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Taking A WLAN Card From Development into Manufacturing

October 2, 2002

Presented by:

Peter Cain

Introduction

If you are asking yourself these questions:

- **What should I look for when assessing a WLAN design?**
- **What tests should I have in manufacturing for 802.11a, g or h?**
- **How can I future proof myself?**
- **How can I ease debugging?**

Then you are in the RIGHT place!!!

Agenda

- Updates in WLAN technology
- The Process Of Getting from Design to Manufacturing
- Inside a WLAN design & the Measurement Methods
- Manufacturing Test Configurations
- Enhanced Test Solutions
- Conclusions
- Q&A

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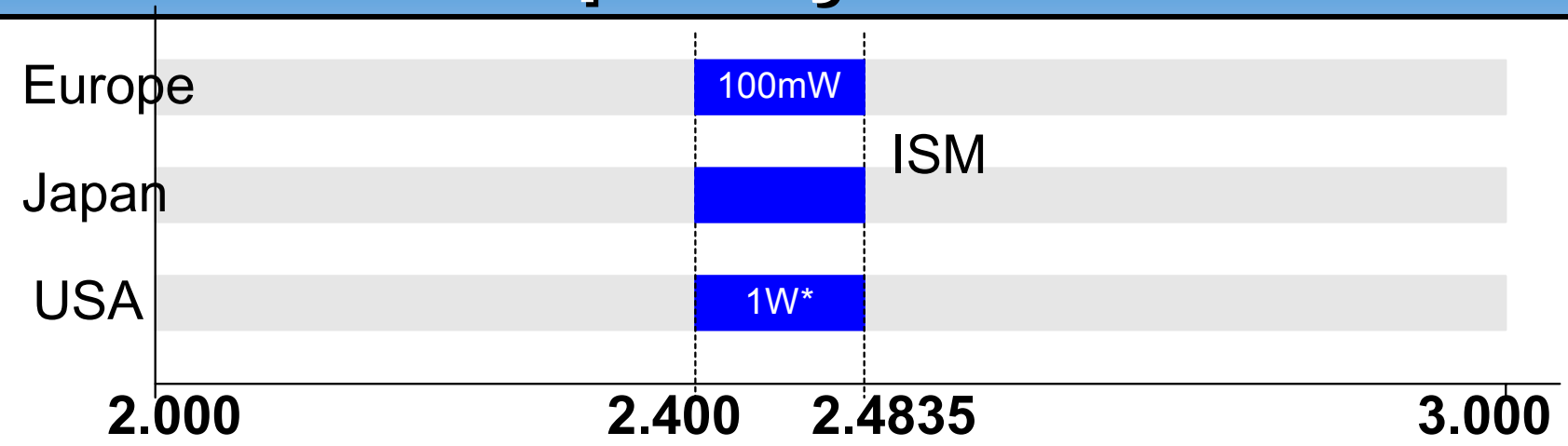
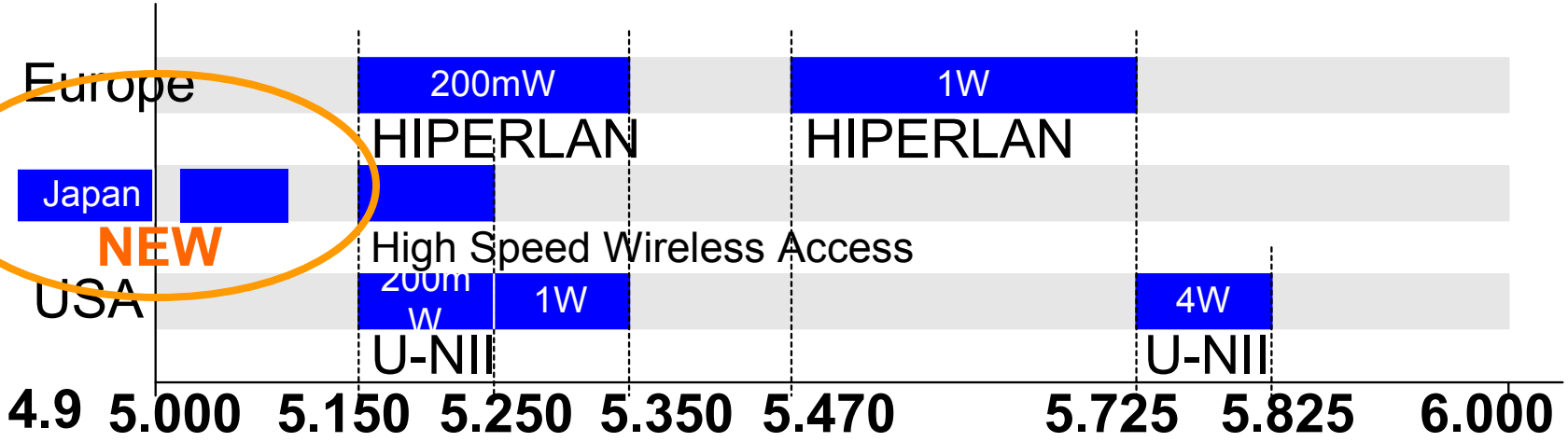
Worldwide Frequency Allocations



2.4 GHz Band



5 GHz Band

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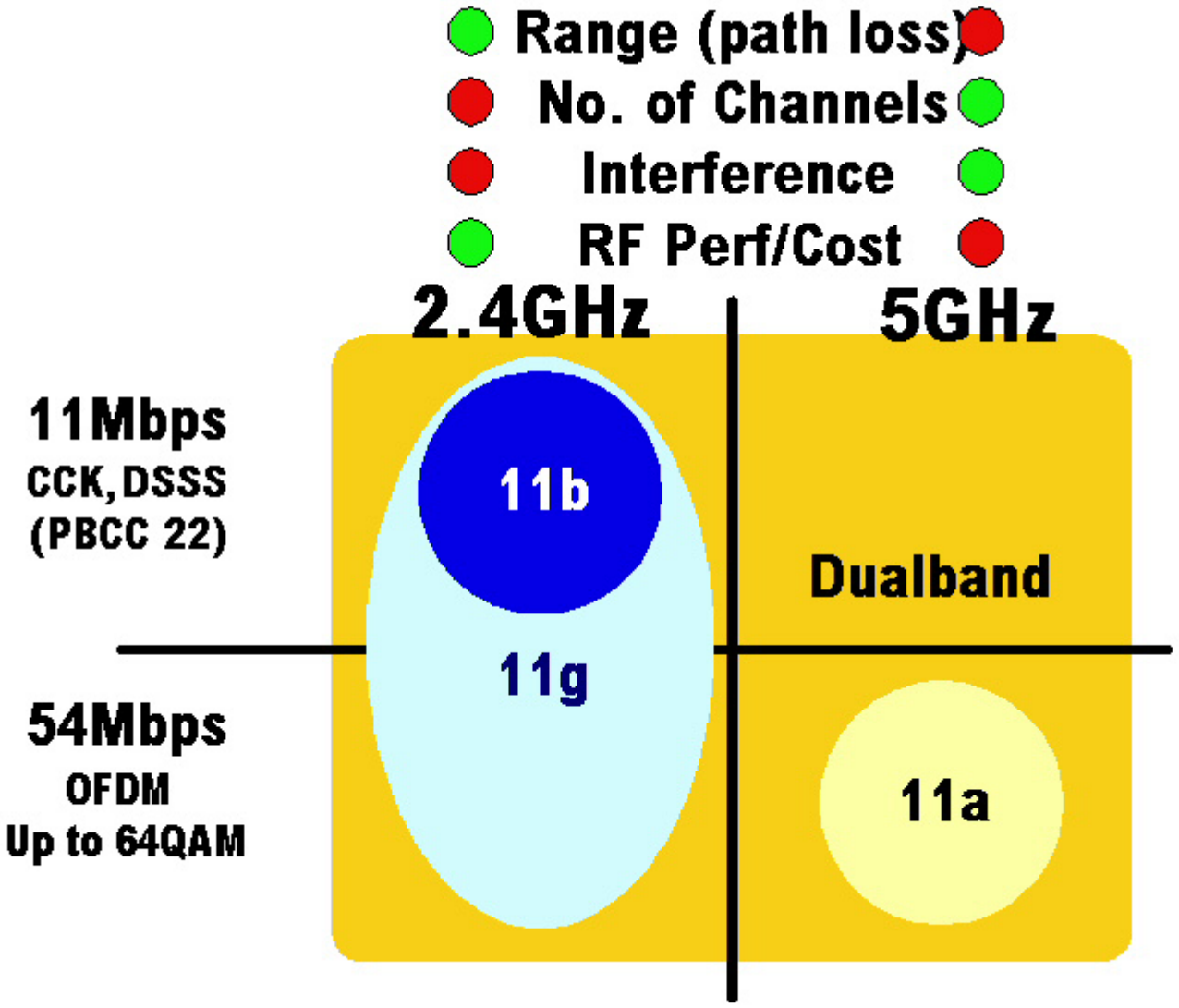
WLAN Technology & Bands



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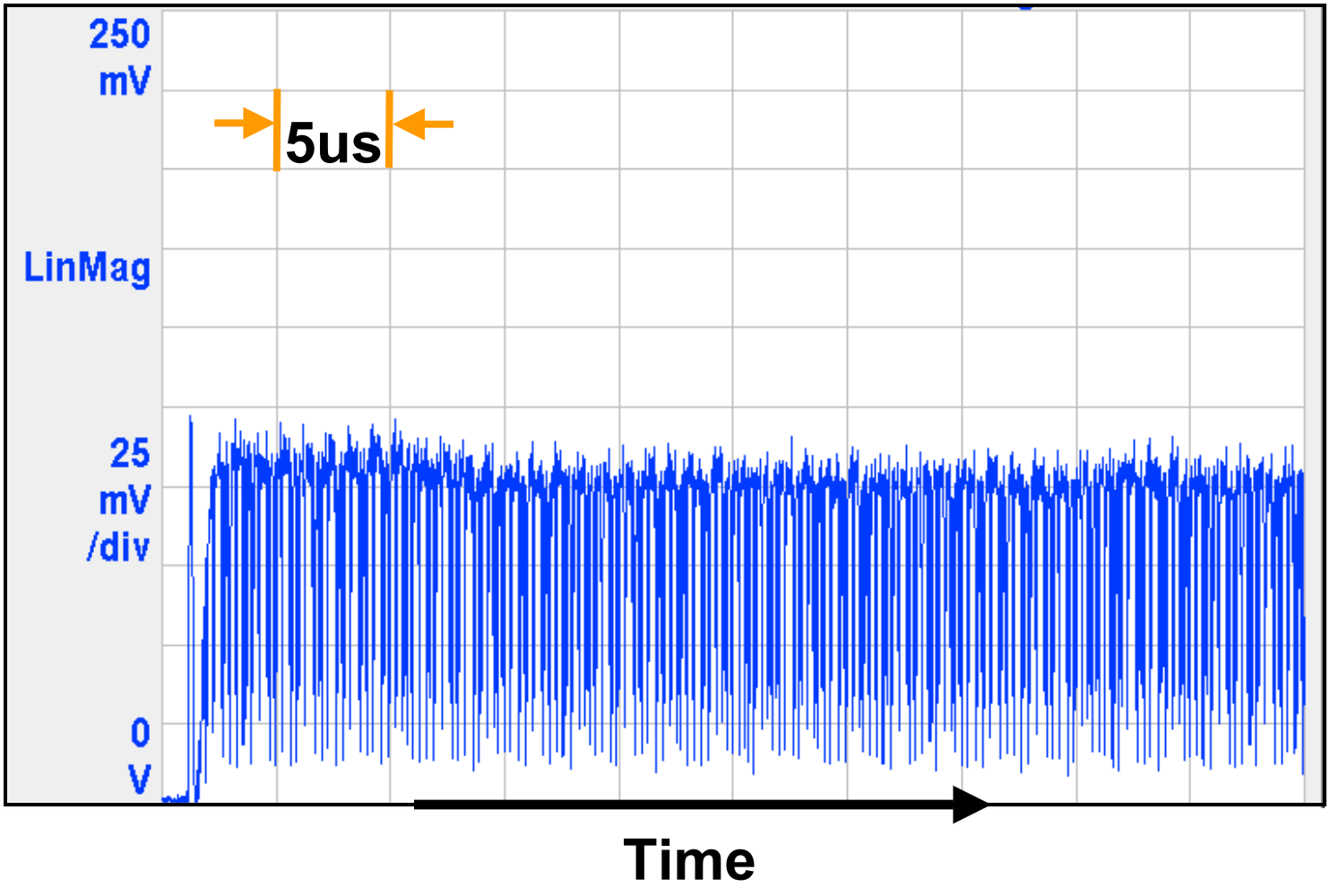
802.11g & 802.11a Complications

