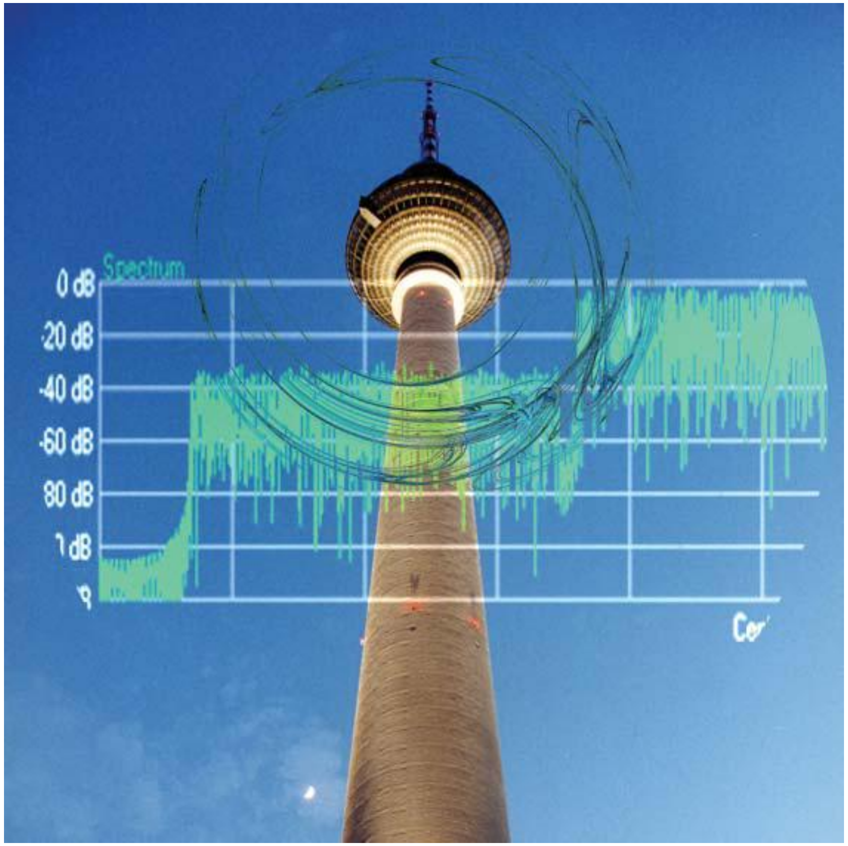
Novita' tecnologiche e soluzioni di test per il DVB-T2 e gli altri standard per il broadcasting



Roberto Sacchi
Application Engineer
Electronic Measurements Group
Agilent Technologies

Agilent Technologies

Agenda

- Introduzione alle tecnologie impiegate nei moderni sistemi per il broadcasting digitale
- Evoluzione degli standard DVB
- Caratteristiche RF e protocollari del DVB-T2
- Verifica della potenza trasmessa:
  - Potenza di canale;
  - Shoulder attenuation, etc.
- Misure di qualità sui trasmettitori e individuazione delle cause di degrado:
  - Costellazione, MER;
  - Risposta in frequenza;
  - Risposta all’impulso, etc.
- Test sui ricevitori in reali condizioni di fading

Digital Video/Broadcast Audio Landscape – types of technologies

Cable TV
- DVB-C/C2
- ITU J.83B
- ISDB-C
- DOCSIS

Satellite TV
- DVB-S/S2
- DirectTV
- ISDB-S
- ABS-S

Terrestrial TV
- DVB-T/T2
- ISDB-T
- ATSC
- DTMB(CTTB)

Mobile TV
- DVB-H
- DVB-SH
- MediaFLO
- ISDB-T 1-Seg
- CMMB
- T-DMB
- S-DMB
- ATSC-M/H

Broadcast Audio
- AM/FM
- FM Stereo/RDS
- DAB/DAB+
- ISDB-T_{SB}
- HD Radio
- XM

Technology Introduction: Standard Overview (1)

Tech	Standards	Channel coding	Mapping	Modulation
Cable	DVB-C, J.83 A/B/C	RS coding	16QAM, 32QAM, 64QAM, 128QAM, 256QAM	Single carrier
Terrestrial	DVB-T	RS+convolutional coding	QPSK, 16QAM 64QAM	OFDM (6,7,8MHz)
	ISDB-T	RS+convolutional coding	DQPSK, QPSK, 16QAM, 64QAM	OFDM (6MHz)
	DTMB	RS+LDPC	QPSK, 16QAM, 32QAM, 64QAM	Single carrier or TDS-OFDM (2/8 MHz)
	ATSC	RS+convolutional coding	8VSB, 16VSB	Single carrier
Satellite	DVB-S	RS+convolutional coding	QPSK	Single carrier
	DVB-S2	RS+LDPC	QPSK, 8PSK, 16APSK, 32APSK	Single carrier

Technology Introduction: Standard Overview (2)

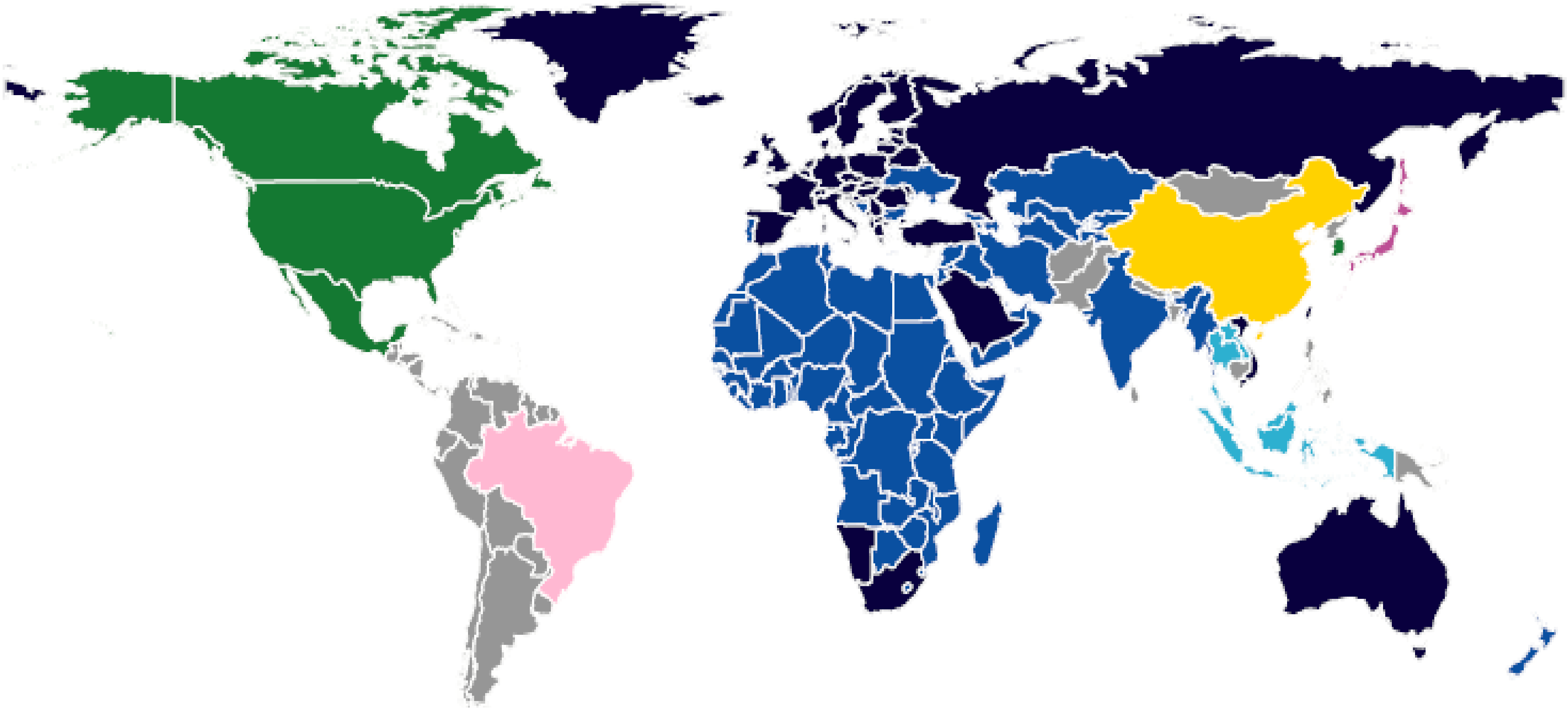
Tech	Standards	Channel coding	Mapping	Modulation
Mobile Video	DVB-H	RS+convolutional coding	QPSK, 16QAM, 64QAM	OFDM (5MHz, 6MHz, 7MHz, 8MHz)
	ISDB-T 1-Seg	RS+convolutional coding	DQPSK, QPSK, 16QPSK, 64QPSK	OFDM (430kHz)
	MediaFLO	RS+Turbo coding	QPSK, 16QPSK, 64QPSK, layered modulation	OFDM (6MHz)
	CMMB	RS+LDPC	BPSK, QPSK, 16QPSK	OFDM (2/8 MHz)
	TMMB	RS+convolutional coding	QPSK	OFDM (1.5MHz)
	T-DMB	RS+convolutional coding	D-QPSK	OFDM (1.5MHz)
	S-DMB	RS+convolutional coding	QPSK	CDM (25MHz)
	DVB-SH	Turbo coding	QPSK, 16QAM	OFDM (1.7MHz, 5MHz, 6MHz, 7MHz, 8MHz)
	ATSC-Mobile	RS+convolutional coding	8VSB, 16VSB	Single carrier

Agilent Technologies

Digital Video Standards by Regions

	Mobile	Terrestrial	Satellite	Cable
Europe Asia	DVB-H, DAB, DVB-SH	DVB-T/T2	DVB-S/S2	DVB-C
China	T-MMB (CMMB and DAB)	DTMB	DVB-S/ ABS-S	DVB-C
Korea	T/S-DMB	ATSC		
Japan	ISDBT 1seg	ISDB-T	ISDB-S	J.83 Annex C
U.S.	MediaFLO	ATSC	Mixed (note)	J.83 Annex B

Digital Terrestrial TV – World Map



- **DVB-T Adopted and On-Air** – Either full commercial services or trial broadcasts
- **DVB-T Adopted or RRC'06* Participant** – No services yet
- **DVB-T Trial Broadcasts**
- **ATSC Adopted** – and services on air
- **ISDB-T Adopted** – and services on air
- **SBTVD-T Adopted** – Based on ISDB-T - Brazilian system
- **DMB-T/H Announced** – Commercial DVB-T services on air

*RRC'06 created a frequency plan for an all-digital environment based exclusively on DVB-T

New Standards on the horizon

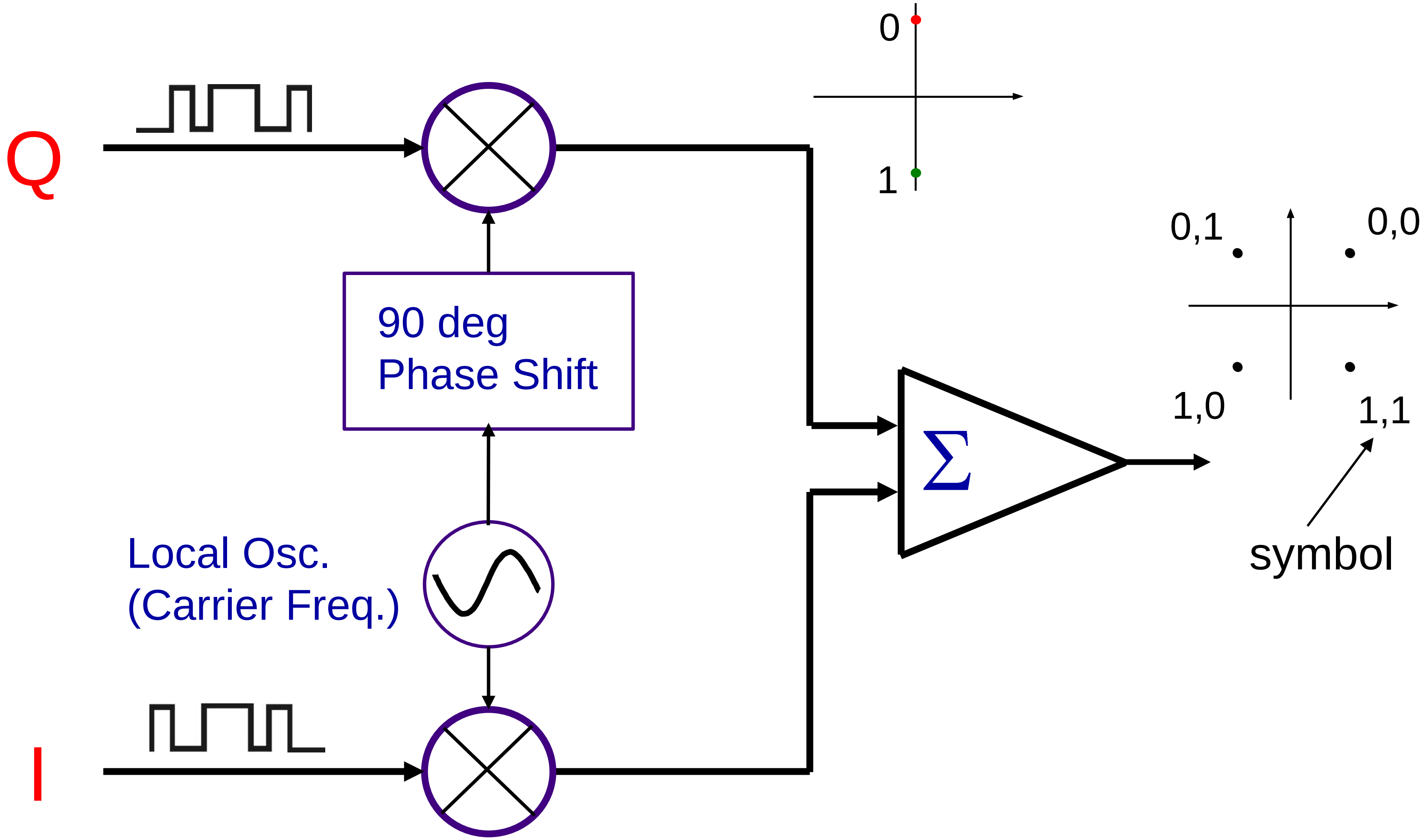
- **DVB-T2**
  - >+30% better than DVB-T
  - Modes up to 256 QAM and FFT Size from 1k to 32K with rotated constellation
  - Standard has been finalized June 2008
  - Modulator and chipset are ready now
  - First deployment may happen in UK by BBC

- **DVB-C2**
  - Increase in capacity at least 30%, support of different input protocols, and improved error performance
  - Modulation will be OFDM or single carrier QAM
  - Modulation Schemes will be 16 to 4096 QAM
  - Standard is likely to be finalized in early 2009
  - Trial or deployment may happen as early as 2010

Digital Satellite TV

- Channel characteristics
  - High bandwidth
  - Low signal-to-noise ratio, strong interference
  - High power needed
- Robust modulation scheme required: QPSK
- Robust channel coding: RS or LDPC + Convolutional
- Standard examples: DVB-S/**S2**, ABS-S
  - DVB-S: QPSK modulated system in Europe
  - **DVB-S2**: new satellite system based on 8PSK/APSK in Europe

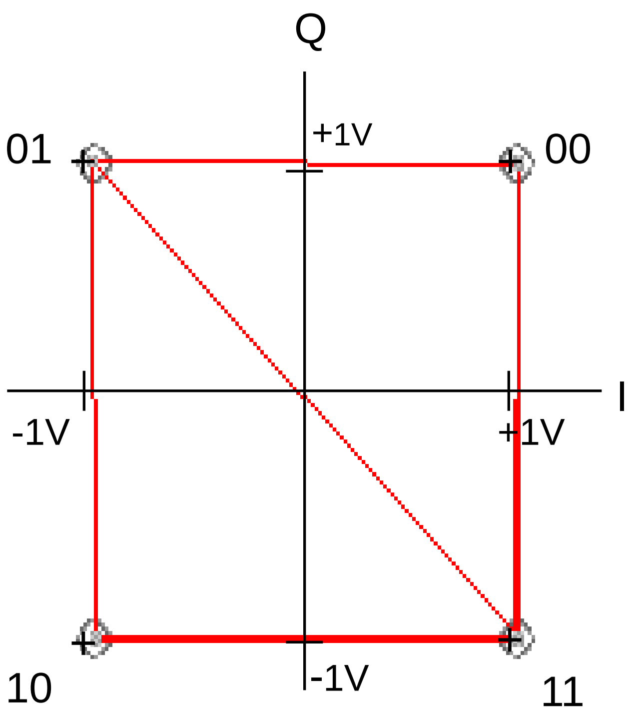
Example: QPSK Modulator



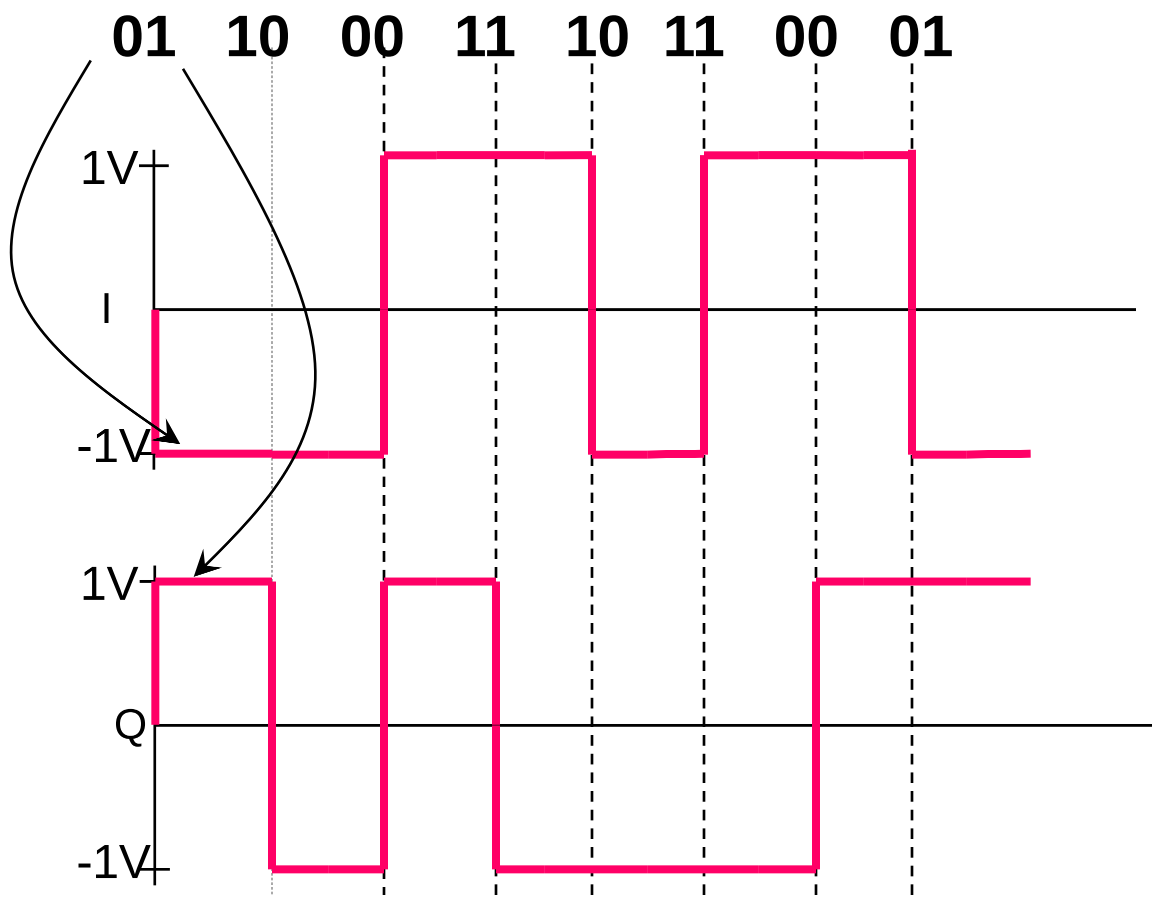
Because of quadrature (90 deg) mixing, I and Q are orthogonal to each other and do not interact

Example of a Digital Bit Stream

QPSK Example

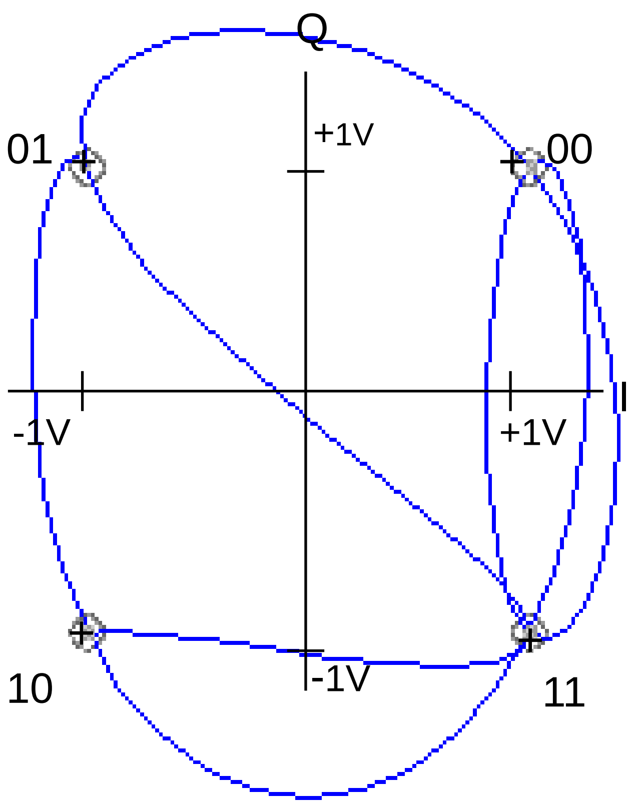


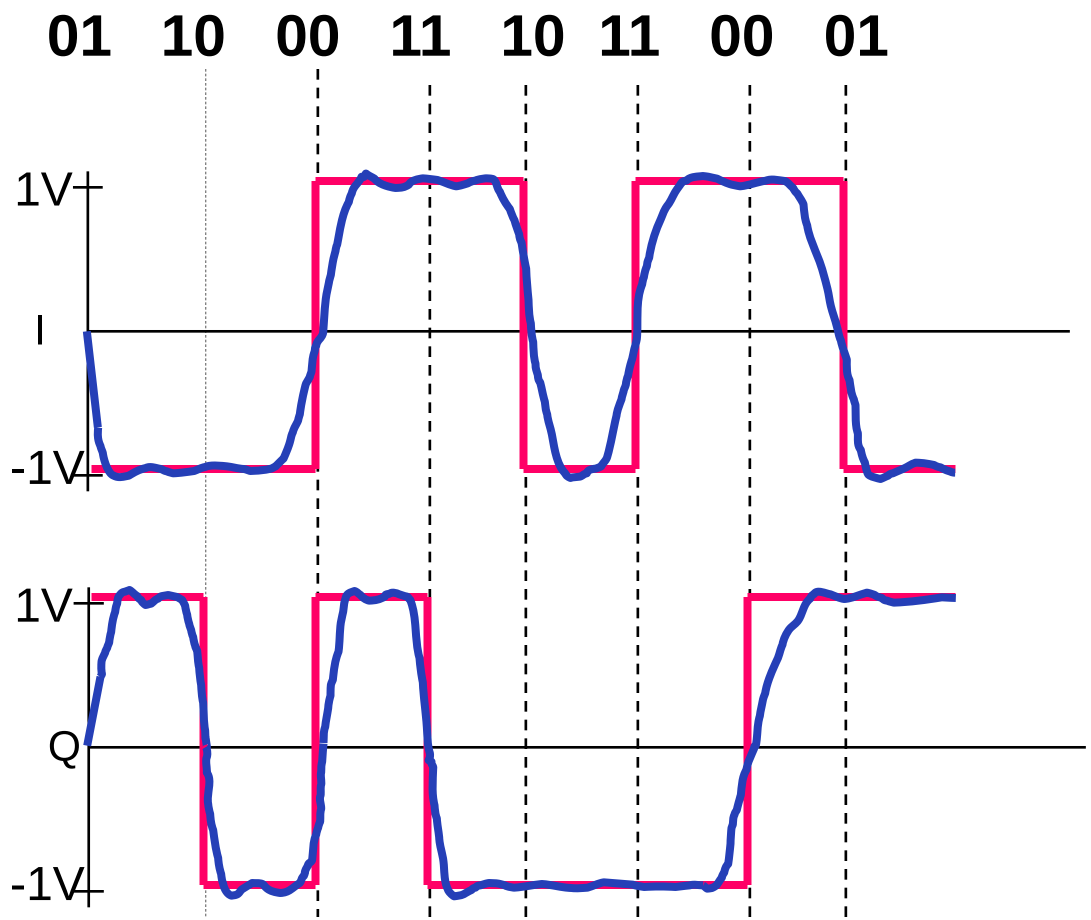
SERIAL DATA TO BE TRANSMITTED



RF Engineer's Version of a Digital Signal

Filtered I & Q Voltages





Why Use I & Q?

