



Agilent Technologies

VSA Considerations for Traditional and Ultra-Broadband Applications

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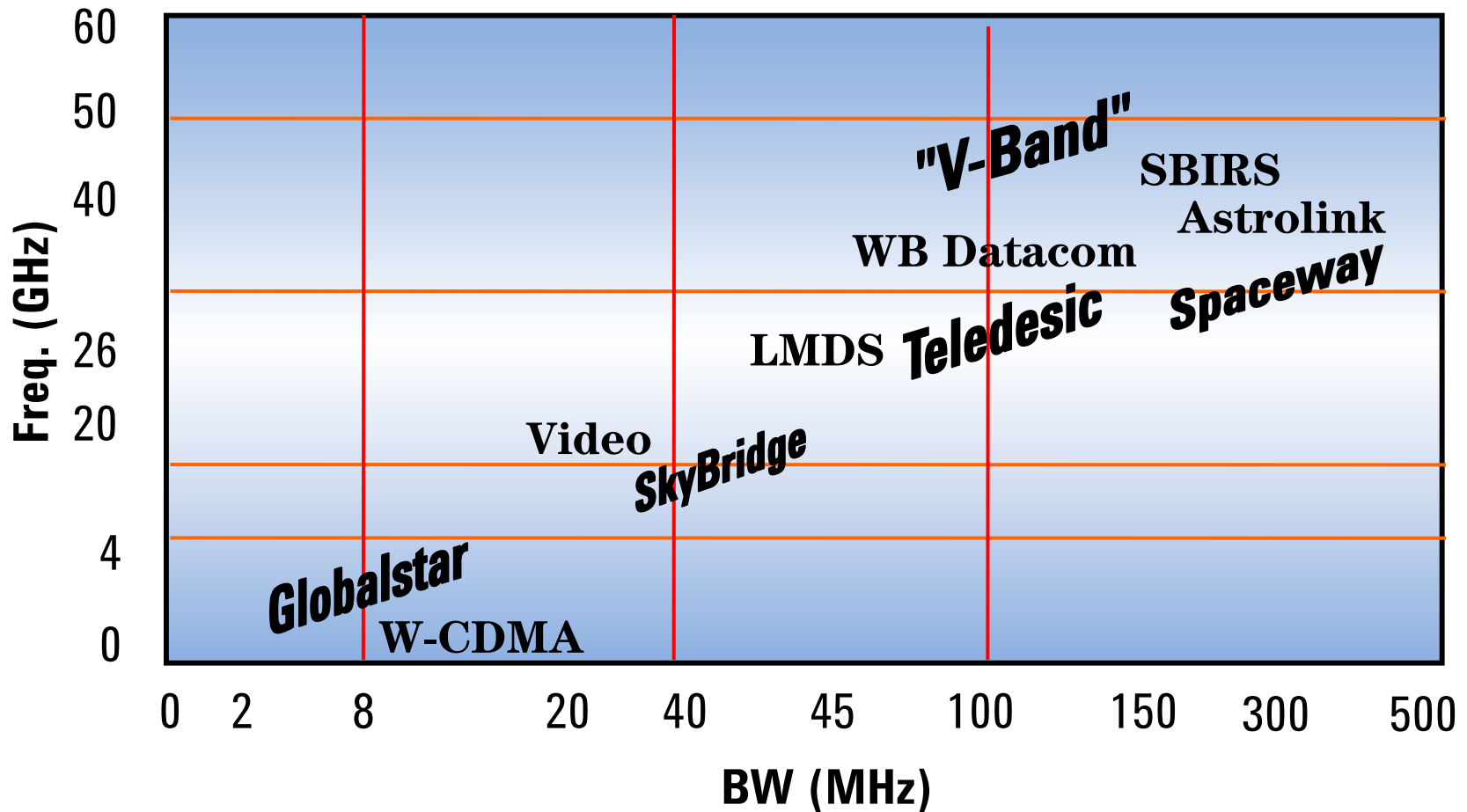
Senior MTS, Signal Analysis Unit,
Santa Rosa, CA

Current Communication Services and Bit Rate

Bit Rate:	10 Kb/s	100 Kb/s	1 Mb/s	10 Mb/s	100 Mb/s
Voice	Telephone Voice Conference	Stereo Music	CDMA Phone	W-CDMA	
Video	Video Telephone	Video Conference	Full Motion Video	Digital Video HDTV	
Data	Facsimile Std. Modem	ISDN	HD Still Picture Remote CAD/CAM	Super High Speed Fax File Transmission LAN	Broadband LMDS/ MMDS WAN
Switching Technologies	Packet Switching Circuit Switching		Frame Switching		SONET ATM



Future Communication Services and Signal Bandwidth



Traditional Instrument

Vector Signal Analyzer c. 1993

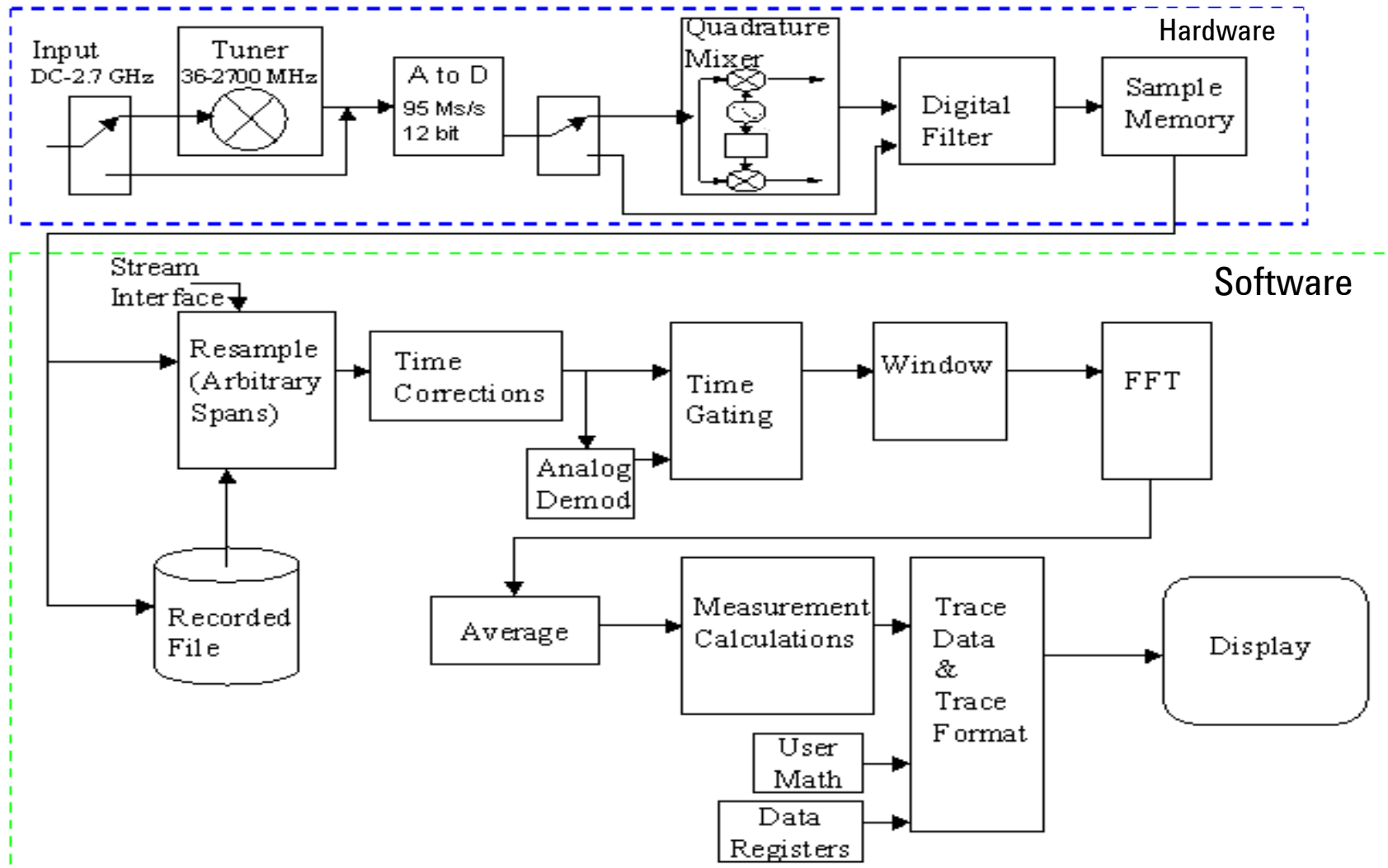


**Agilent 89400 Series
Vector Signal Analyzer**

- **2700 MHz freq. range**
- **7 MHz meas. BW**
- **Built-in signal capture memory**
- **Wide selection of flexible demodulators**
- **Built-in equalizer**
- **Many time-, freq-, mod-domain displays**