- **Extended frequency ranges, from [4.9] 5.150 to 5.35 [5.825] GHz**
- **OFDM / Up to 64-QAM modulation**
- **52 Carriers, 312.5kHz apart**
- **11dB peak/average ratio**
- **EVM test limit varies according to bit rate**
- **Modified Receiver tests**

- **Coming soon - 802.11h**

802.11b (DSSS) Voltage versus Time



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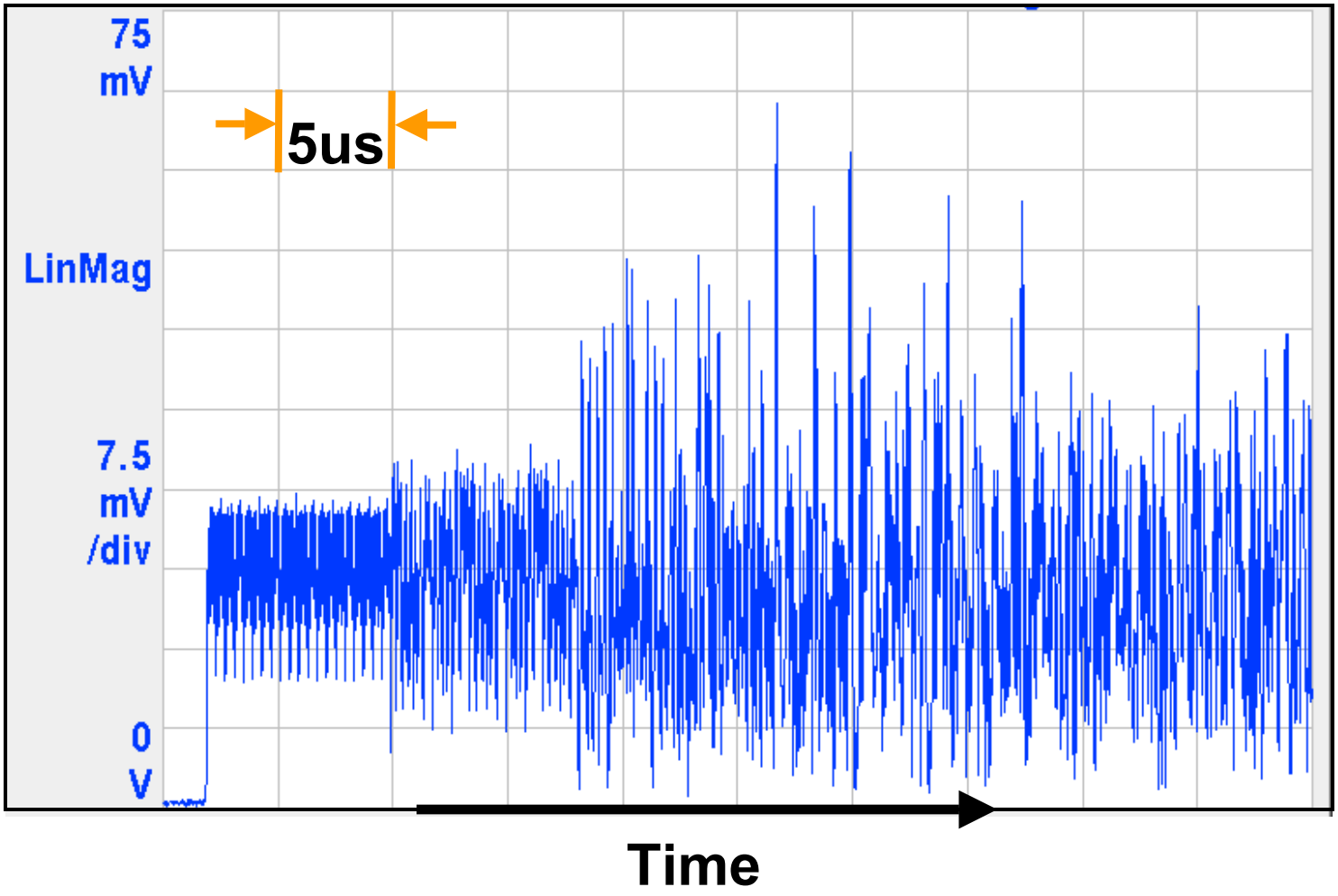
802.11a,11g (OFDM) Voltage vs. Time



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Who Does What?

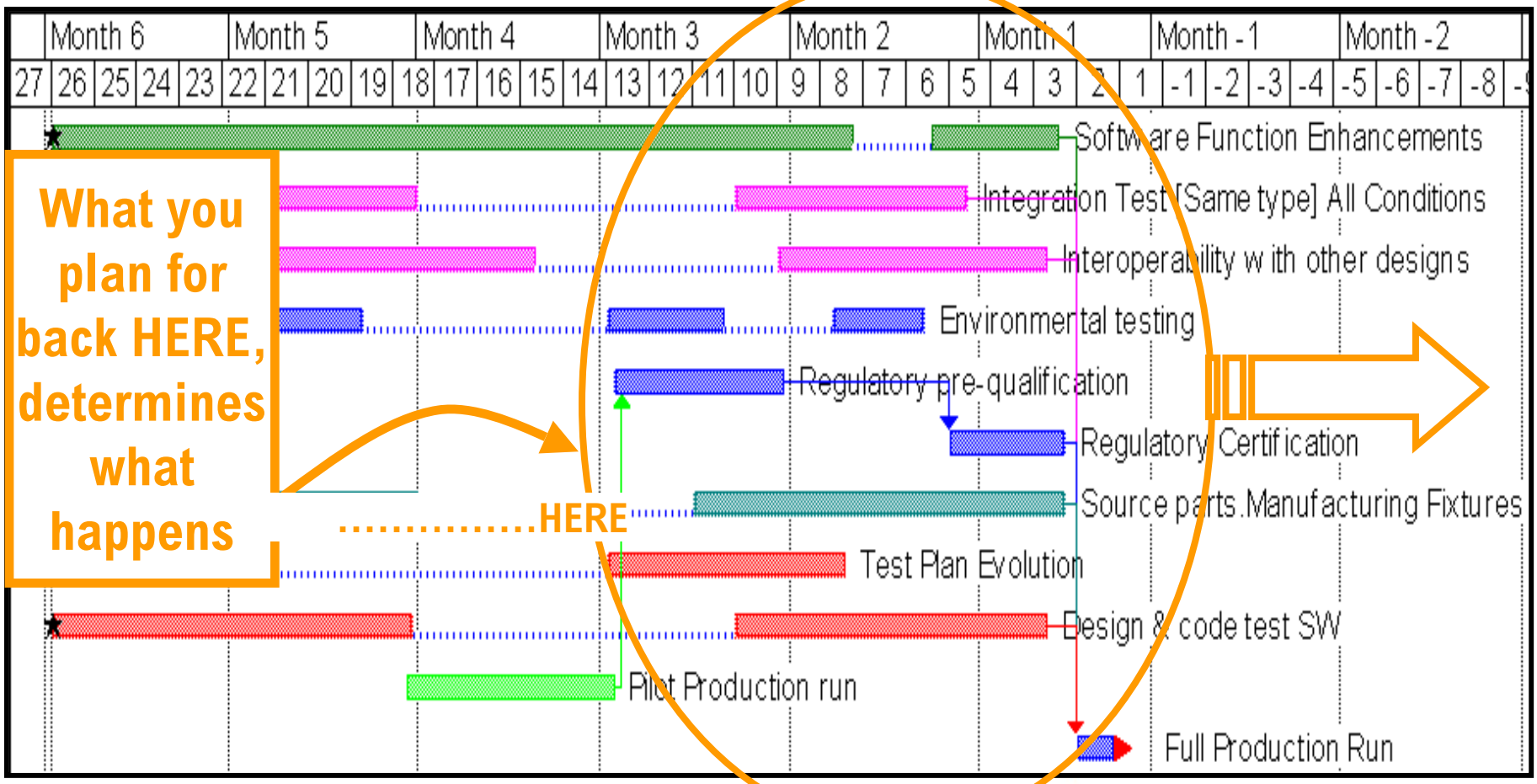
Few people see the whole story = “lost” knowledge

TASK	R&D engineering			Integration QA Eng	Manuf Eng	Material Proc
	HW	DSP	SW			
Complete software functions						
Get the complete radio to work with same type under all test conditions						
Check interoperability with other designs [host & other WLAN cards]						
Environmental testing						
Regulatory pre-qualification						
Source parts. Set up manufacturing capability						
Devise test plan						
Design & code test SW						
Test variations in new manufacturing batches						

Main Role Secondary

When Does It Happen?

A lot of Concurrency of effort = risk of slip



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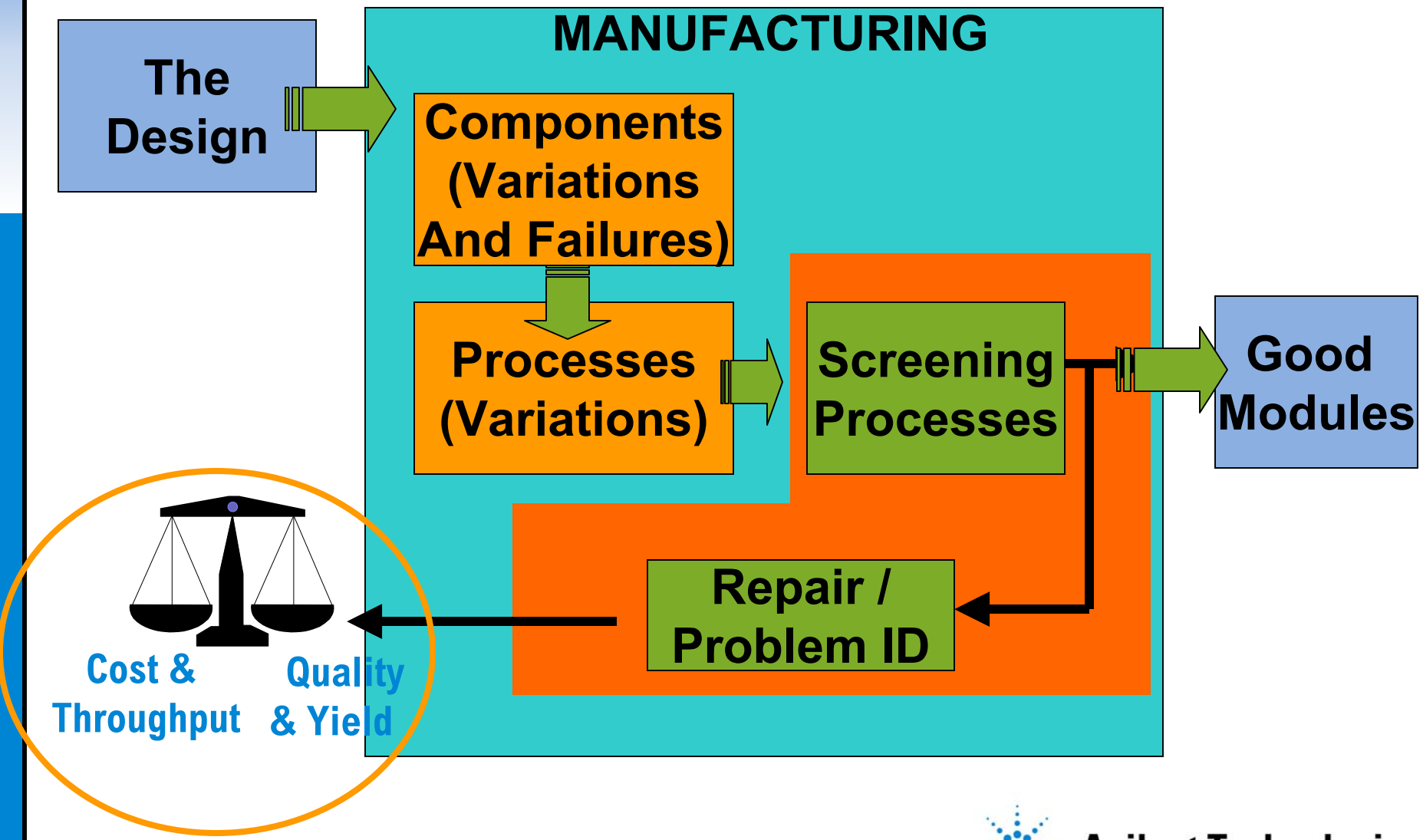
The Real World As Seen In Production



