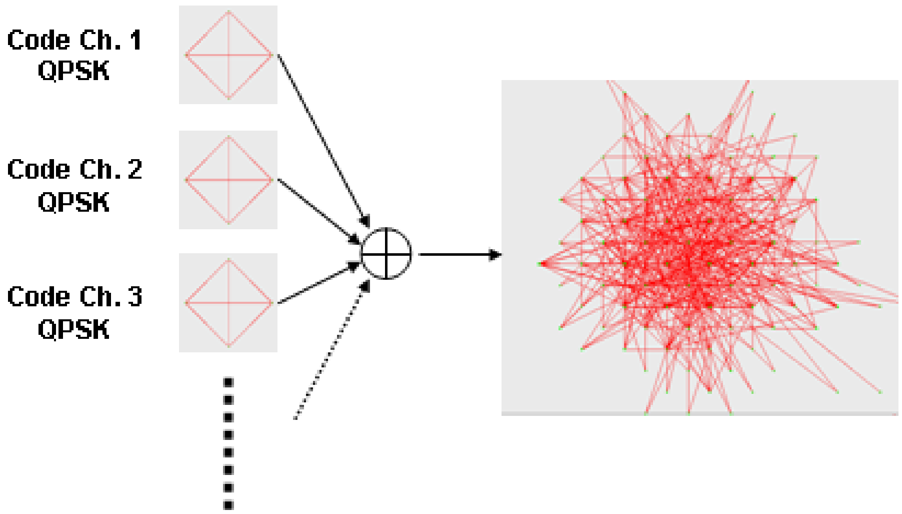

Figure 4. Vector Diagram of CDMA

The constellation diagram of multi-code channel signals does not give a clear idea on the quality of the modulation. Rather, this can be evaluated better by using the composite EVM measurement.

Figure 5 shows the simplified processing algorithm to calculate composite EVM. In order to generate the reference waveform, the measured waveform is demodulated and bit data of active code channels are decoded. Then, the bit data are processed in the same way as the measured signal was generated in the DUT and reference waveform is generated. The EVM are calculated by comparing the reference waveform and the measured waveform.

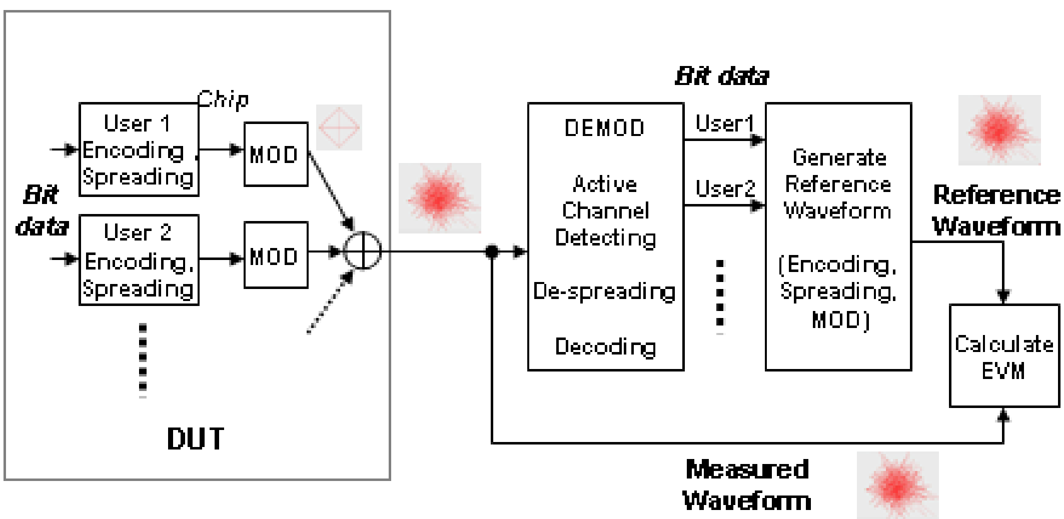

Figure 5. Simplified Process to Calculate Composite EVM

4. Demodulation on V93000

The V93000 demodulation engine supports TD-SCDMA standard. As discussed above, there are several key parameters that need to be extracted from the signal to properly demodulate the TD-SCDMA signal, such as channelization code, modulation type, active code channel, and so on. The default setting of the demodulation engine for TD-SCDMA can usually extract the necessary information to demodulate the output of the device. This greatly improves the ease of test development despite of the complexity of the demodulation process.

The time slot to be tested is the users' choice. The input parameter for this information is provided ("TimeSlotUnderTest"). The user can choose any time slot (TS0 - TS6) including special time slots (UpPTS, DwPTS).