VSA Architecture

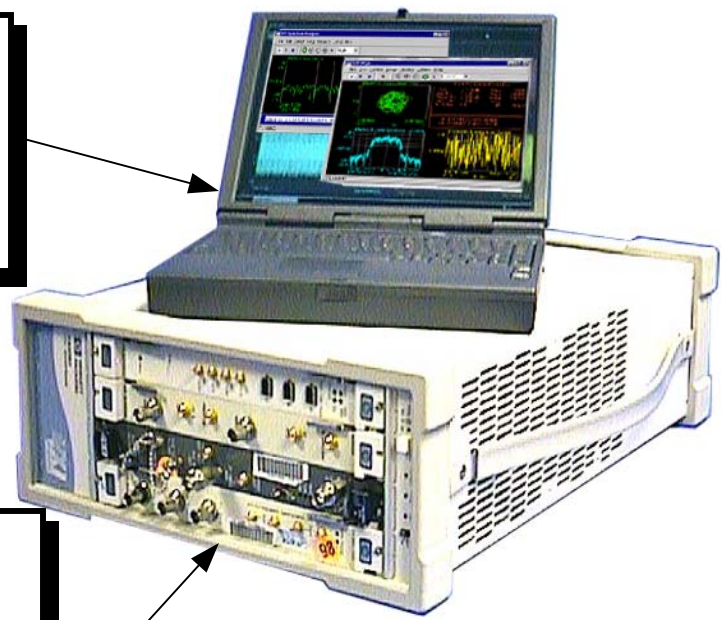


A Systems Optimized

Wide-Bandwidth Vector Signal Analyzer c.2000

COMPUTER

- Analysis DSP
- Display



- 2700 MHz freq. range
- 36 MHz meas. BW

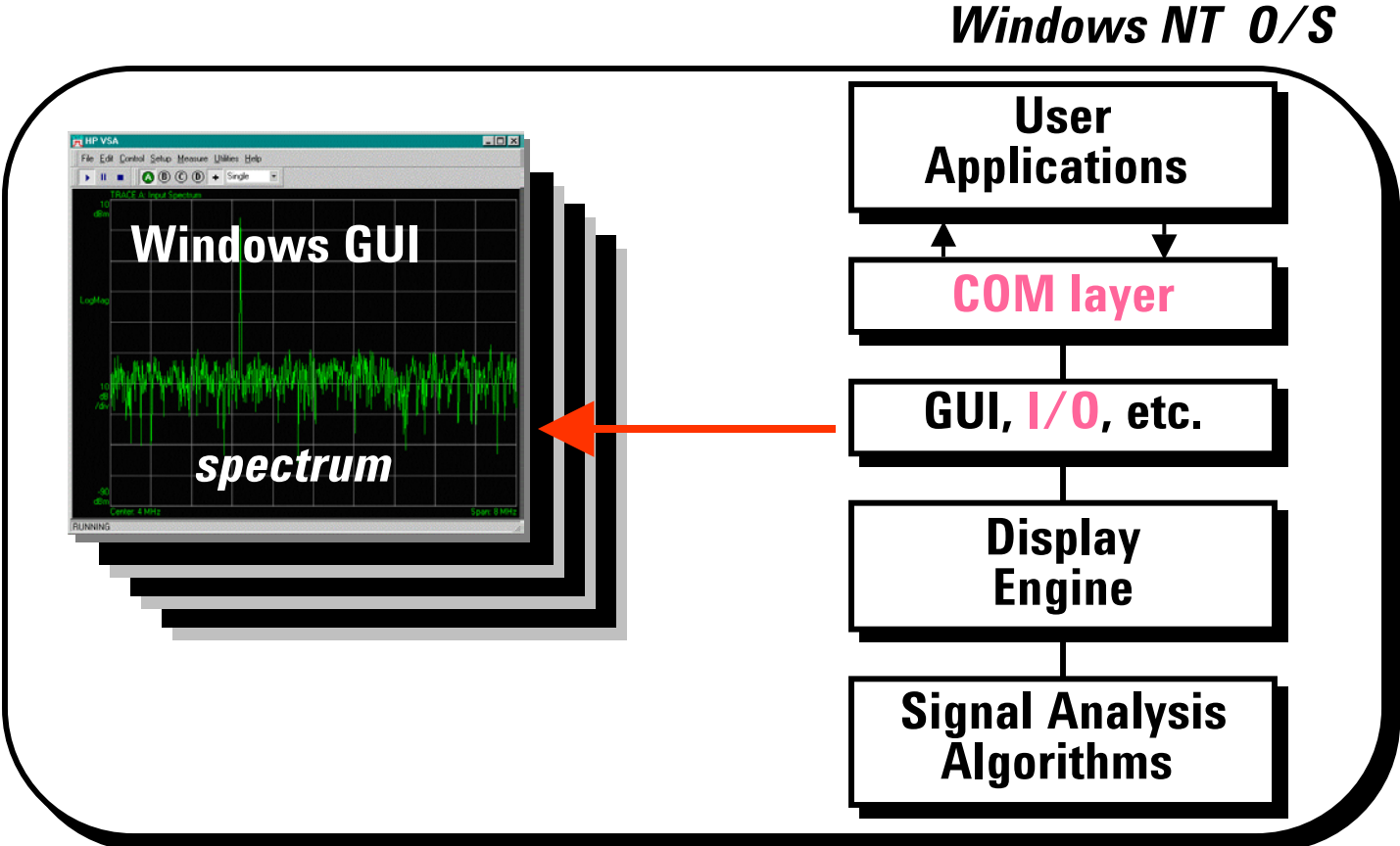
VXI Rack

- RF Tuner
- A/D Converter + Tune-Zoom DSP + Calibrator

Agilent 89600 Series Vector Signal Analyzer



Open System Architecture



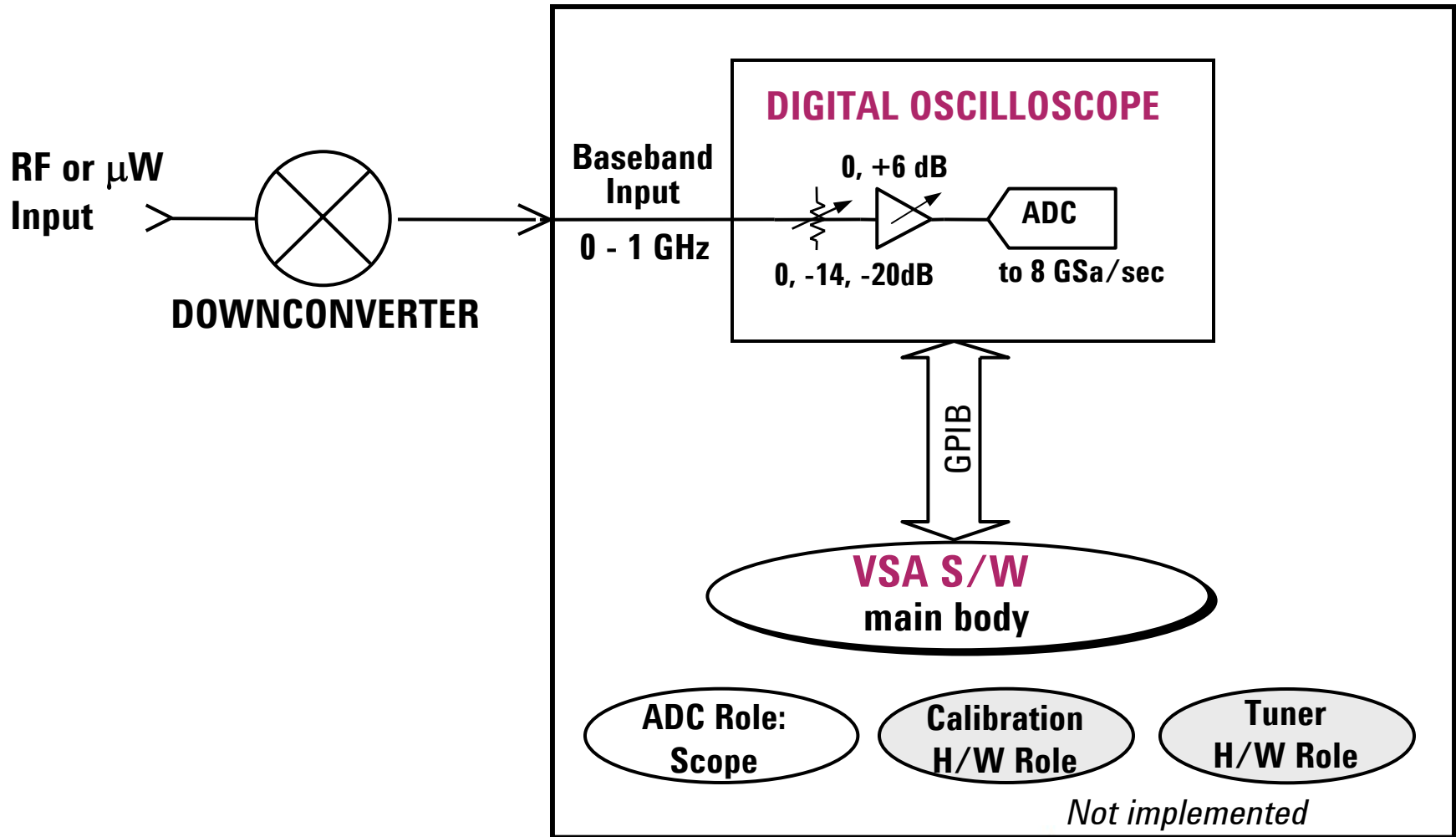
Front End



digitized waveform



Ultra-Wideband Vector Signal Analyzer



Troubleshooting Digital Communications Systems

- Digital modulation requires new test methods
- Difficult to gauge system performance with traditional parameters
remember:
the Data is digital, but the Modulation is analog
- Evaluate modulation accuracy in the same way the customer's demodulator sees the signal:
in the time domain, at symbol decision time