Designed for Shipping bits at Radio Frequencies

- Good Interface with Digital Signals and Circuits
- Can be Implemented with Simple Circuits
- Can be Modified for Bandwidth Efficiency
- Effectively doubles (or more) the data rate within the same bandwidth
- Modulation Format dependent on Firmware

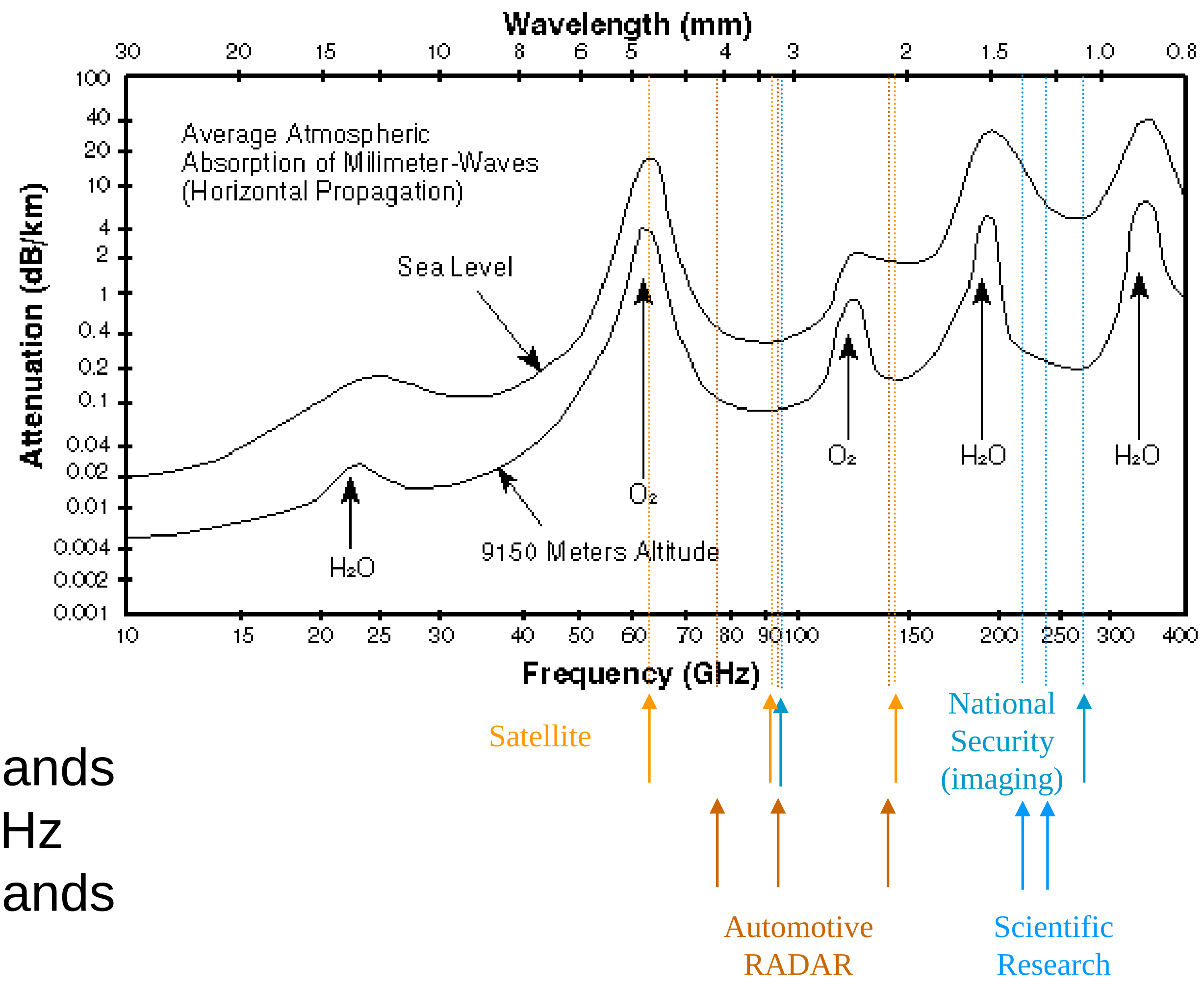
Rain Scattering

- Scattering of Microwaves by rain is very important above 10 GHz
- The rain droplets size becomes appreciable in comparison to wavelength
- These droplets cause scattering of microwave energy .
- The main effect of scattering is heavy attenuation in the path
- The loss of horizontally polarized wave is higher than that for vertically polarized
- Rain drops can also cause depolarization of microwave beam
- Scattering and depolarization occur simultaneously, so effect is not additive.

mmWaves' Atmospheric Windows

Millimeter waves (30-300 GHz) have unique transmission channel characteristics of great interest for:

- Communications
- Transportation
- Scientific Research
- National Security



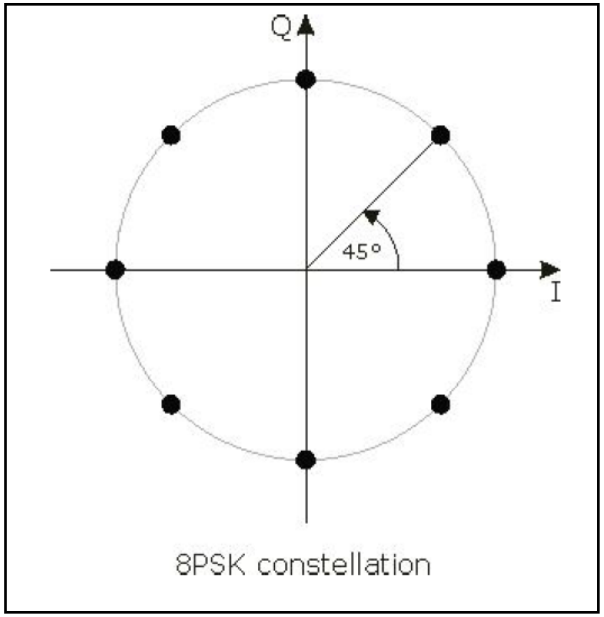
Minimum attenuation bands

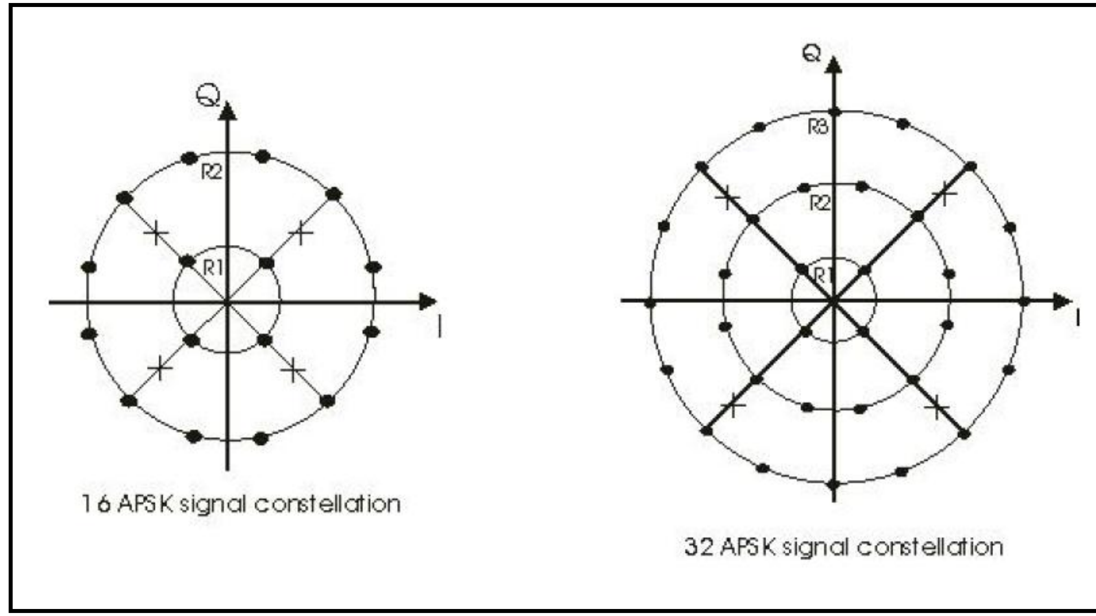
35, 94, 140, 220 GHz

Maximum absorption bands

60, 120, 182 GHz

DVB-S2 modulation schemes

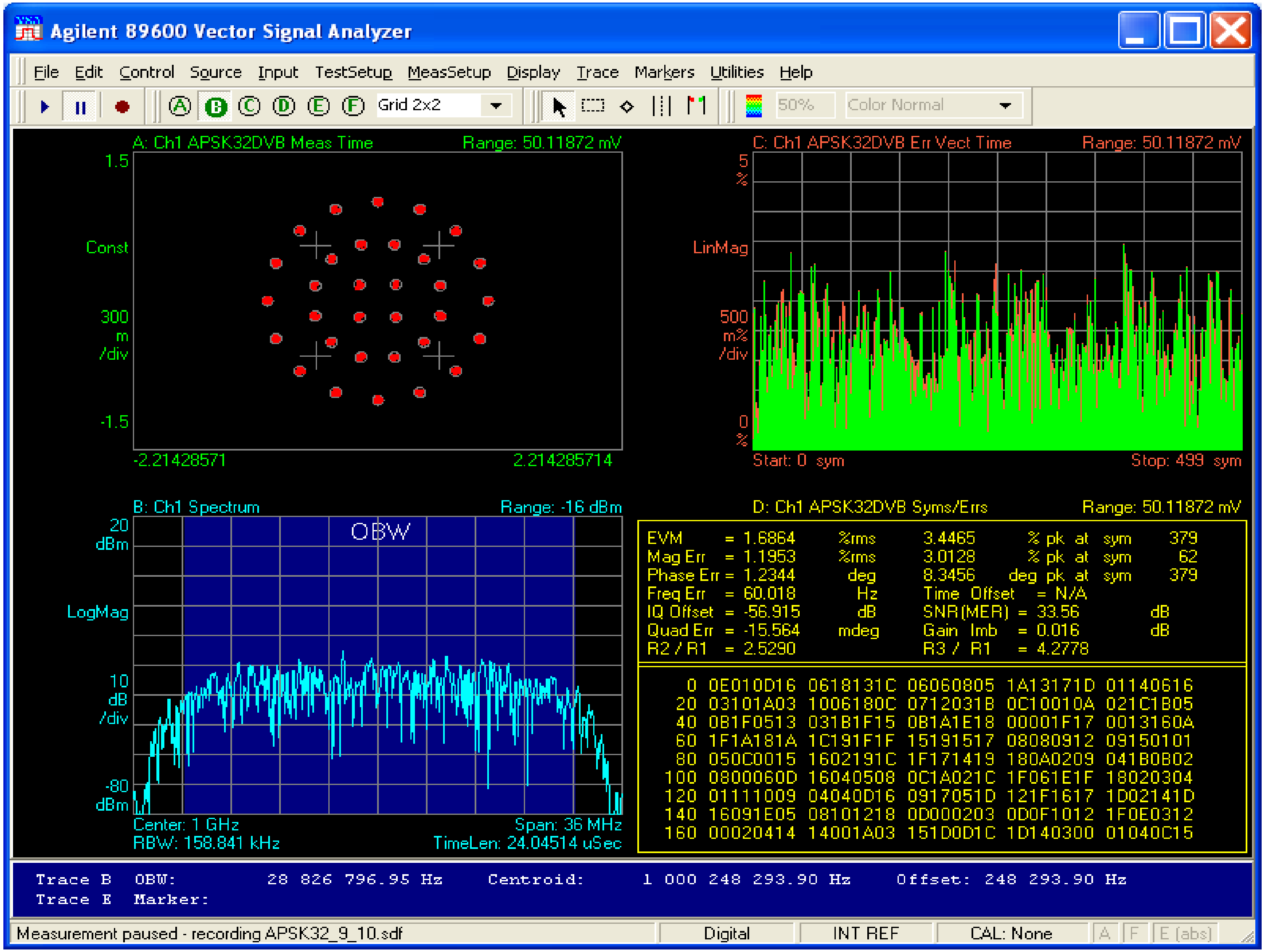




Amplitude and Phase-Shift Keying or Asymmetric Phase-Shift Keying, (APSK), is a digital modulation scheme that conveys data by changing, or modulating, both the amplitude and the phase of a reference signal (the carrier wave).

The advantage over conventional QAM, for example 16-QAM, is lower number of possible amplitude levels, resulting in less problems with non-linear amplifiers

32 APSK DVB-S2 signal



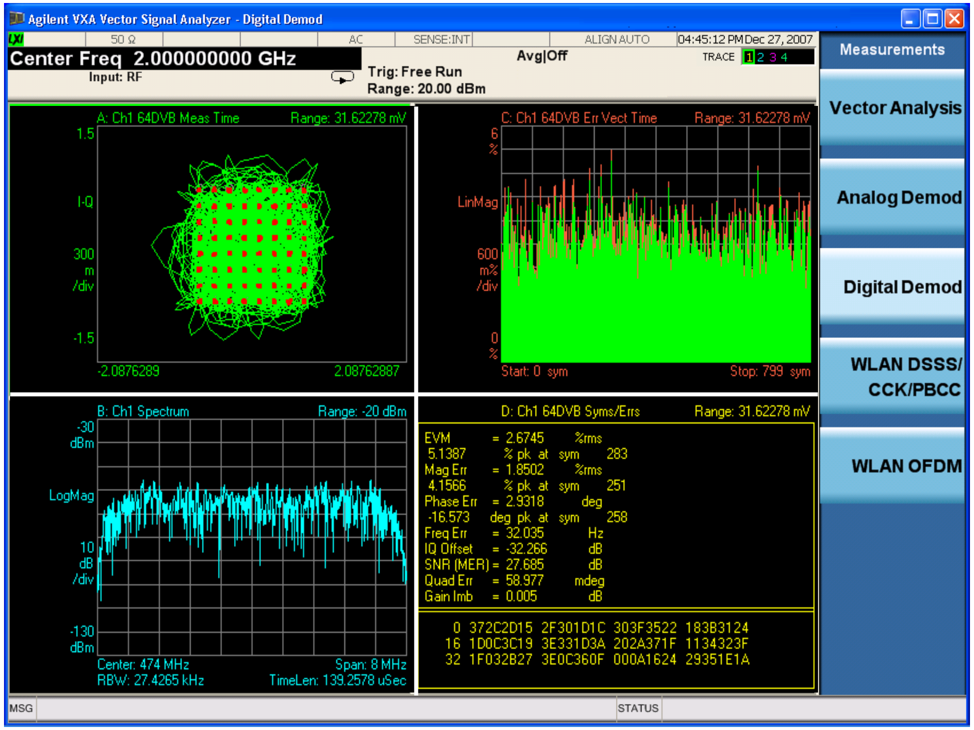
89601X VXA Modulation Analysis Application

for DVB-C/S/S2, J.83 Annex A/B/C, ATSC 8/16VSB

- MXA/EXA measurement app with manual UI and SCPI control
- Modulation analysis for QAM and VSB based digital video standards
- Standard preset for DVBQAM 16/32/64/128/256, APSK 16/32, VSB 8/16
- Built-in adaptive equalizer

Modulation Analysis Results:

- EVM rms, peak
- SNR (MER)
- Mag Error rms, peak
- Phase Error rms, peak
- Freq Error
- IQ offset, Quad Error, Gain Imb



Note: R&D customers could also choose 89601A PC SW for more features and flexibilities like recording/playback, source control, macros etc.

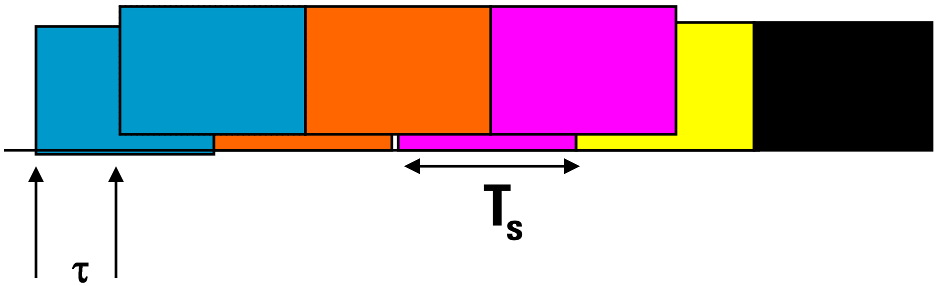
Live demo!

Channel delay spread and bit rate
From Single carrier to OFDM

τ is the delay spread for the propagation channel

T_s is the symbol period for the transmission

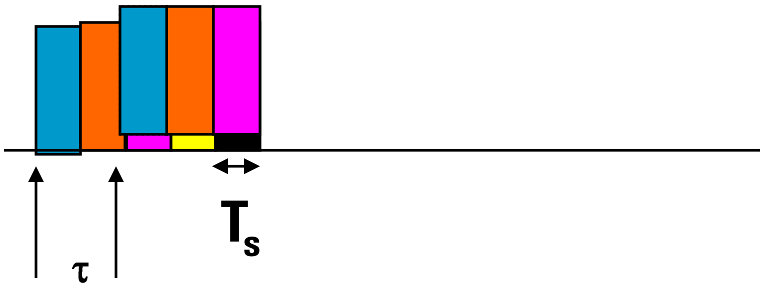
A)



$\tau < T_s$

Reception Ok, with equalization

B)



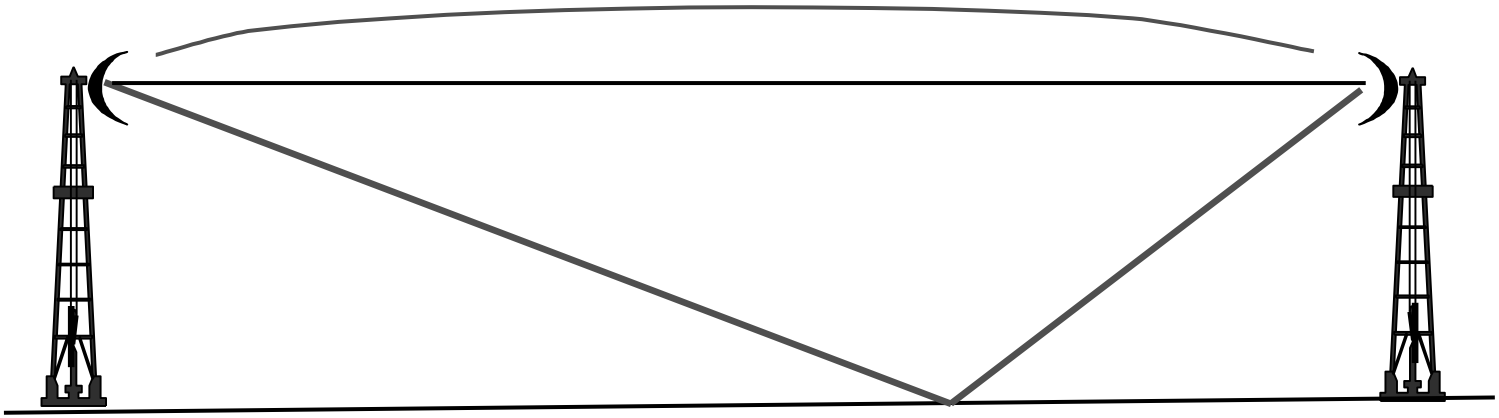
$\tau > T_s$

Reception is Distorted, NOT recoverable

High bit-rate streams are sensitive to irreducible distortion due to multipath

Frequency Selective Fading

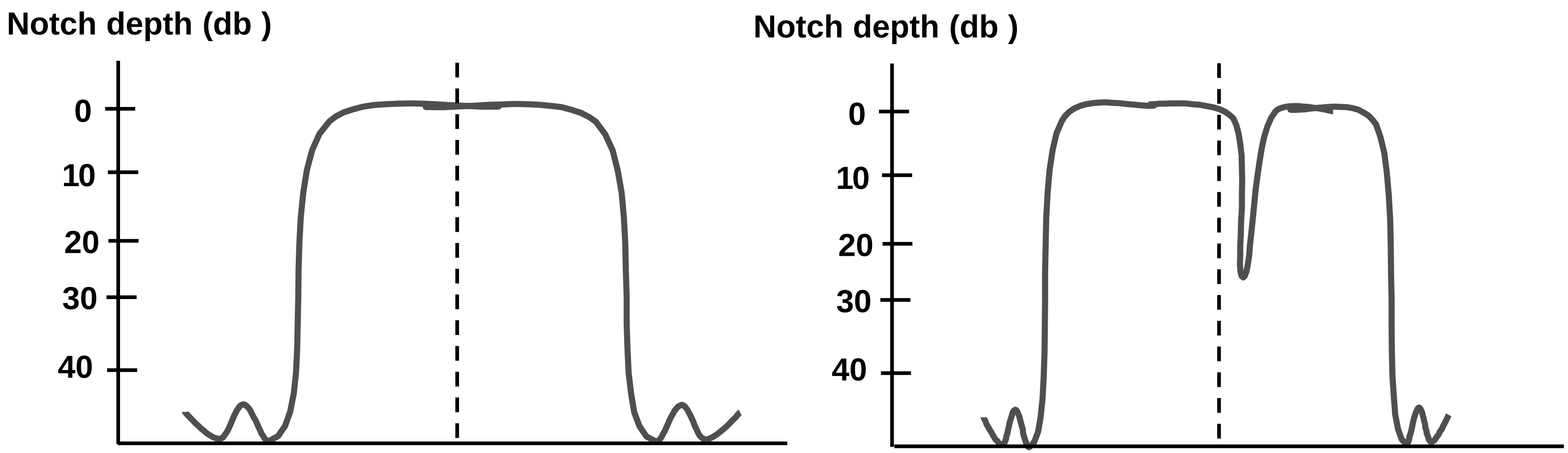
- Interaction of multipath signals result into frequency selective fading
- Digital Microwave Radio has large spectrum bandwidth
- During multipath, signals with different amplitude and phase arrive at the receive antenna
- Multipaths can be formed by atmosphere, terrain reflection and diffraction



Agilent Technologies

Frequency Selective Fading

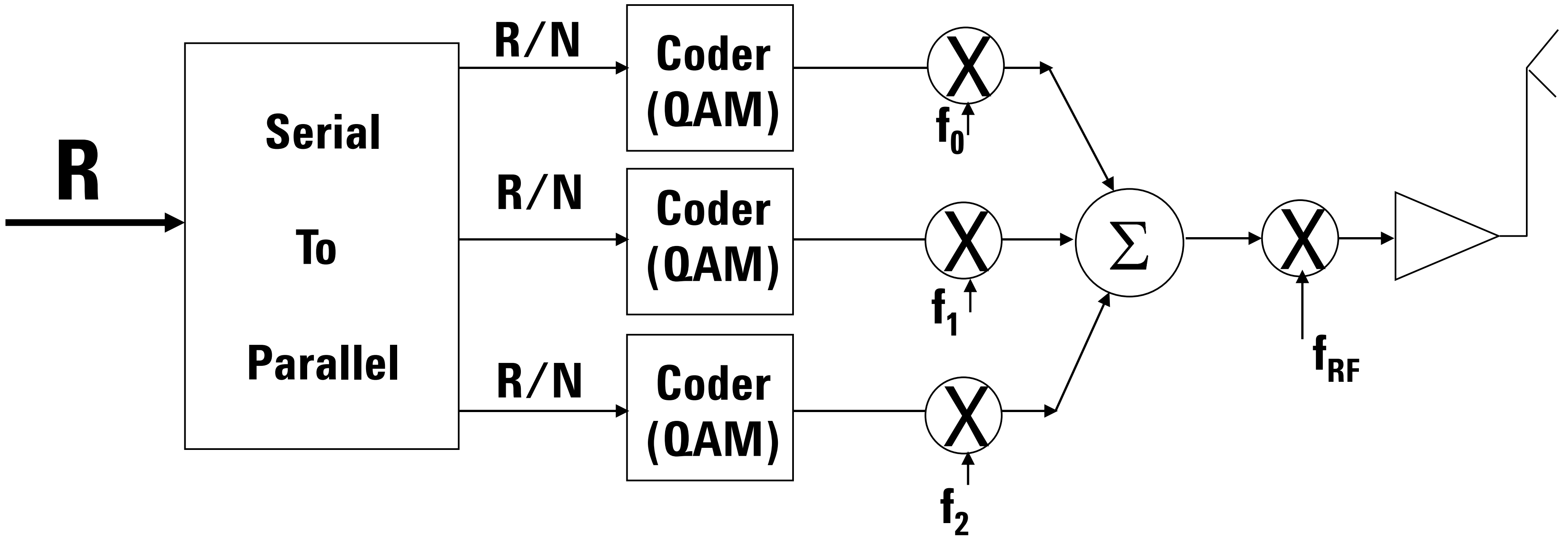
- Depending on phase relationship , signals may add or cancel each others .
- This creates spectral distortions appearing as a "notch" or a slope across the band
- Spectrum will be notched at particular frequency only, depending on delay
- The notch depth will depend on the relative amplitude of reflective wave



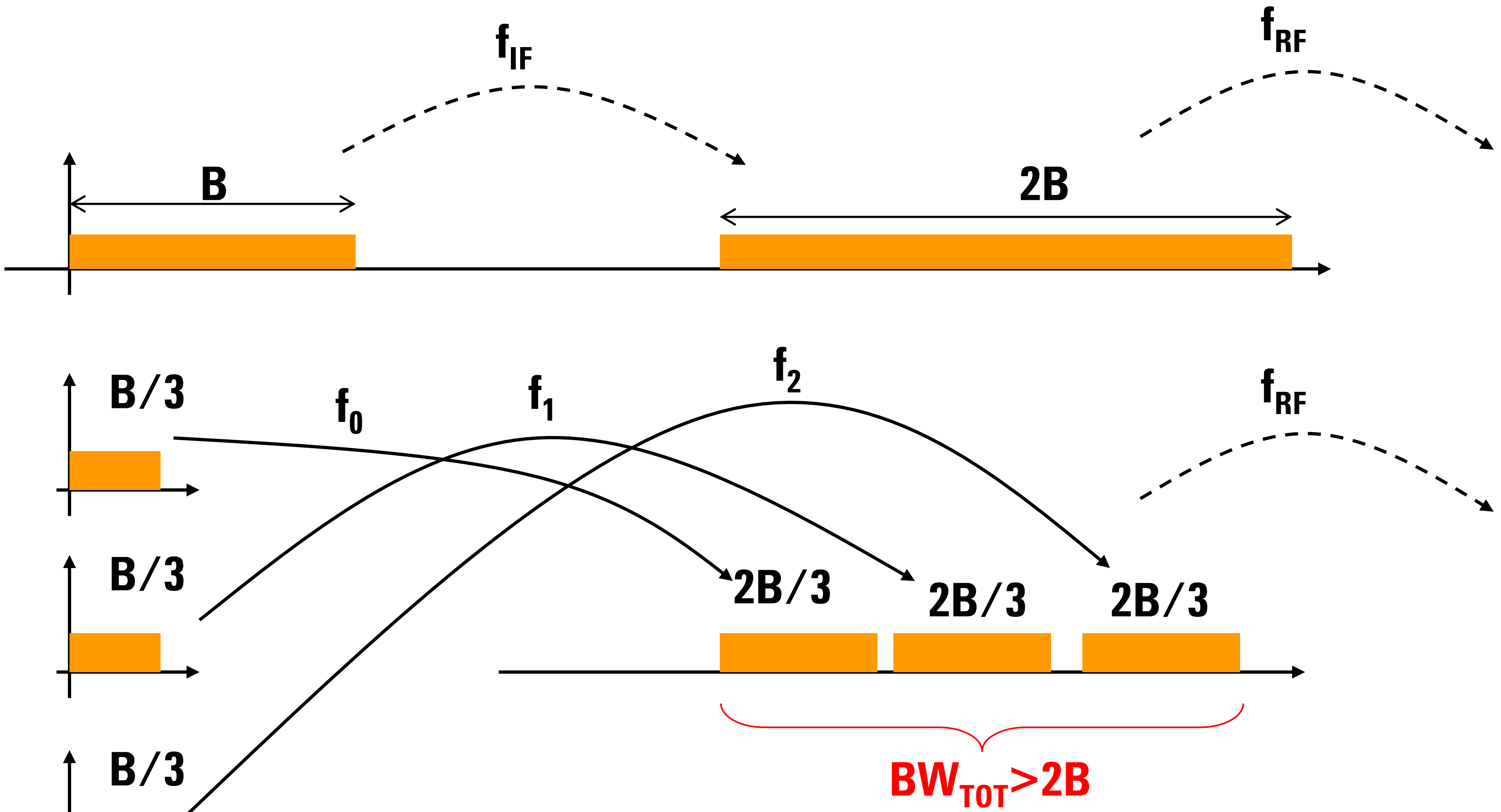
From Single Carrier Modulation (SCM) to Frequency Division Multiplexing (FDM)

A single high-rate information stream modulated on a single carrier is too sensitive to multipath,

IDEA: divide it in multiple lower-rate information streams!



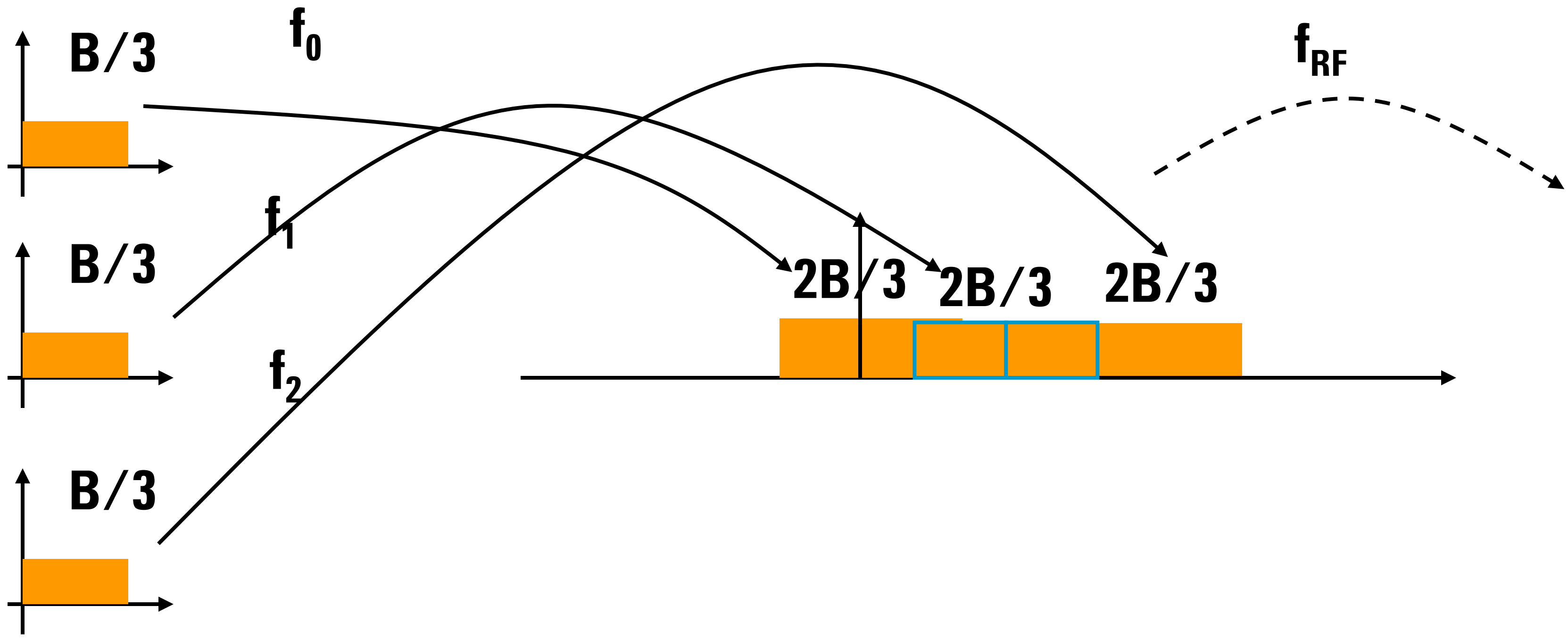
FDM Bandwidth Efficiency Example: N=3



Not very efficient!

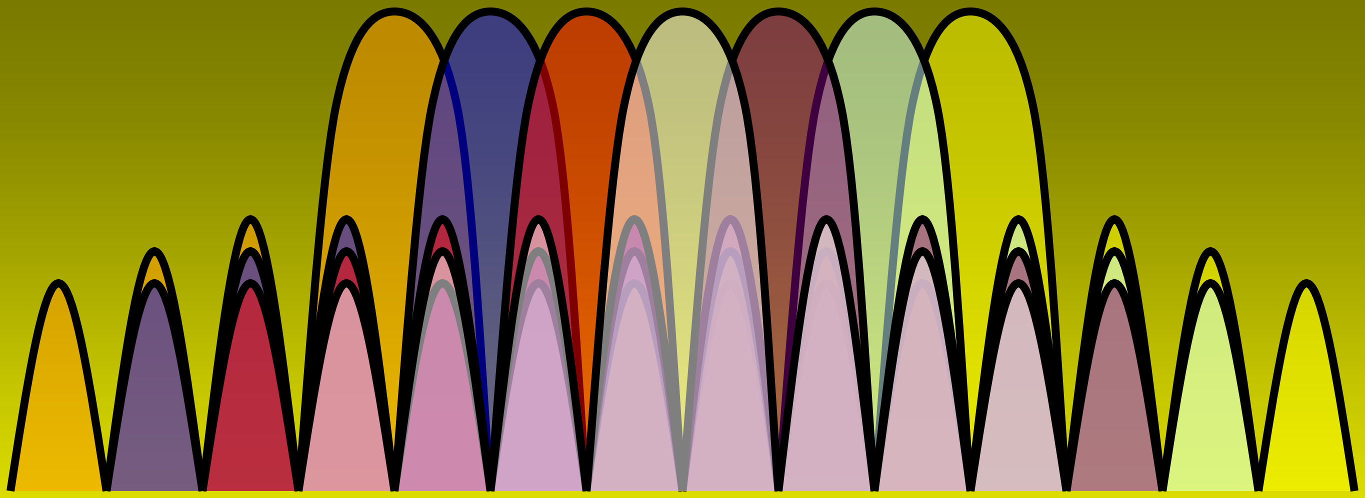
Advance: from FDM to Orthogonal FDM (OFDM)

If the sub-carrier frequencies are chosen from an *orthogonal* set, individual sub-bands can be partially super-imposed,



What does it mean that frequencies are <u>orthogonal</u> ??

