NeuHelium
新氦类脑智能

类脑智能

驱动未来

信号发生器

类脑智能

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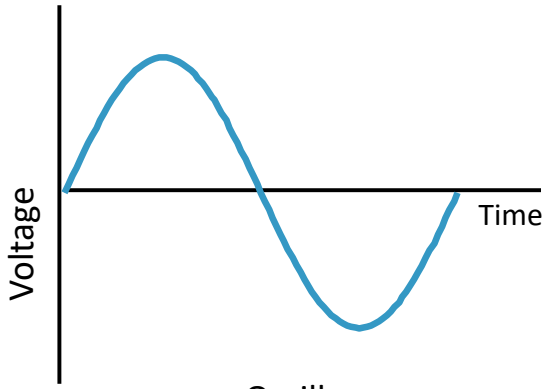
BY
NeuHelium

Agenda

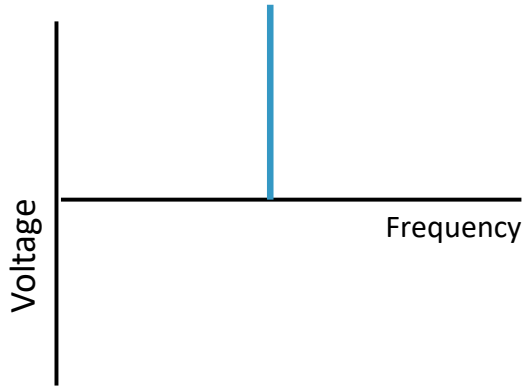
- **Generating Signals**
  - **Continuous Wave (CW)**
  - Sweep Signal
  - Analog Modulation
  - Digital Modulation
- Signal Generator Architecture
- Basic Applications
- Applications in Modern Wireless Communications

Generating Signals – No Modulation

Continuous Wave (CW)

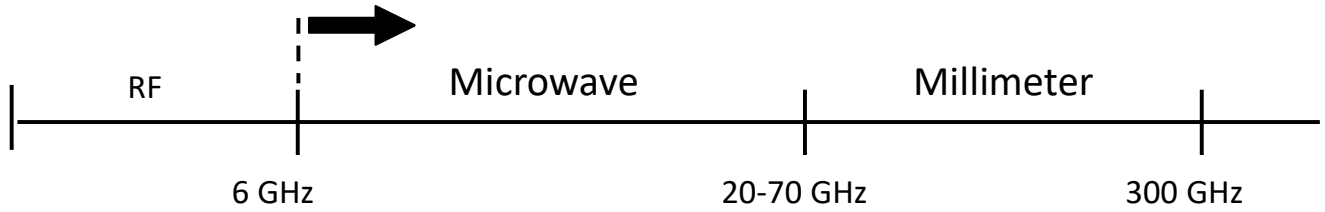


Oscilloscope



Spectrum Analyzer

The sine wave is the basic, non-modulated signal: It is useful for stimulus/response testing of linear components and for Local Oscillator substitution. Available frequencies range from low RF to Millimeter.



CW Source Specifications

Amplitude Parameters

- Range (-136dBm to +13dBm)
- Accuracy (+/- 0.5dB)
- Resolution (0.02dB)
- Switching Speed (15ms)
- Reverse Power Protection