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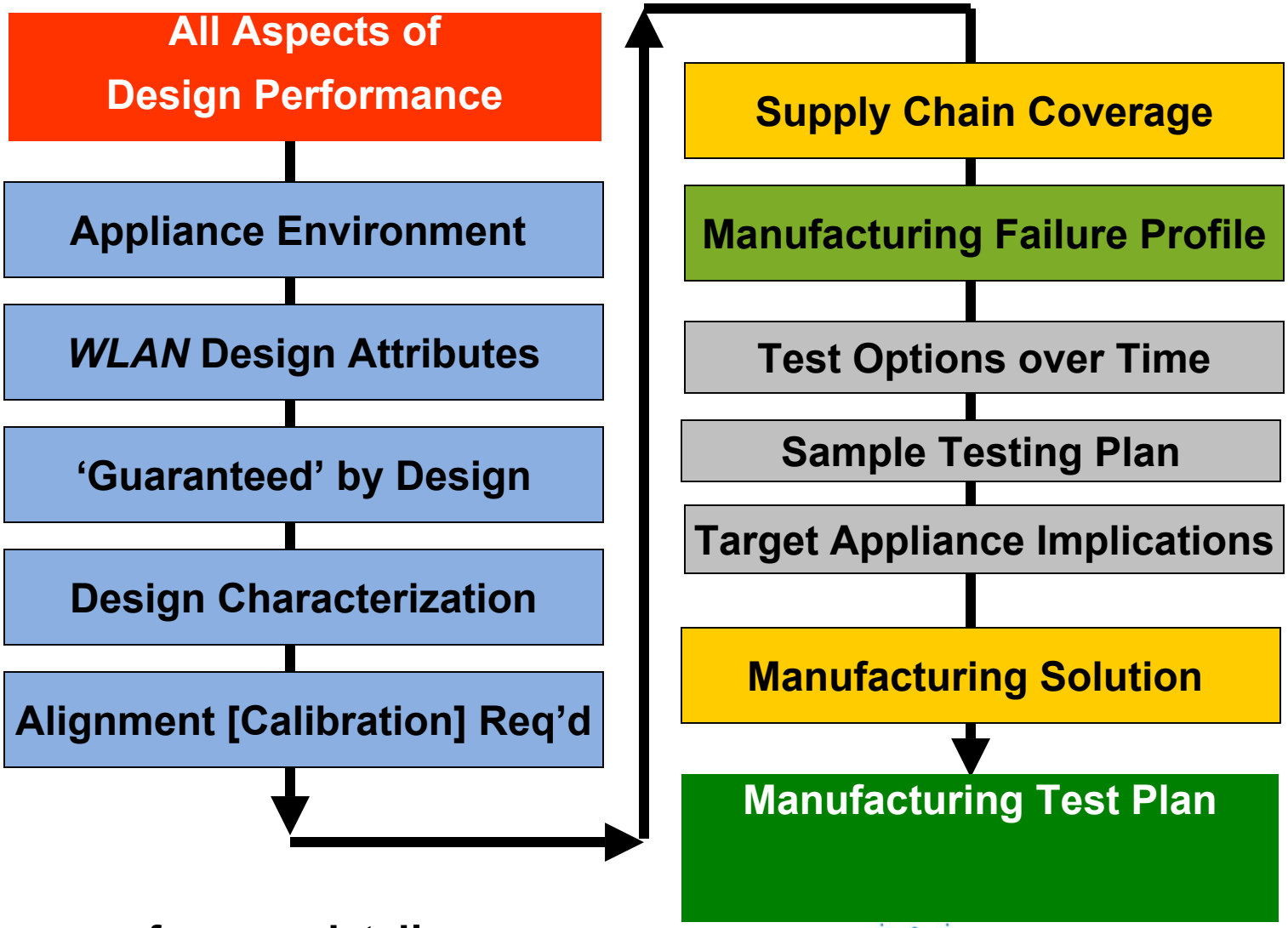
Applying Filters To Select Tests



See References for more details

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Example of a Filter : Supply Chain Test

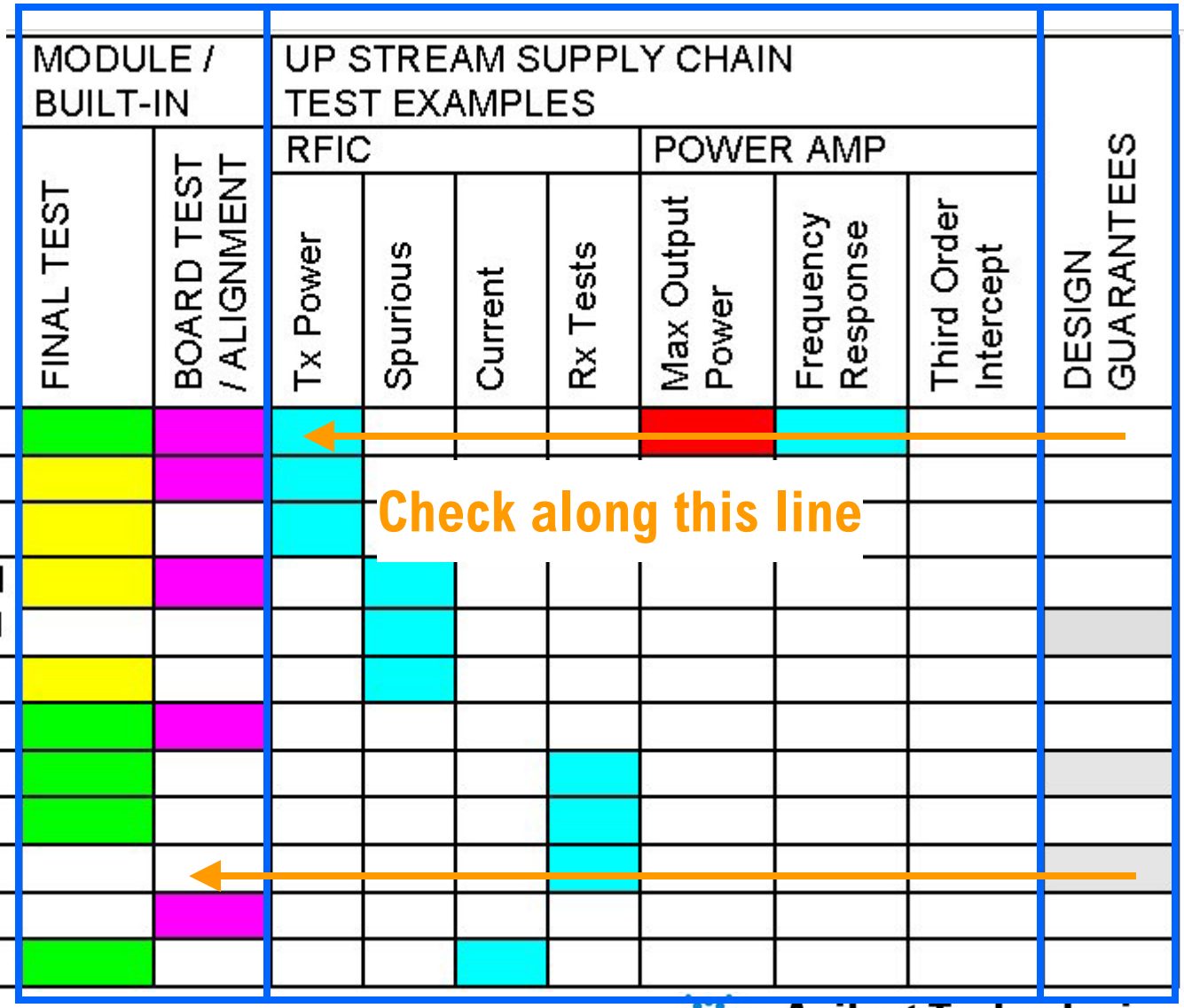
PERFORMANCE TEST LIST	MODULE / BUILT-IN		UP STREAM SUPPLY CHAIN TEST EXAMPLES						
			RFIC				POWER AMP		
	FINAL TEST	BOARD TEST / ALIGNMENT	Tx Power	Spurious	.....	.....	Max Output Power	.....	Third Order Intercept
Output Power									
Power Control									
.....									
Spectrum Emissions In Band									
Spectrum Emissions Out of Band									
Modulation Quality									
Frequency									
.....									
Receiver Sensitivity									
Adjacent Ch rejection									
.....									
Battery Current									

Components move in the direction of the arrow

Example: Supply Chain Test Coverage

KEY

- **Strong meas. link**
- **Weak meas. link**
- **Calib. Required**
- **Consider Test**
- **Test Needed**



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Observations On The Process

- **SHARE KNOWLEDGE EFFECTIVELY**
  Look for ways to reduce the effort required by Development Engineering staff. Standardize where possible
- **TRY TO MAINTAIN TOOL CONSISTENCY**
  Uncertainty in Test Methods or use of Different Equipment will create Artificial Problems, and add to the difficulty in resolving real ones
- **TAKE ACCOUNT OF UPSTREAM TESTING**
  Manufacturing tests rely on, and should be based on the design & tests done at IC level

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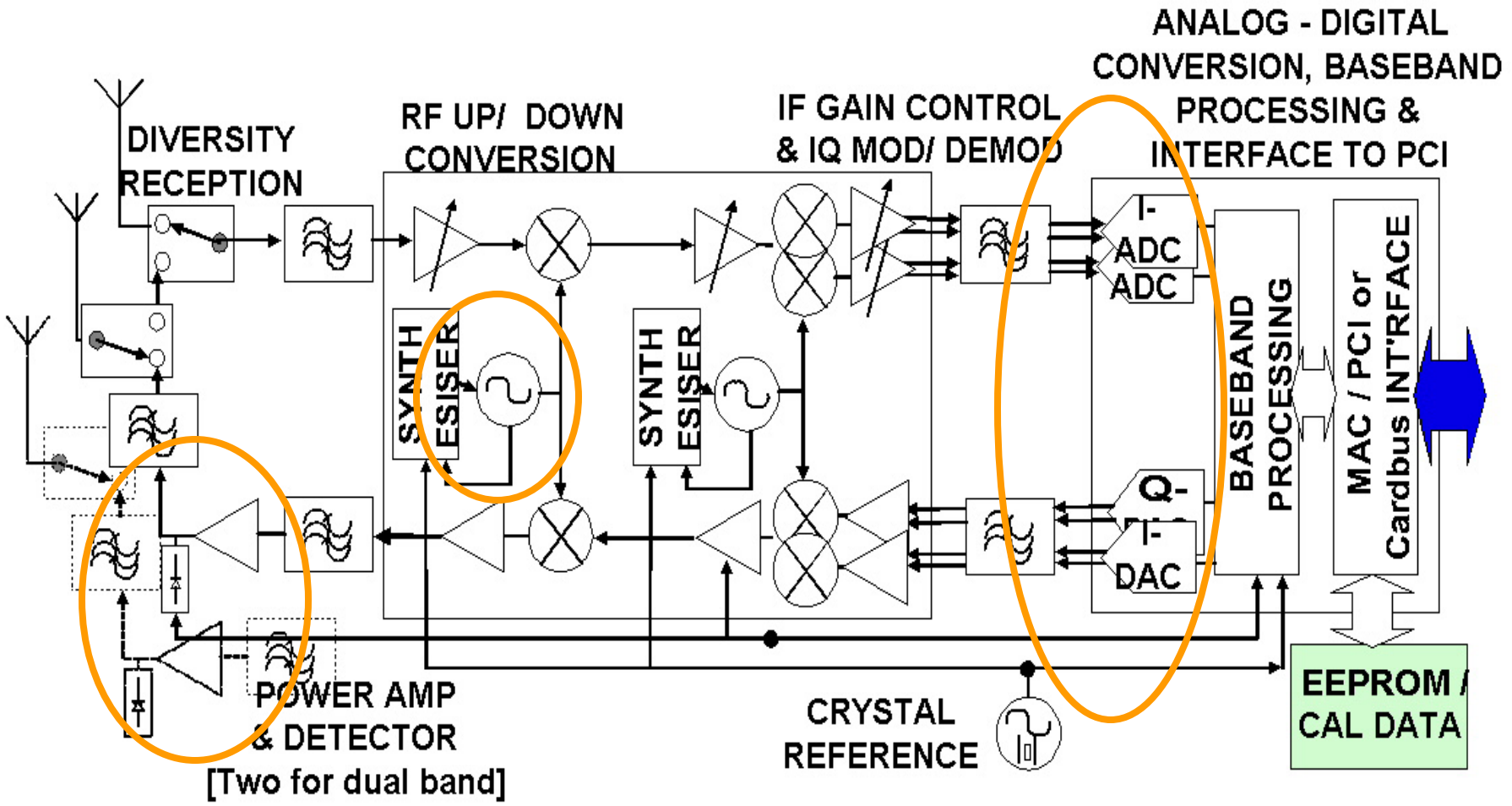
WLAN Card Circuitry