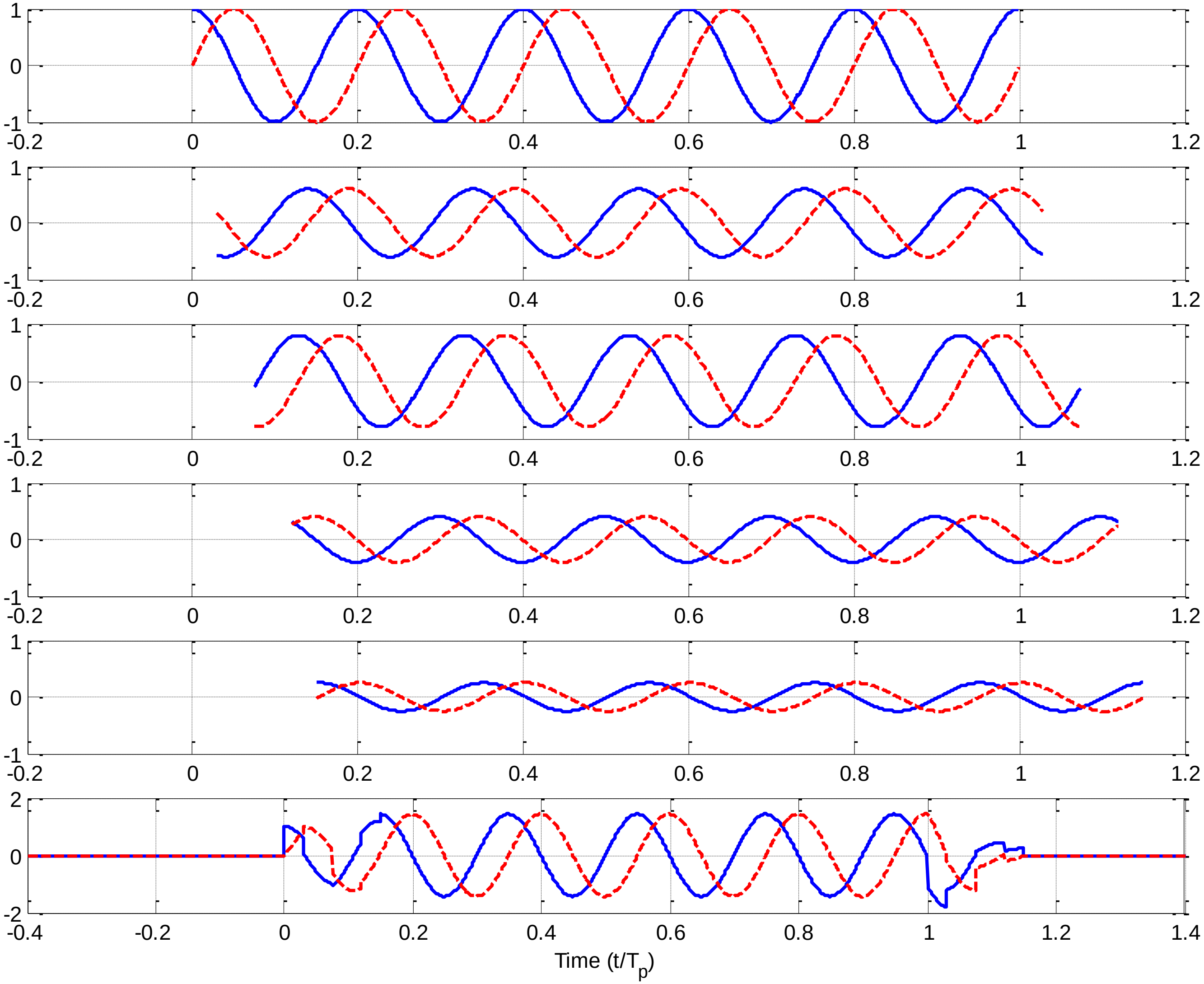
OFDM: Orthogonal Carriers



- Closely spaced carriers overlap
- Nulls in each carrier’s spectrum land at the center of all other carriers for Zero Inter-Carrier Interference

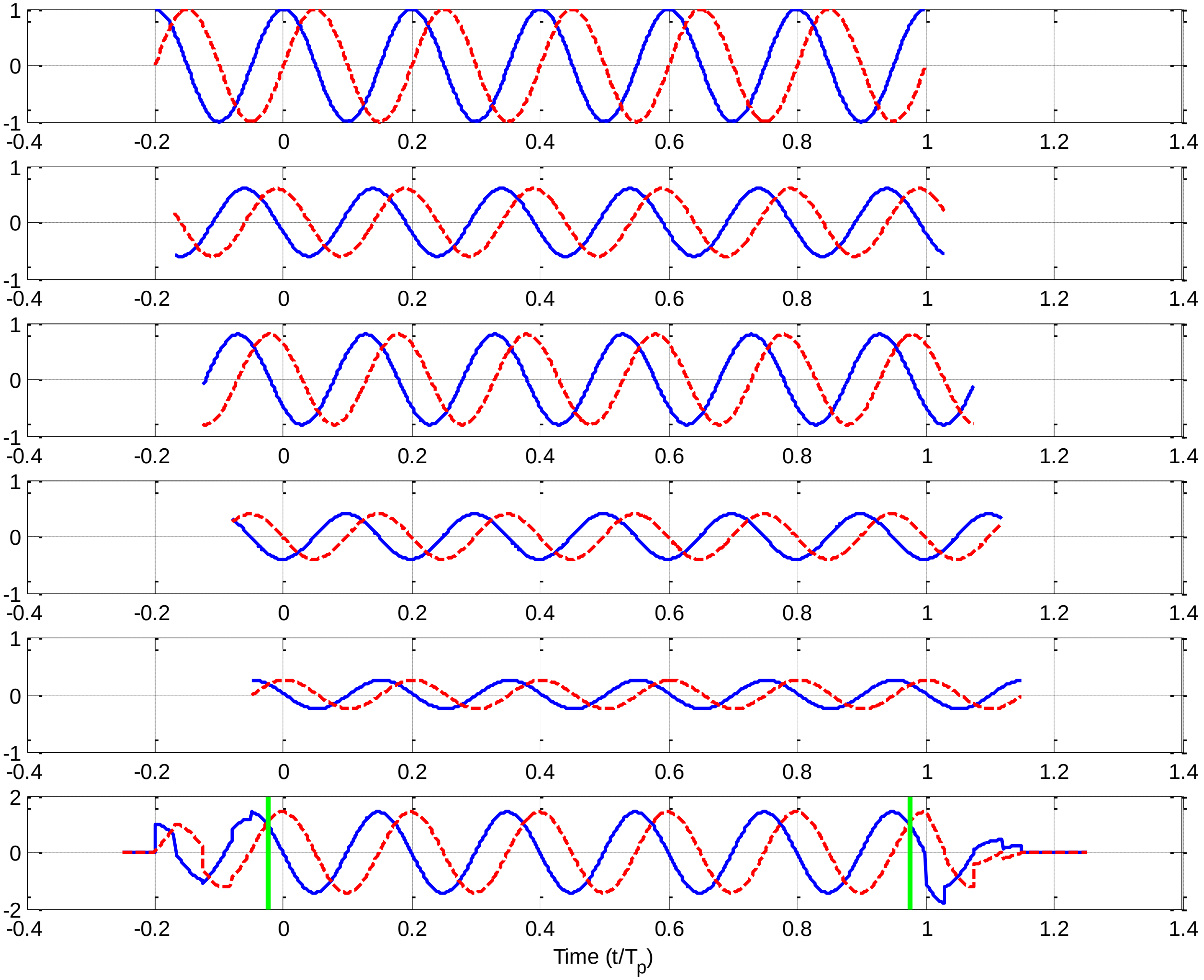
Multipath Effects (cont)

Response of Channel for Carrier at n = 5



Multipath Effects with Cyclic Prefix

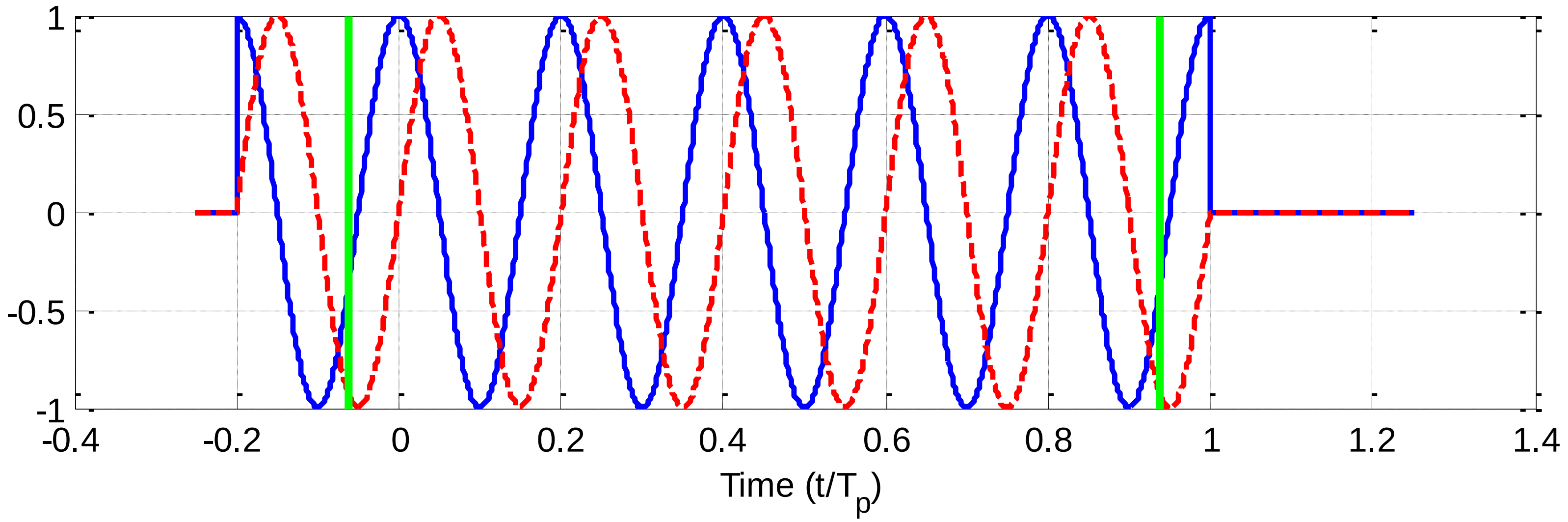
Response of Channel to Carrier at n = 5 with Cyclic Prefix. Note the Clean Tonal Response Between -0.05 and 1.



Cyclic Prefix (CP)

If the sample duration is delayed until the last ray has arrived, and terminated before the first ray ends, the signal is a pure sine wave that is free from inter-symbol interference.

The Cyclic Prefix is the time delay between first arrival and start of sampling.



DVB-T – Key Technologies

- Hierarchical coding
  - Outer code (Reed-Solomon)
  - Inner code (convolutional)
  - Interleaving
    - Outer Byte-wise
    - Inner bit-wise and symbol interleaving
- OFDM Modulation
  - 2K mode – doppler tolerant for short distances
  - 8K mode – longer symbols to minimize ISI over long distances
  - Mapping: QPSK, QAM: 16, 64
- Frame Structure
  - scattered pilot cells
  - continual pilot carriers and TPS (Transmission Parameters Signaling)
- Hierarchical transmission
  - HP/LP bit stream, α = 2, 4

TPS (Transmission Parameter Signaling)

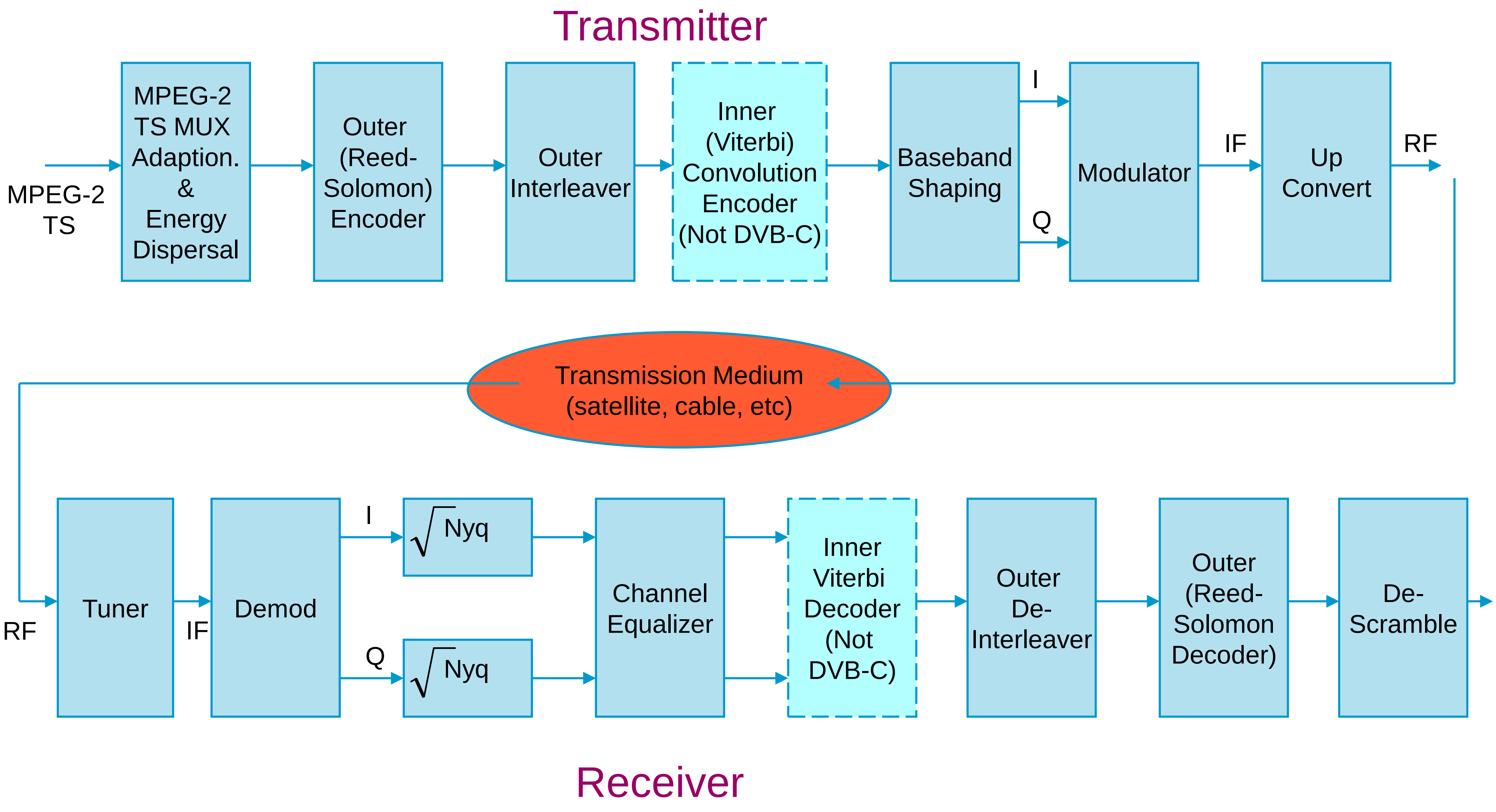
Each TPS block contains 68 bits

- 1 initialization bit;
- 16 synchronization bits
- 37 information bits (channel coding, modulation, guard interval…)
- 12 redundancy bits for error protection

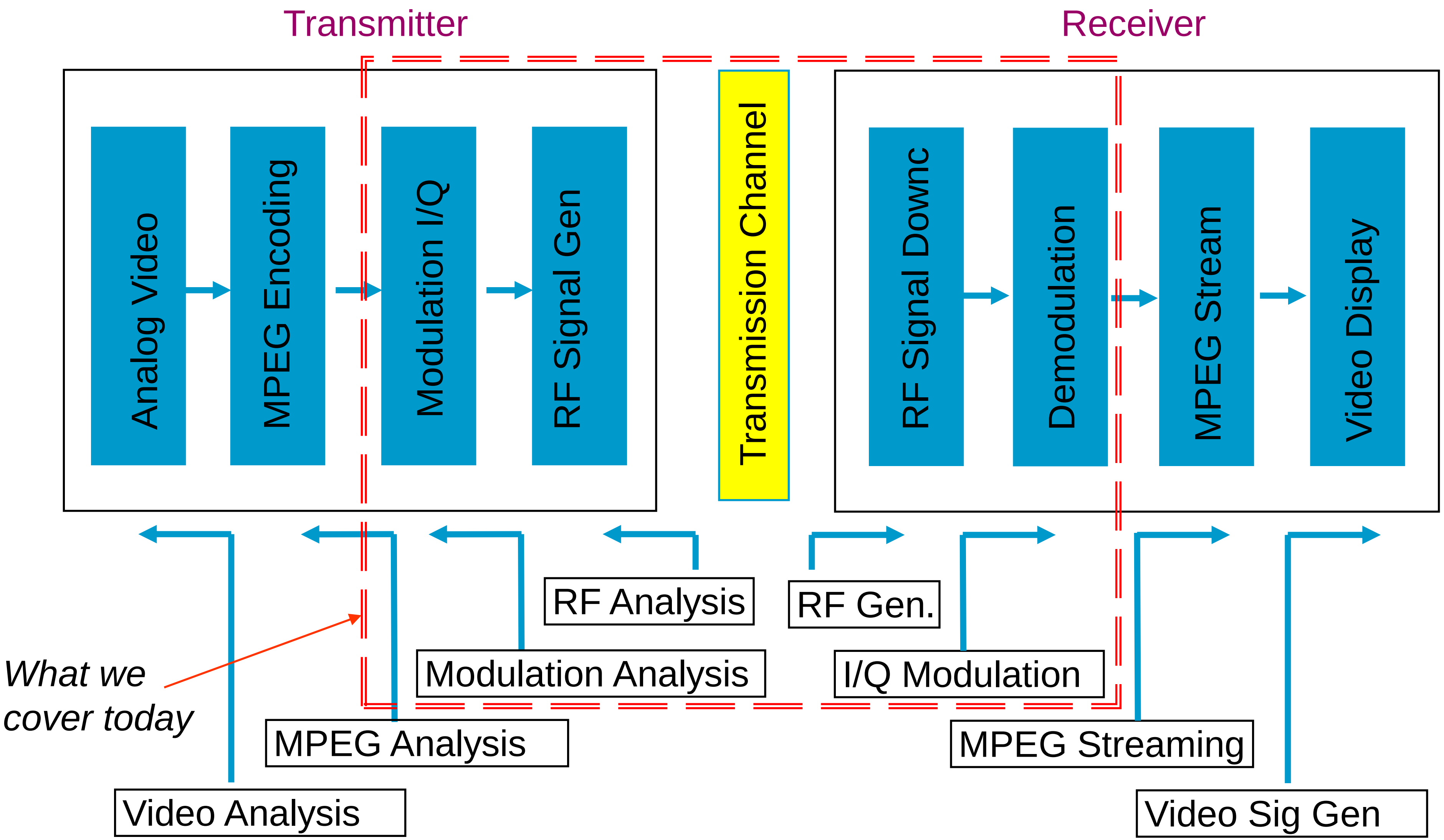
Modulation: DBPSK

Transmitted over 68 consecutive OFDM symbols (a frame), every TPS carrier in the same symbol conveys the same differentially encoded information bit

DVB - Block Diagram



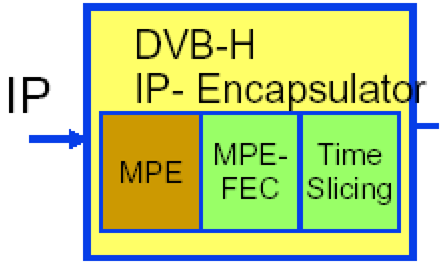
Digital Video Typical Transmission System



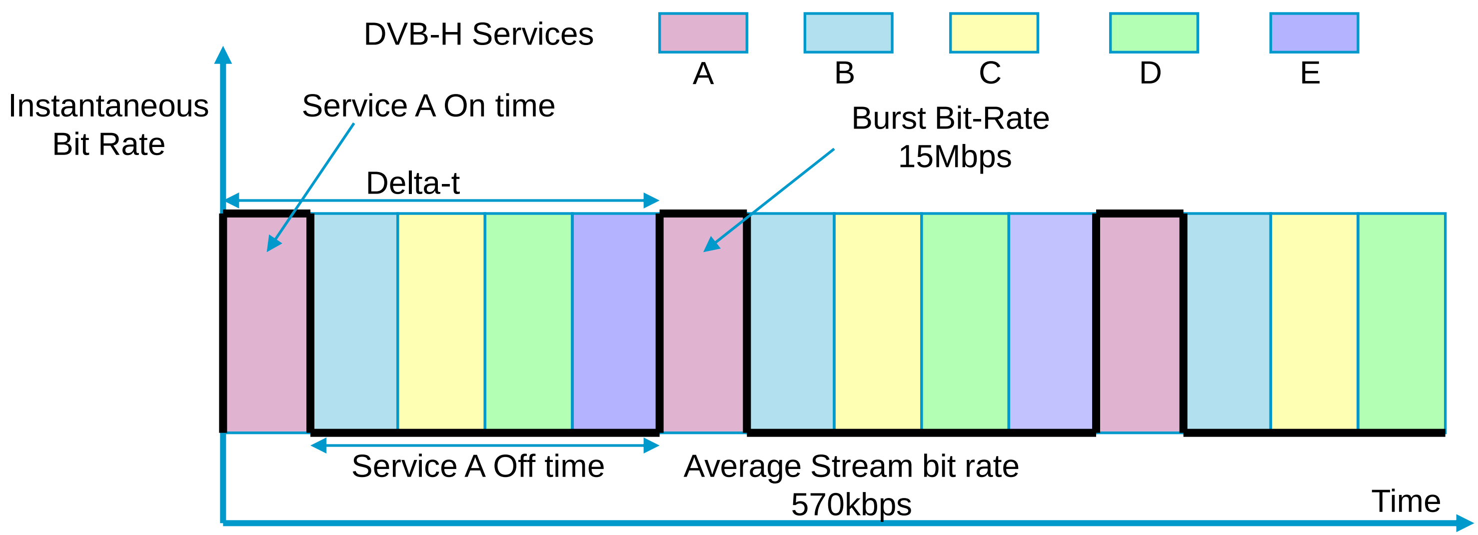
PHY Layer Considerations for Mobile Video

- OFDM Modulation
  - Overcome multipath fading
  - SFN (Single Frequency Network)
- Layered modulation in some systems
  - Base layer for wide coverage with acceptable quality
  - Enhancement layer for enhanced quality
- Strong channel code scheme (outer + inner codes)
  - RS+ LDPC/Convolutional
- Deep interleaving to prevent burst errors (byte and bit-level)
- Variable bandwidth and configurations for different environments and service requirements
- Allocated timeslots (TDM) or group of sub-carriers in freq domain (FDM) to cover multiple TV channels within one physical channel
  - CMMB: TDM
  - MediaFLO: OFDMA+TDM
  - Service multiplexing by time-slicing (DVB-H)

DVB-H – Key Technologies



- Time-slicing for power saving in the Rx
- MPE-FEC for additional robustness and mobility
- 4k mode for mobility and network design flexibility
- In-depth inner interleaving
- Additional minor changes, e.g. signaling
- Supports DVB-T frequencies
  - 6, 7 or 8 MHz BW
  - Also a new 5 MHz channel (L band, USA)



DVB-T Measurements

Transmitter Test

RF Characteristics

•RF frequency accuracy (freq error)

•Occupied bandwidth (OBW)

•LO phase noise

•RF/IF signal power

•Linearity characterization (shoulder attenuation)

•Out-of-band Emissions (SEM)

•Adjacent Channel Power (ACP)

•Peak-to-average power ratio (CCDF)

•Spurious emissions

Modulation Quality Analysis

•EVM/MER, SNR

•I/Q offset, I/Q imbalance, quad error, phase jitter, freq error

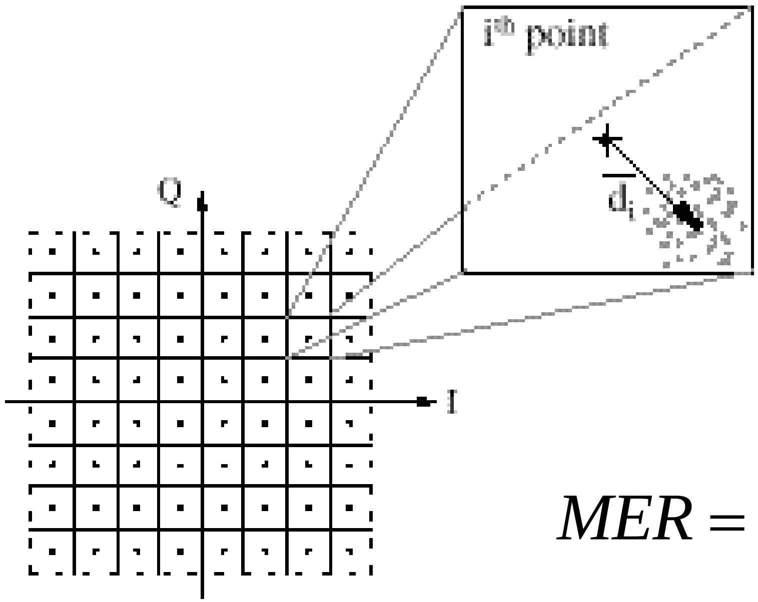
•CH freq response, impulse response (delay profile)

BER Analysis (if needed)

- BER before Viterbi (inner) decoder
- BER before RS (outer) decoder
- BER after RS (outer) decoder (Bit error count)
- Equivalent Noise Degradation (END) and Noise margin

Modulation Error Ratio (MER): Definition

- In constellation diagram which demodulates modulated signal, MER is defined as ratio of signal power value and error power value from Ideal constellation point



Signal power

$$MER = 10 \times \log_{10} \left\{ \frac{\sum_{j=1}^{N} \left(I^2{}_j + Q^2{}_j \right)}{\sum_{j=1}^{N} \left(\delta I^2{}_j + \delta Q^2{}_j \right)} \right\} dB$$

Noise & Residual Error power

Agilent Technologies

Modulation Error Ratio (MER): Definition

Broadcast Industry

$$MER = 10 \times \log_{10} \left\{ \frac{\sum_{j=1}^{N} \left(I_j^2 + Q_j^2 \right)}{\sum_{j=1}^{N} \left(\delta I_j^2 + \delta Q_j^2 \right)} \right\} dB$$

$$EVM_{RMS} = \sqrt{\frac{\frac{1}{N} \sum_{j=1}^{N} \left(\delta I_j^2 + \delta Q_j^2 \right)}{S_{\max}^2}} \times 100\%$$

Where *I* and *Q* are the ideal co-ordinates, δ_I and δ_Q are the errors in the received data points. Smax is the magnitude of the vector to the outermost state of the constellation.

$$EVM_V = \frac{1}{MER_V \times V}$$

where V is the peak to mean ratio PAPR

Wireless Industry

$$\text{EVM} = \frac{\text{RMS}(\mathbf{E})}{\text{RMS}(\mathbf{R}')} \text{ x } 100\%$$

(here, EVM is relative and expressed in %)

E = Z' – R'

where:

Z' - the signal under test

R' - the reference signal

Agilent Technologies

N6153A DVB-T/H Measurement Application

- PXA/MXA/EXA measurement app with manual UI and SCPI control
- DVB-T/H standard based power measurements and modulation analysis

Measurements:

Channel Power (Shoulder Attenuation, Spectrum Mask with adjacent analog TV)

Spectrum Emission Mask

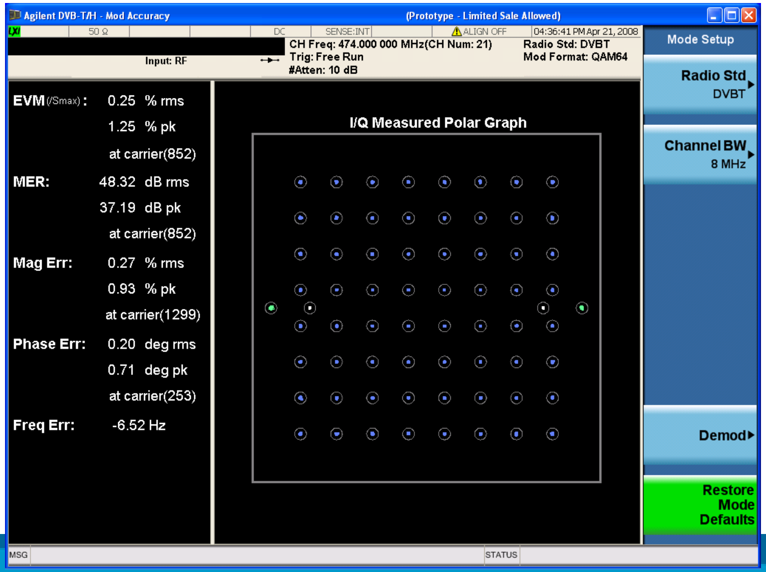
ACP, CCDF, Spurious Emissions

Modulation Accuracy

- Constellation, MER/EVM
- TPS decoding
- Frequency Error, Mag Error, Phase Error
- Quadrature Error, Amplitude Imbalance, Carrier Suppression, Phase Jitter
- BER before Viterbi, before RS, after RS
- Channel Frequency Response
- Channel Impulse Response

Parameters Setups:

- Radio Std: DVB-T and DVB-H
- Bandwidth: 5/6/7/8 MHz
- Auto Detection
- FFT Size: 2K/4K/8K
- Modulation: QPSK/16QAM/64QAM
- RF Input or Analog IQ Input (MXA with BBA option)



Out-of-band Emissions Test Challenge

- The DVB-T/H standard define out-of-band emissions in several cases, including analog TV case, non-critical and critical cases.