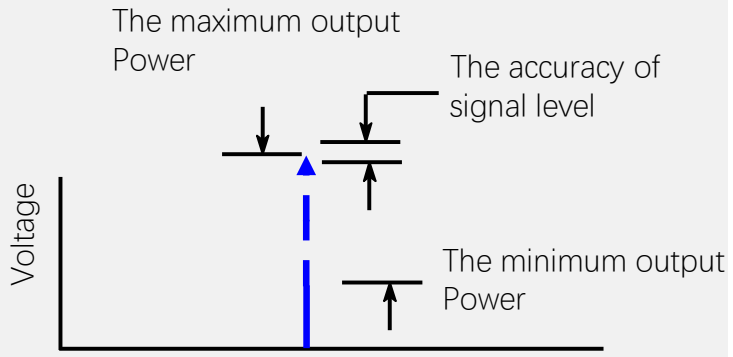
Power

	Options 501-504	*With Option UNB*	*Option 506*
250 kHz to 250 MHz	+11 to –136 dBm	+15 to –136 dBm	+12 to –136 dBm
> 250 MHz to 1 GHz	+13 to –136 dBm	+17 to –136 dBm	+14 to –136 dBm
> 1 to 3 GHz	+10 to –136 dBm	+16 to –136 dBm	+13 to –136 dBm
> 3 to 4 GHz	+7 to –136 dBm	+13 to –136 dBm	+10 to –136 dBm
> 4 to 6 GHz	N/A	N/A	+10 to –136 dBm

Level accuracy [dB]

Options 501-504 [1,2]

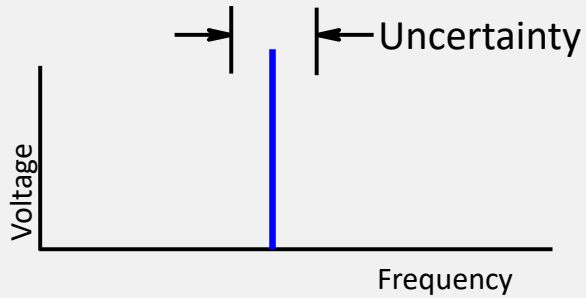
	Power level			
	+7 to –50 dBm	< –50 to –110 dBm	< –110 to –127 dBm	< –127 dBm
250 kHz to 2.0 GHz	±0.5	±0.5	±0.7	(±1.5)
2.0 to 3 GHz	±0.6	±0.6	±0.8	(±2.5)
3 to 4 GHz	±0.7	±0.7	±0.9	(±2.5)



CW Source Specifications

Frequency

- Range: Range of frequencies covered by the source
- Resolution: Smallest frequency increment.
- Accuracy: How accurately can the source frequency be set.
- Frequency change speed: How fast the frequency change



Frequency range

Option [1]	
501	250 kHz to 1 GHz
502	250 kHz to 2 GHz
503	250 kHz to 3 GHz
504	250 kHz to 4 GHz
506	250 kHz to 6 GHz [requires Option UNJ]

Frequency minimum 100 kHz [2]

	Standard	**High Stability (1E5)**
Aging Rate	<±1ppm/yr.	**<±0.1ppm/yr.**
Temperature (0-55deg C)	<±1ppm, typical	**<±0.005ppm, typical**
Line Voltage	<±0.1ppm(+5%,-10%), typical	**<±0.002ppm(+5%,-10%), typical**