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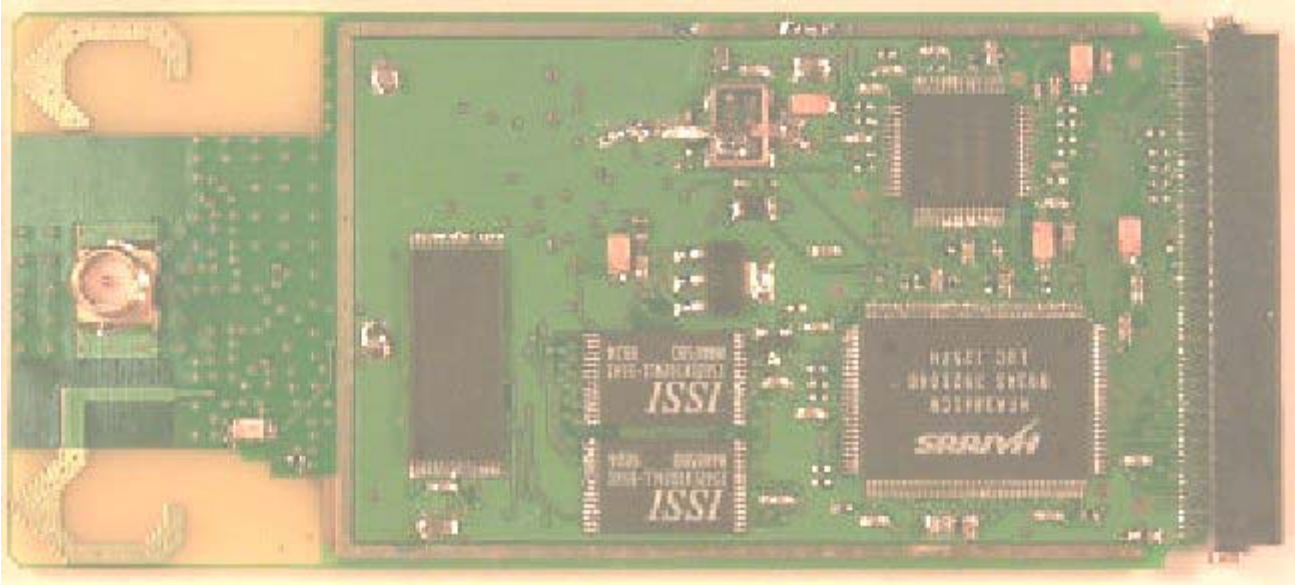
Inside a Typical WLAN Card



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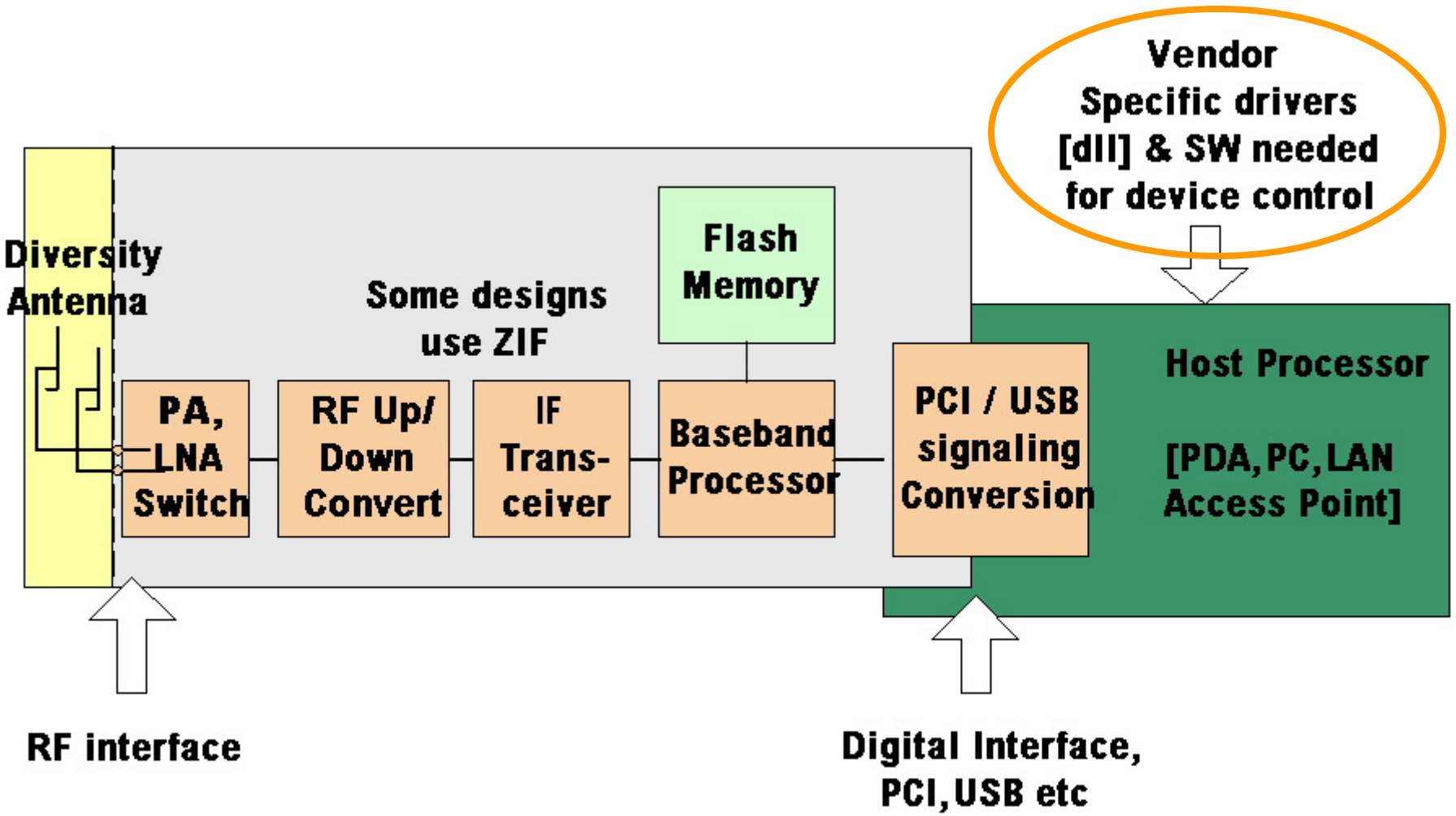
A WLAN Card As a System



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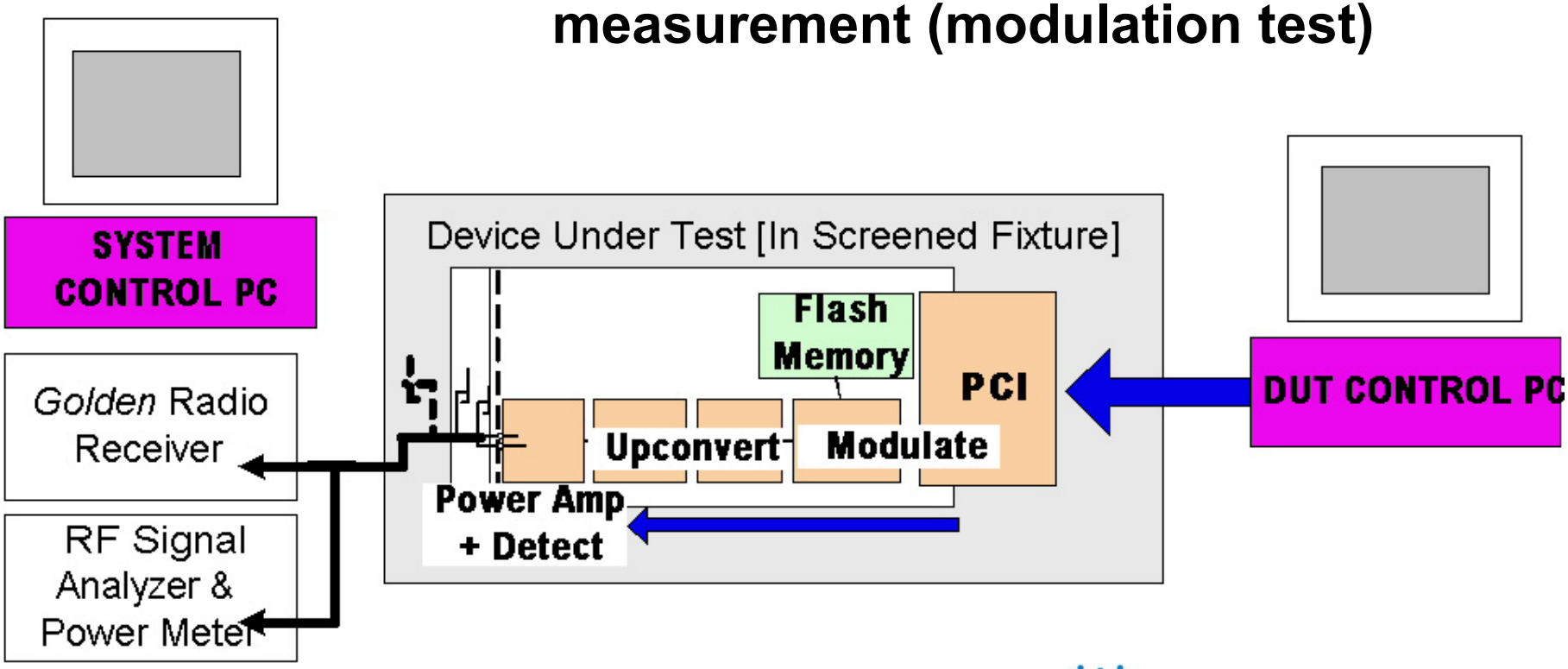
Transmitter Test – Basic Configuration

- Test Device instructed to create Test Frames, on the channel to be tested
- Spectrum Analyzer makes Narrow-band measurement
- *"Golden"* Radio used to make Tx Packet Error Rate measurement (modulation test)



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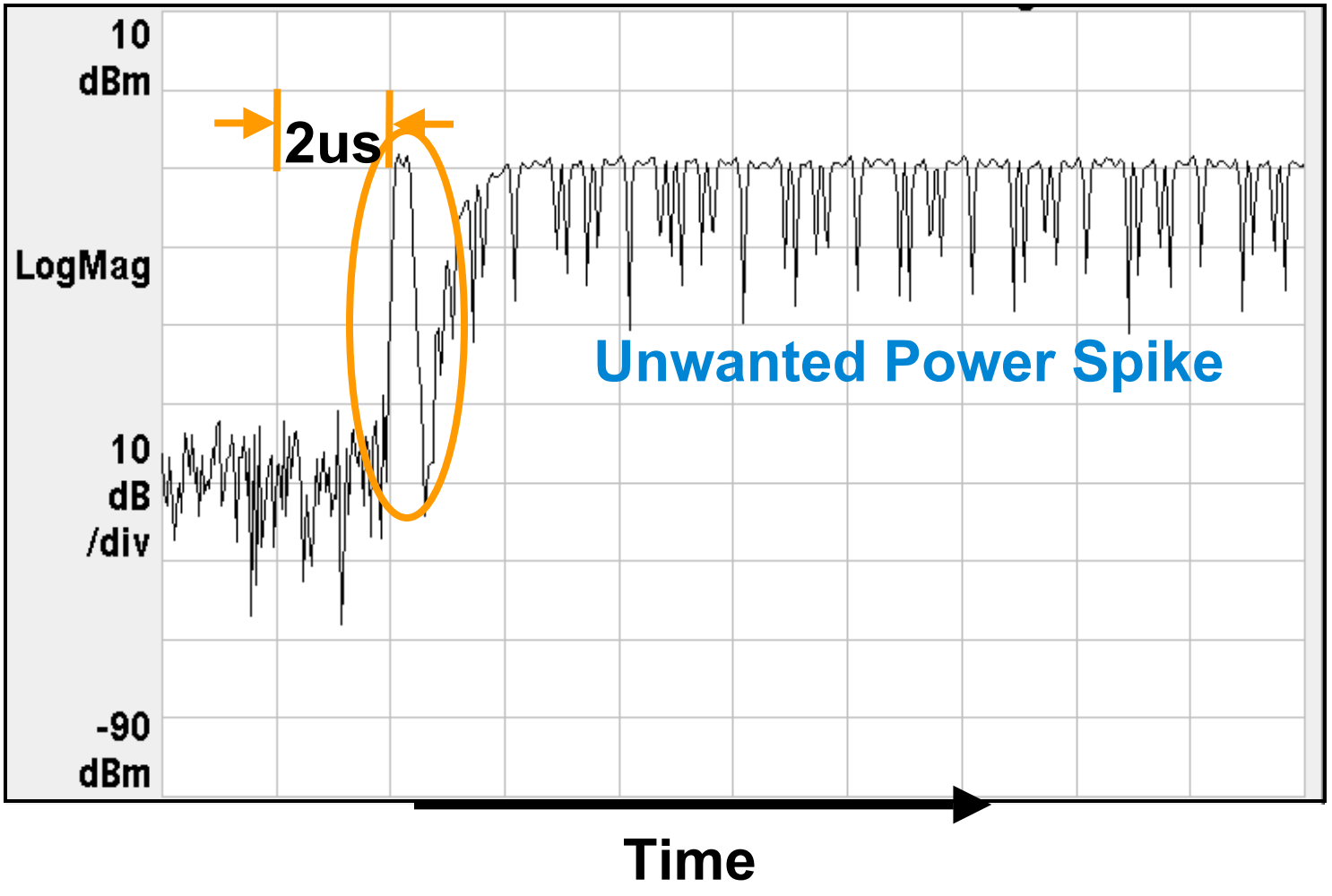
802.11b Burst Ramping Example