- All of those three cases requires high dynamic range up to 120 dB.

- Spectrum analyzer doesn't support 120 dB dynamic range, so we have to consider a work around method.

- A possible measurement method is using Amplitude Correction, first measure the channel filter frequency response then compensate the SEM measurement trace with amplitude correction, which can achieve more than 120 dB dynamic range.

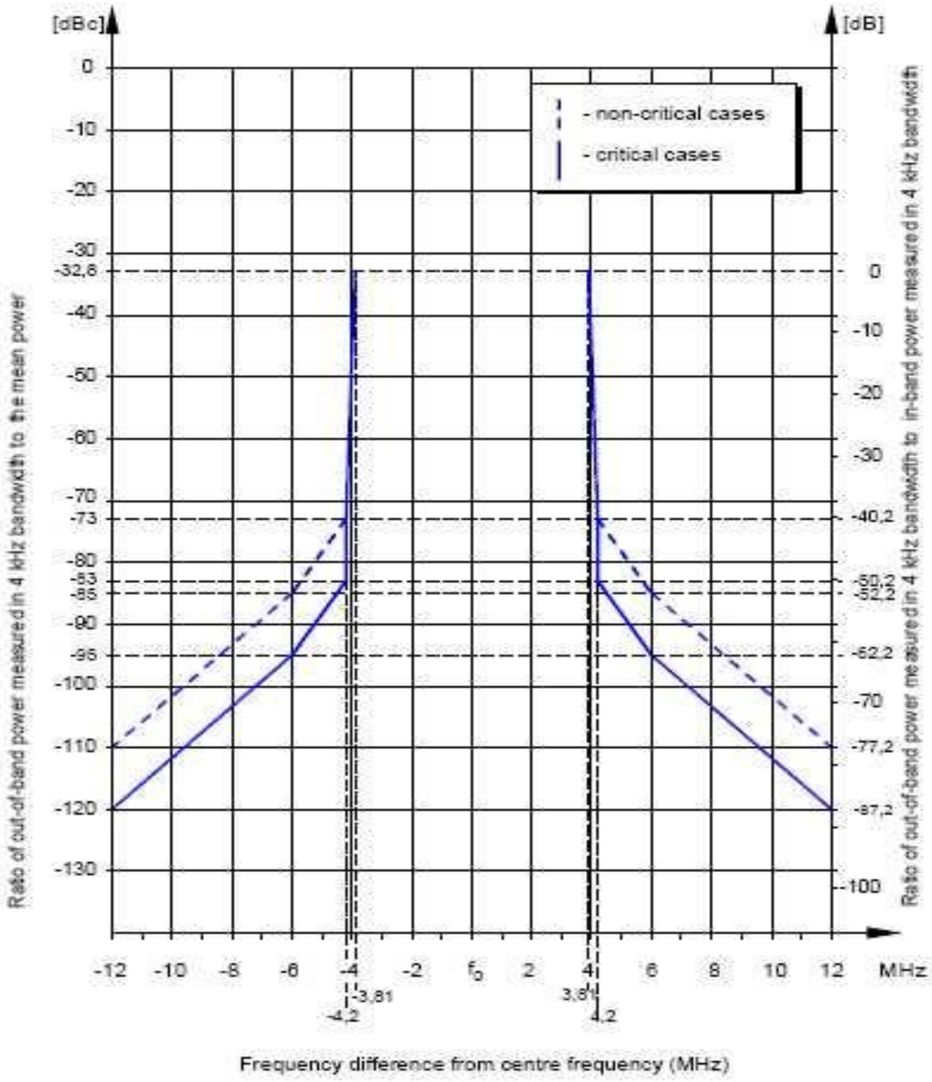
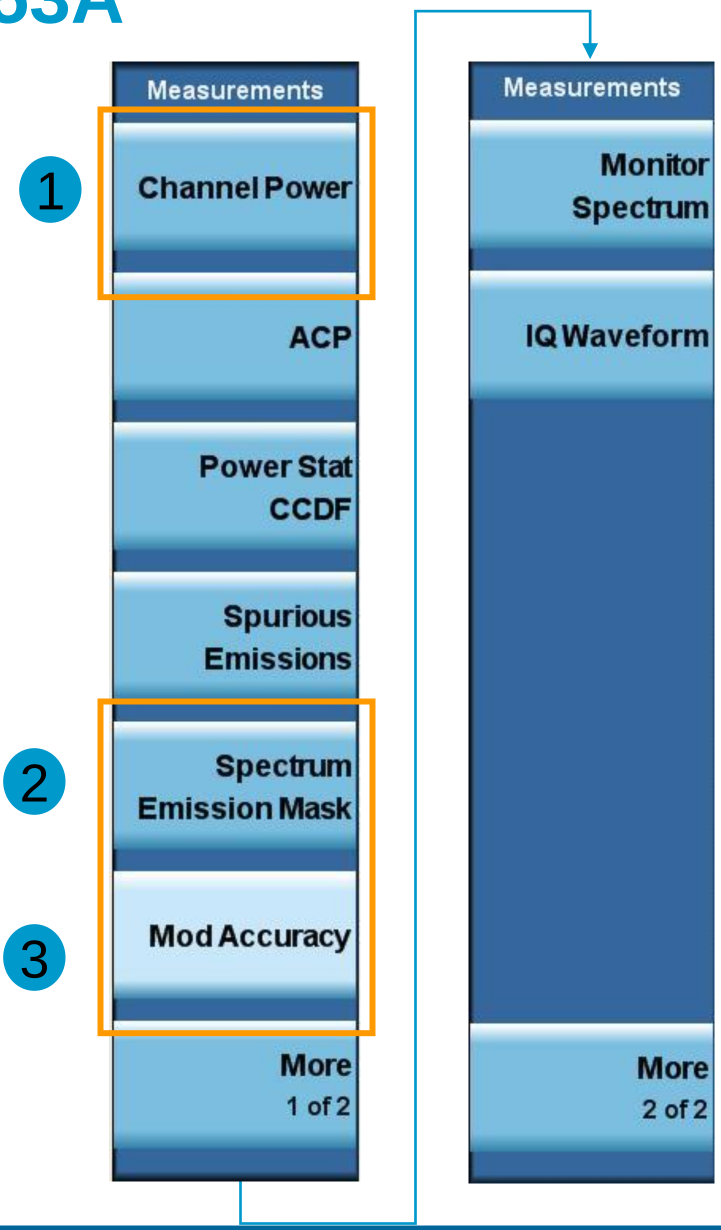


Figure 4.4: Out-of-band limits for DVB-T transmitters ≥ 25 W in 8 MHz channels

Measurement Summary for N6153A

1. <u>Power measurements:</u>
   - **Channel Power (Shoulder Attenuation, Spectrum Mask with adjacent analog TV)**
   - **Spectrum Emission Mask**
   - ACP, CCDF, Spurious Emissions
   - Monitoring Spectrum, I/Q Waveform

2. **<u>Modulation accuracy measurements</u>**:
   - Constellation
   - TPS decoding
   - MER/EVM
   - Frequency Error, Mag Error, Phase Error
   - Quadrature Error, Amplitude Imbalance, Carrier Suppression, Phase Jitter
   - Pre-Viterbi/Pre-RS/Post-RS BER
   - Channel Frequency Response
   - Channel Impulse Response



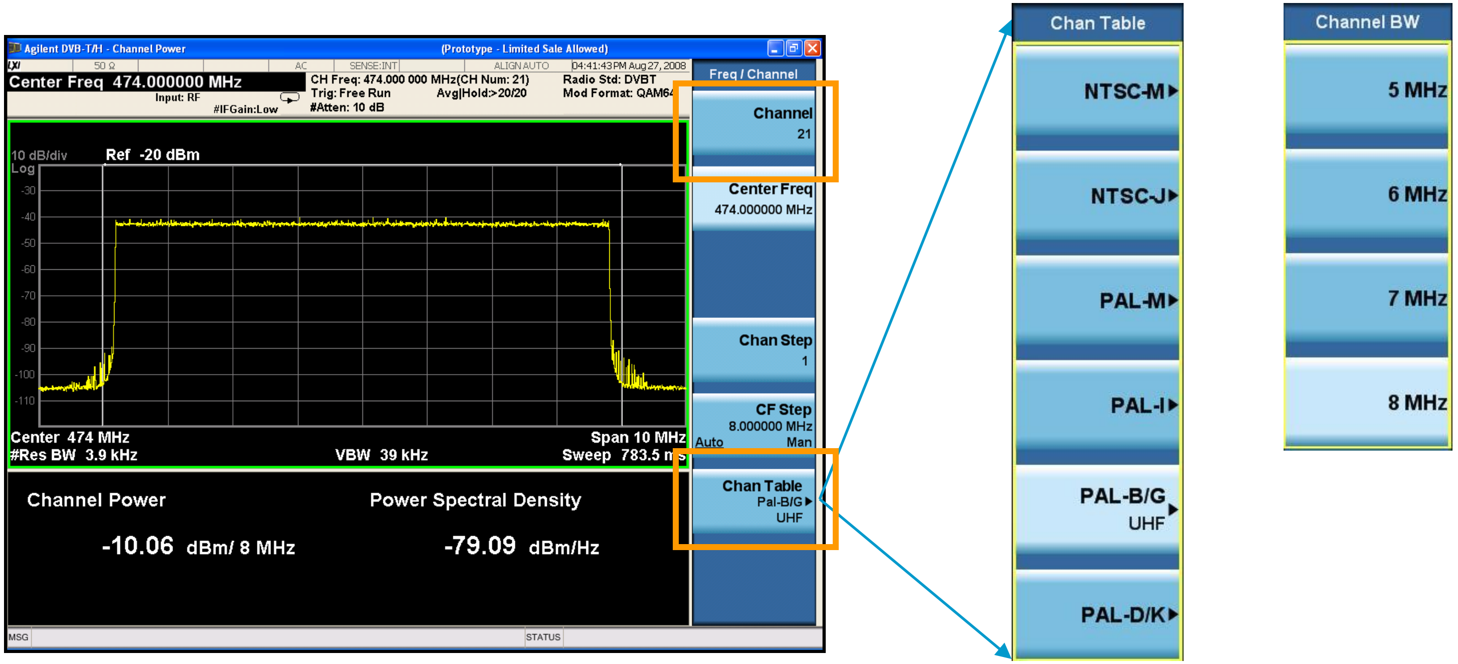
DVB-T/H Applications and Examples

1. Channel Power

– Channel Power can measure and report the integrated power in a defined bandwidth and power spectral density (PSD) displayed in dBm/Hz or dBm/MHz

– Channel Frequency can be configured either by Center Frequency or by Channel Table and Channel Number

– Channel Bandwidth can be chosen from 5/6/7/8 MHz



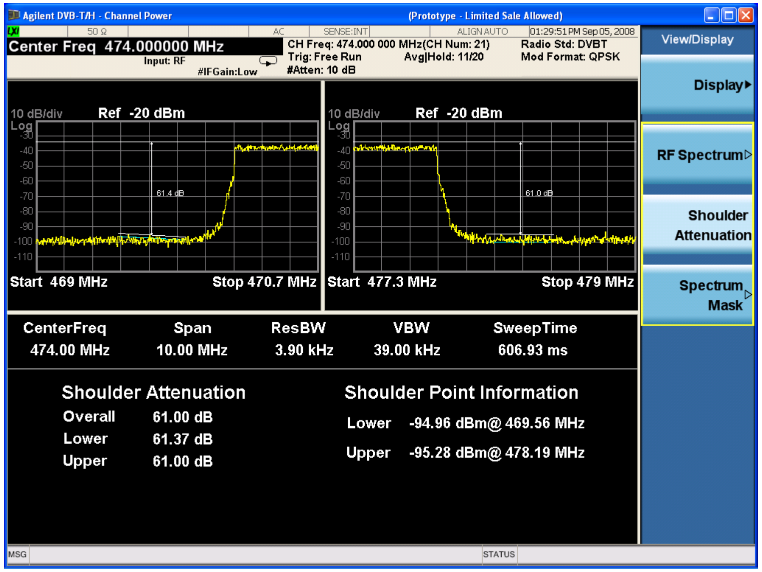
DVB-T/H Applications and Examples

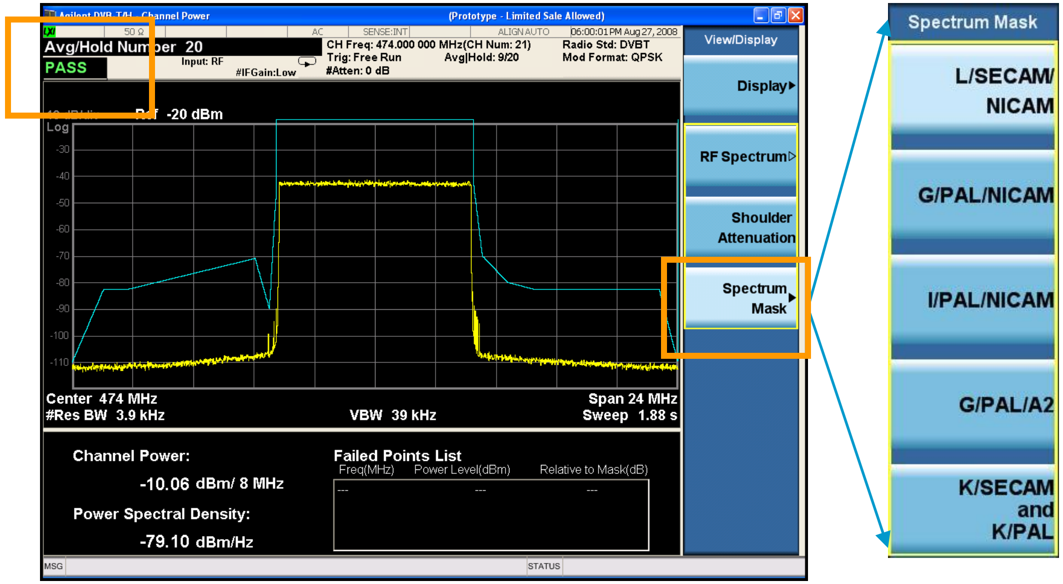
2. Channel Power - Shoulder Attenuation and Spectrum Mask

– Channel Power has two other View/Display: Should Attenuation and Spectrum Mask

– Shoulder Attenuation is measured to check the linearity of an OFDM signal w/o reference to spectrum mask which is a defined in DVB-T/H test specification

– Spectrum Mask View is to check the spectrum emission mask in the case of Analog TV signal in adjacent channel





Agilent Technologies

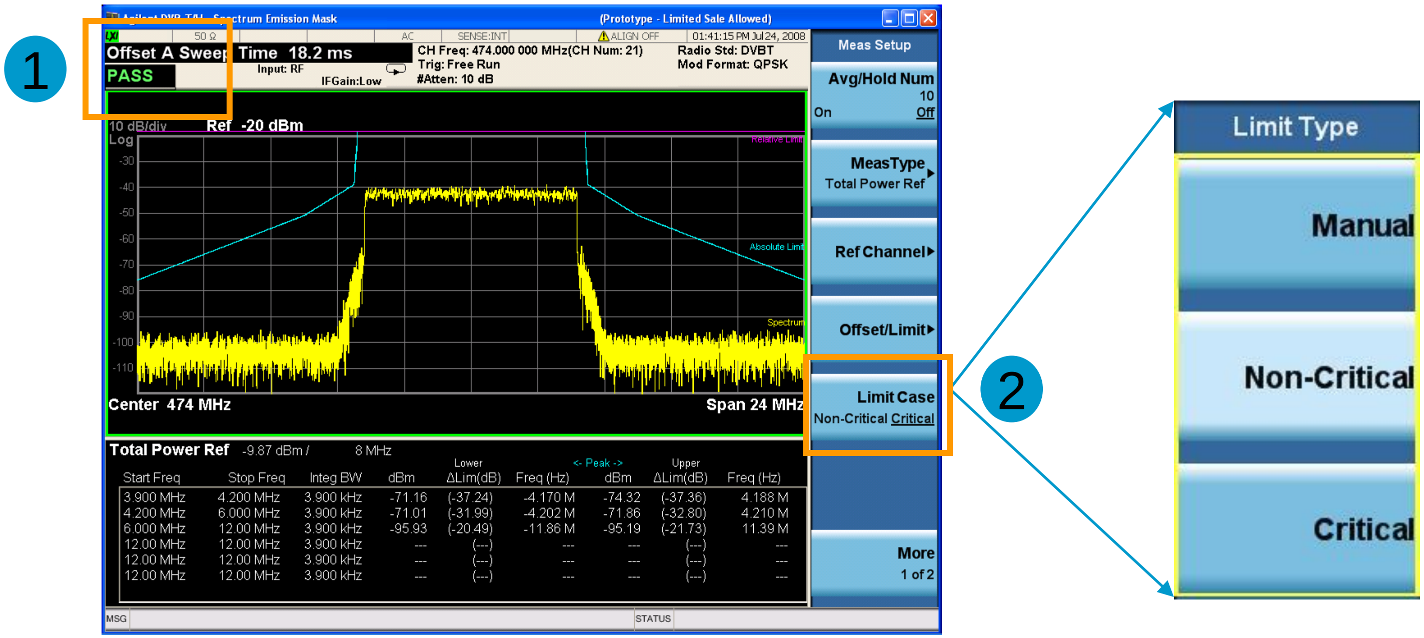
DVB-T/H Applications and Examples

3. SEM – Spectrum Emission Mask

– SEM is a key measurement linking amplifier linearity and other performance characteristics

–Limit Type supports Manual, Non-Critical and Critical (The last two type are defined in DVB-T/H standard.)

– PASS/FAIL indicator is convenient for R&D, Mfg and Performance Test customers



DVB-T/H Applications and Examples

4. Modulation Analysis

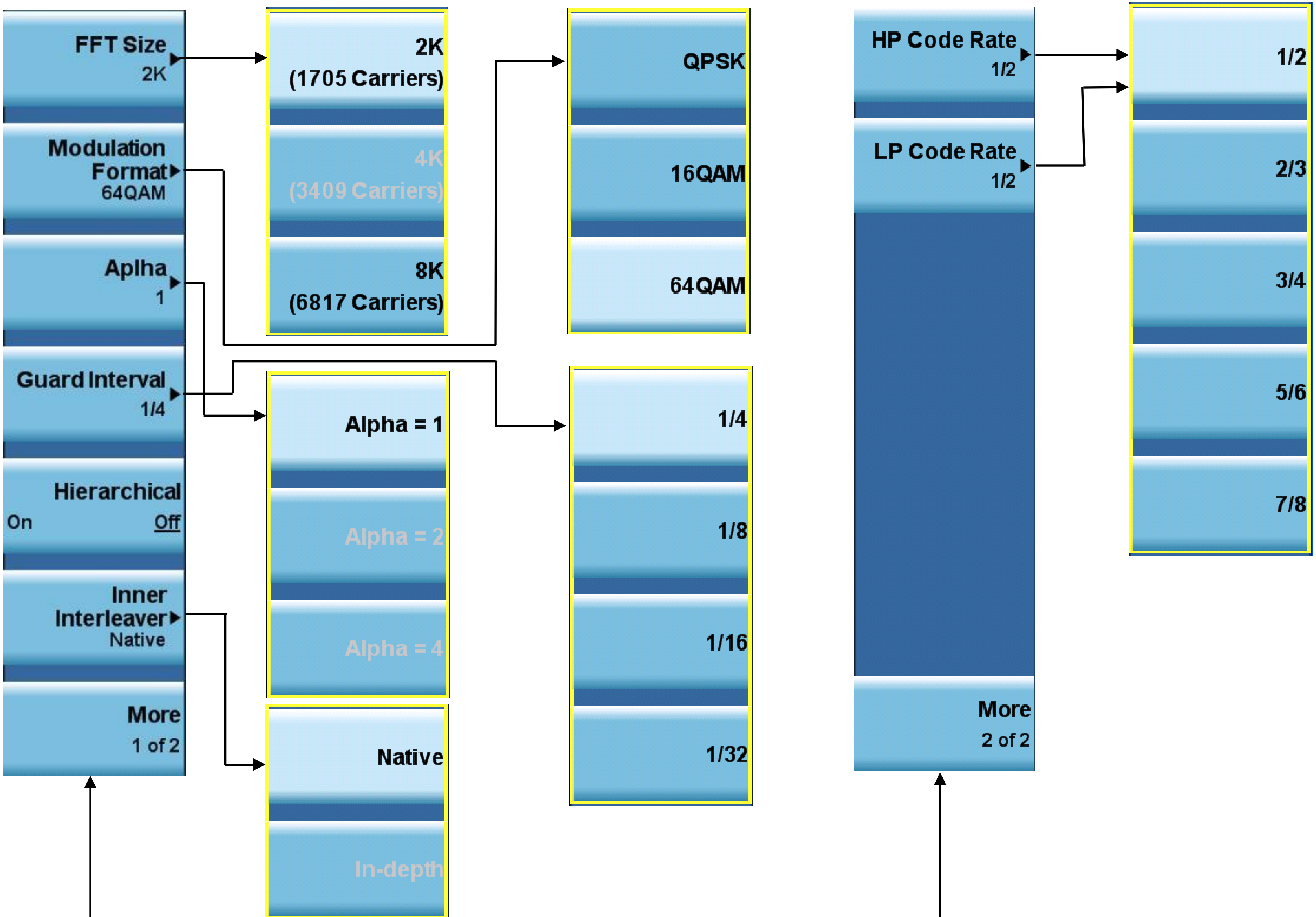
• Modulation Analysis measurement is the most important one in DVB-T/H measurement application.

• It includes the measurement of MER (Modulation Error Ratio), which is an indicator of noise, interferences or distortions on signal and is a figure of merit widely used in broadcasting industry similar to the EVM in wireless industry.

• Modulation Analysis measurement is helpful and necessary to meet DVB-T/H defined test specification and ensure proper operations of the transmitters.

• This measurement provides the flexibility of RF input or Analog IQ input (only available in MXA)

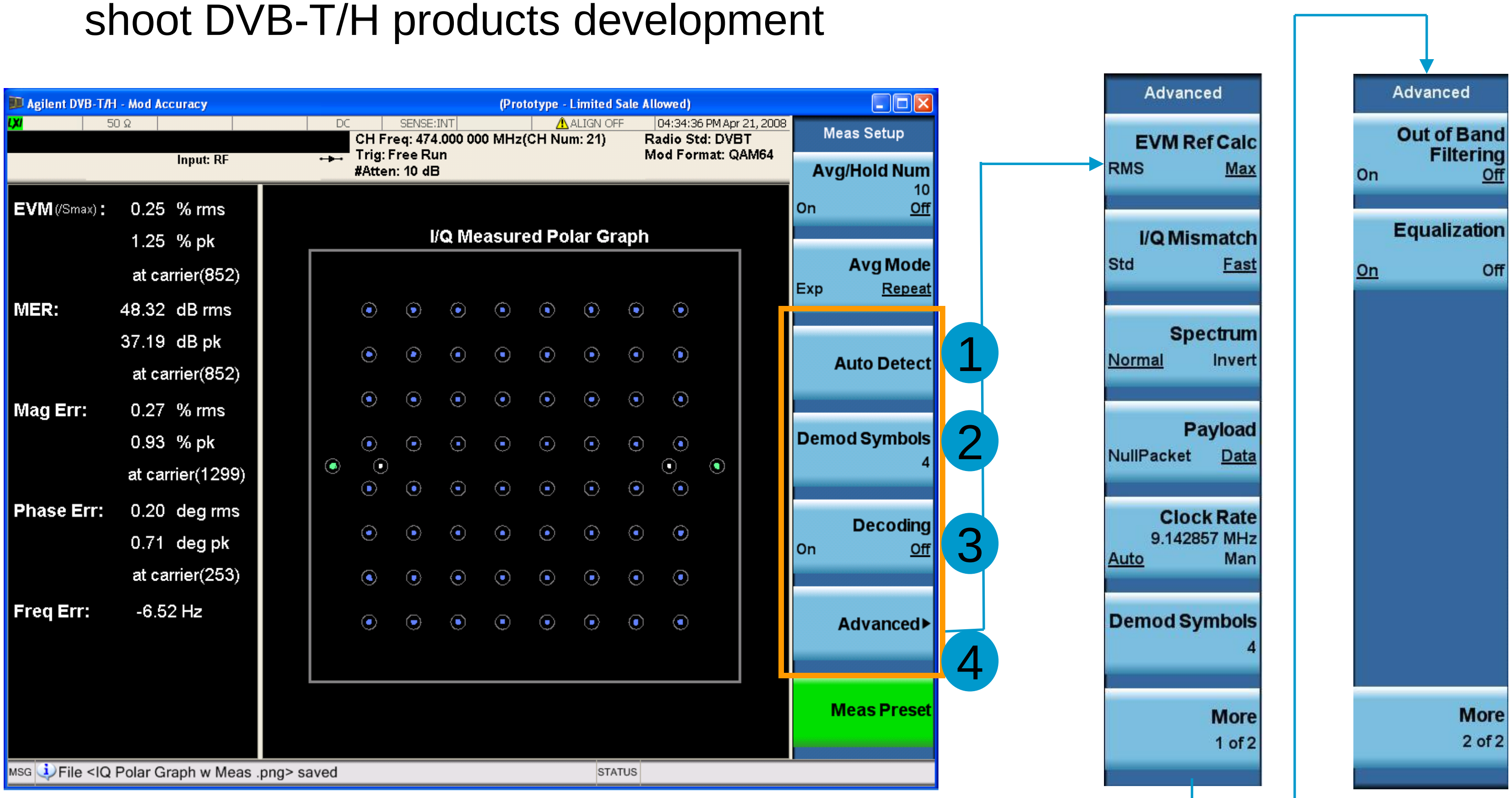
Demod Parameters



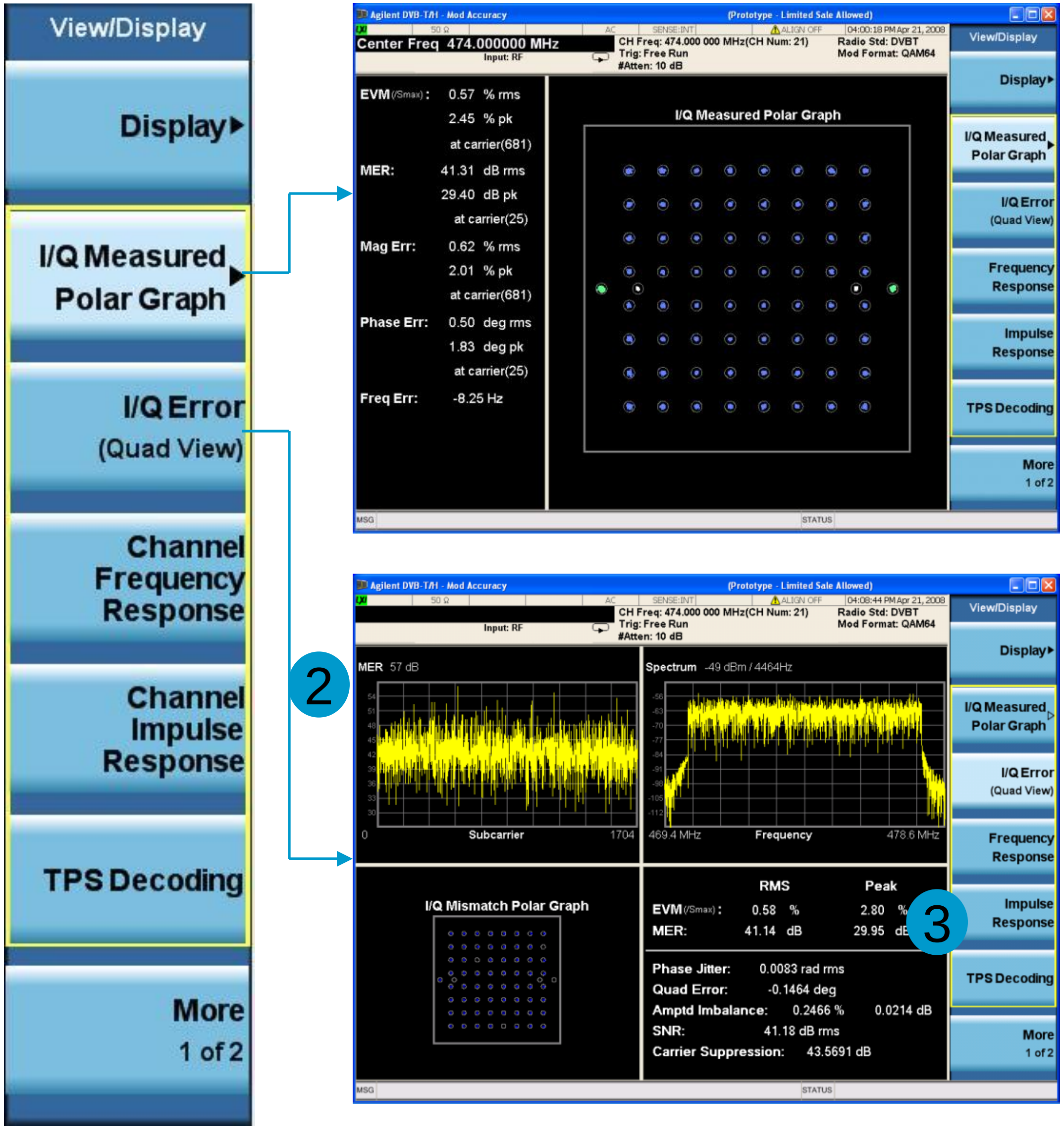
Agilent Technologies

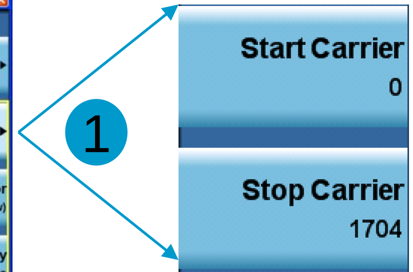
Modulation Accuracy – Meas Setup Parameters