Example

Accuracy = $\pm f_{CW} * \tau_{aging} * \tau_{cal}$

f_{CW} = CW frequency = 1 GHz

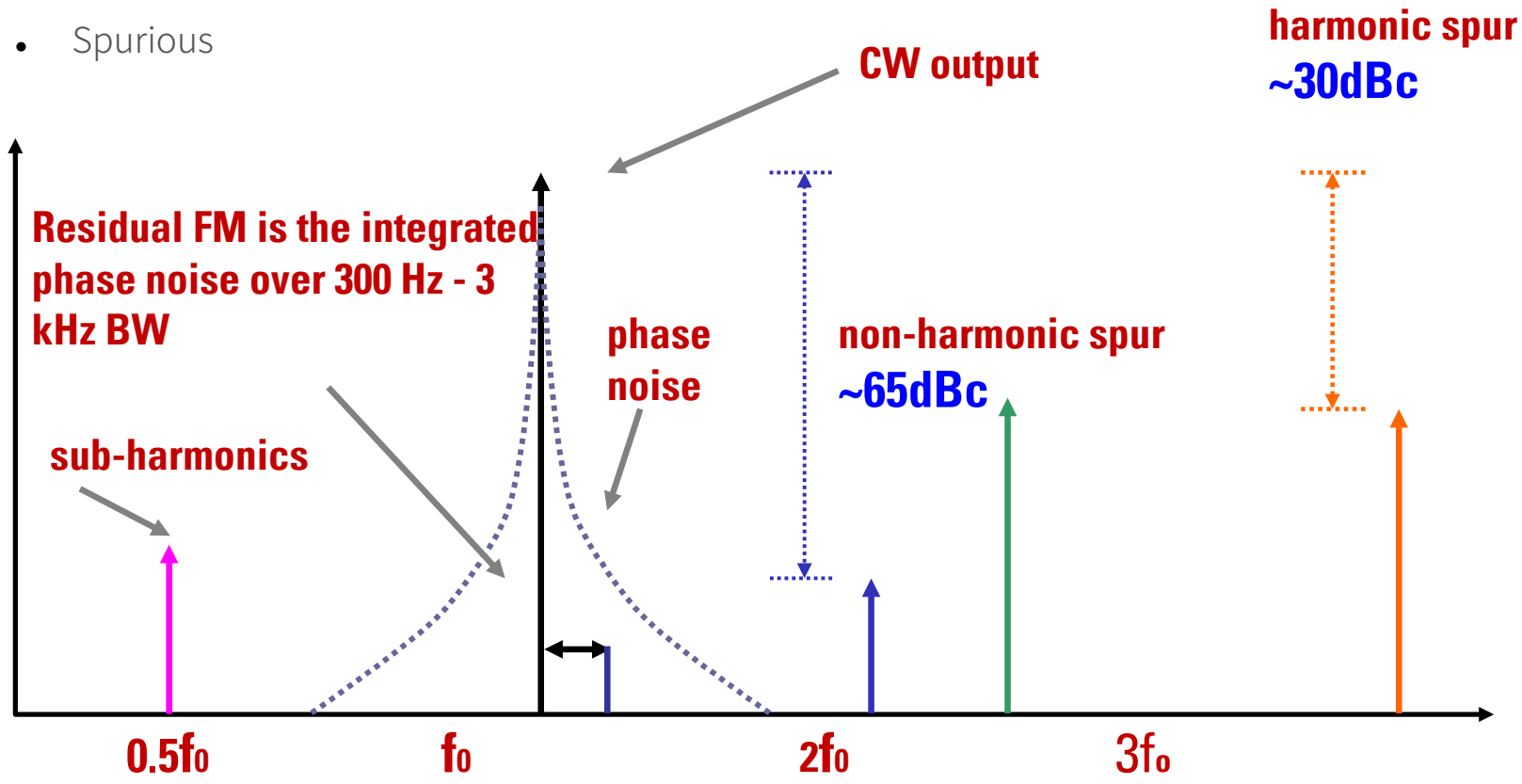
τ_{aging} = aging rate = 0.1ppm/year

τ_{cal} = time since last calibrated = 1 year

CW Source Speci cations

Spectral Purity

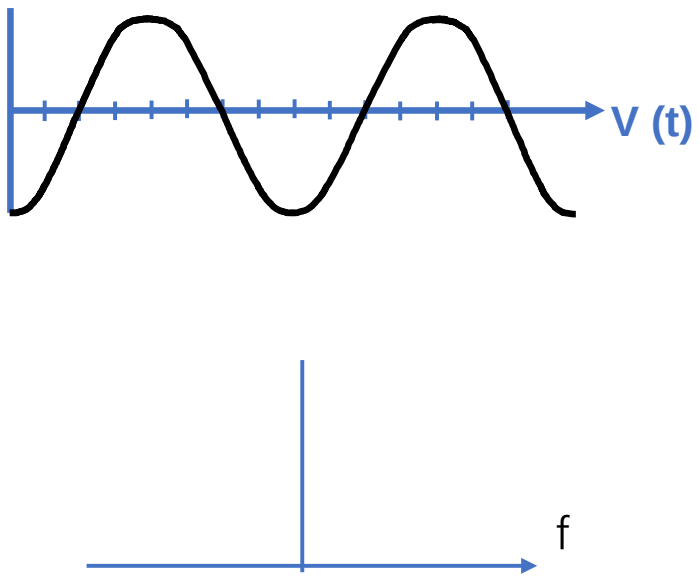