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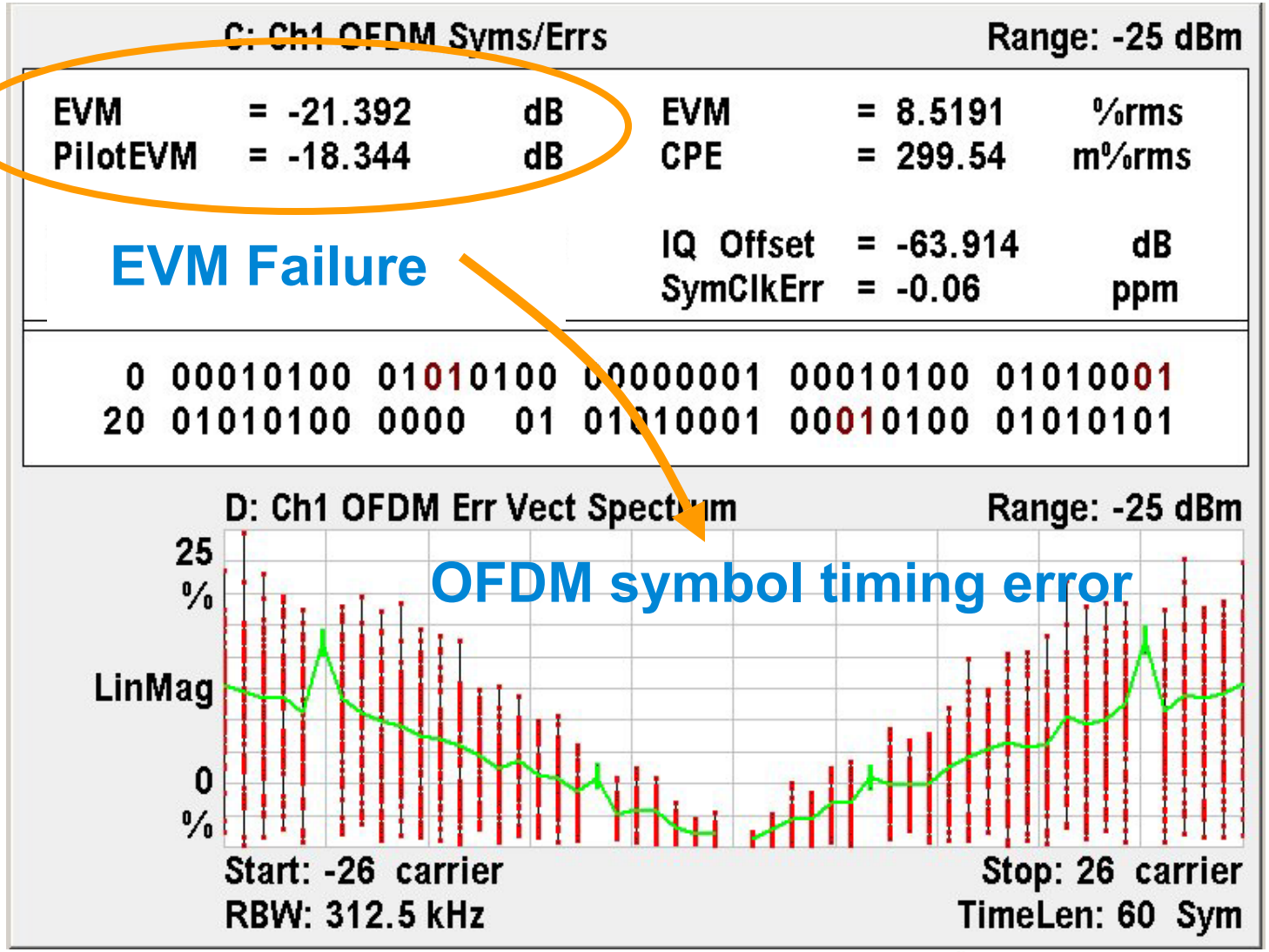
802.11a EVM example



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Making Transmitter Measurements

KEY

- **Measurement provided**
- **Some limitations**
- **Calib.Required**
- **Consider Test**
- **Test Needed**

PERFORMANCE TEST LIST	TEST EQUIPMENT: WIDEBAND SIGNAL ANALYZER	TEST EQUIPMENT: NARROW BAND SPECTRUM ANALYZER	FILTER RESULTS: FINAL TEST	FILTER RESULTS: BOARD TEST / ALIGNMENT
Output Power				
Peak Output Power				
Power Density				
Output Spectrum: -20dB BW, Freq Range				
Output Spectrum: Spurious				
Output Spectrum: Adj. Channel Power				
Modulation Accuracy [EVM]				
Carrier Frequency Tolerance				
Carrier Frequency Leakage				

Assumes Device Under Test is configured to transmit the required signals.

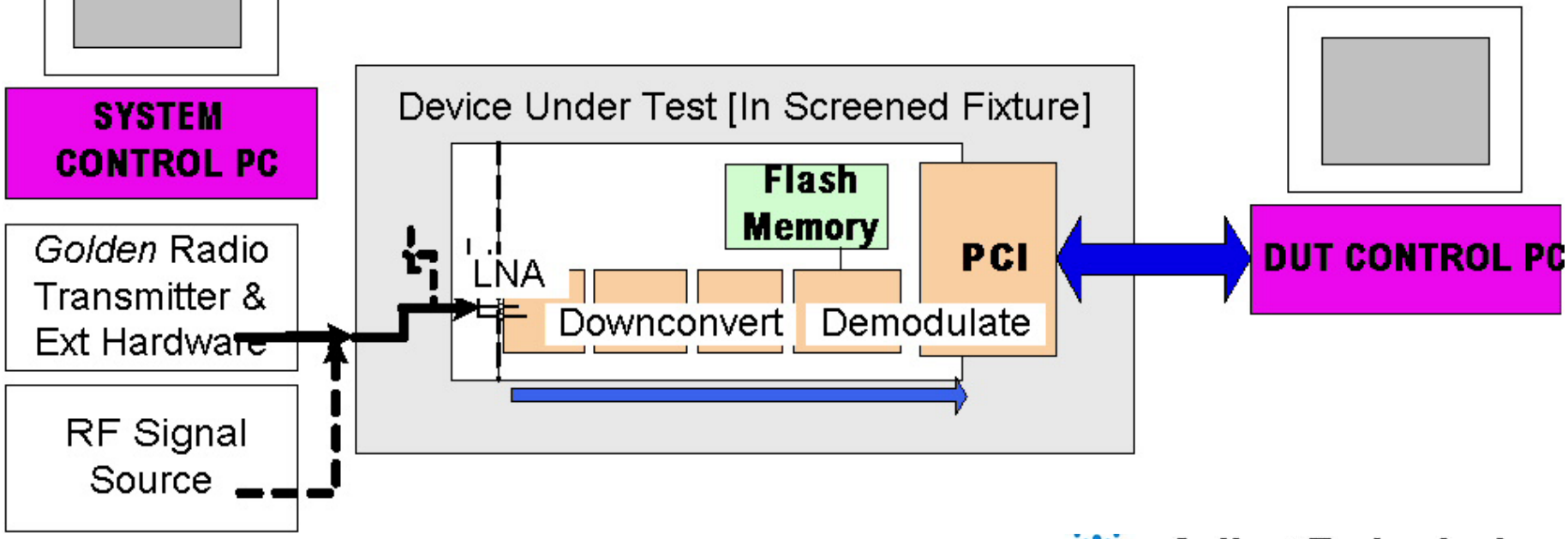
Issues With Transmitter Testing

- **Modulation Accuracy using Tx PER or EVM?**
  - **Tx PER result depends on the design [HW & DSP] of the *Golden* radio. Difficult to trace or compare.**
  - **Only bad packets tell you anything**
  - **EVM gives information from every burst. Likely to be faster**
- **Do You Get The Data to Analyze a Problem?**
  - **Wideband measurements contain the signal information needed to understand the problem**

Receiver - Basic Configuration

- **No Test Signal *Loopback* path provided, *but "One Way"* method is used elsewhere, e.g. in IS95 CDMA**
  - **Test Frame transmitted to DUT.**
  - **DUT uses vendor's Test Mode SW for measurement**

! Proprietary Test Signals limit the test options



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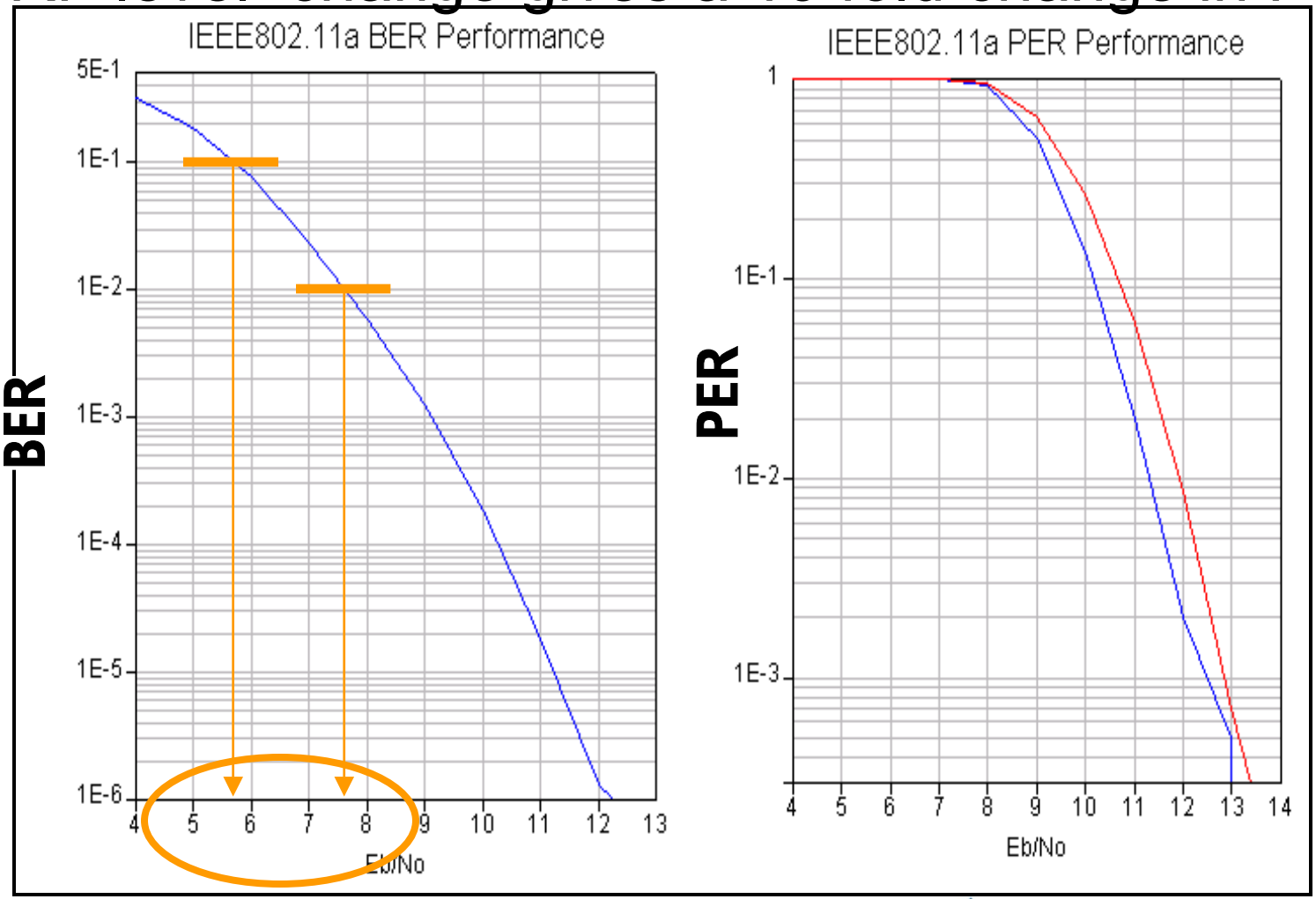
BER & PER vs. RF Level

2dB RF level change gives a 10 fold change in PER



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Making Receiver Measurements

KEY

- **Measurement provided**
- **Some limitations**
- **Calib.Required**
- **Consider Test**
- **Test Needed**

PERFORMANCE TEST LIST	TEST EQUIPMENT: SIGNAL GENERATOR	TEST EQUIPMENT: GOLDEN RADIO & EXTERNAL ATTNEUATORS	FILTER RESULTS: FINAL TEST	FILTER RESULTS: BOARD TEST / ALIGNMENT
Sensitivity				
Sensitivity With Impairments				
Maximum Input Level				
Co & Adjacent Channel Interference				
Blocking Performance				
Data Throughput	1			
RSSI				
Dynamic Freq. Selection test? [802.11h]				

All measurements need specialized, Vendor specific Test SW.