Vector Signal Analyzer Capability

Modulation Formats

FSK, BPSK, 8PSK, MSK, GMSK

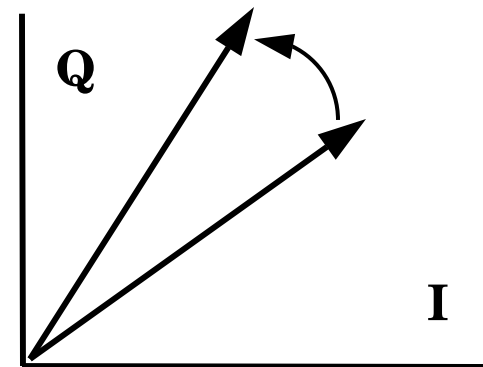
QPSK, OQPSK, DQPSK, $\pi/4$ DQPSK

16 QAM, 32 QAM, 64 QAM, 128 QAM, 256 QAM

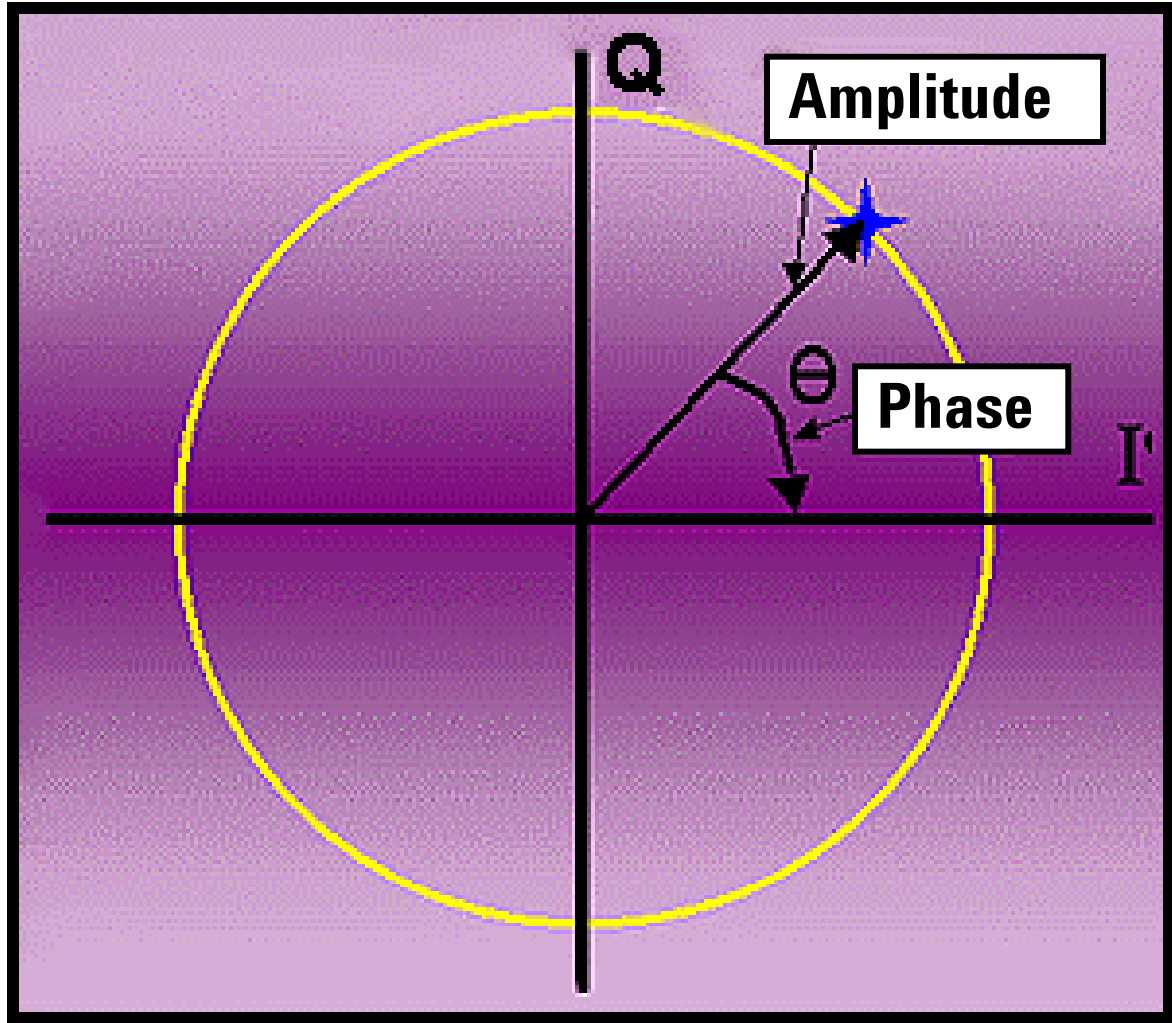
COFDM, 8 VSB, 16 VSB

Display Types

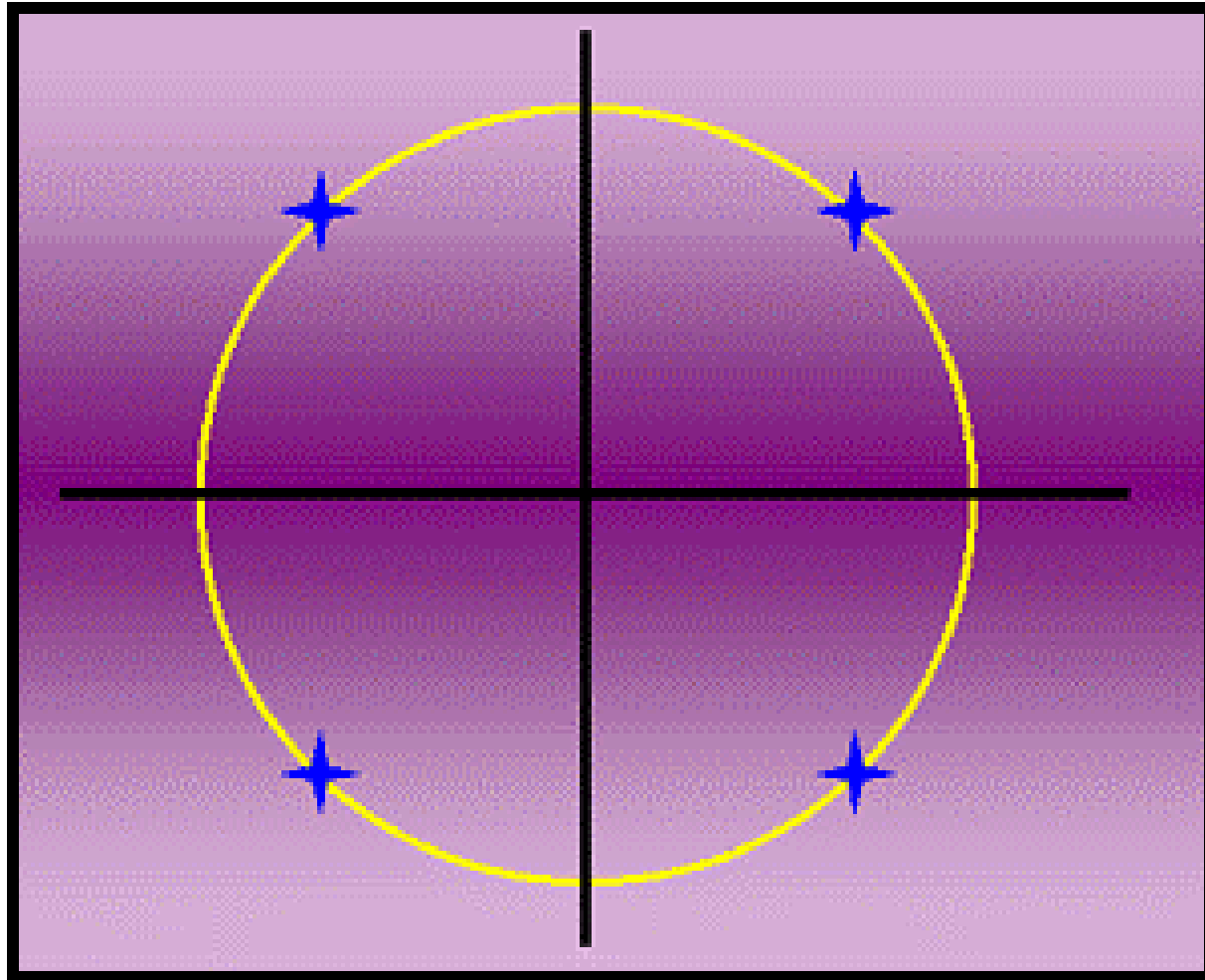
**Eye, constellation, vector,
error vector magnitude (EVM)
spectrogram, data table**