1. User friendly feature “Auto Detect”
2. Demod symbols can be customized to balance between speed and accuracy
3. Switch “Decoding” On to get the TPS Decoding and BER results
4. Flexible advanced modulation settings are beneficial for customers to trouble-shoot DVB-T/H products development



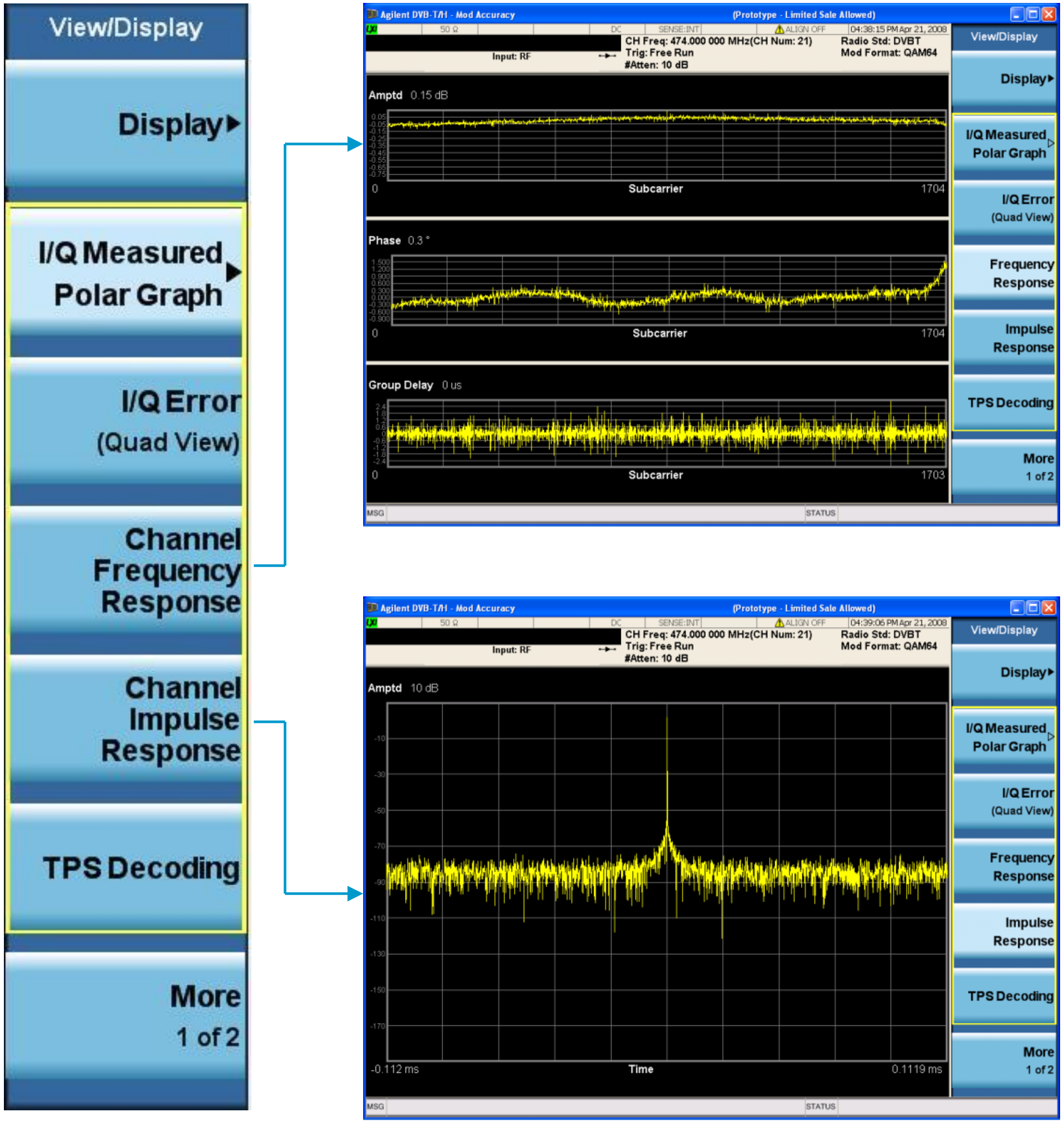
Modulation Accuracy Measurement





1. Use can specify the measured subcarriers range from the 0 to 1704 (2K mode)
2. MER vs. Subcarriers can show the MER result at each-subcarrier
3. More detailed modulation analysis results can be shown in the I/Q Error view like AI/QE/SNR/CS/Phase Jitter etc

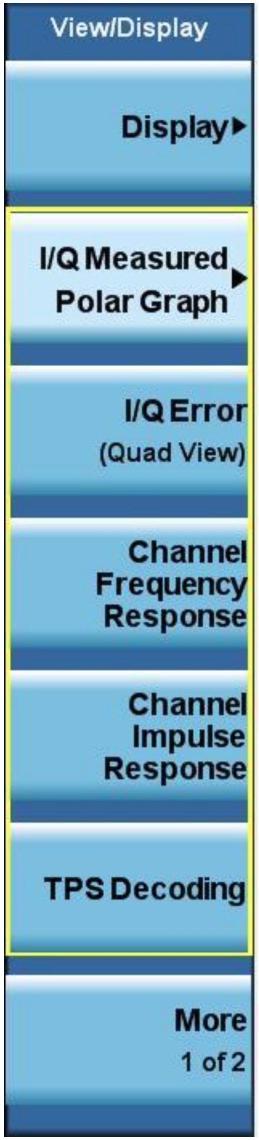
Modulation Accuracy Measurement

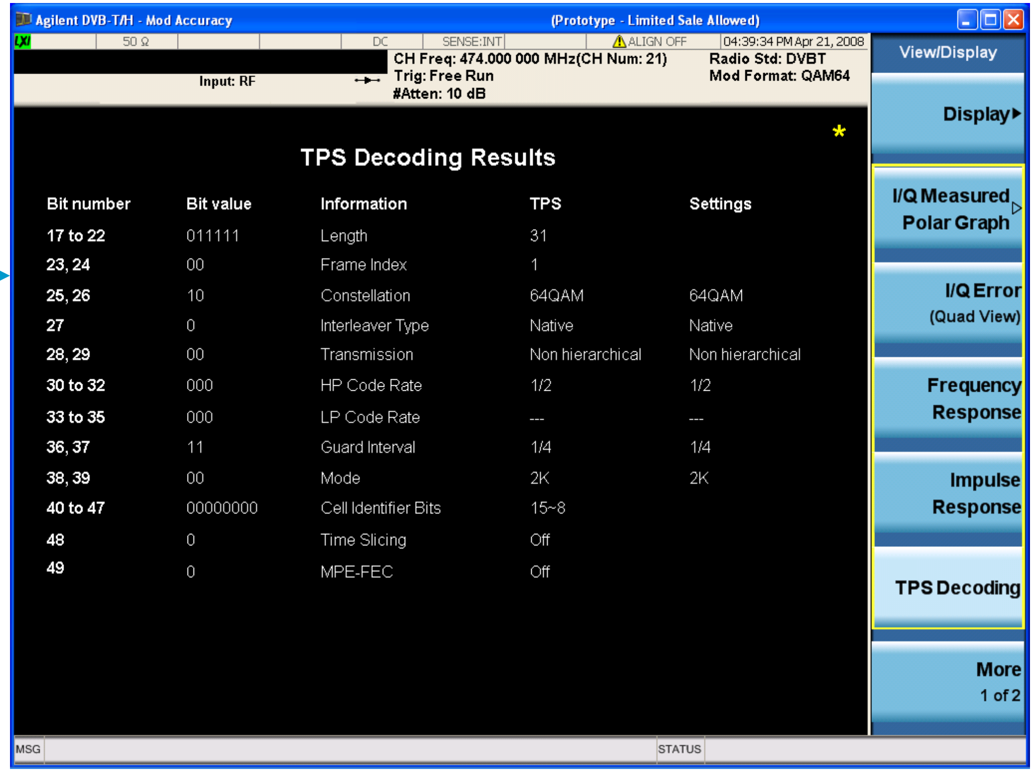


- Channel Frequency Response view includes three traces:
  - Amplitude vs. subcarriers
  - Phase vs. subcarriers
  - Group Delay vs. subcarriers

- Channel Impulse Response can be shown for multi-path measurement.

Modulation Accuracy Measurement

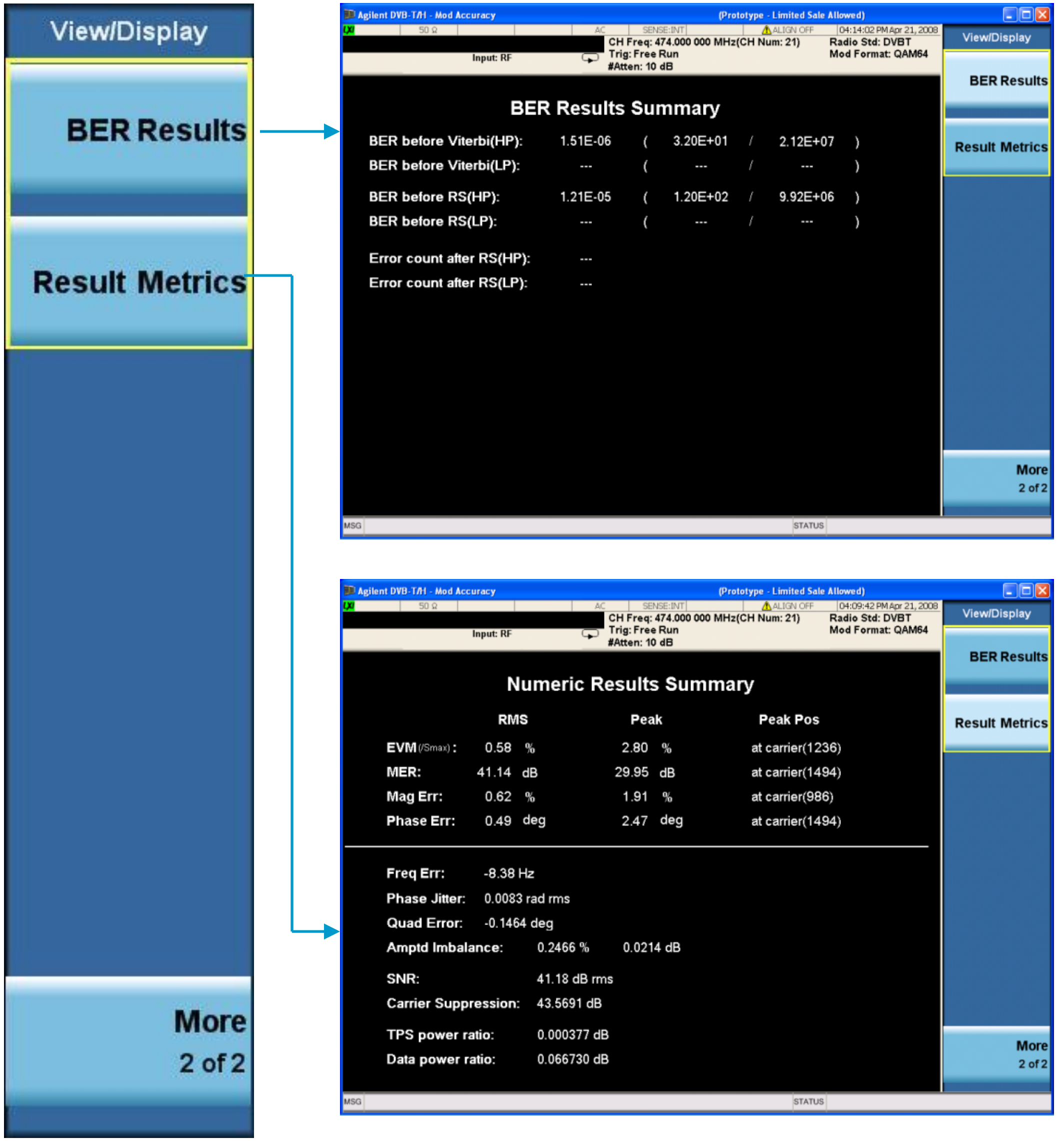




- TPS means **Transmission Parameter Signaling**
- TPS carriers are used for the purpose of signaling parameters related to the transmission scheme, i.e. channel coding and modulation.

Agilent Technologies

Modulation Accuracy Measurement



- Pre-Viterbi/Pre-RS BER results can be calculated when turning on the “Decoding” switch
- Post-RS BER result can be only shown for “NullPacket” payload
- All of the available modulation analysis results will be shown in the “Result Metrics” view.

DVB-T2 Overview

New standard for terrestrial broadcasting, providing increased capacity and ruggedness, primarily for HDTV broadcasting to fixed and mobile video for portable receivers.

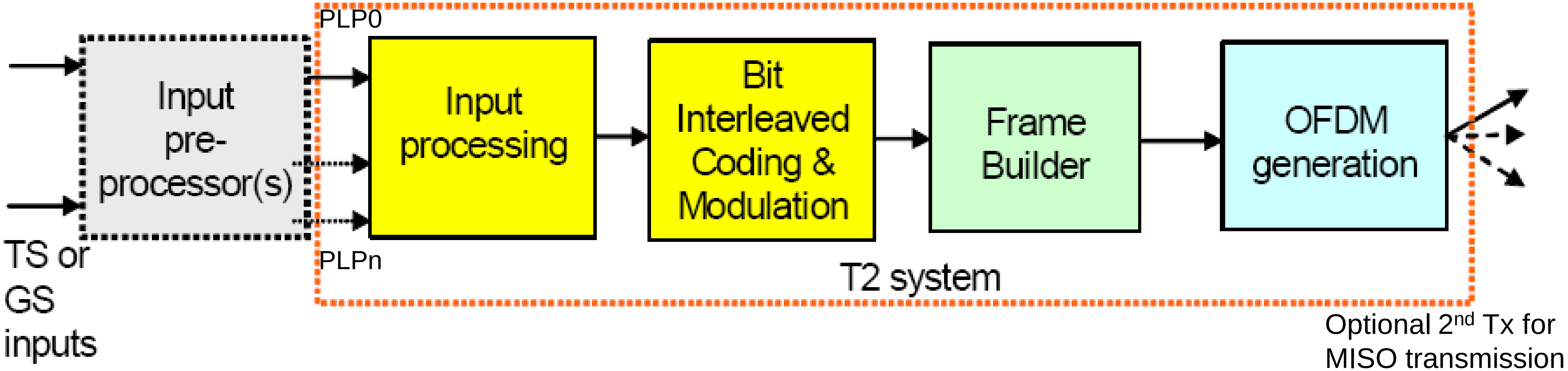
Key Requirements

- Must be able to use existing domestic receive antenna and transmitter infrastructure for services to fixed and portable receivers
- Should provide minimum of 30% capacity increase over DVB-T
- Should provide improved SFN performance
- Should have mechanism for providing service-specific robustness
- Should provide means to reduce peak-to-average power ratio

Key Technologies

- FEC coding: BCH + LDPC, interleaving
- Mapping: QPSK/16QAM/64QAM/256QAM, constellation rotation
- OFDM: 1K,2K,4K,8K,16K,32K
- Guard interval: 1/128,1/32,1/16,19/256,1/8,19/128,1/4
- Multiple PLPs (Physical Layer Pipe)
- PAPR reduction: ACE (Active Constellation Extension), TR (Tone Reservation)

DVB-T2 Block Diagram



- Input Processing (including pre-processor): add the new concept of multiple PLPs
- Bit Interleaved Coding & Modulation: Leverage the BCH/LDPC coding scheme from DVB-S2, with new concept of multiple PLPs
- Frame Builder: new Preamble structure (P1, P2 = L1-pre + L1-post), sub-slicing of multiple PLP's
- OFDM Generation: more OFDM FFT modes and pilot schemes compared to DVB-T

GS: Generic Stream
GSE: Generic Stream Encapsulation
PLP: Physical Layer Pipe

Max TS rate < 100Mbps
Max TS rate (after deletion) < 50Mbps in one 8MHz channel

DVB-T2 Input Modes and PLP

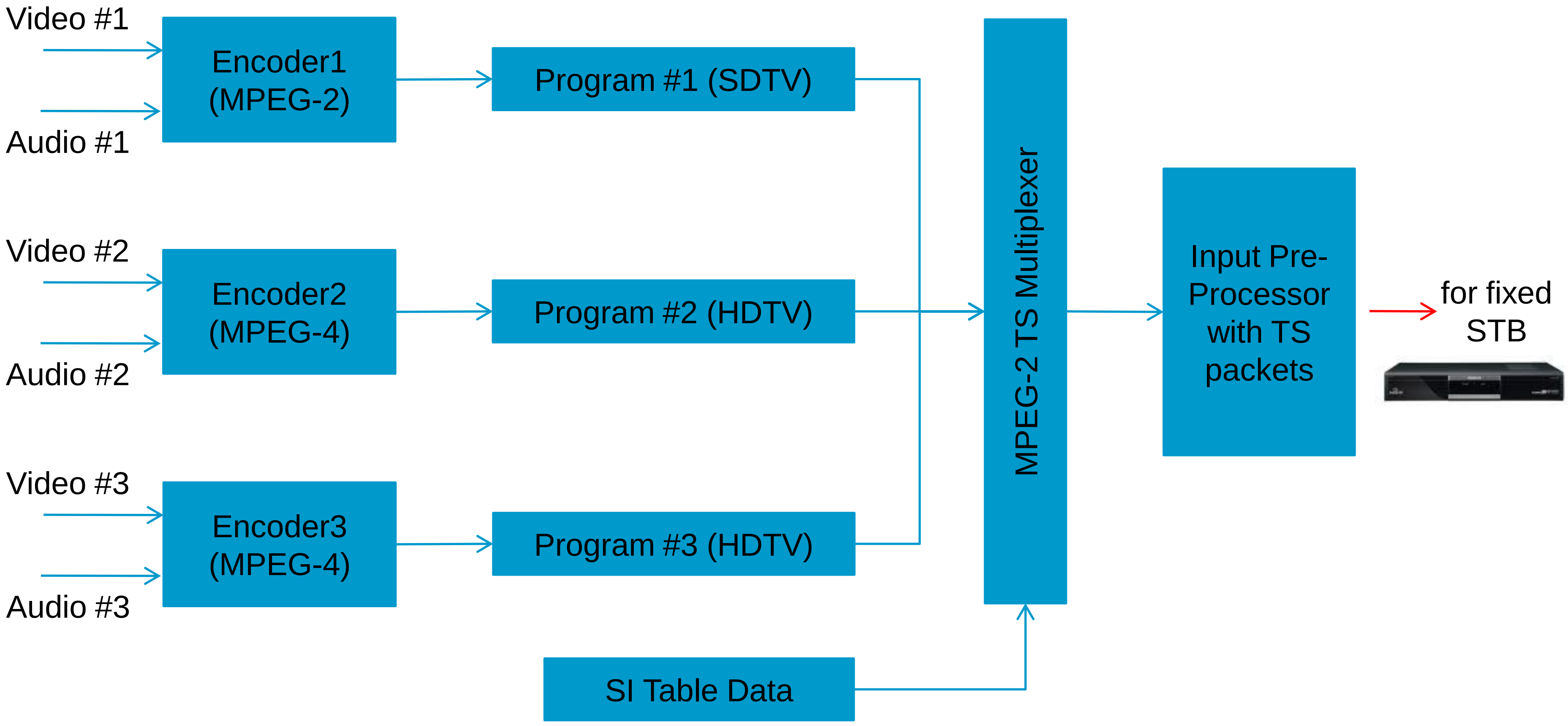
-PLP (Physical Layer Pipe): represent one service (one or multiple programs) having same QoS requirements (FEC coding scheme, interleaving etc.)

-DVB-T2 has 2 input modes: Input Modes A and B

- Input Mode A:
  - Single PLP (with single input stream, could be multiplexed TS programs)
  - Similar to DVB-T but with more FFT modes and higher throughput (max 50Mbps)
  - Receivers supposed to demod the full stream together
  - Good for HDTV broadcast services
- Input Mode B:
  - Multiple PLPs (up to 255 max), with different input stream per PLP
  - Brand new concept to support different services at different QoS levels
  - PLPs are grouped together to form PLP groups and could share common PLP (like EPG)
  - Receivers supposed to demod the specific PLP (+ common PLP) based on its own needs

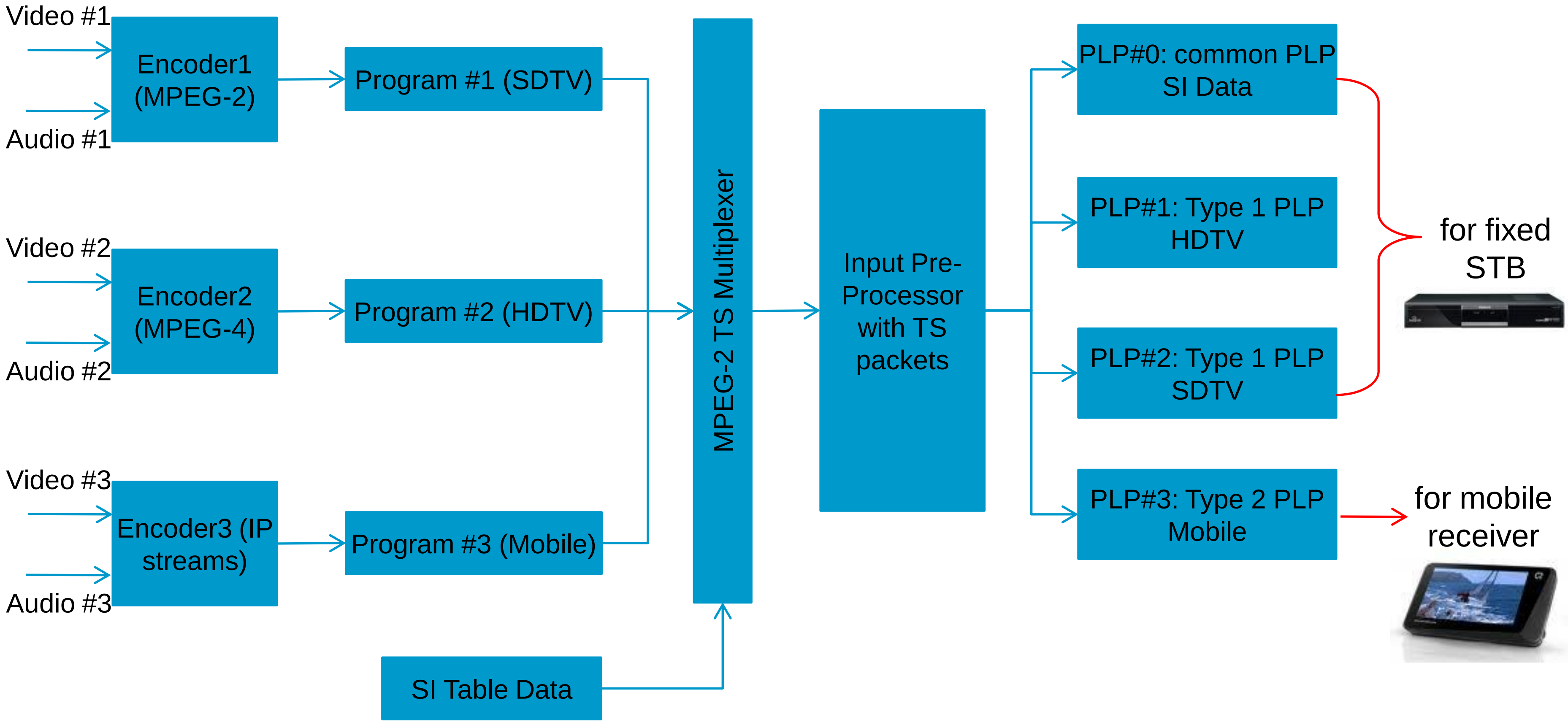
Input Mode A: Single PLP

Example: Single PLP mode used in UK for HDTV broadcasting (32k mode FFT extended mode, 1/128 GI, single PLP with 256 QAM rotated)



Input Mode B: Multiple PLPs

Example: Using different PLPs for different services (HDTV/SDTV vs. mobile video). No commercial deployment yet.