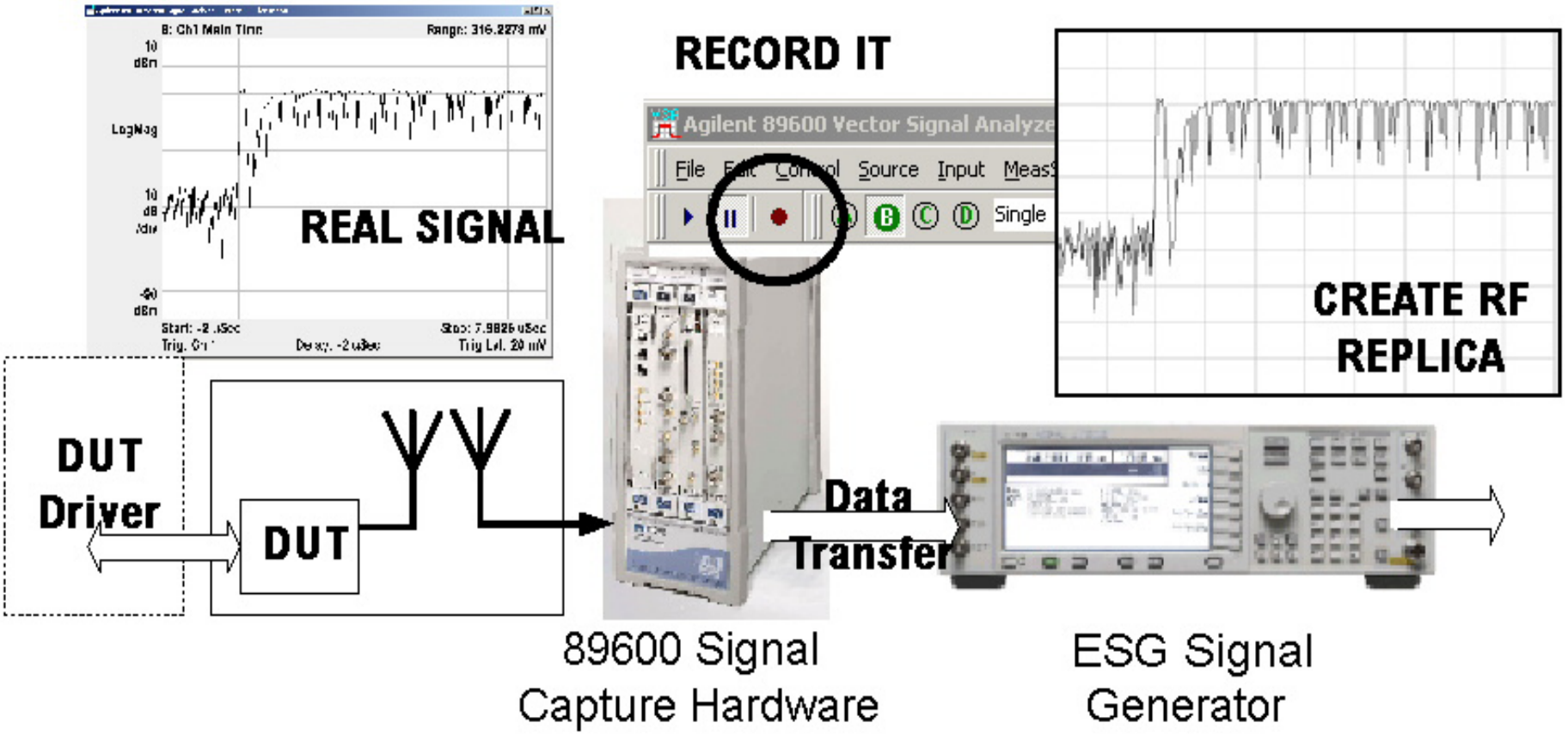
1: Use IQ data inputs

Issues With Receiver Testing

- **Use of *Golden* Radio**
  - Vendor specific test
  - Temperature changes and Unit-unit variations can cause inconsistent results
  - Engineering effort req'd for Calibration & Support
- **PER or BER**
  - PER is the WLAN system characteristic, but is likely to be slower to measure than BER
  - Details of PER measurement vary in practice

A Technique for Resolving *Interop.* Problems

Record the Suspect Signal & Replay as required!



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Wider Characterization May Be needed

- **Other Opportunities for Information gathering**
  - Modulation Performance versus Channel
  - Sensitivity versus Channel
  - Phase Drift during burst

  - Correlation between measurements
  - Battery emulation characteristics
  - Distributions of performance over lots

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Manufacturing Solution "Preamble"

- **Qualification & R&D based tests have different goals to a production test suite**
  - Many of the methods are very time consuming
  - May lack insight into verifying what can go wrong in manufacturing

- **Select methods and conditions that focus on your design and your processes.**

Selecting Tests: Combining all the Filters

Approach Filter Matrix

- Area of Potential Weakness
- Performance 'Guaranteed'
- Alignments Required
- Strong Correlation to IC Test
- Weak Correlation to IC Test

X-Selected for Relationships

A-Always Tested

R-Candidate for Removal

O-Omit

	Appliance Environment	WLAN Design Attributes	Guaranteed Design	Design Characterization	Design Alignment Requir	Suply Chain Coverage	Manufacturing Failure P	Manufacturing Solution	Test Solution vs Time	Sample Testing Plan
									A	
Power Output				X				X	A	X
Power Control									R	X
Modulation Characteristics				X					A	X
Initial Carrier Frequency									A	X
Carrier Frequency Drift									R	X
Sensitivity				X				X	A	X
RSSI								X	A	
Battery Current vs Operational M									A	X
Frequency Settling									O	
Pulse Shape									O	
Output Spectrum				X				X	R	X
Maximum Usable e				X					R	X
Output Spec n re nge									O	
Output S u A ch Power									O	X
Out f r S u ou Emissions									O	X
ie In erence Performance				X					R	X
ki g Performance									O	
Intermodulation Characteristics									O	
Power Density									O	

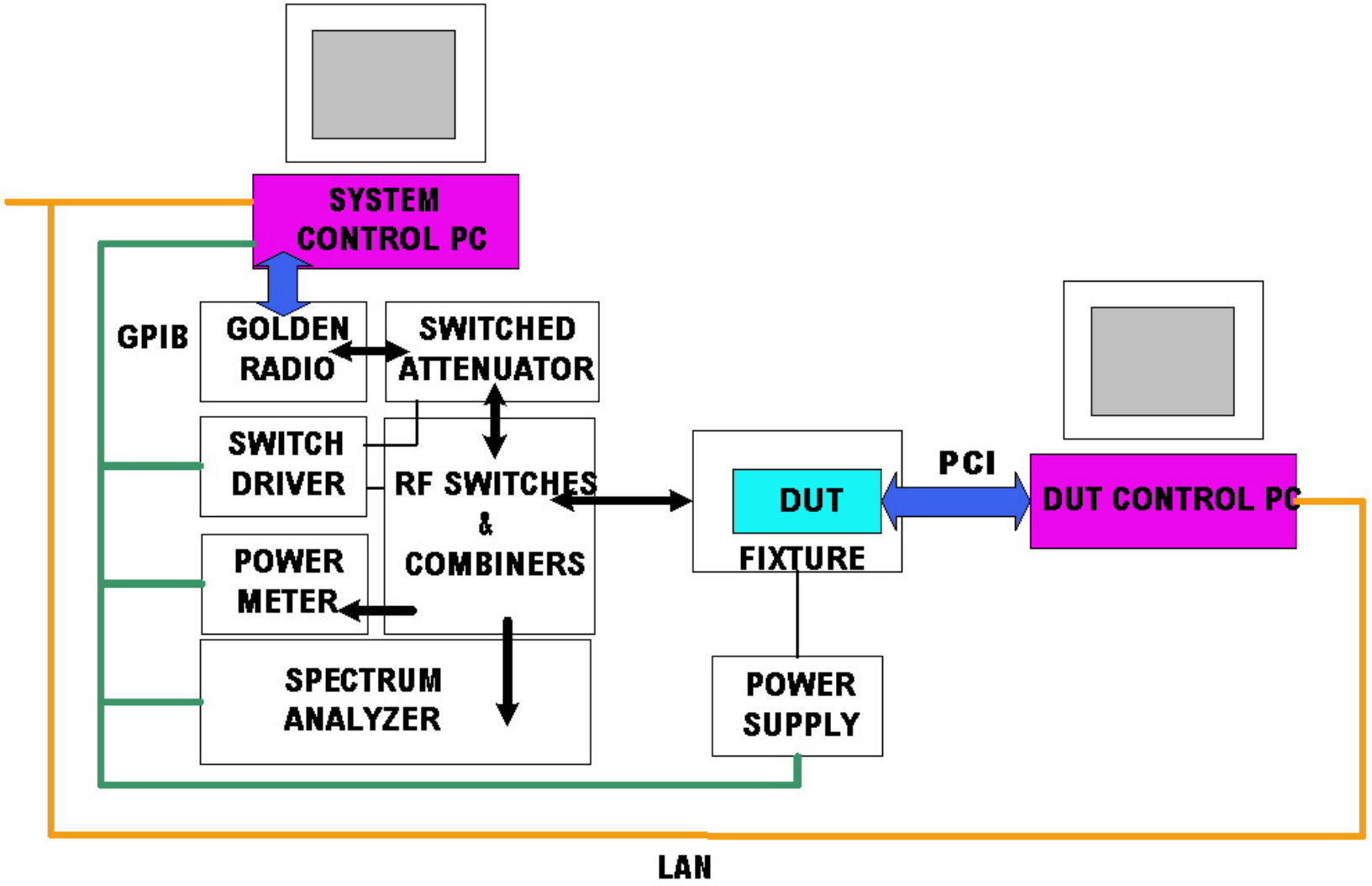
Selecting Equipment: Criteria

- Flexibility / Adaptability
- Measurement Capability / Consistency
- Cost
- Fixturing
- Throughput
- Calibration / Support
- Firmware Downloading
- Power Supply Provision

Implementing A WLAN Manuf. Test Plan

	Interface Basic Operation, FW Download
	Crystal Tuning and Trim
	Battery Current vs. Operational Mode
	Transmit Power
	Transmit Spectrum
	EVM / Tx. PER
	Center Frequency Tolerance
	Center Frequency Leakage
	Received Signal Strength Indicator
	Receiver Sensitivity
	MAC Address Download