- Phase Noise
- Residual FM
- Spurious



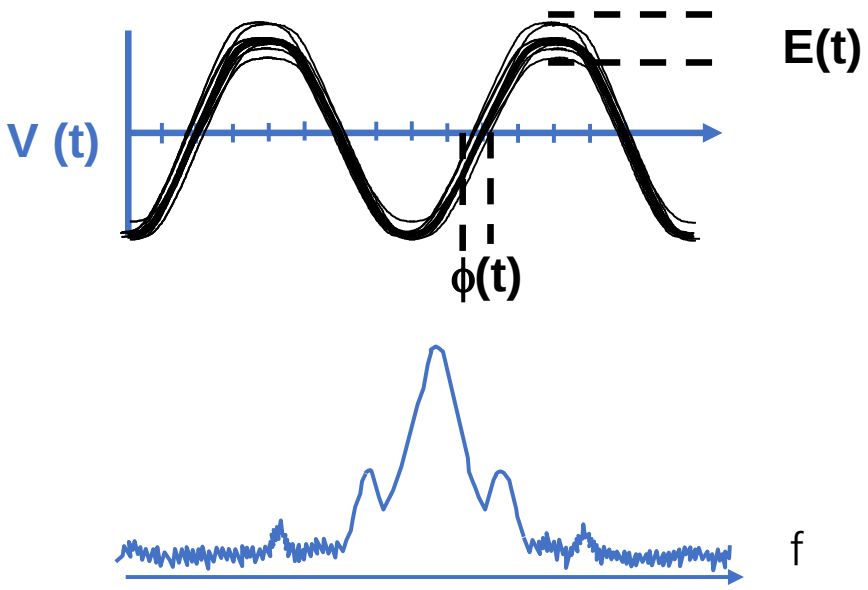
CW Source Specifications

Spectral Purity：Phase Noise——Basic Concepts

Idea signal

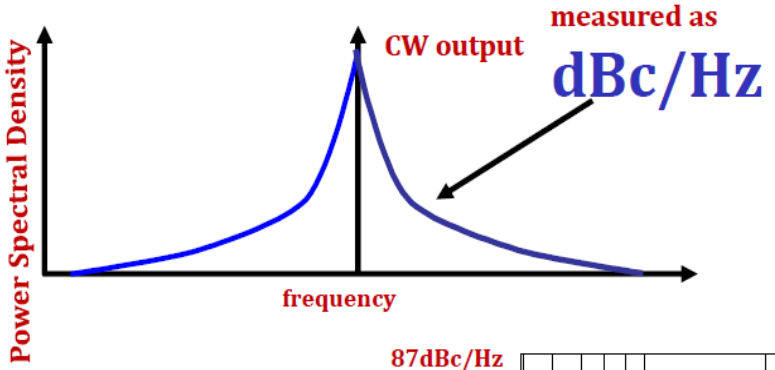


Real world signal



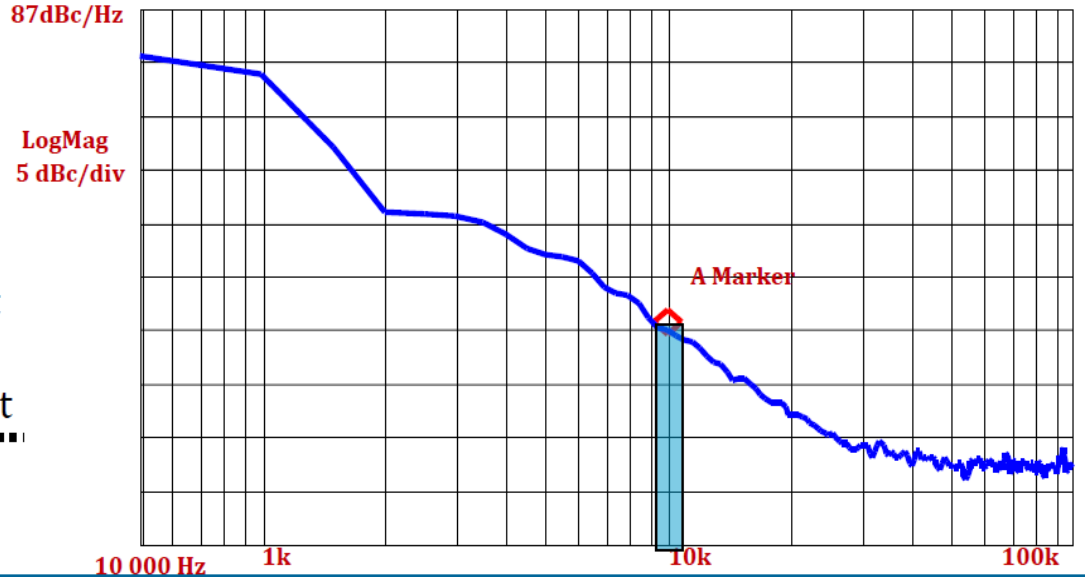