Why Multiple PLP's

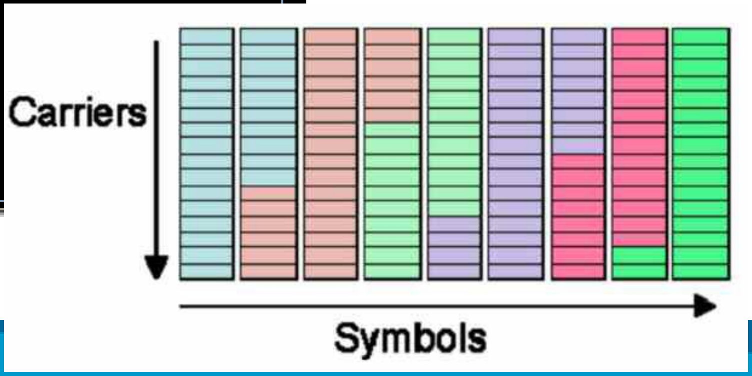
-Support different kind of services with different QoS levels => HDTV vs. mobile TV in same 8MHz channel requires different robustness (through FEC scheme and interleaving depth)

-Allow receiver to tune to interested services only for power saving, especially critical for mobile receivers

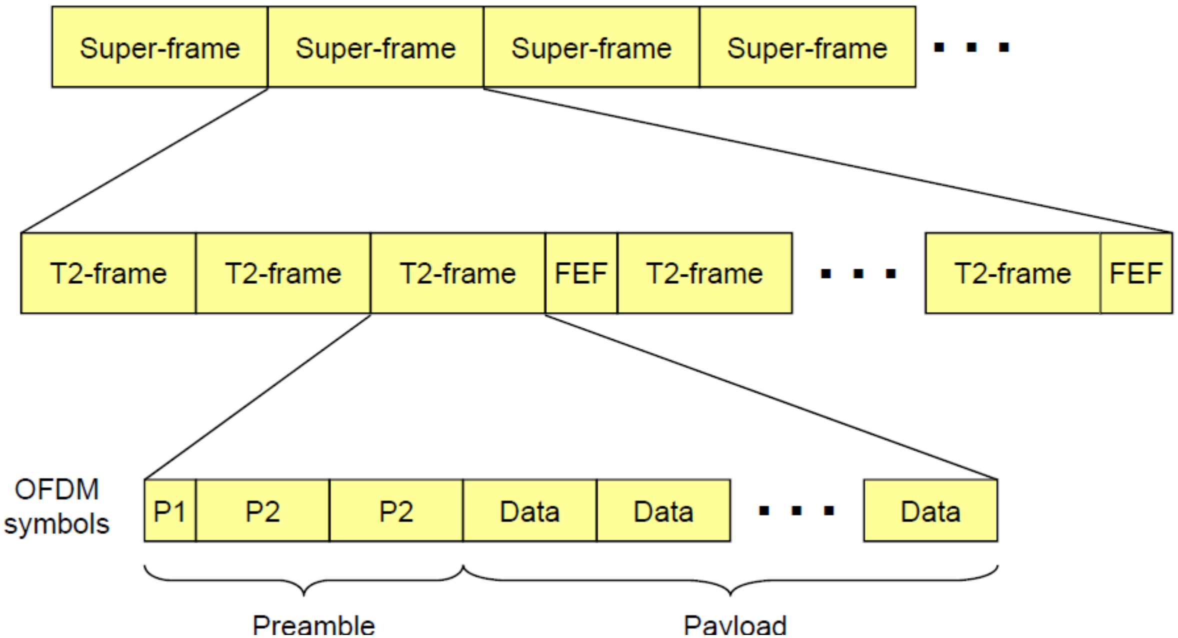
-Allow dynamic scheduling of services at different (and varying) data rates to a constant frame structure, for better usage of overall bandwidth

PLP Info

ID	Group ID	Type	Payload	FEC Type	FEC Block	Mod	Rot	CR	TIL Len	TIL Type	Start
000	000	Data2	TS	64K	8	256QAM	Yes	2/3	1	0	413100
001	000	Data2	TS	64K	8	256QAM	Yes	2/3	1	0	413700
002	000	Data2	TS	64K	8	256QAM	Yes	2/3	1	0	414300
004	001	Data1	TS	16K	12	QPSK	Yes	2/3	1	0	24300
005	001	Data1	TS	16K	12	QPSK	Yes	2/3	1	0	121500
006	001	Data1	TS	16K	12	QPSK	Yes	2/3	1		
007	001	Data1	TS	16K	12	QPSK	Yes	2/3	1		
008	001	Common	TS	16K	3	QPSK	Yes	2/3	1		



DVB-T2 Frame Structure



$$T_{SF} = N_{T2} \times T_F + N_{FEF} \times T_{FEF}$$

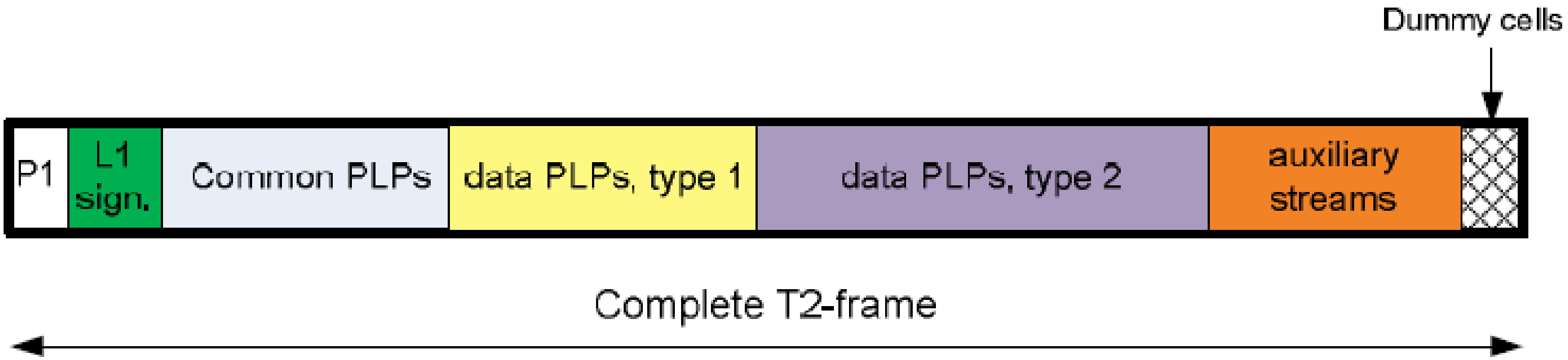
$$N_{FEF} = N_{T2} \text{ / FEF\_interval}$$

$$T_F = L_F * T_s + T_{P1}$$
$$= (N_{P2} + L_{data}) * T_s + T_{P1}$$

(max 250 ms)

- T2 frame length is not fixed, max 250 msec. Length of Super Frame max 64 secs (256 frames), or 128 secs with FEF (Future Extension Frame).
- T2 frame consists of Preamble P1 (for sync), Preamble P2 (L1-Pre and L1-Post) for L1 signaling, and data (PLPs).
- Unchanged in one super frame except Dynamic L1 post-signaling

DVB-T2 Frame Structure (cont.)



Layer 1 signaling

- P1 Signaling – P1 symbol to indication transmission type & basic parameters (SISO/MISO, FFT size)
- P2 Signaling – including L1 pre-signaling and L1 post-signaling, signaling of the T2-frame structure and PLPs
  - L1 pre-signaling to enable reception and decoding of L1 post-signaling
  - L1 post-signaling for receiver to access PLP's
  - L1 post-signaling includes Configurable, Dynamic, Extension, CRC and padding

Common PLP: Contains data shared with multiple PLPs e.g. SI Tables

Type 1 data PLP: Sent in single "slice" once per T2-Frame

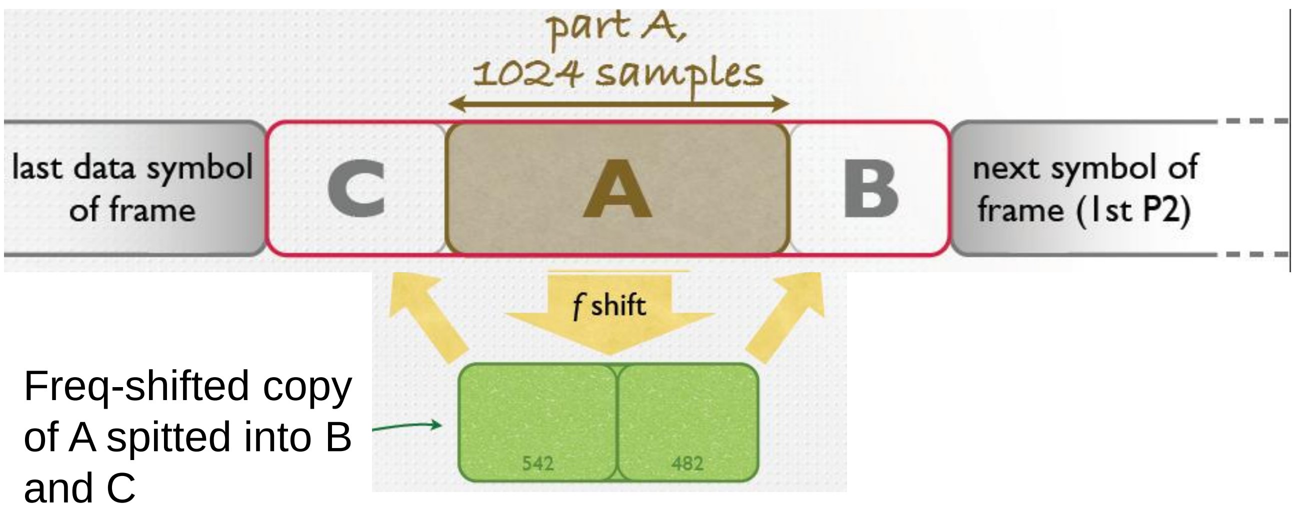
Type 2 data PLP: Sent in two or more "sub-slices" per T2-Frame

DVB-T2 L1 Signaling: P1 Symbol

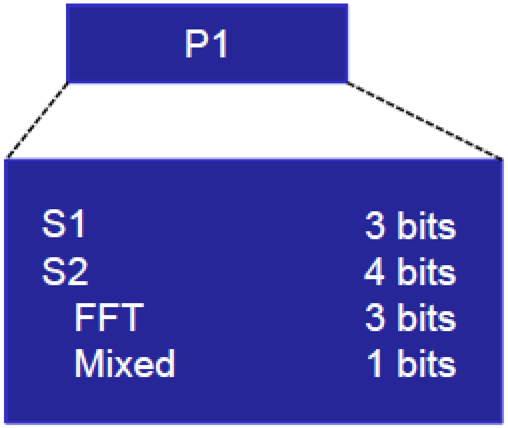
•Specific symbol for receiver sync and identification of DVB-T2 signal (from DVB-T and others)

• Designed for fast sync with basic information (FFT mode), and robustness against freq error.

• Occur at the beginning of every frame (max 250 ms), fixed symbol structure with coded bits (7 bits S1/S2, FFT mode with possible GI, SISO/MISO).



Freq-shifted copy of A spitted into B and C



DVB-T2 L1 Signaling: P2 symbols

- P2 Signaling – including L1 pre-signaling and L1 post-signaling
  - L1 pre-signaling to enable reception and decoding of L1 post-signaling
  - L1 post-signaling for receiver to access PLP's
  - L1 post-signaling includes Configurable, Dynamic, Extension, CRC and padding
- L1 Pre-signaling
  - Total 200 bits (25 bytes) of information (fixed length)
  - Include setting of Tx input stream, PAPR, L1 coding/modulation, Pilot pattern, GI, L1-post length
  - BCH outer code and LDPC inner code (shortened 16k LDPC with code rate ¼)
  - Mapped to BPSK symbols (fixed), then OFDM modulation
- L1 Post-signaling
  - Dynamic in length with multiple PLP configurations (PLP coding/modulation/FEC/Interleaving)
  - Transmitted over one or multiple 16k LDPC blocks
  - Bit interleaving
  - Mapped to BPSK/QPSK/16QAM/64QAM symbols, then OFDM modulation

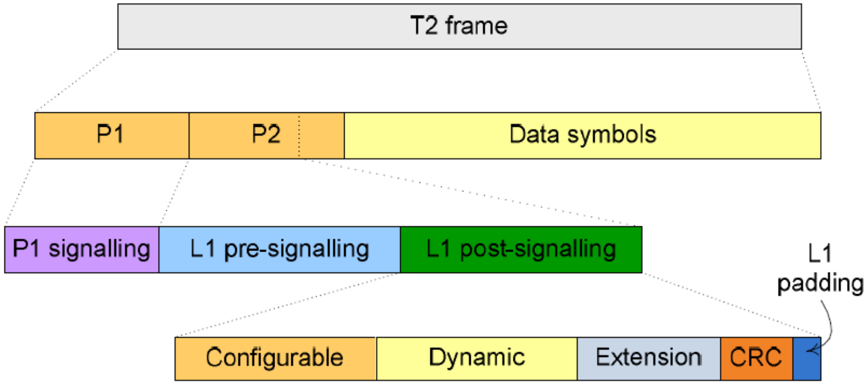


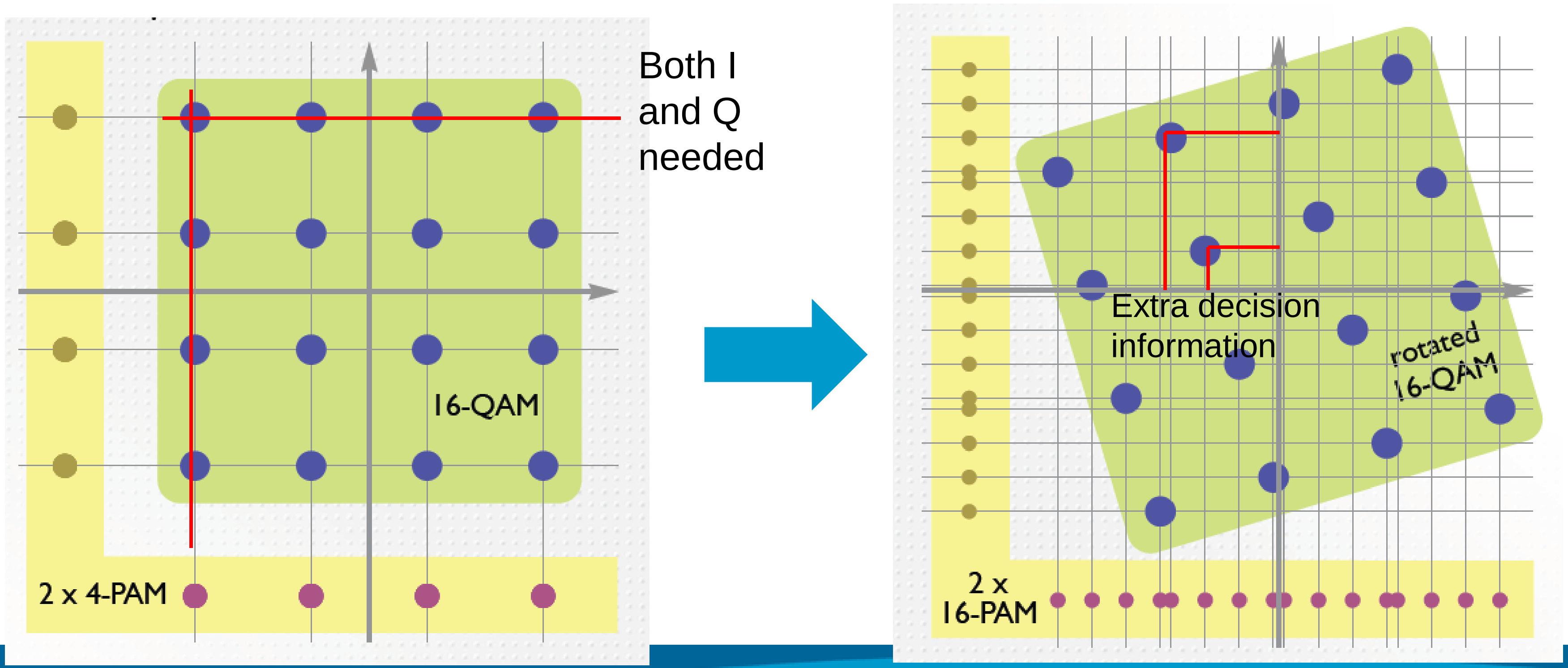
Figure 24: The L1 signalling structure

Rotated Constellation

-Mapping bits onto constellations: QPSK/16QAM/64QAM/256QAM

-New modulation scheme in DVB-T2 to improve the robustness (under fading channel)

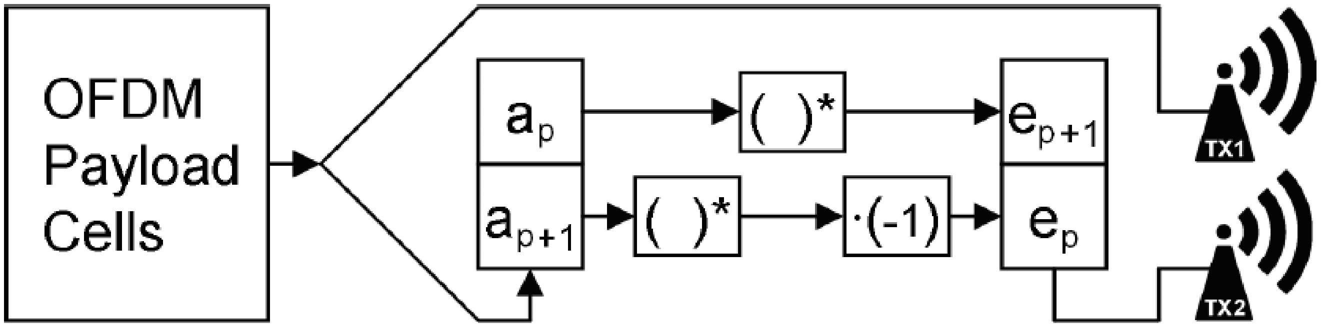
-No overlapping of projections in I/Q axis for any constellation points



Refer BBC slides from Jonathan Scott

DVB-T2 MISO Configuration

- MISO (Multiple Input Single Output) defined in DVB-T2 as optional feature
  - 2x1 MIMO
  - Modified Alamouti encoding for 2 transmitters (2 different signals to one antenna at receiver)
  - Different from DVB-T SFN: one same signal from many transmitters, received through different paths and timing
  - Improve receiver performance (so this is more required for receiver test)



Alamouti Matrix $$C_2 = \begin{bmatrix} c_1 & c_2 \\ -c_2^* & c_1^* \end{bmatrix}$$

Agilent Technologies

DVB-T2 Technical Summary

- Two modes: Single PLP and Multiple PLP (Physical Layer Pipe)
  - Each PLP has an input stream
  - Each PLP can be independently coded and modulated
    - FEC structure is similar to DVB-S2: Outer coding BCH, Inner coding LDPC
    - Modulation scheme: QPSK, 16QAM, 64QAM, 256QAM with constellation rotation and Q delayed
  - Up to 255 PLPs
- OFDM in 1.7/5/6/7/8/10MHz bandwidth
  - Modes: 1k, 2K, 4k, 8k, 16k, 32k
  - Guard Interval: 1/128,1/32,1/16,19/256,1/8,19/128,1/4
- PAPR reduction used
- Support both terrestrial and mobile services

N6153A DVB-T/H/T2 Measurement Application

- PXA/MXA/EXA/CXA measurement app with manual UI and SCPI control
- DVB-T/H/T2 standard based power measurements and modulation analysis
- When DVB-T2 license is enabled, the mode name will change to “DVB-T/H with T2”

Measurements:

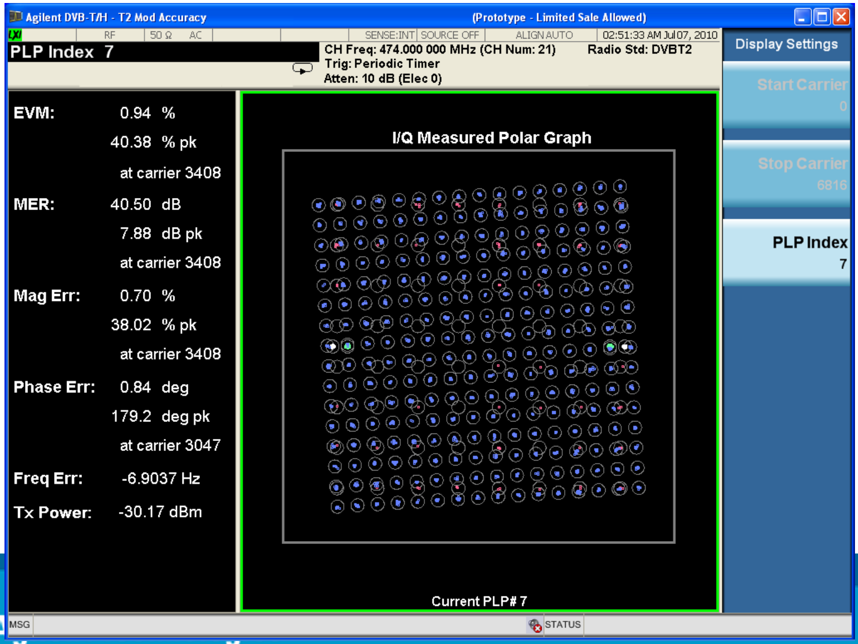
Power Meas: Channel Power, Shoulder attenuation, ACP, SEM, CCDF, Spurious

DVB-T2 Modulation Accuracy

- Constellation (w/ specified PLP ID)
- MER/EVM, Frequency Error, Amp Error, Phase Error, SNR
- IQ Distortion: AI, QE
- Channel Freq Response
- Channel Impulse Response (w/ Peak Table)
- Result Metrics Summary
- MER monitoring (new feature)
- L1 Signaling (incl. P1 Signalling, L1-Pre and L1-Post Signalling)
- BER (Only support in DVB-T/H)

Parameters Setups:

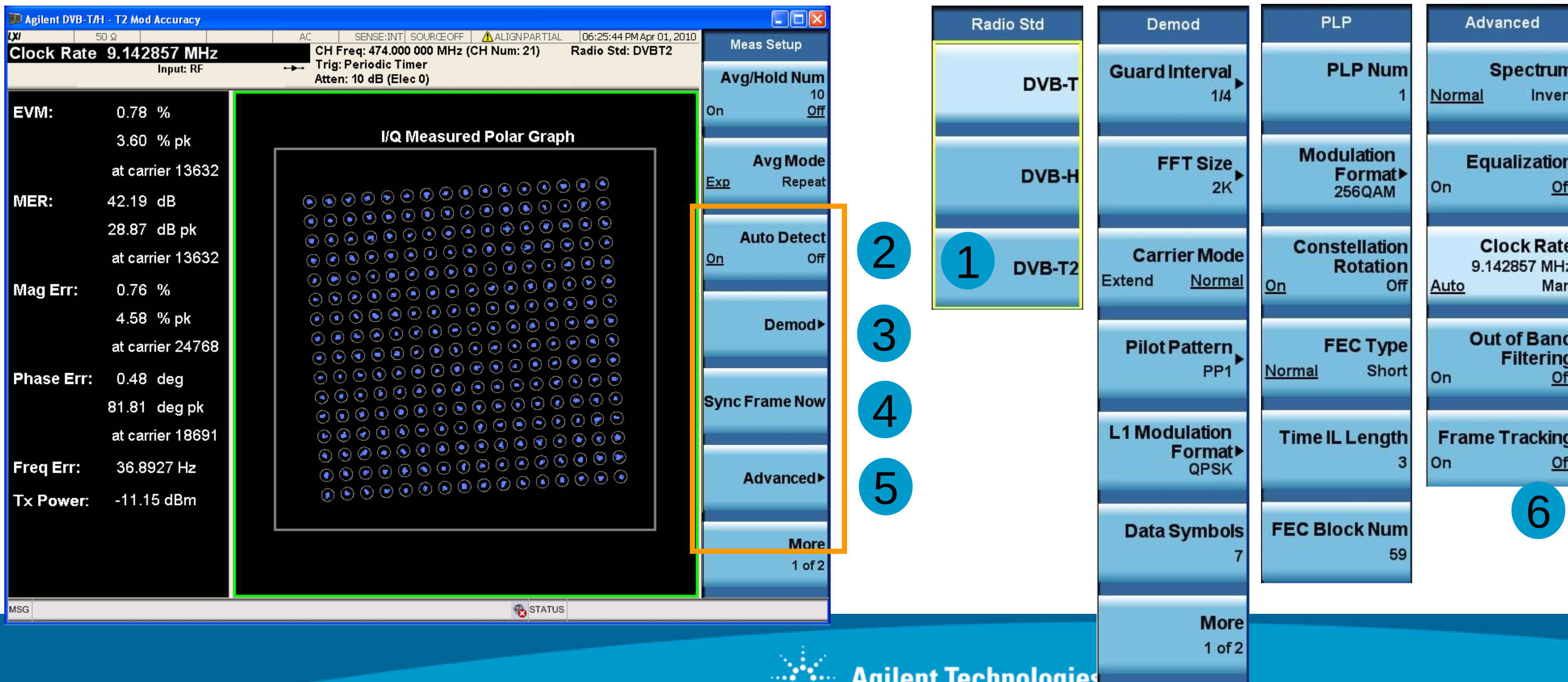
- Radio Std: DVB-T, DVB-H, DVB-T2
- Bandwidth: 1.7/5/6/7/8/10 MHz
- Auto Detection
- FFT Size: 1k/2k/4k/8k/16k/32k
- Modulation: QPSK/16/64/256QAM
- RF Input or Analog IQ Input (MXA with BBA option)



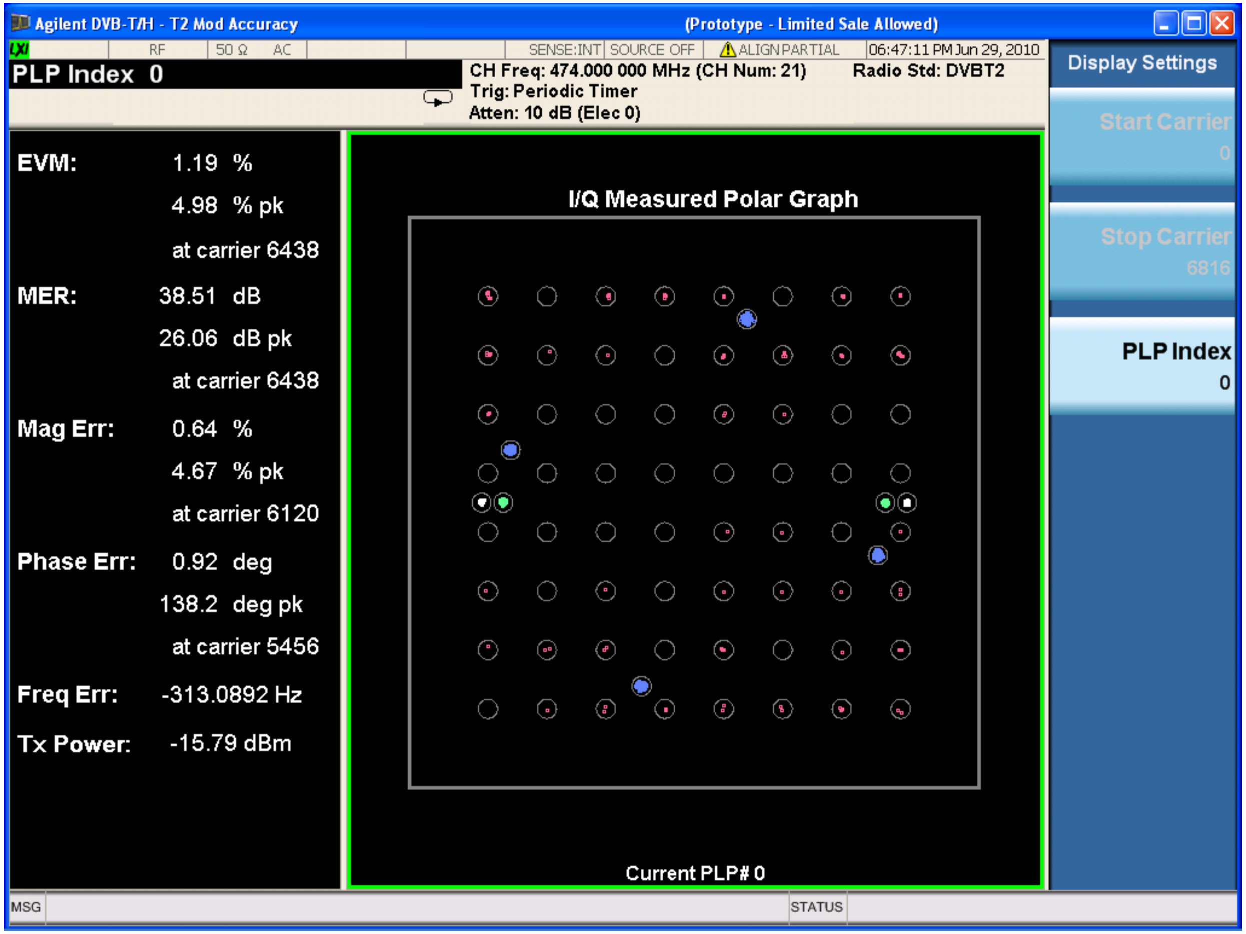
DVB-T2 option still under development now

DVB-T2 Modulation Accuracy – Meas Setup Parameters

1. Radio Std DVB-T, DVB-H or DVB-T2 under Mode Setup should be chosen first.
2. “Auto Detect” feature for demod parameters auto-detection from L1-signaling
3. When Auto Detect is off, it can support the manual setting for all of the Demod parameters
4. **Sync Frame Now** action is needed each time to synchronize the DVB-T2 frame signal.
5. Flexible advanced modulation settings are helpful for customers troubleshooting such as Clock Error, Low Quality LO etc
6. Recommend to turn “Frame Tracking” on while using periodic trigger for testing (default).



DVB-T2 Modulation Accuracy - IQ Polar View Color Coding

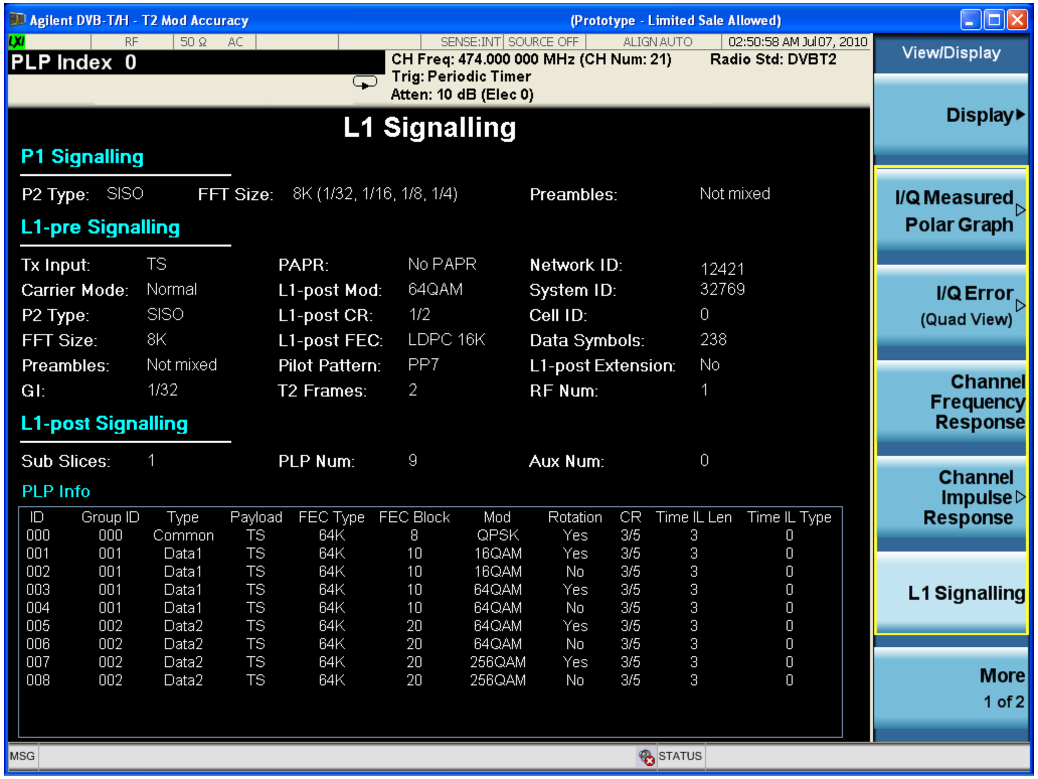


- Blue – data
- Green – L1-pre
- Hot Pink – L1-post
- White – P2 pilot
- Sky Blue – Continued Pilot
- Green Yellow – Scattered Pilot
- Purple – Frame-closing Pilot

Note: In Polar Graph window, the blue points (■) are data points, the green points (■) are L1-pre points, the hot pink points (■) are L1-post points, the white points (■) are P2 pilot points, the sky blue points (■) are continued pilot points, the green yellow points (■) are scattered pilot points and the purple points (■) are frame-closing pilot points.