Typical WLAN Test System



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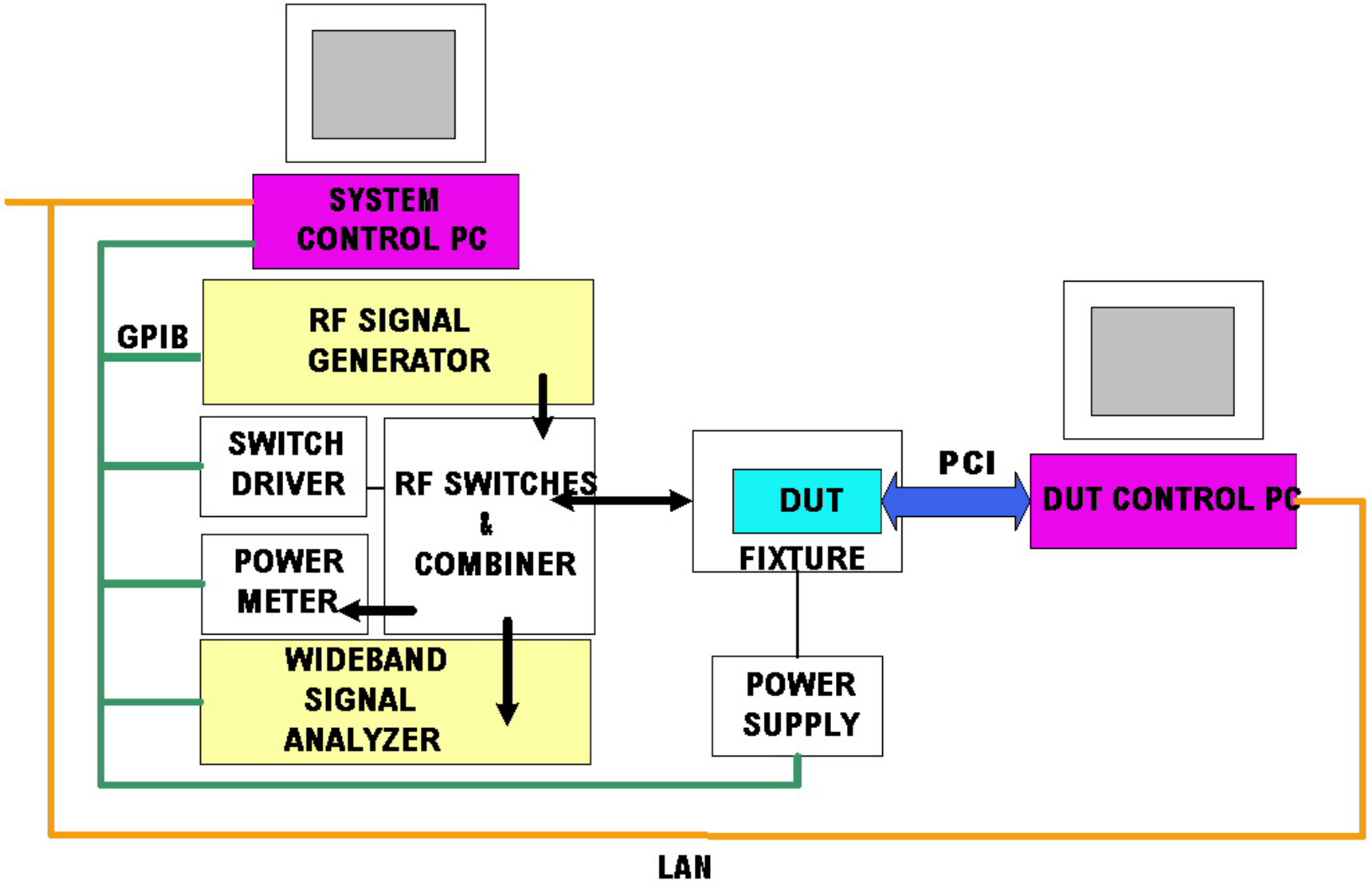
An Enhanced Test System



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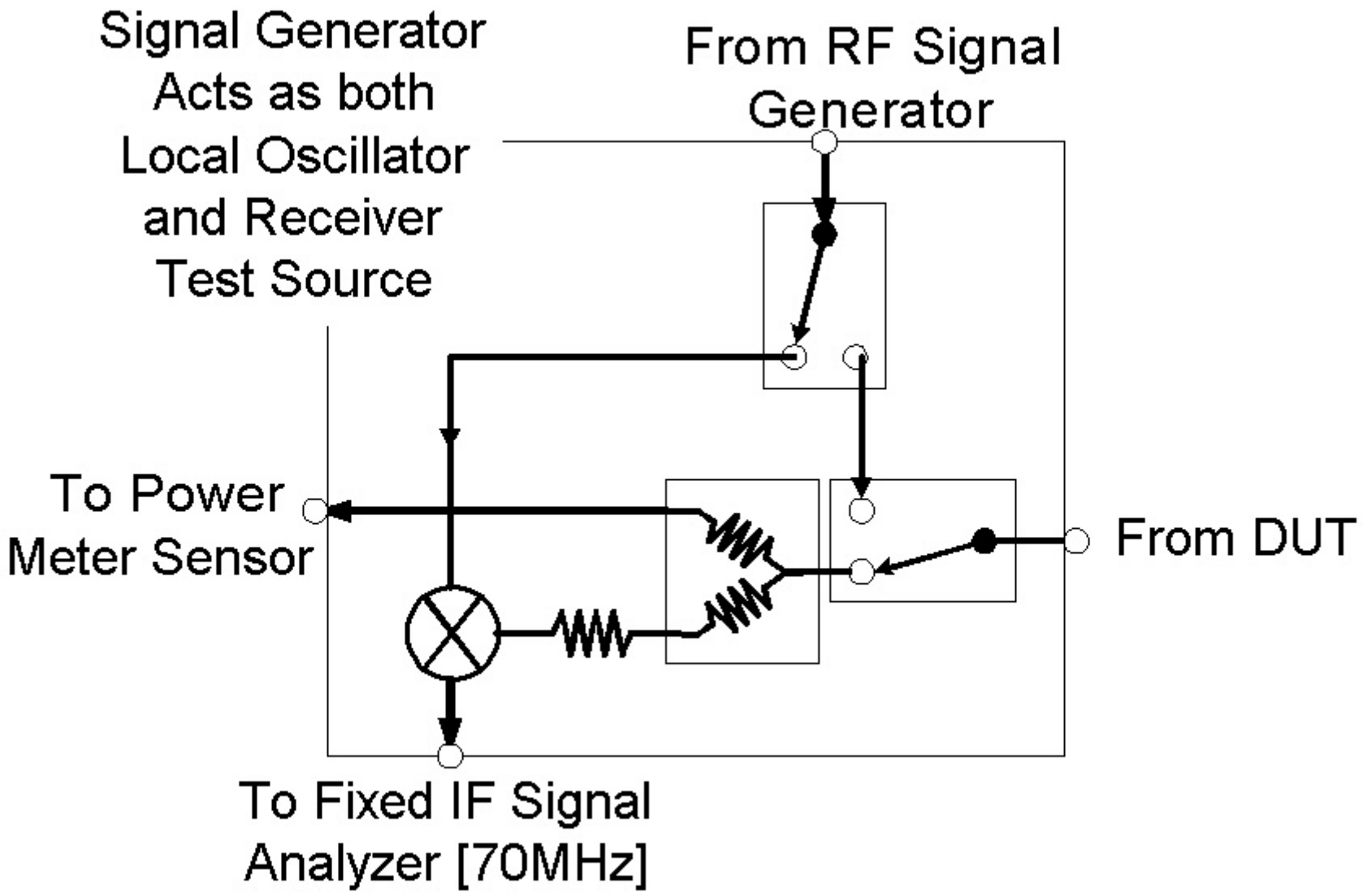
Inside The Switch Box?



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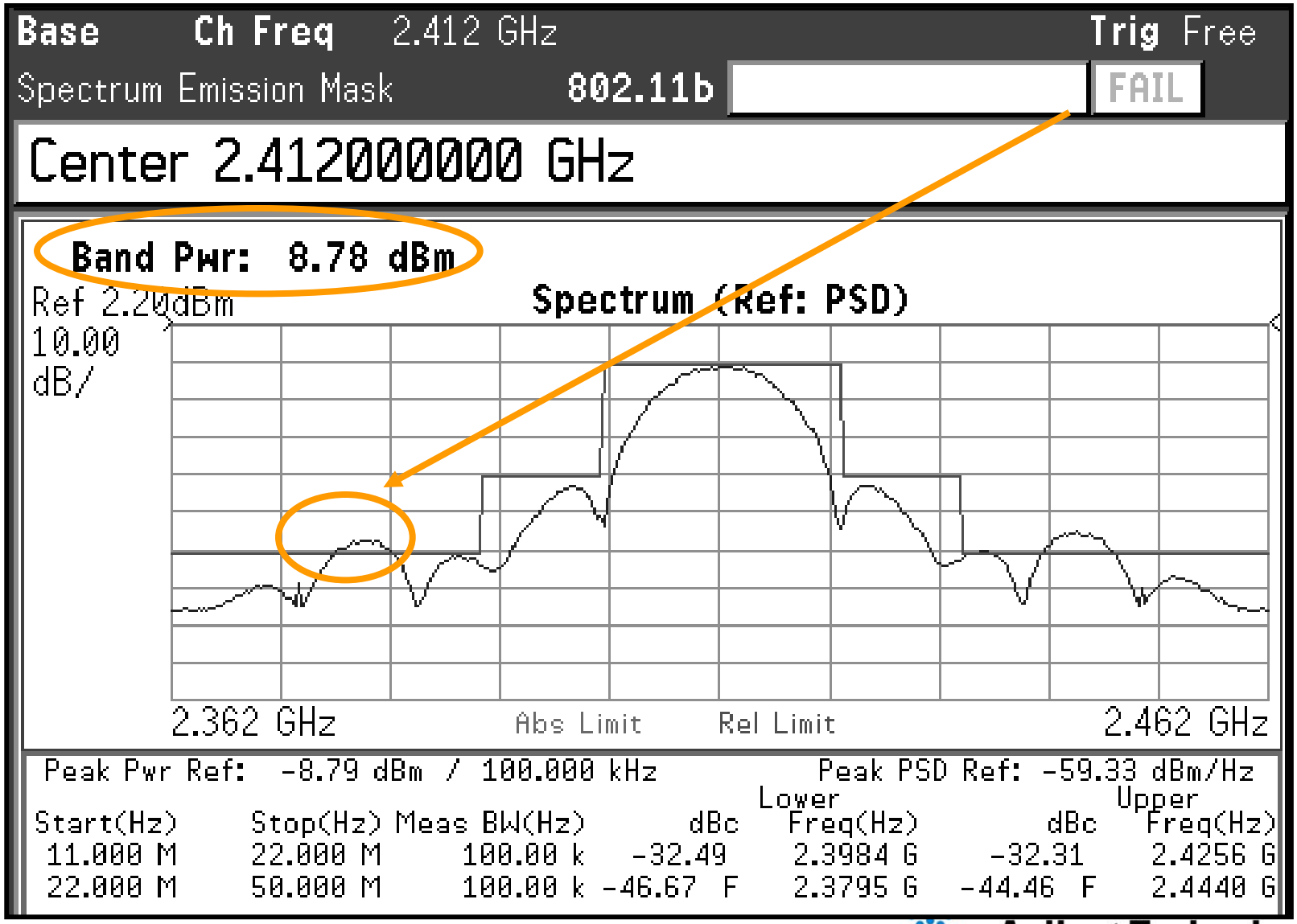
Combined Spectrum Mask + Avg. Pwr.



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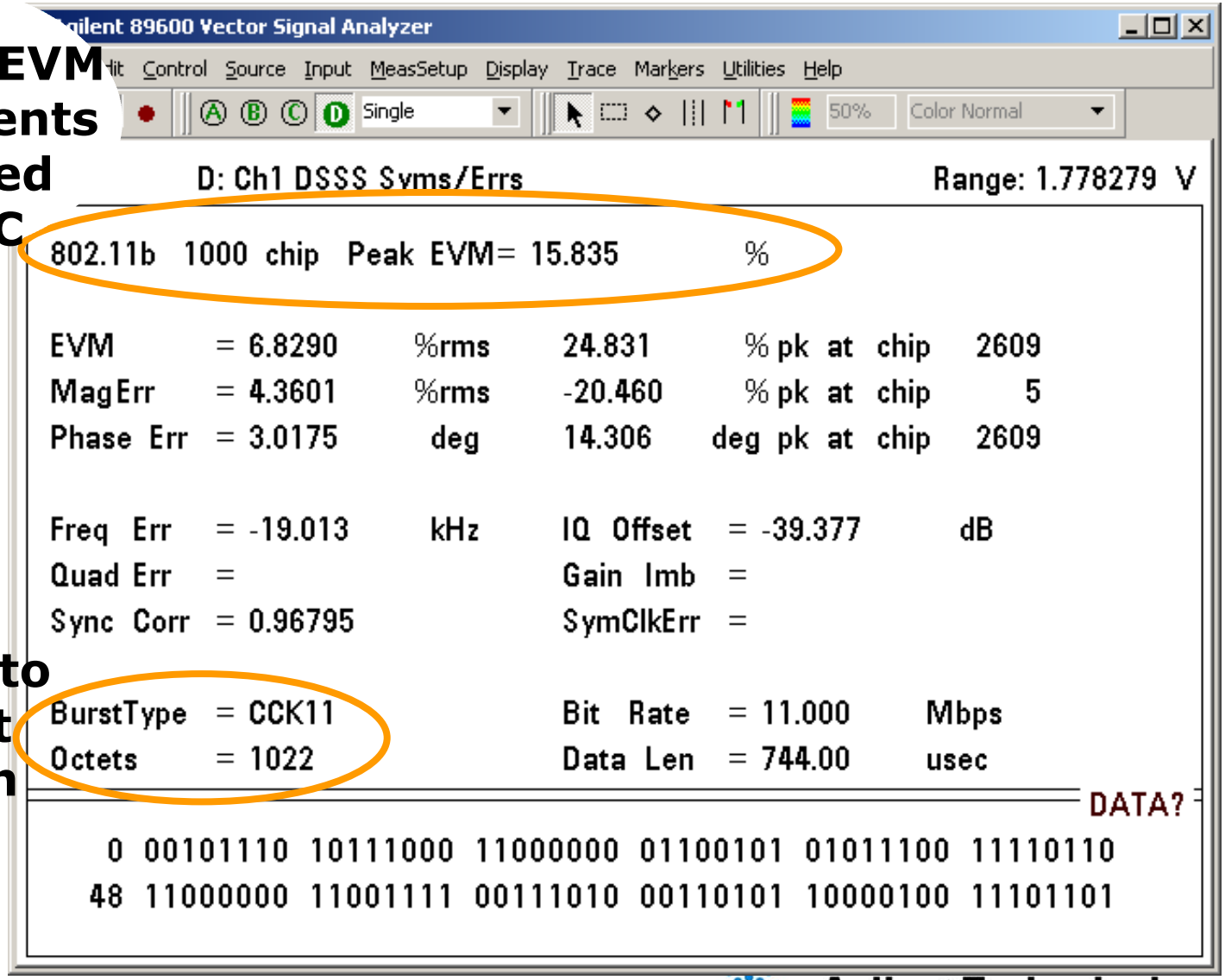
802.11g Wideband Measurements