CW Source Specifications

Spectral Purity:Phase Noise——Performance



N5182B

-87dBc/Hz @10Hz offset
-93dBc/Hz @ 100Hz offset
-123dBc/Hz @1KHz offset
-141dBc/Hz @10kHz offset



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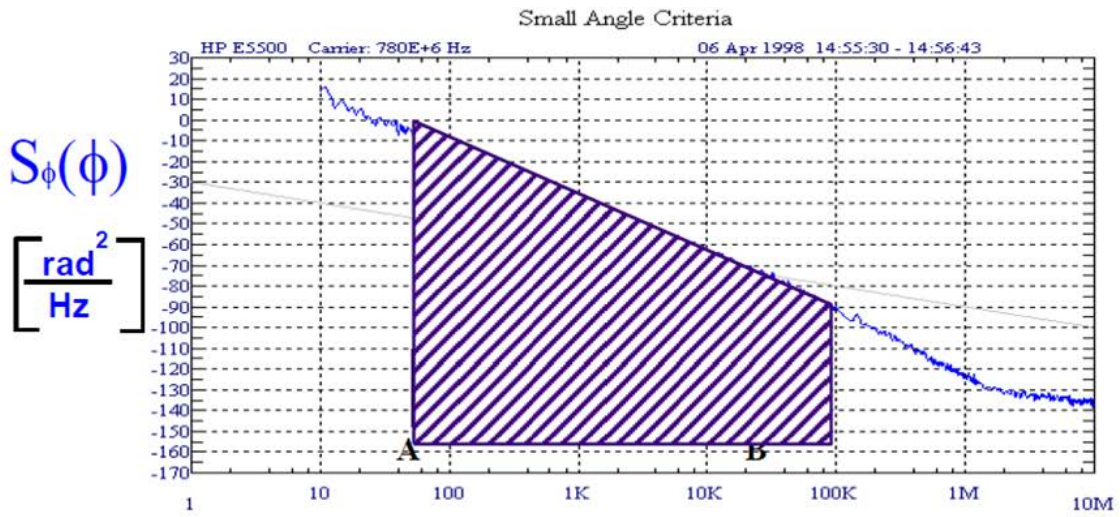
CW Source Specifications