Agilent Technologies

DVB-T2 Modulation Accuracy – L1 Signalling



1. P1 signaling: indicating transmission type and basic parameters
2. P2 signaling includes
   - L1 Pre-signaling to enable reception and decoding of L1 post-signaling
   - L1 Post-Signaling for receiver to access PLP's
3. Unchanged in one super-frame except dynamic L1 post-signaling mode
4. L1 Signalling is import to validate the signalling correctness and the PLP demodulation process.

Support auto and manual setup for PLP parameters:
-Manual UI for single PLP
-Config file for multiple PLP's

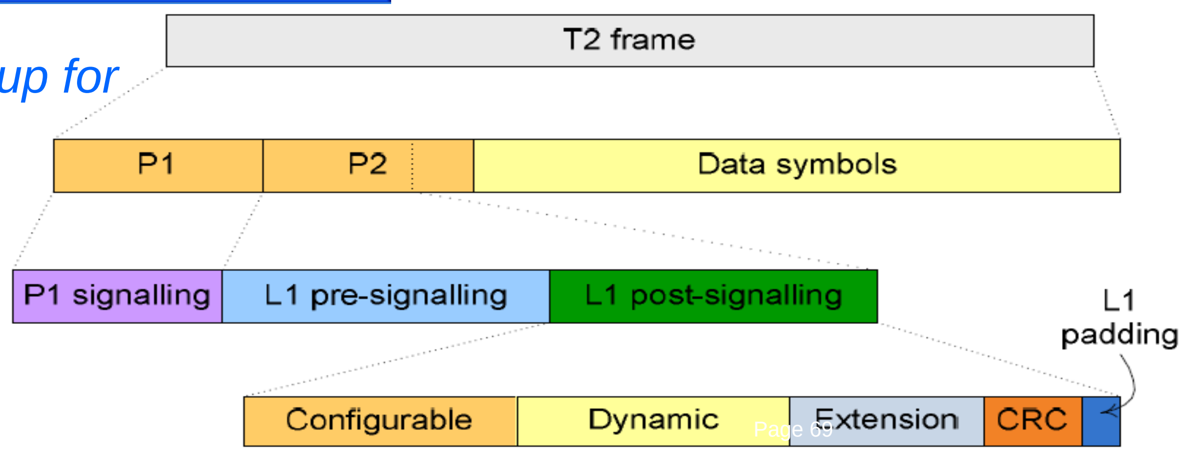
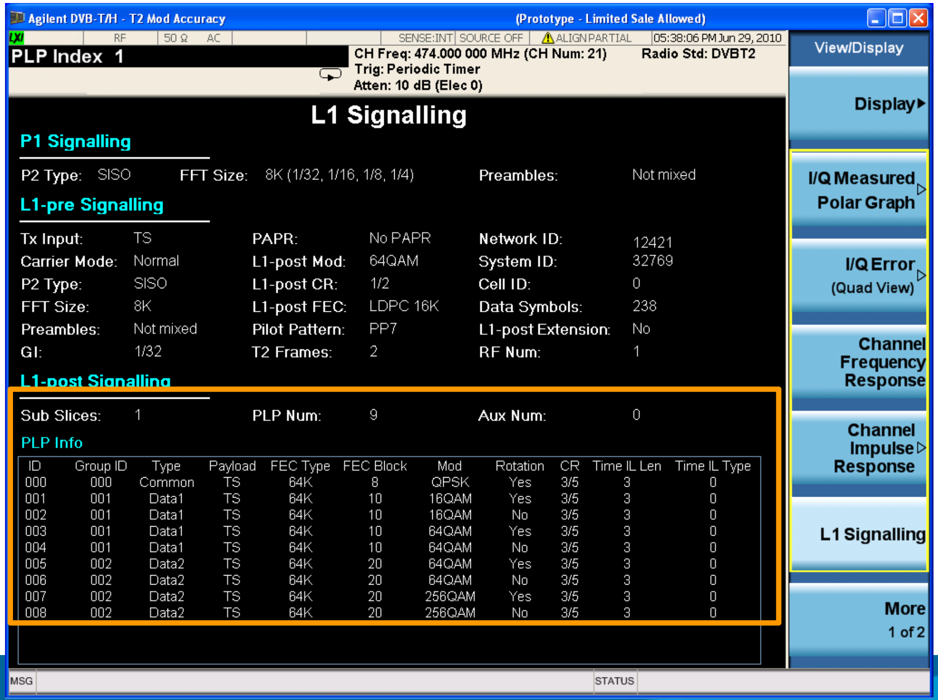


Figure 24: The L1 signalling structure

DVB-T2 Modulation Accuracy – Multi PLPs Setup

1. DVB-T2 Mode B (Multi PLPs) is still under developing now.
2. There are two methods to demodulate a DVB-T2 signal with multi PLPs configuration,
   - Auto-Detection method, same as Single PLP Demod. This method is always recommended as default. **Steps: {Auto Detect}->On; Press {Sync Frame Now}**
   - If auto-detection fails, we support the manual PLP configuration through a CSV file like the following format with PLP number equals to 4.

     Steps: {Auto Detect}->Off; {Recall}->PLP Config file; Press {Sync Frame Now}
3. The multiple PLPs configuration will be shown in the L1 Signalling view if correctly demodulated.



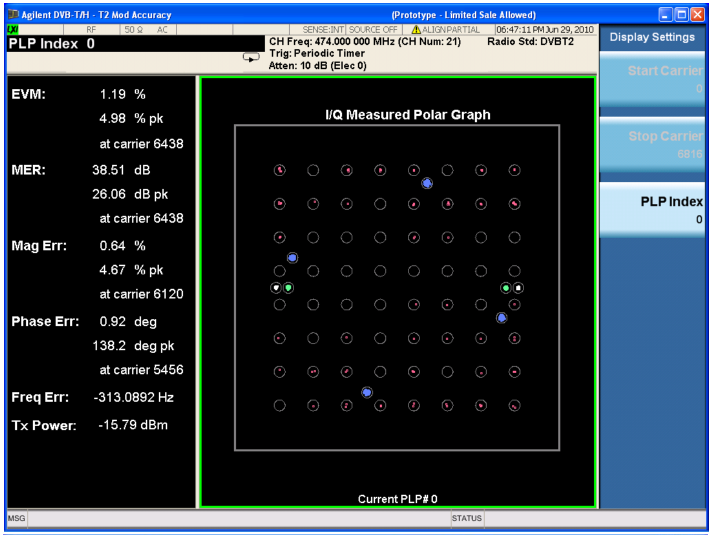
Multiple PLPs config file example (.csv file viewed in Excel)

Carrier Mode	Normal								
Data Symbols	238								
FFT Size	8K								
Guard Interval	Jan-32								
L1Post Modulation	64QAM								
PAPR	OFF								
Pilot Pattern	PP7								
PLP Num	9								
SubSlice Interval	756000								
SubSlices Num	1								
Vector-FEC Block Num	8	10	10	10	10	20	20	20	20
Vector-FEC Type	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
Vector-PLP ID	0	1	2	3	4	5	6	7	8
Vector-PLP Modulation	QPSK	16QAM	16QAM	64QAM	64QAM	64QAM	64QAM	256QAM	256QAM
Vector-PLP Rotation	TRUE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE	TRUE	FALSE
Vector-PLP Start	0	259200	421200	583200	691200	799200	1015200	1231200	1393200
Vector-PLP Type	Common	Data Type 1	Data Type 1	Data Type 1	Data Type 1	Data Type 2	Data Type 2	Data Type 2	Data Type 2
Vector-Time IL Length	3	3	3	3	3	3	3	3	3

DVB-T2 Modulation Accuracy – Constellation per PLP

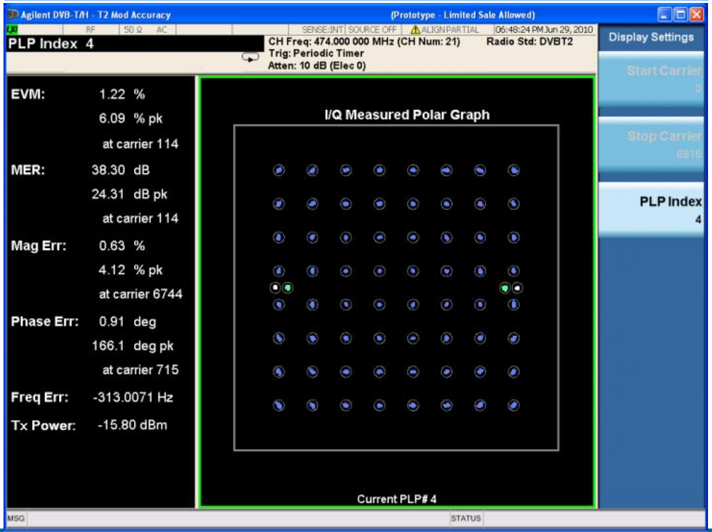
- IQ constellation for each PLP can be shown separately with specifying the PLP index number in the IQ Measured Polar Graph view as the following examples .

PLP0
QPSK
Rotation:
Yes

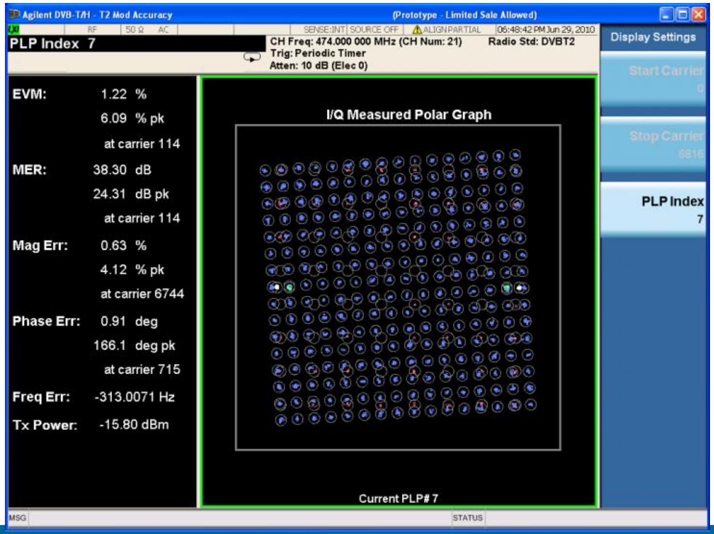


PLP1
16QAM
Rotation:
Yes

PLP4
64QAM
Rotation:
No



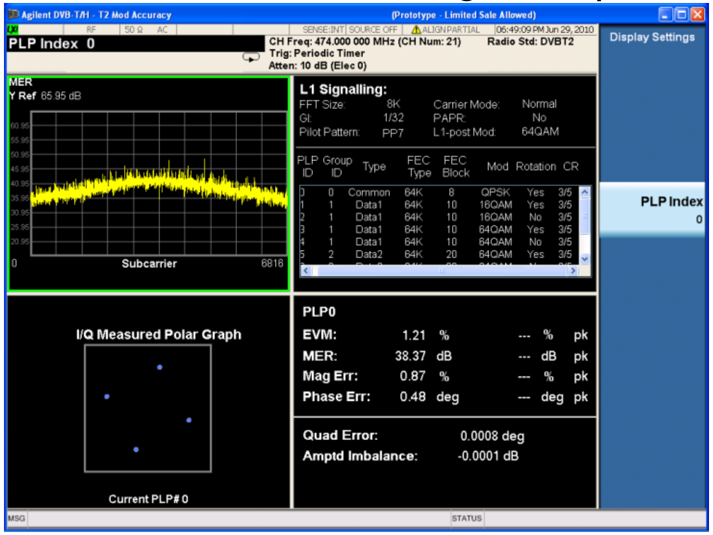
PLP7
256QAM
Rotation:
Yes

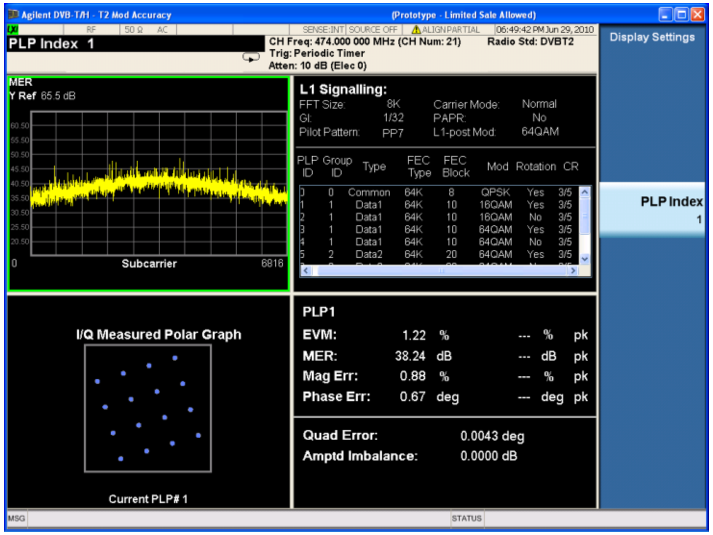


DVB-T2 Modulation Accuracy – MER per PLP

- MER for each PLP can be shown separately with specifying the PLP index number in the IQ Error view as the following examples.

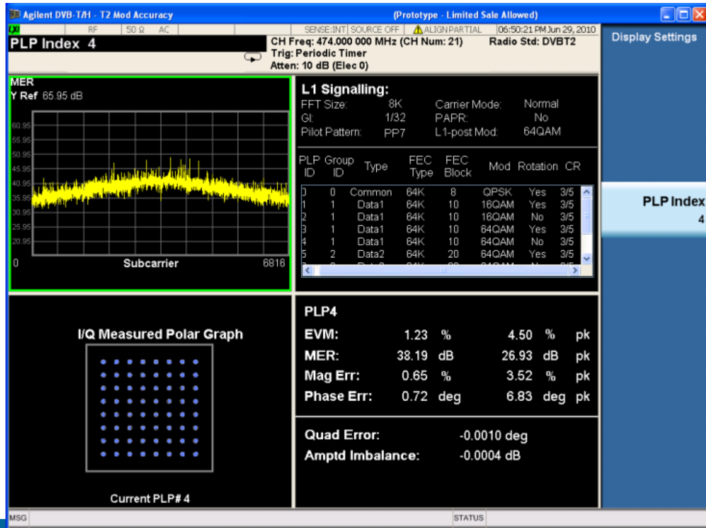
PLP0
QPSK
MER:
38.37 dB

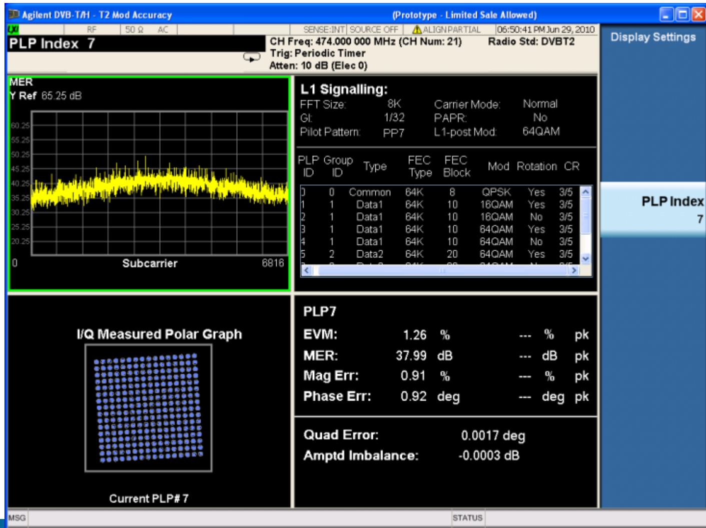




PLP1
16QAM
MER:
38.24 dB

PLP4
64QAM
MER:
38.19 dB



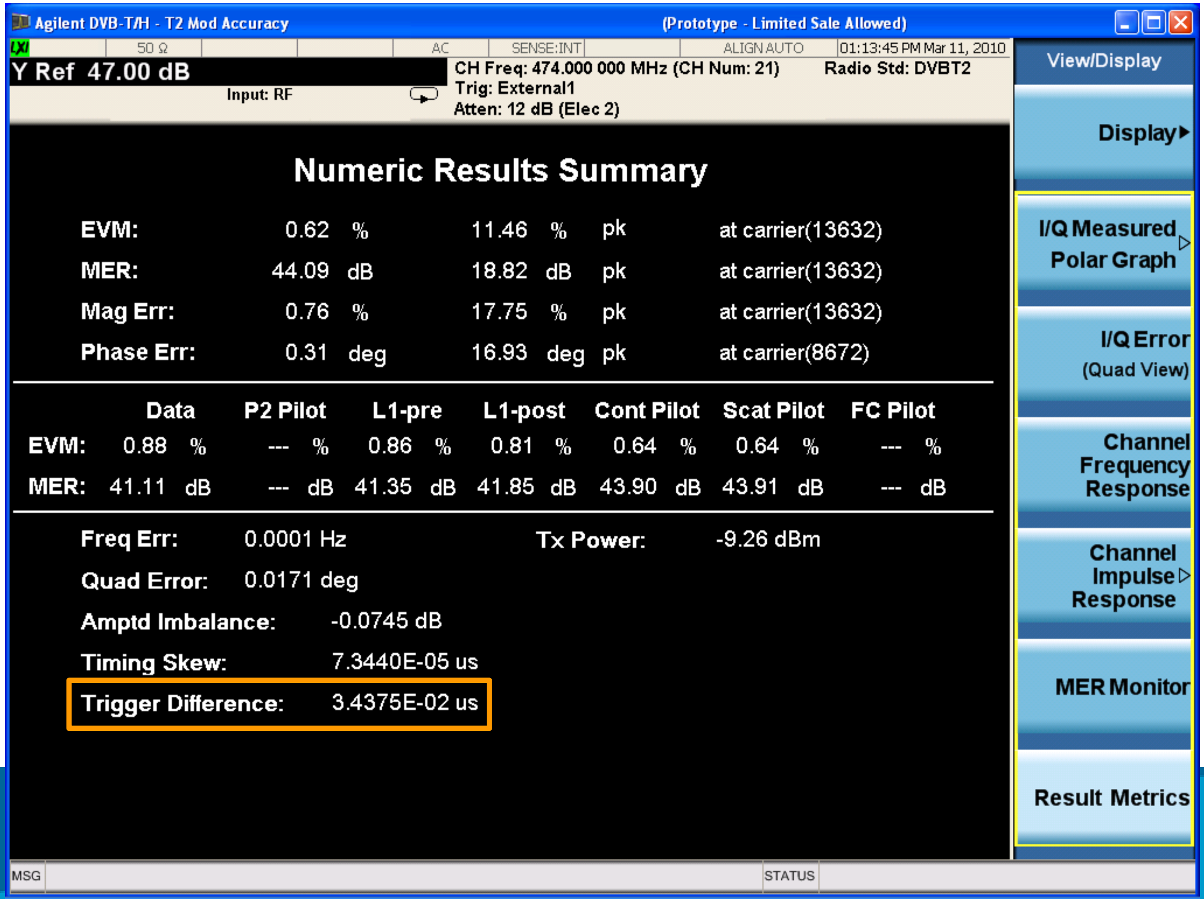


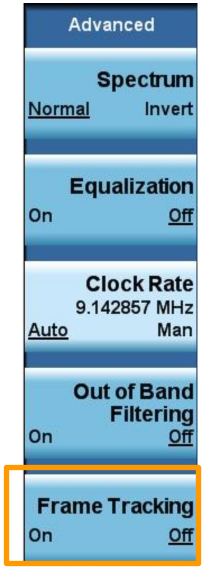
PLP7
256QAM
MER:
37.99 dB

Agilent Technologies

DVB-T2 Modulation Accuracy – Result Metrics

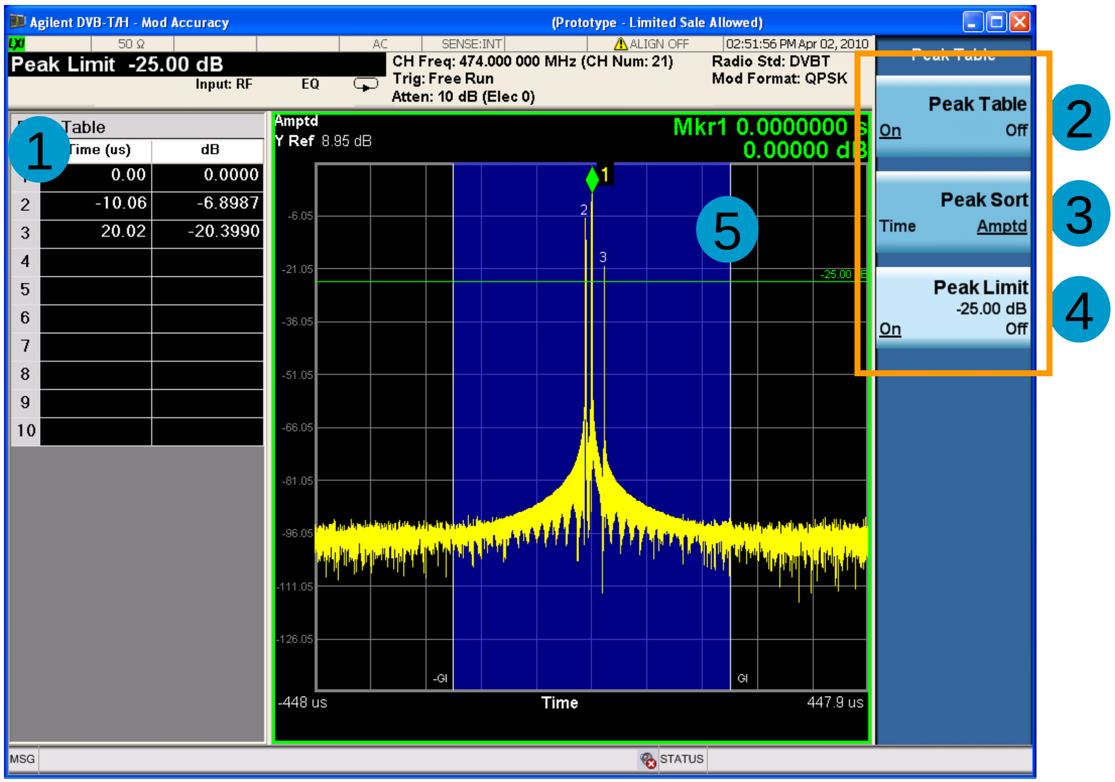
1. All of the signal quality measurement results will be shown here.
2. MER/EVM by Data, P2 Pilot, L1-Pre and L1-Post Signalling, Continuous Pilot, Scatter Pilot and FC Pilot will be shown separately.
3. Tx Power will be shown with some detailed errors showing Freq Error, Quad Error, Amplitude Imbalance and Timing Skew.
4. Trigger Difference is to show the frame duration drift measured by application. When this value is larger than +/-27.2 us, it may cause the sync loss.





Modulation Accuracy – Channel Impulse Response

1. Channel Impulse Response is updated with Peak Table.
2. You can turn on or turn off this feature by [Peak Search]->{More 1 of 2}->{Peak Table}
3. Equalization is recommended to turn on when you measure the CIR
4. Peak Sort can be specified according to Time or Amplitude with default Peak Limit -35 dB.
5. Guard Interval can be shown to display its range and validate whether all of the paths are within the GI.



Live Demo

PXB N5106A Baseband Platform - Multi-Channel Generator and Channel Emulator

Industry Leading Baseband Performance

Up to 4 baseband generators (with up to 8 faders)

125 MHz BW & 512 MSa of memory per BBG

Real-time signal creation for receiver test

Support analog and digital IQ outputs

Fading

Up to 8 real-time faders (with RF in or up to 4 BBGs)

Up to 125 MHz real-time fading BW

Up to 24 paths per fader

Stress devices beyond standard requirements with custom fading setups to ensure design robustness

MIMO

Up to 4x2 MIMO in one box

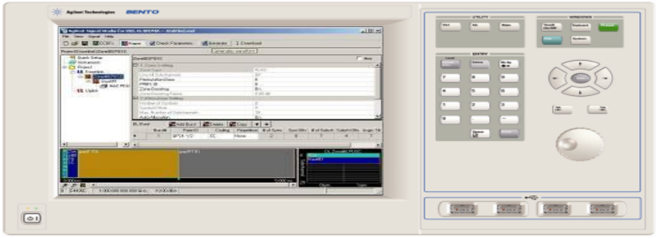
Supports MIMO channel models + diversity

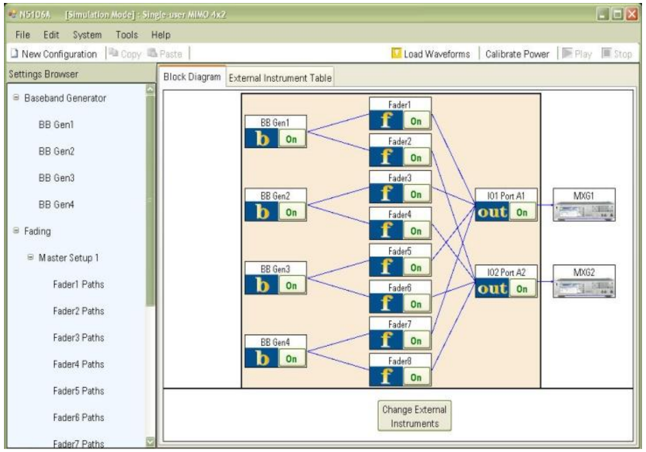
Power management and noise calibration

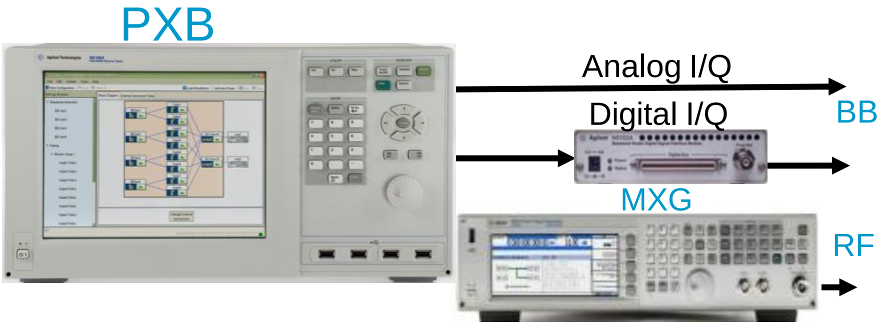
Upgrade to higher order configurations in one hour

Leverage existing Agilent RF equipment for RF->RF fading up to 6 GHz

Flexible digital I/Q outputs with N5102A







Real-time DVB-T/H for Receiver Verification

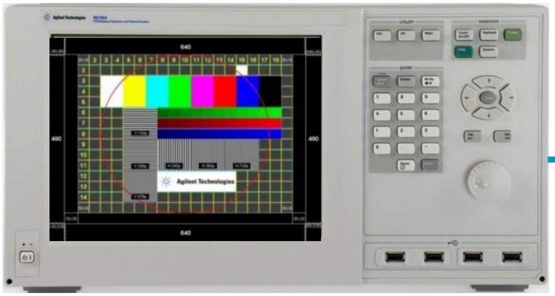
2 GB for TS file playback (20 minutes to a few hours)

1

Signal Studio in the PXB generates real-time DVB-T/H signals with TS file encoding