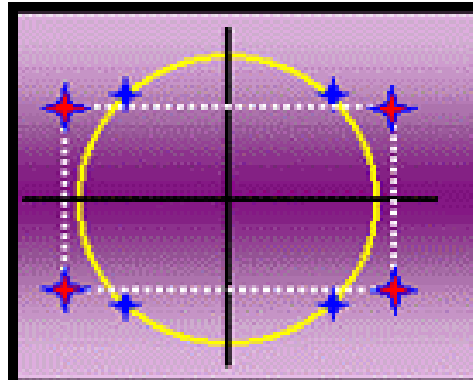
Typical I/Q Diagram



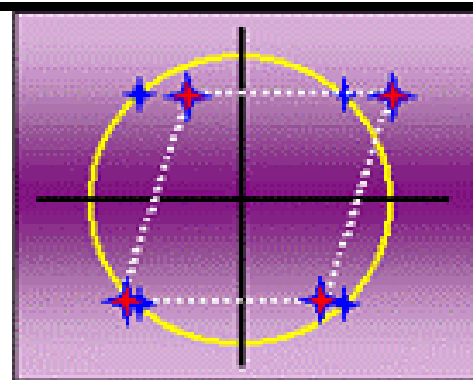
Four-Phase Modulation Scheme



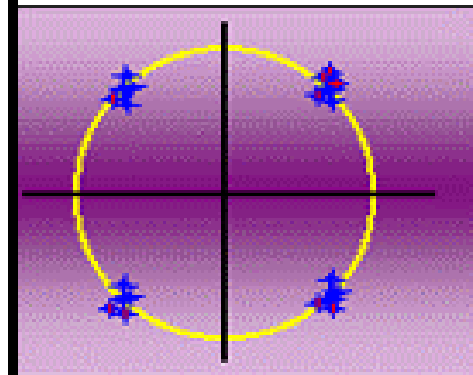
Common Modulation Errors



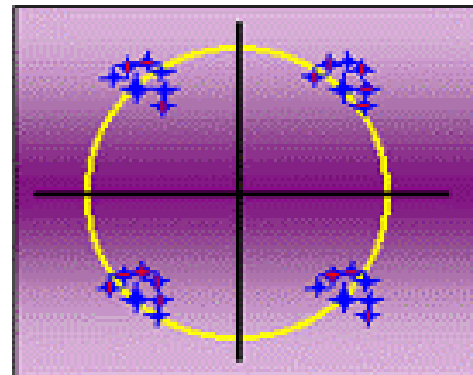
a) Gain imbalance



b) Phase imbalance



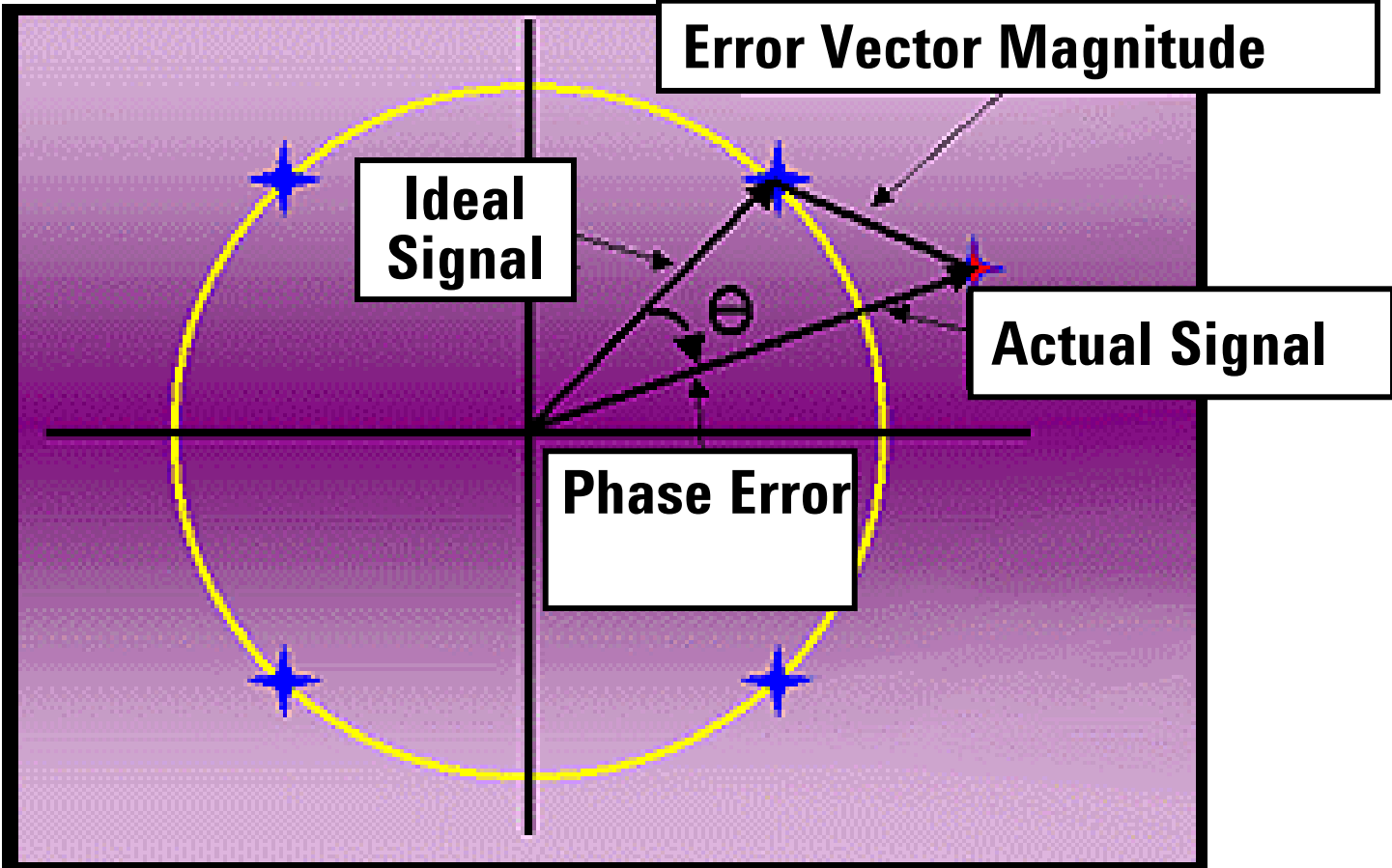
c) Noise contamination



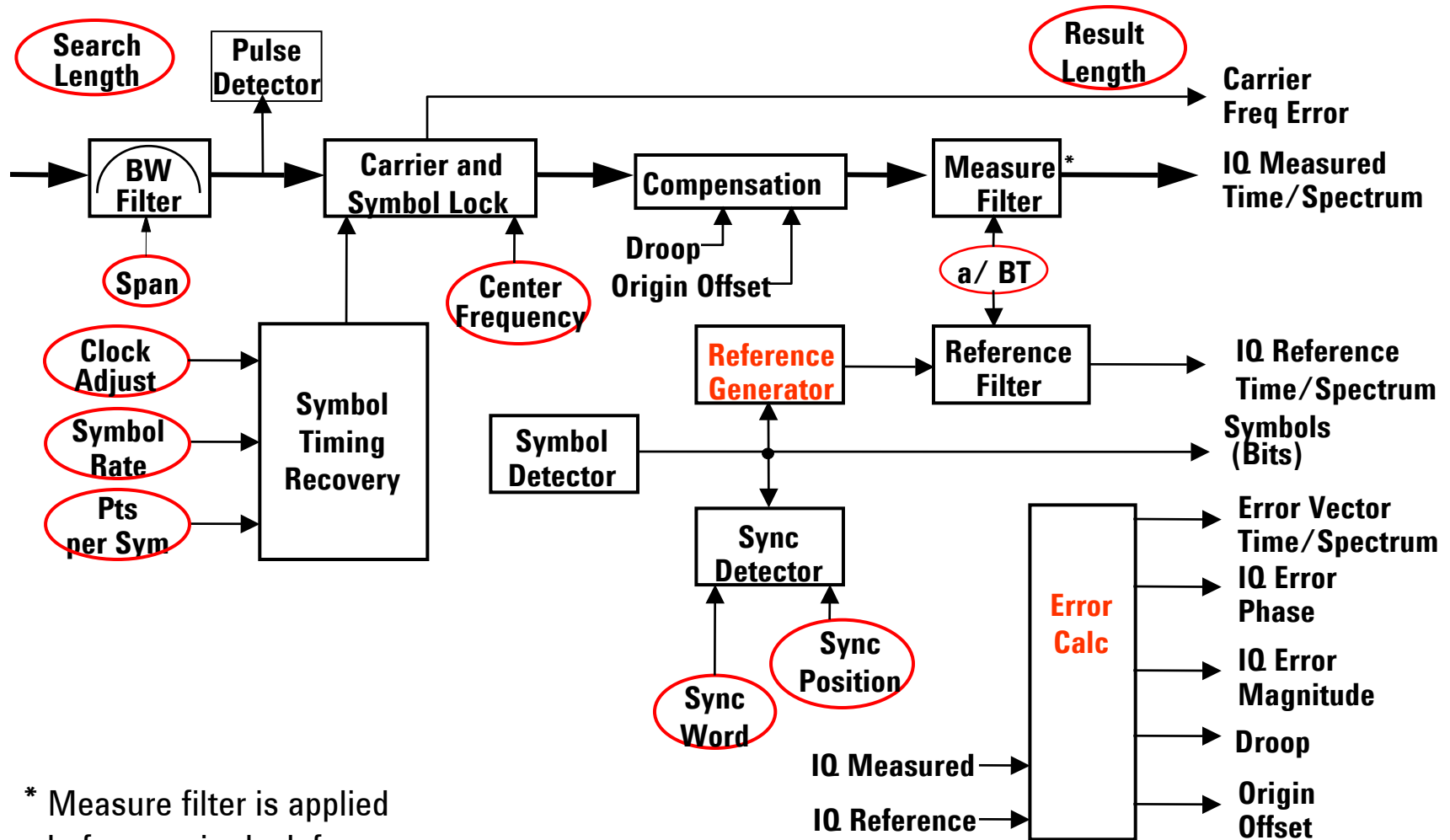
d) Signal interference



EVM Measurement



Digital Demodulation System



* Measure filter is applied before carrier lock for MSK demodulators



EVM Technique yields Numerous Results UWBW