- **Automatic EVM measurements on formatted CCK & PBCC bursts**
- **Data de-scrambled to give packet information**



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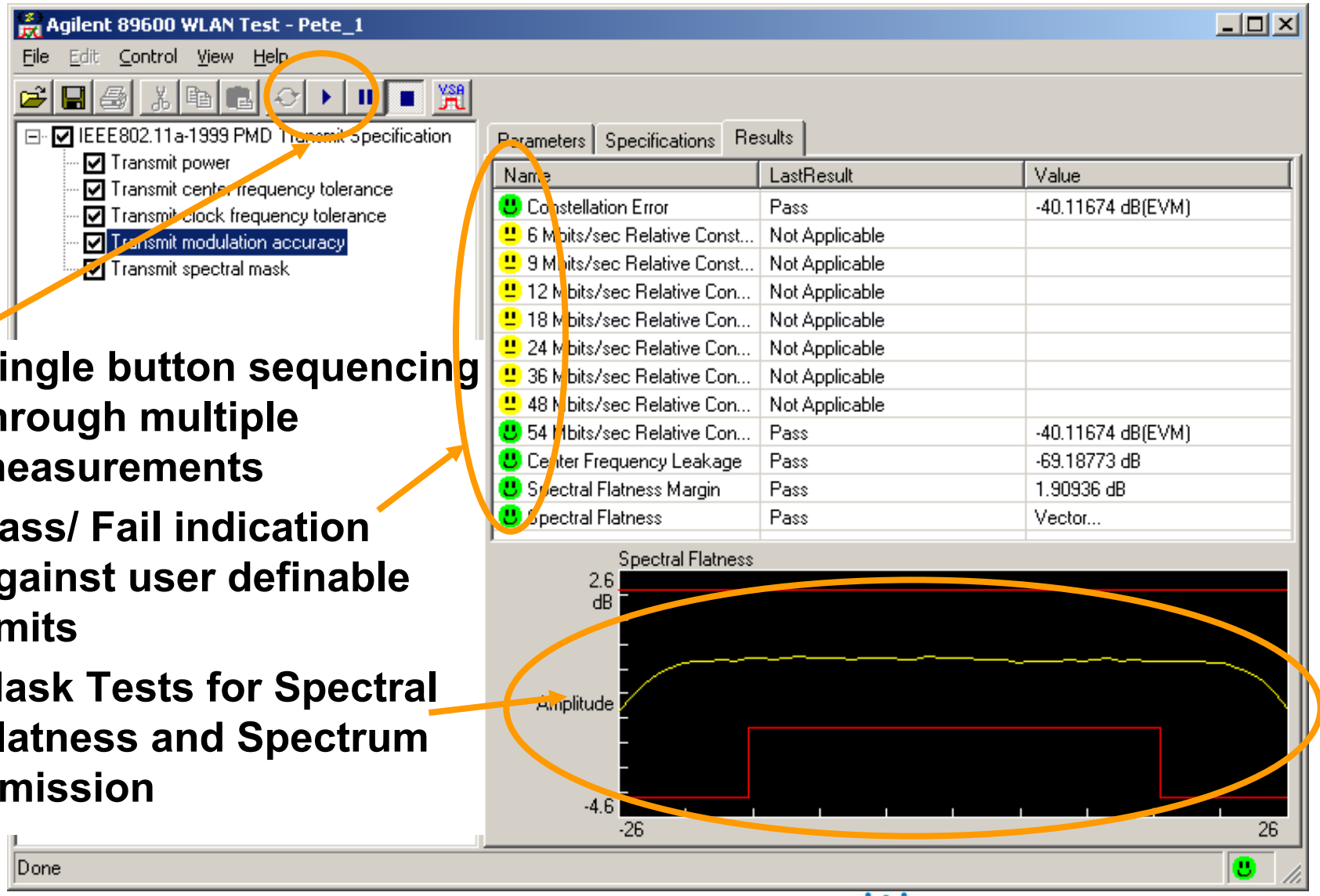
802.11a Semi-Automated Measurements



- **Single button sequencing through multiple measurements**
- **Pass/ Fail indication against user definable limits**
- **Mask Tests for Spectral Flatness and Spectrum Emission**

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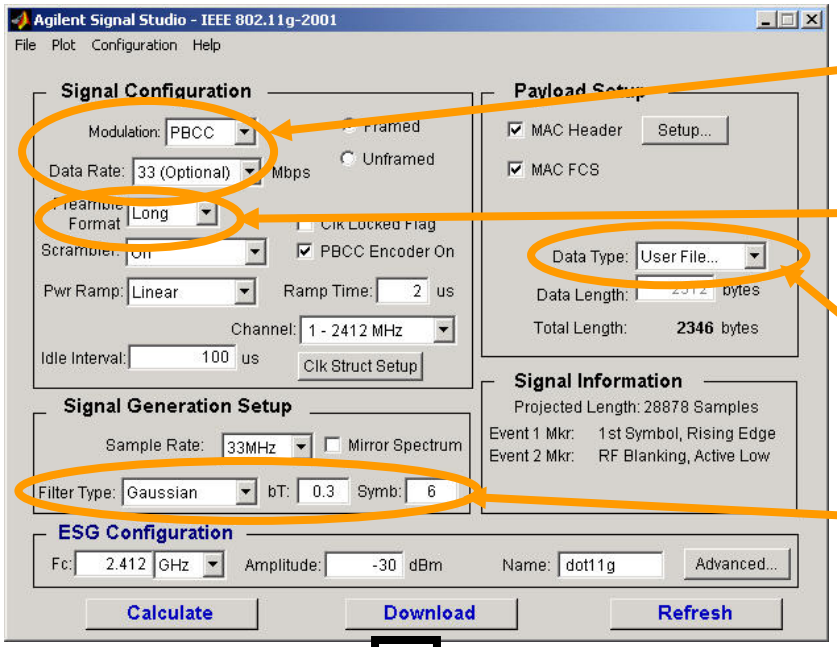
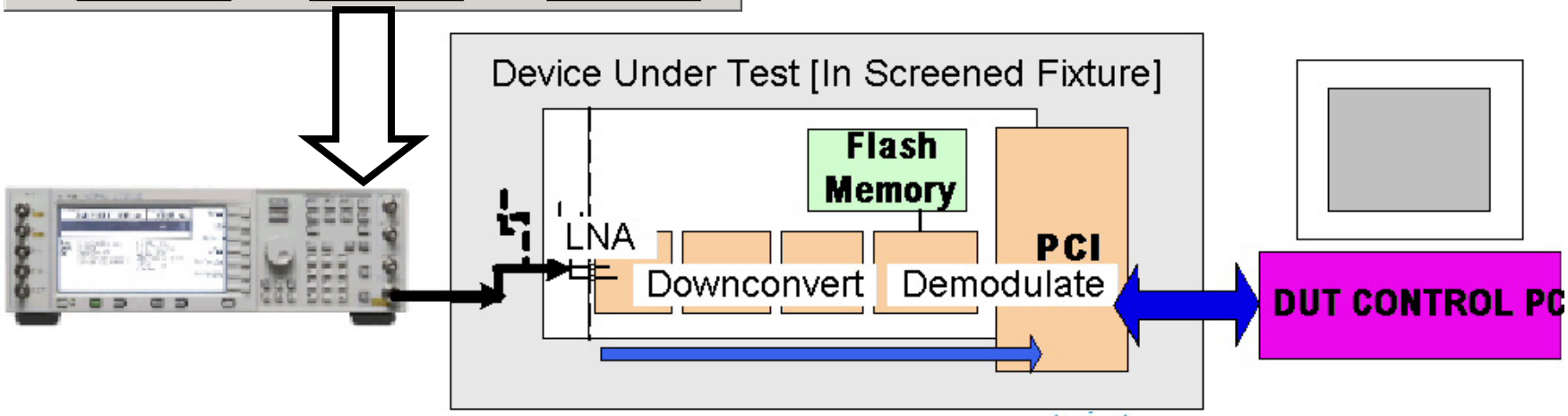
802.11g PBCC Packet Generation



- PBCC Modulation
- Selectable Preamble
- Input data from User file
- Selectable Modulation filter



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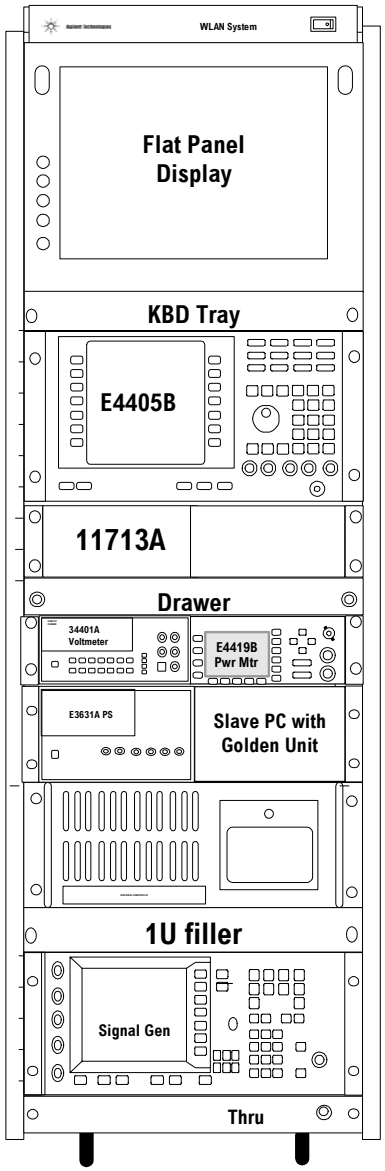
802.11b Custom System Example



- Delivers a Tested system.
- Calibration & support integrated
- Support Multiple DUT form factors (PCMCIA, CF, USB, Mini PCI, AP….)
- Easy Customization of the Test Plan
- Built-in Database capability

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Recommended Products

PERFORMANCE TEST LIST	896xxA Vector Signal Analyzer	E4418B EPM-P Power Meter	E4405B ESA-E Spectrum Analyzer	E4438C Signal Generator	66319 DC Power Supply
2.4GHz	640A			Opt 503	
Dualband	641A			Opt 506	
Output Power					
CCDF					
EVM					
Frequency Error					
Spectrum Mask					
Spurious / Harmonics					
Center Freq. Leakage					
RSSI					
Receiver Sensitivity					
Adjacent Ch rejection					
Battery Current					

Summary Slide

- WLAN device design is changing rapidly to keep pace with market expectations
- Highly integrated designs are offering increased data rates for moderate costs, but production yields & margins need to be watched
- Existing methods for testing the cards lack flexibility and may not ultimately use the most effective techniques
- Further enhancements to Agilent's broadly adopted Wideband test equipment provide a bridge to more general use of new techniques.

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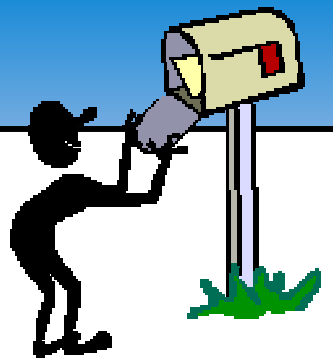

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