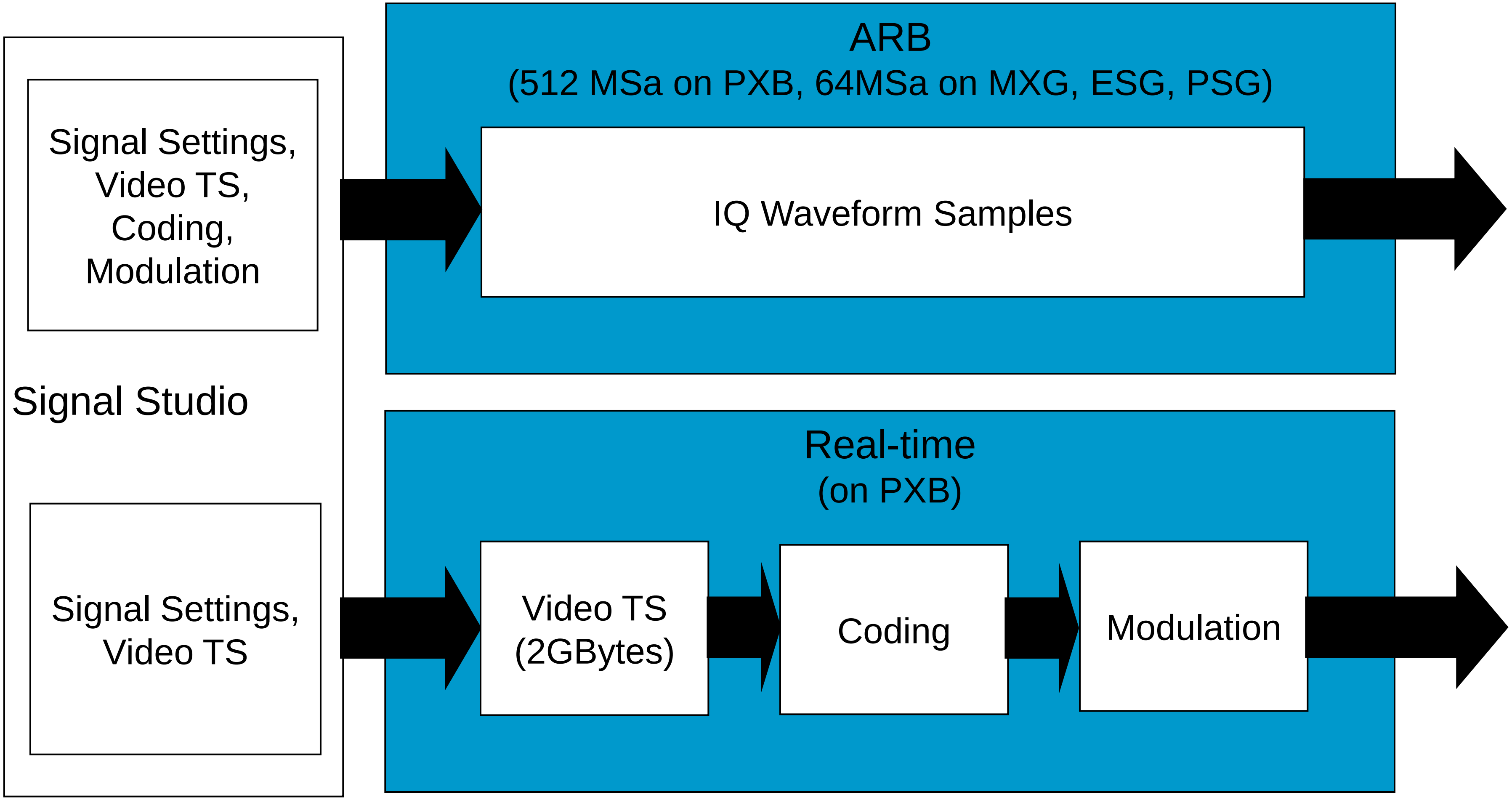
2

Vector MXG or ESG used as a RF up converter



No BBG required for MXG

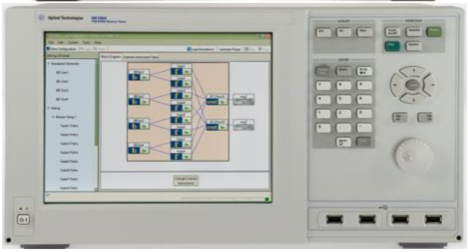
ARB vs. Real Time DVB Signal Generation



Digital Video Sources Positioning

High-end R/D


MXG


PXB

Real-time & ARB solution

- Real-time, fading, interference in one box
- Supports continuous PN sequence with RT (ARB not sufficient even at 512MSa)
- Tx Diversity & MIMO support
- Fast waveform file download
- 2-box solution… but multi-format, general purpose
- No ASI input

R&D + Mfg


ESG

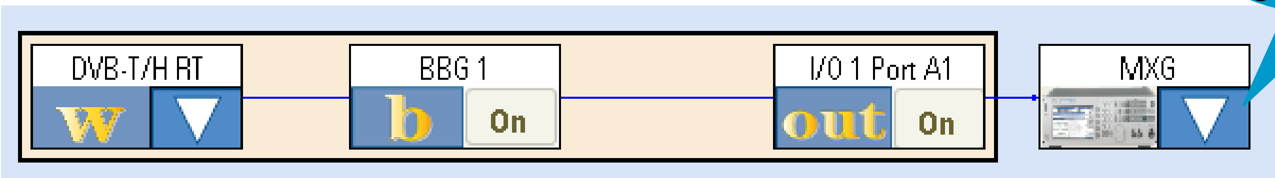

MXG

ARB solution

- Cost effective upgrade for install base
- Easy for mfg test
- Limited ARB memory
- Long waveform download time
- Continuous PN sequence not supported (playback memory limited)

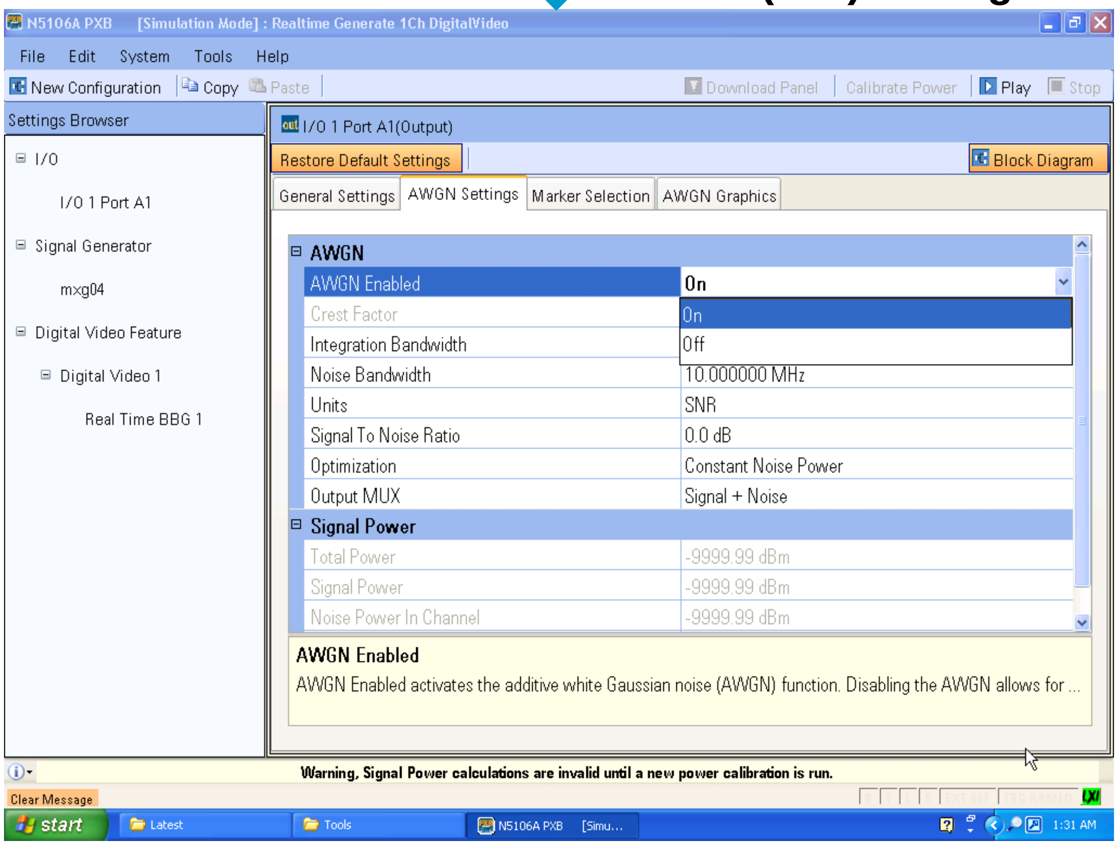
Test Cases: Sensitivity and AWGN

Power level setting

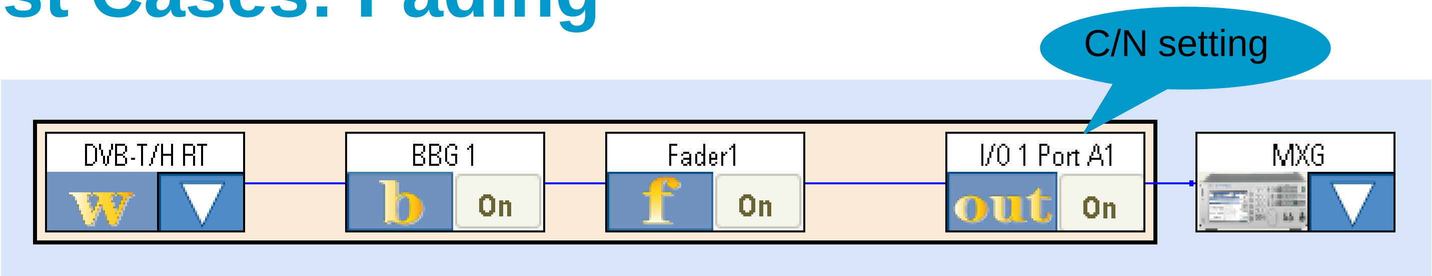


BER reported

AWGN (C/N) setting

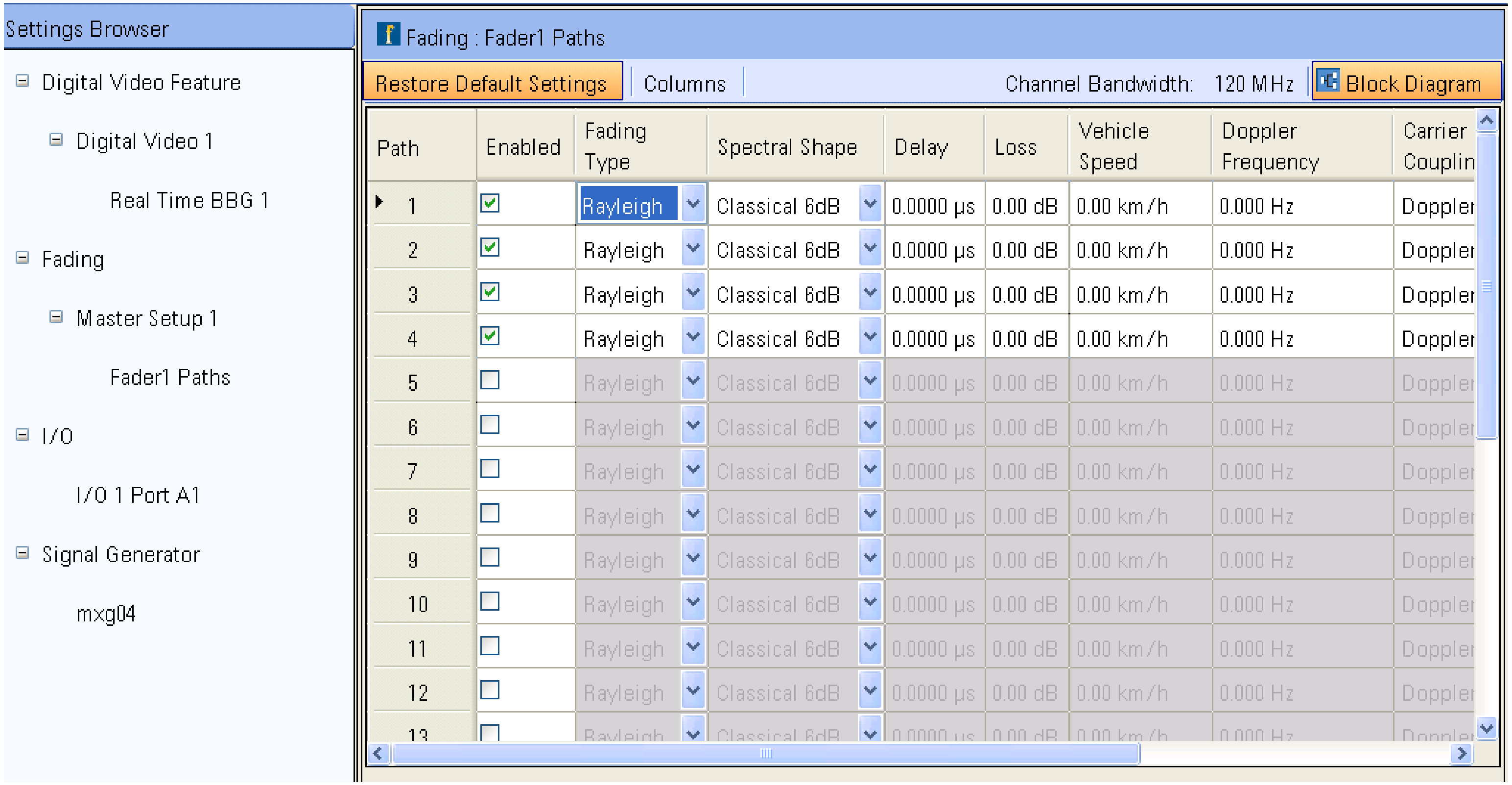


Test Cases: Fading



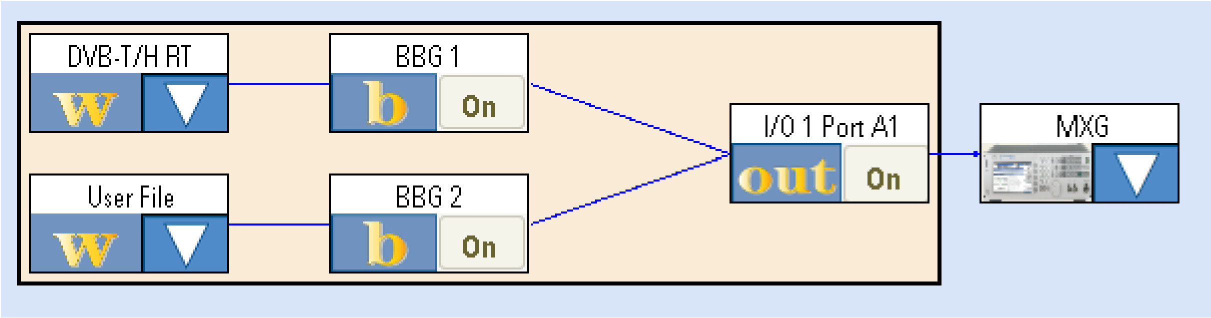
BER reported

Fading setting:
- **Pre-defined**
- **User defined**

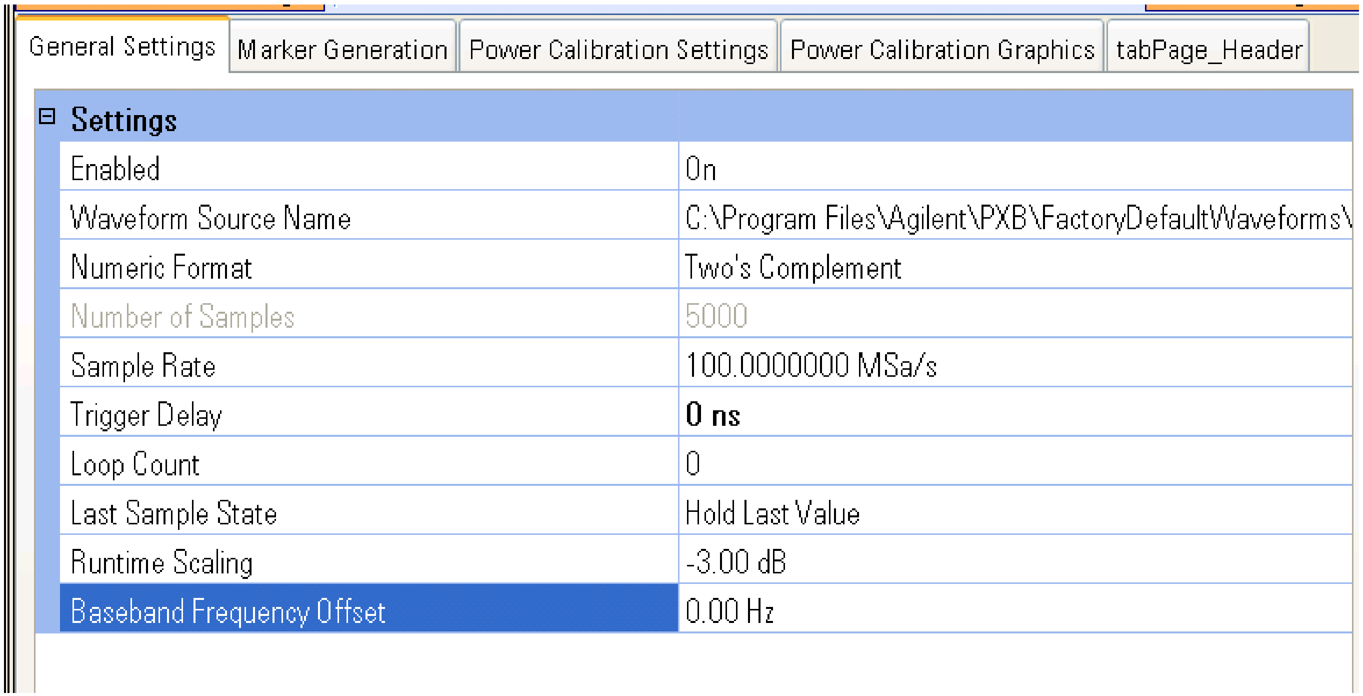


Path	Enabled	Fading Type	Spectral Shape	Delay	Loss	Vehicle Speed	Doppler Frequency	Carrier Couplin
1	☑	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
2	☑	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
3	☑	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
4	☑	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
5	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
6	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
7	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
8	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
9	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
10	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
11	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
12	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
13	☐	Rayleigh	Classical 6dB	0.0000 μs	0.00 dB	0.00 km/h	0.000 Hz	Doppler

Test Cases: Interference



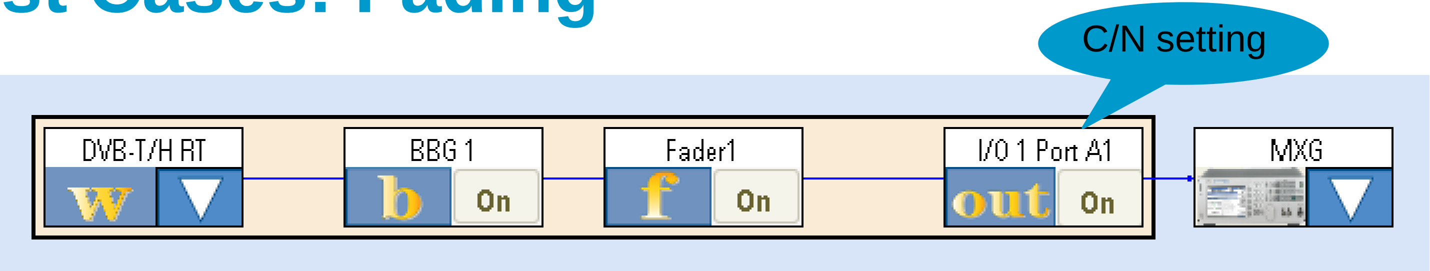
Real time BBG for wanted video signal
Arb BBG for interference signal (analog TV, cellular signal…)
Signals from two BBGs summed


General Settings | Marker Generation | Power Calibration Settings | Power Calibration Graphics | tabPage_Header

Settings	
Enabled	On
Waveform Source Name	C:\Program Files\Agilent\PXB\FactoryDefaultWaveforms\
Numeric Format	Two's Complement
Number of Samples	5000
Sample Rate	100.0000000 MSa/s
Trigger Delay	**0 ns**
Loop Count	0
Last Sample State	Hold Last Value
Runtime Scaling	-3.00 dB
Baseband Frequency Offset	0.00 Hz

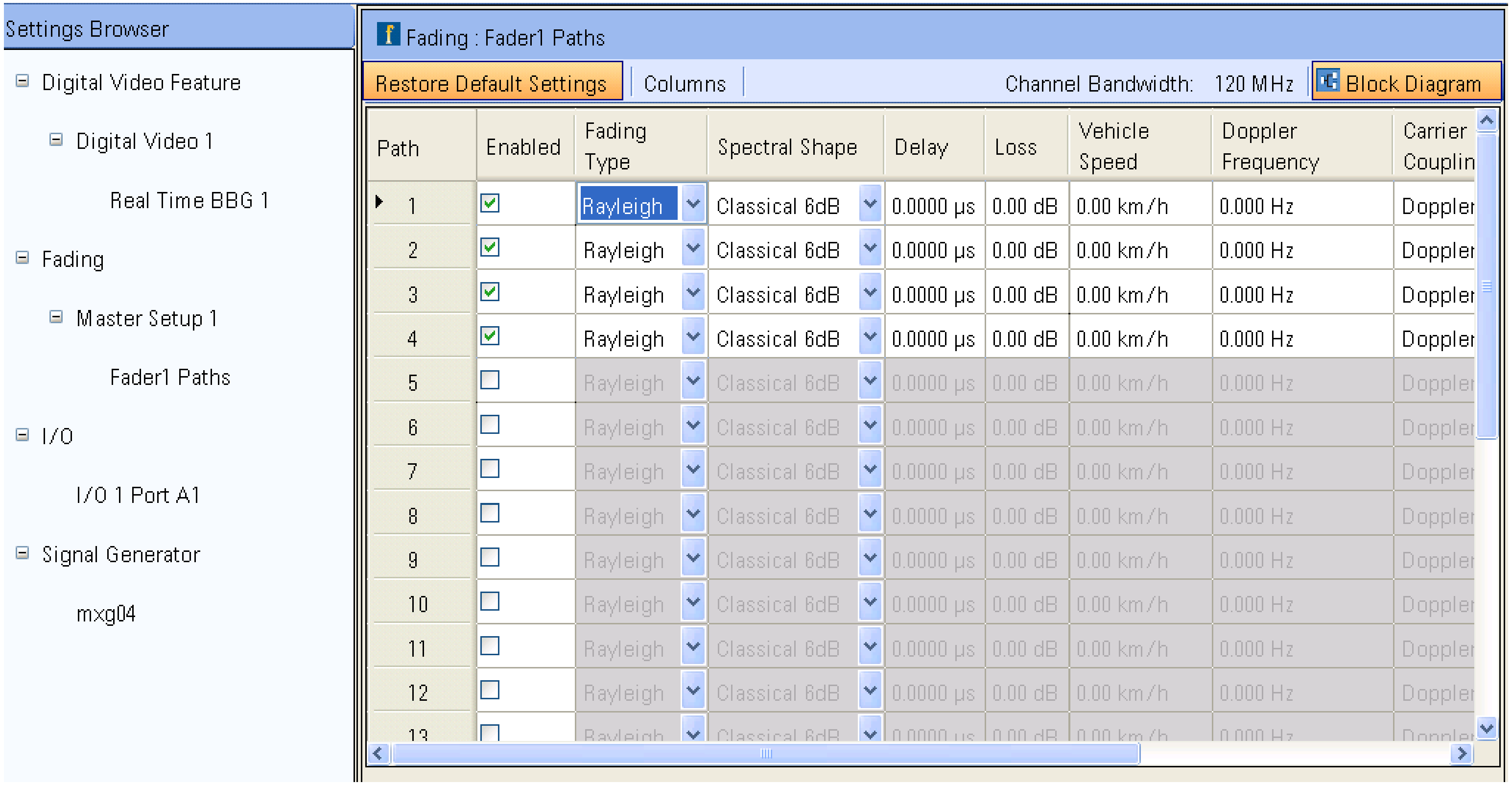
Power level and frequency offset can be set for each BBG

Test Cases: Fading



BER reported

Fading setting:
- **Pre-defined**
- **User defined**



Path	Enabled	Fading Type	Spectral Shape	Delay	Loss	Vehicle Speed	Doppler Frequency	Carrier Couplin
1	☑	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
2	☑	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
3	☑	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
4	☑	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
5	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
6	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
7	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
8	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
9	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
10	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
11	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
12	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler
13	☐	Rayleigh	Classical 6dB	0.0000 µs	0.00 dB	0.00 km/h	0.000 Hz	Doppler

Agilent Digital Video Analysis Apps Summary

HW Platforms (X-series)

Performance

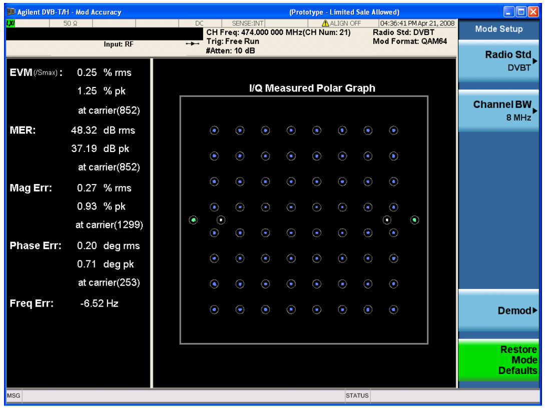
PXA

MXA

EXA

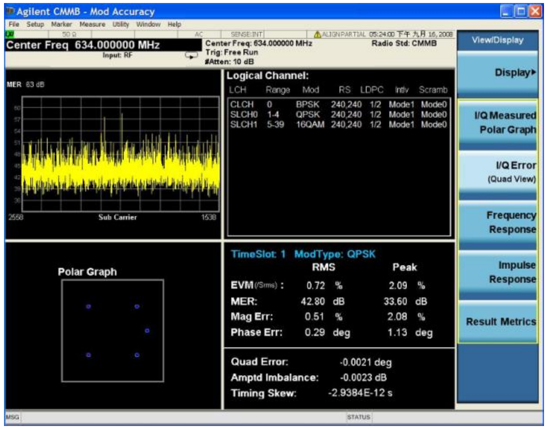
CXA

SW Apps with all formats



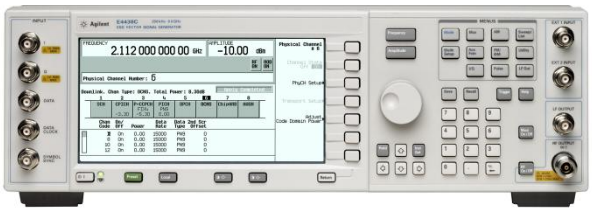
N6153A DVB-T/H/T2
N6155A ISDB-T/Tsb/Tb
N6156A DTMB (CTTB)
N6158A CMMB
N6152A Digital Cable TV (DVB-C, J.83 A/B/C)

89601X DVB-C/S/S2, ATSC, J.83B
N9063A AM/FM



E9285B-H05 XM
E9285B-H06 DAB/T-DMB
E9285B-H07 DVB-SH

Agilent RF Vector Signal Generators



ESG

MXG

Target Applications

- **RF and baseband component and transceiver test**
- **R&D design and verification**
- **Manufacturing**

Performance

- **Up to 6 GHz**
- **160 MHz RF mod BW (ext IQ)**
- **80 MHz RF mod BW (int BBG)**
- **Up to 100 MSa/s + upsampling HW**
- **64 MSa playback/1 GSa storage**
- **Real-time and arb signal creation**
- **Advanced baseband capability**

Performance optimized for manufacturing

Fastest switching speeds

Best ACPR performance

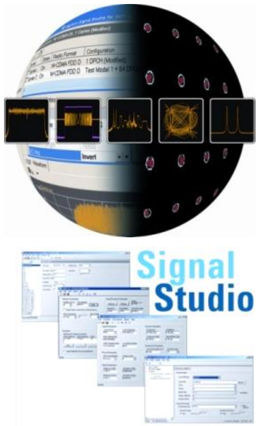
Reliability and simplified self-maintenance

Performance

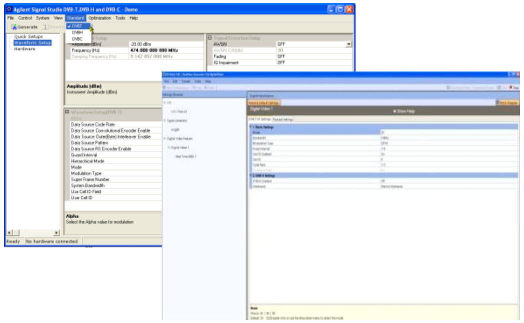
- **Up to 6 GHz**
- **Fastest switching speed**
- **Best ACPR**
- **Excellent EVM**
- **100 MHz BBG RF BW**
- **160 MHz I/Q mod BW**
- **64 MSa playback memory**
- **High output power, high DR options**

Agilent Signal Studio for Digital Video

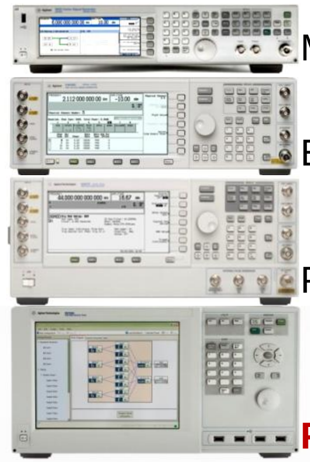
Test digital video components and receivers



N7623B
Signal Studio for Digital Video



Platform Support



MXG
ESG
PSG
PXB NEW

Video Formats Support

Real-time

– **DVB-T/H** NEW

ARB

– DVB-T/H/C/S/S2
– **DVB-T2 (single PLP only)** NEW
– J.83 Annex A/B/C
– DOCSIS DS
– ISDB-T/T_{SB}/T_B
– ATSC
– DTMB
– CMMB + TS library

Broadcast Audio Format Support

– FM Stereo/RDS
– DAB/DAB+
– **ETI support for DAB/DMB** NEW

Agilent Technologies

?

Thank you!!!