Example 1 Lab Reference signal 200 Mbps QPSK

TRACE A: Ch1 QPSK Meas Time

1.5

I-Q

300 m /div

-1.5

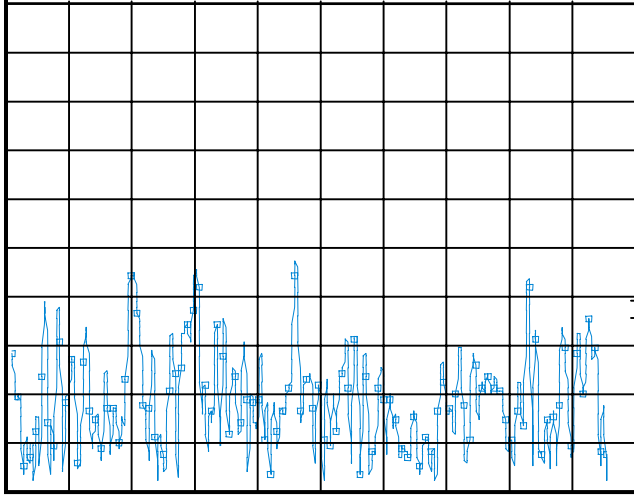
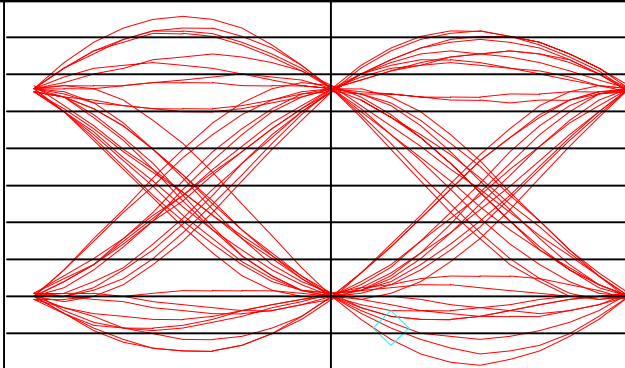
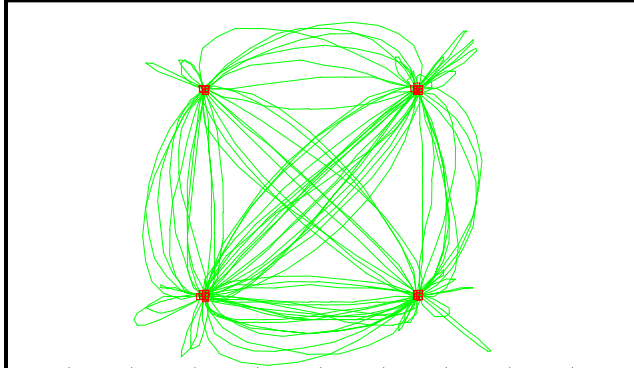
5%

LinMag

500 m%

/div

0%



EVM = 1.1123 %rms
 2.4110 % pk at sym 47
 Mag Err = 716.03 m%rms
 1.8255 % pk at sym 29
 Phase Err = 487.30 mdeg
 1.3125 deg pk at sym 20
 Freq Err = -26.892 Hz
 IQ Offset = -66.774 dB
 Rho = 0.99988

EVM = 1.1%

F_{if} = 140 MHz

0 11011101 00011101
 16 11010100 10110011
 32 0000 10 1001110100
 48 00101100 10111100
 64 01110011 10110101