The V93000 demodulation engine outputs multiple results such as mean rms EVM value over all symbols, respective peak EVM values, IQ data for constellation plots and so on. In addition to EVM results, various result parameters which can be used to evaluate the signal are also provided such as, Gain/Phase imbalance, Frequency Offset, etc. The demodulation engine also provides useful graphical information for debugging purpose. Figure 6 shows some of the graphical outputs generated by the V93000 demodulation engine.

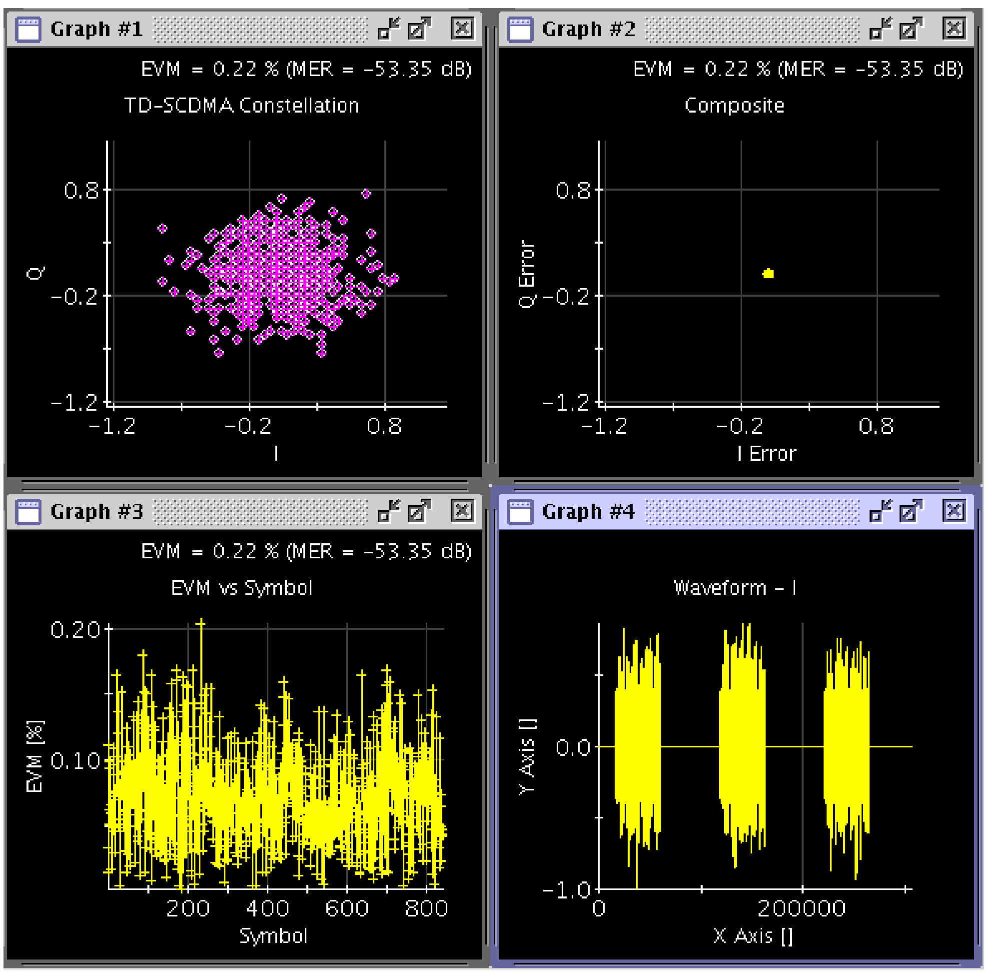

Figure 6. Graphical Outputs from V93000

5. Conclusion

There are a lot of challenges to measuring EVM for TD-SCDMA. Having the right tools to make the measurements is crucial. This paper shows the basics of TD-SCDMA modulation and what V93000 demodulation engine provides to test the modulation accuracy. TD-SCDMA EVM can be easily tested in production on the V93000 in a very short period of time because of the simplified usage and the useful debugging information.

6. References

[1] Agilent 89600 VSA Manual
[2] Agilent Signal Studio for 3GPP TD-SCDMA Manual
[3] http://en.wikipedia.org/wiki/TD-SCDMA
[4] Designing and Testing 3GPP W-CDMA User Equipment (Agilent Application Note 1356)
[5] China Wireless Telecommunication Standard; 3G digital cellular telecommunications system; Base Station System (BSS) equipment specification; Release 3