-1.9736841917

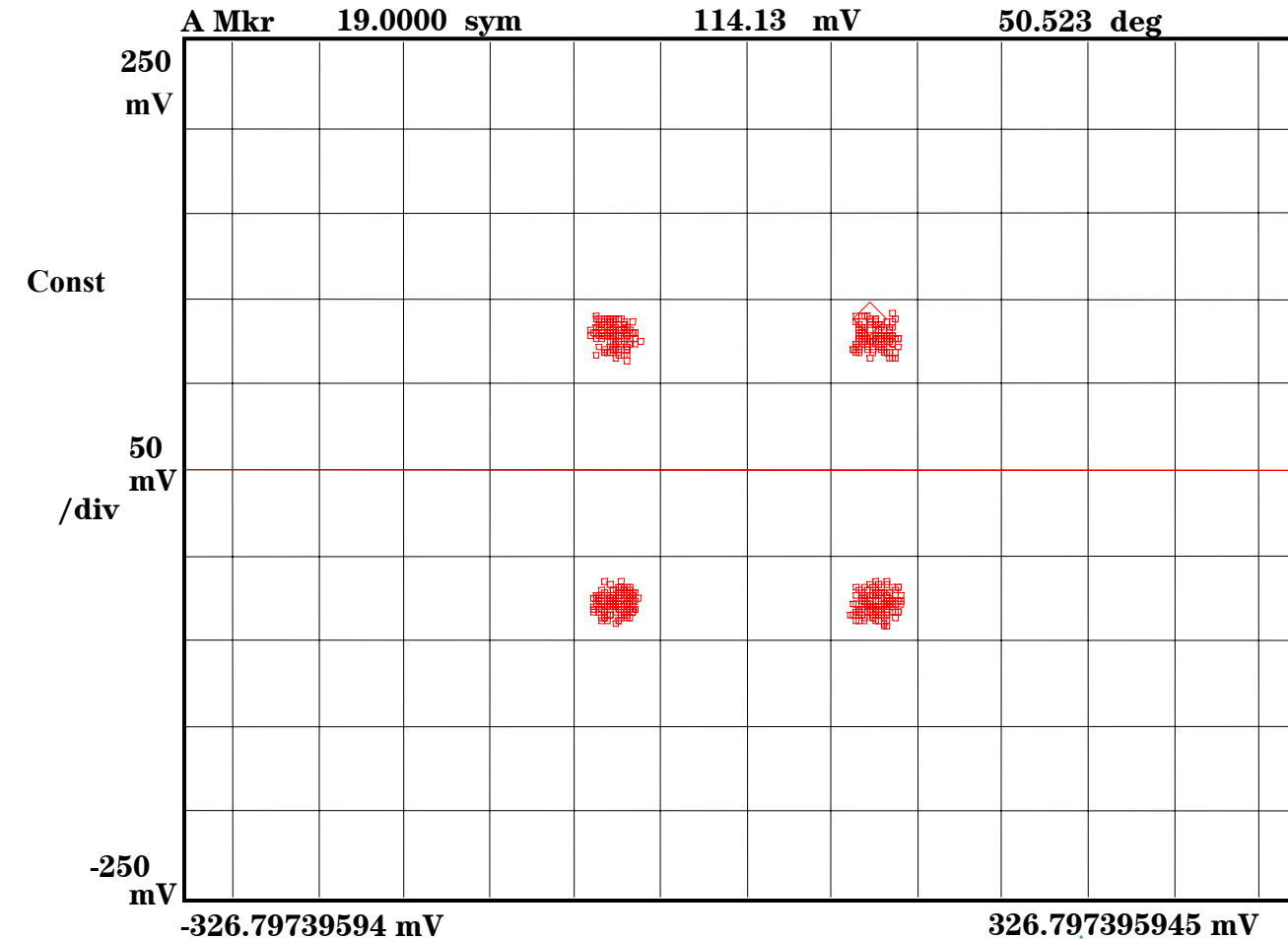
1.9736841917



Some signals need further examination

QPSK with 8% EVM

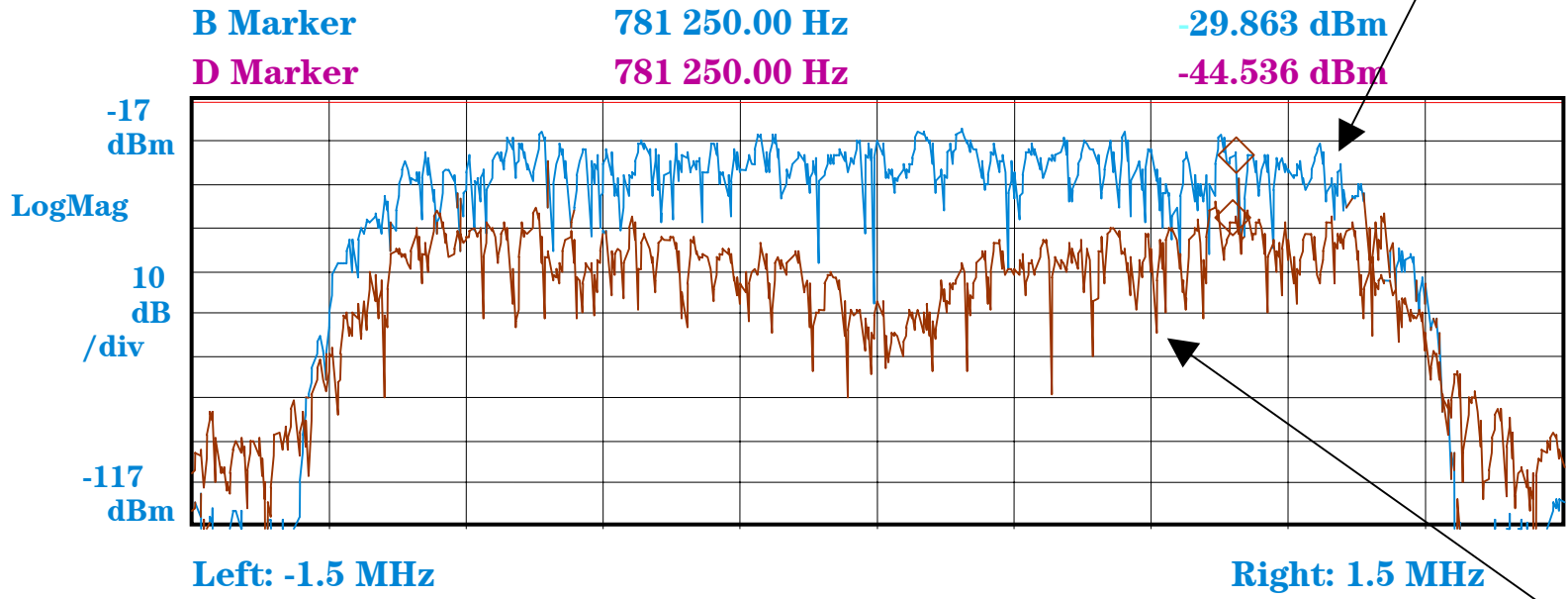
TRACE A: Ch1+jCh2 QPSK Meas Time



Error Vector Spectrum reveals

“shape” of the problem

TRACE B: Ch1+jCh2 QPSK Meas Spec



Measured Spectrum

Error Vector Spectrum



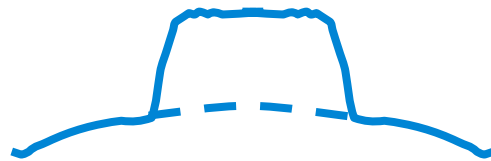
Troubleshooting with EVM Spectrum

Spectrum



Ideal Signal

EVM Spectrum



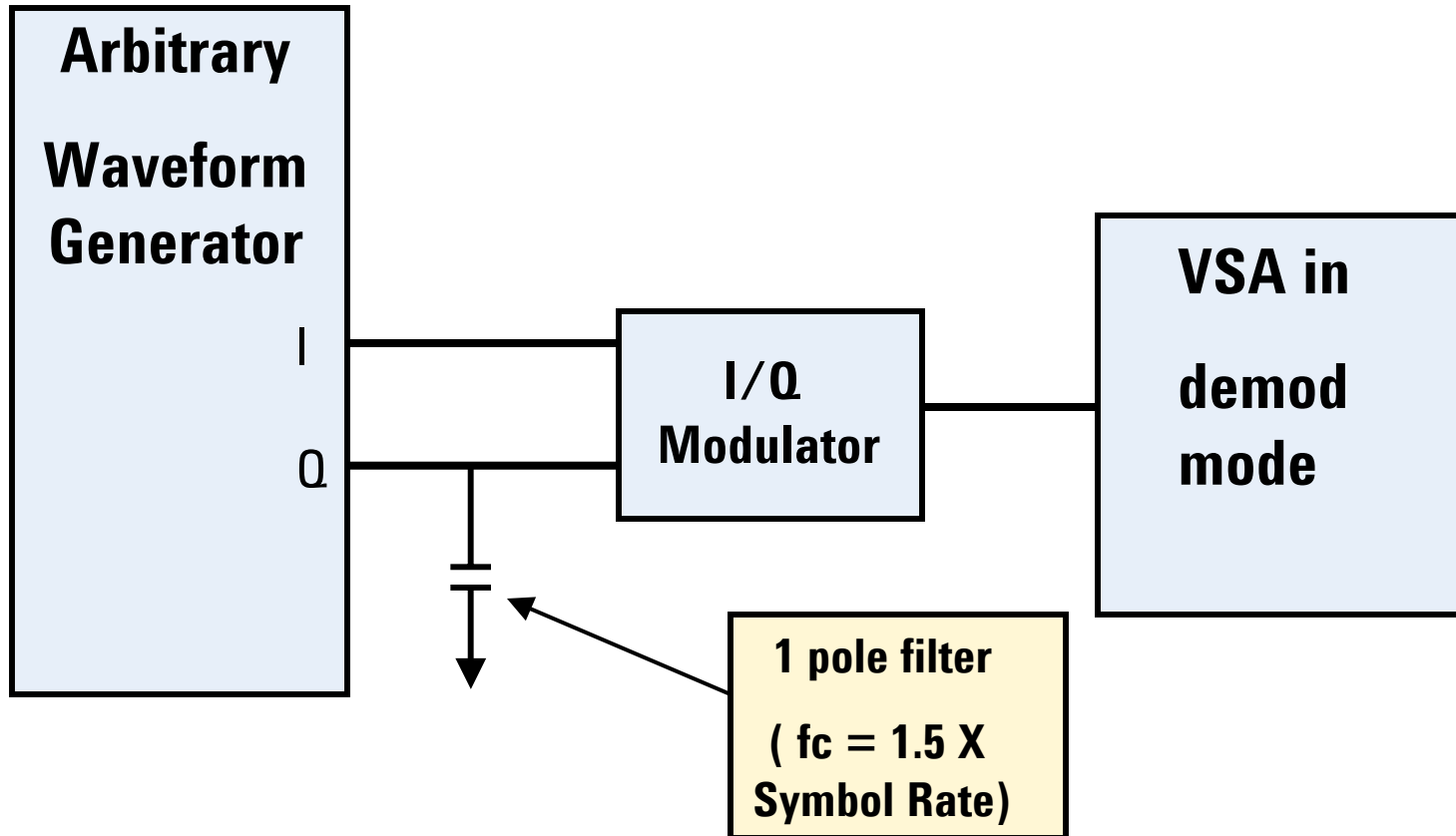
Impaired Signal
-is it only distortion?



NO- EVM Spectrum Display reveals
it is distortion plus I/Q imbalance.



Simulated I/Q imbalance



I/Q Imbalance Analysis

shows precise nature of problem

Phase Imbalance
10 deg/

Mag Imbalance
0.5 dB/

TRACE A: F6 F3/(F4/F5)

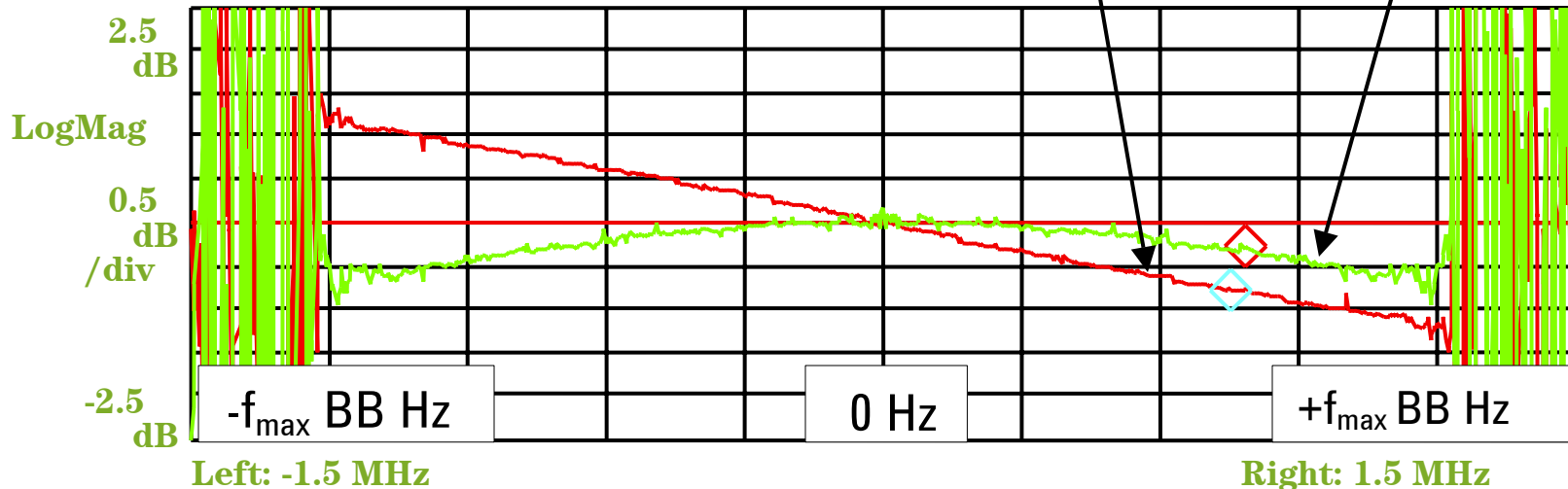
A Marker

781 250.00 Hz

C Marker

750 000.00 Hz

-0.273 dB
-15.300 deg

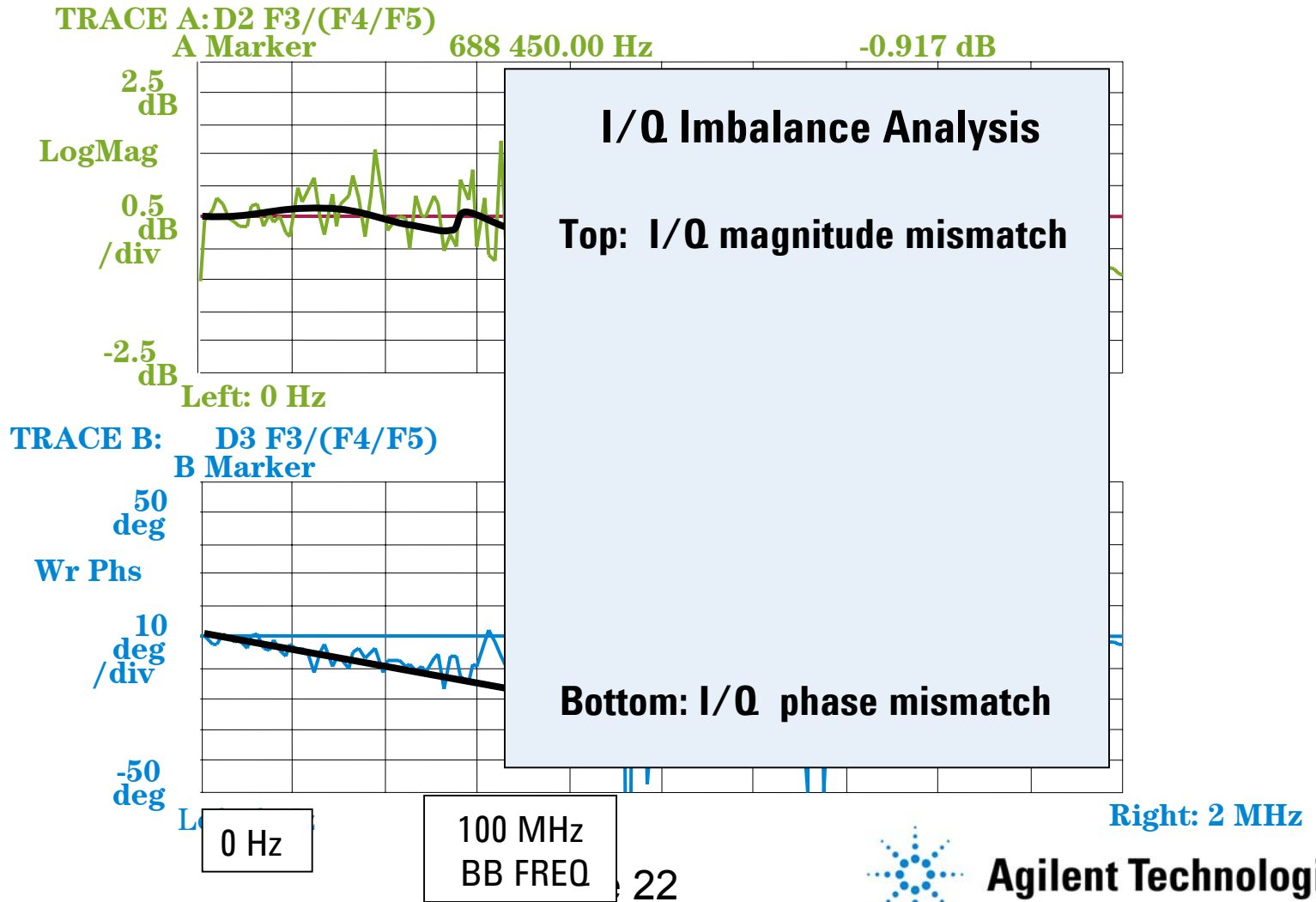


max



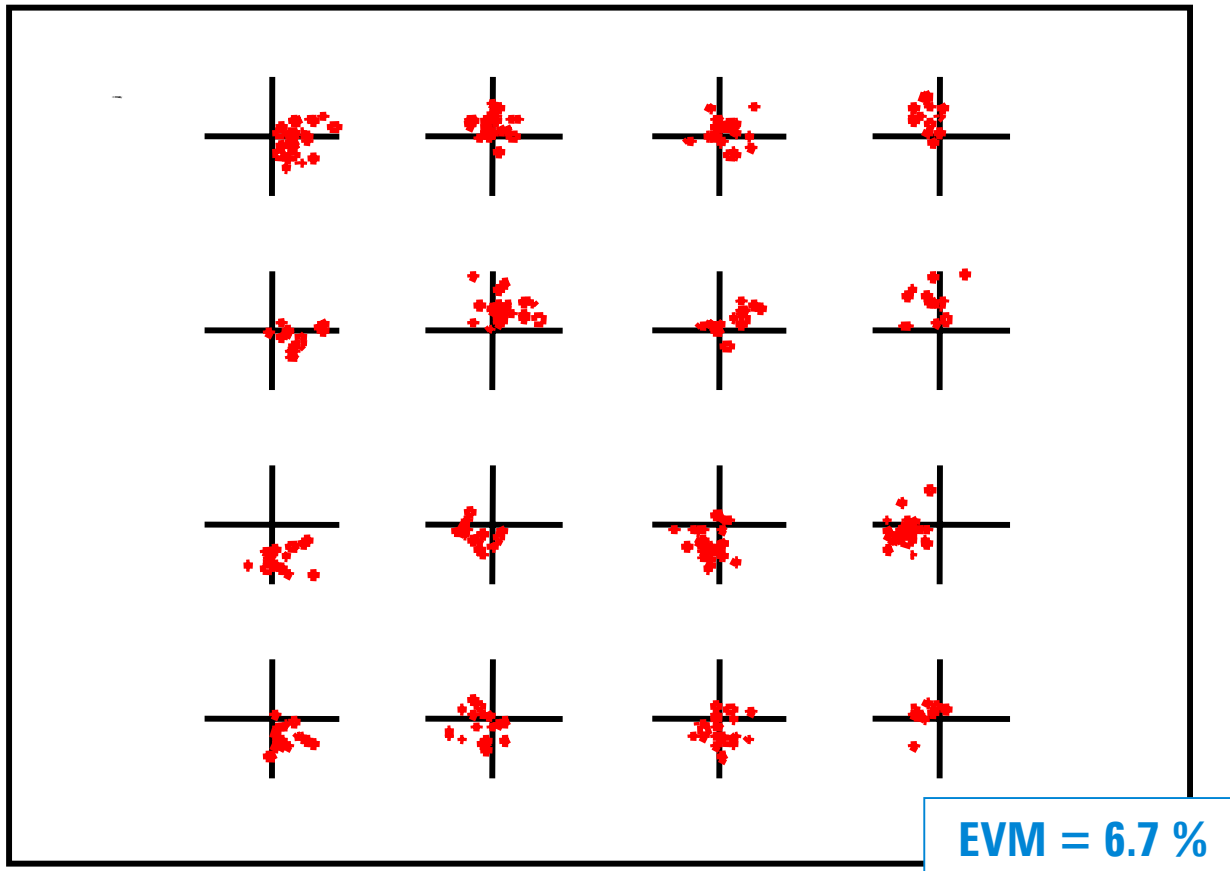
Example 2:

Satellite Downlink 200 MSymbol/sec



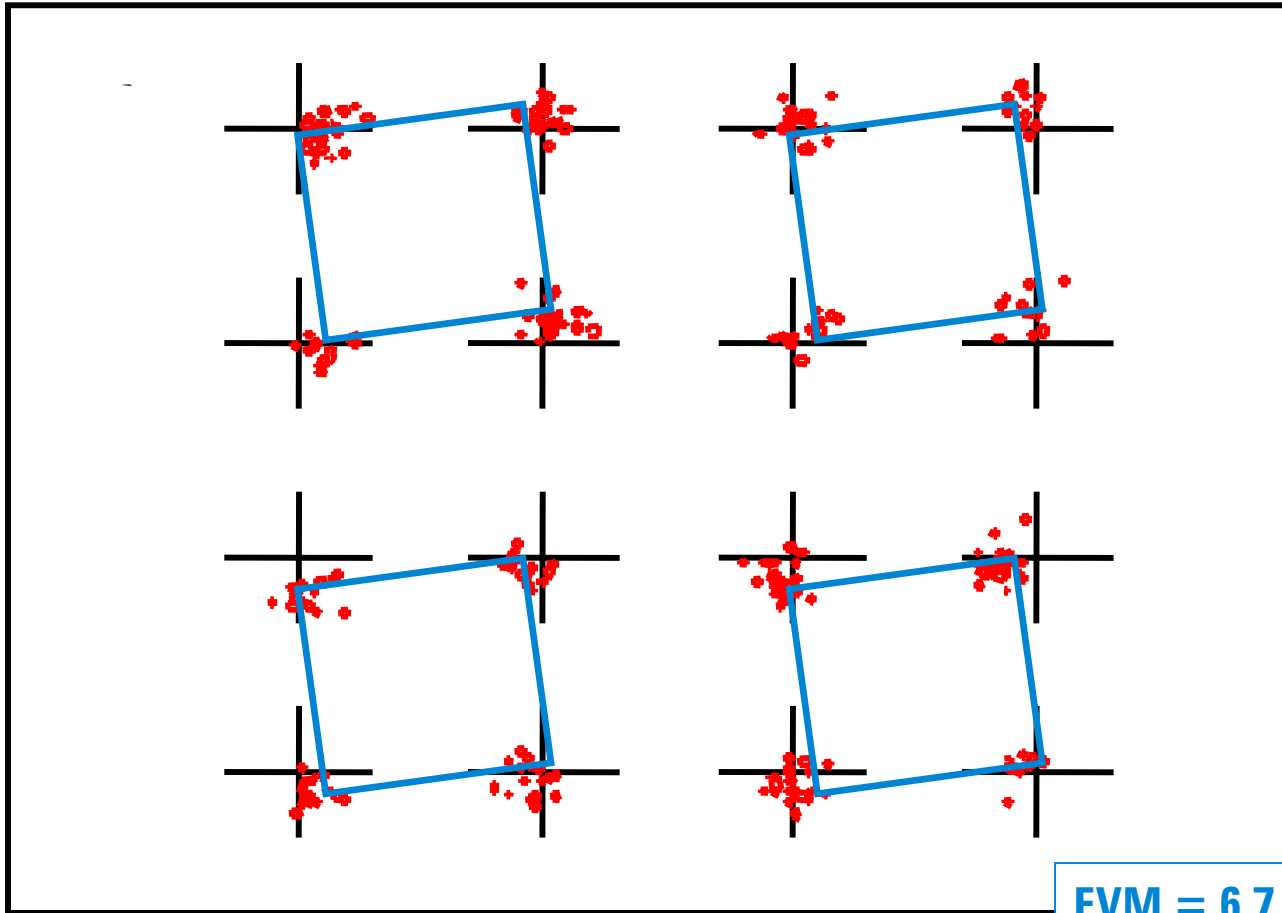
Example 3:

1.2 Gbps Fiber-to-Wireless 16 QAM Constellation

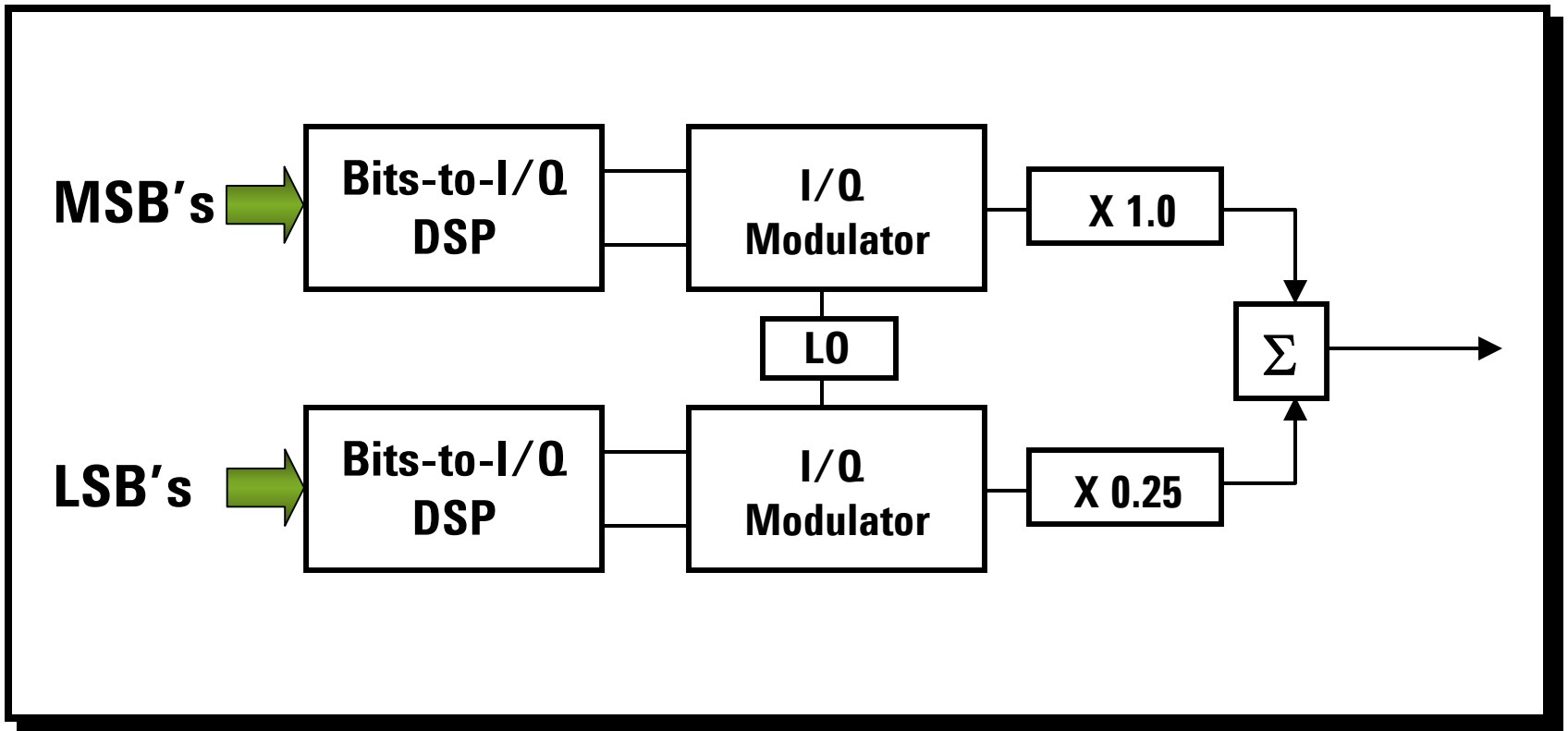


Example 3:

1.2 Gbps, 16 QAM Constellation



Dual Stage I/Q Modulator



Conclusion

- Vector Signal Analyzers with partitioned block diagrams allow for higher sample rate digitizers to increase measurement bandwidth
- Now the same techniques as for narrow band signal can be applied to UWBW satellite transponders and terrestrial transmitters
- I/Q imbalance can reveal transmitter problems