Spectral Purity:Residual FM



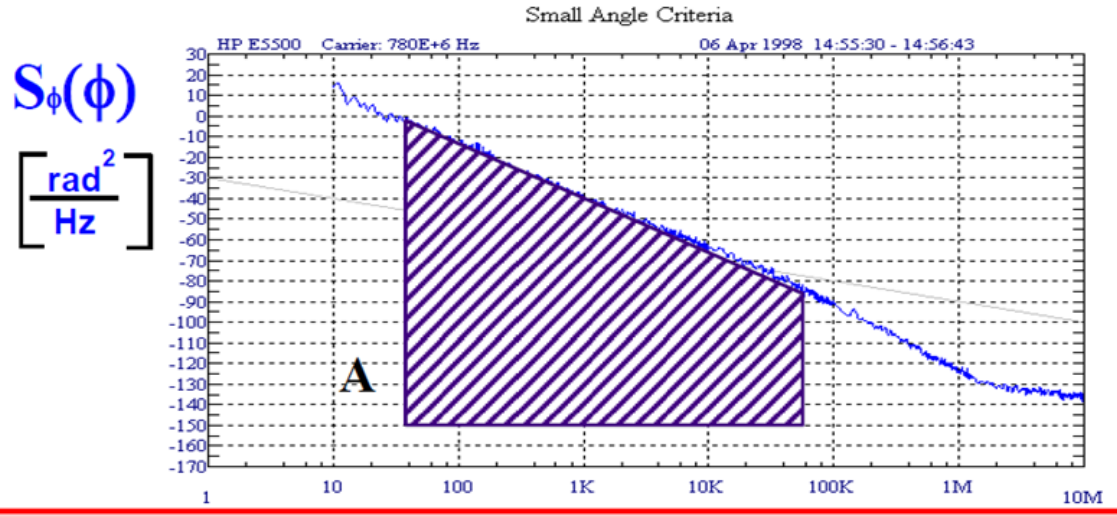
Residual FM =

Total rms frequency deviation within a specified bandwidth

$$\text{Residual FM} = \sqrt{\int_A^B f^2 S_\phi(f)df} = \sqrt{\int_A^B S_\nu(f)df} \quad [\text{Hz}]$$

CW Source Specifications

Spectral Purity:Phase Jitter

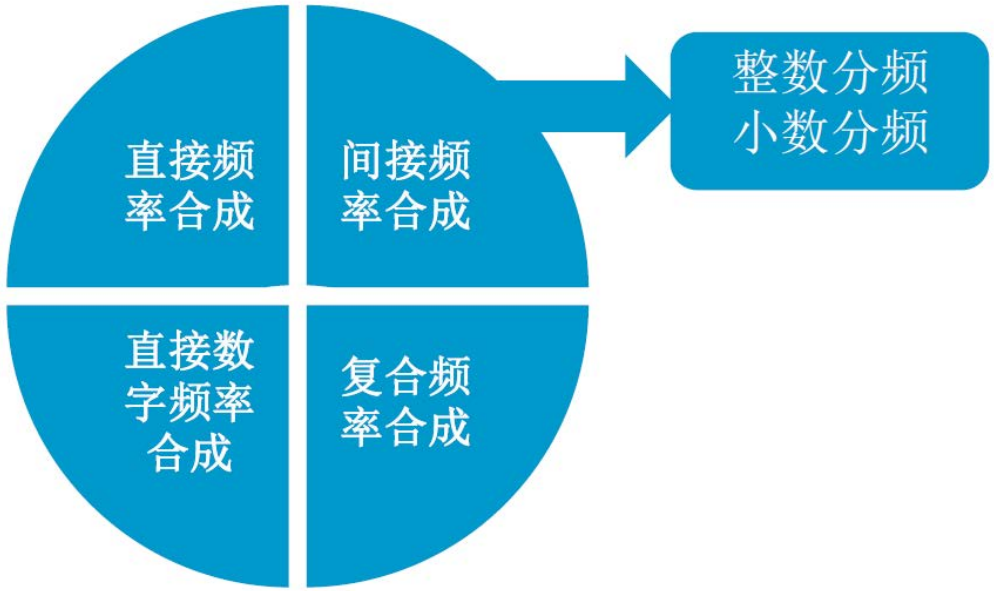


$$\text{Phase Jitter} = \sqrt{\int_A^B S_\phi(f)} \quad \text{[rad]} \qquad \text{Relative to } 1\ \text{rad}_{rms} = \text{[dB]}$$

$$\text{Phase Jitter} = \frac{360}{2\pi} \sqrt{\int_A^B S_\phi(f)} \quad \text{[degrees]}$$

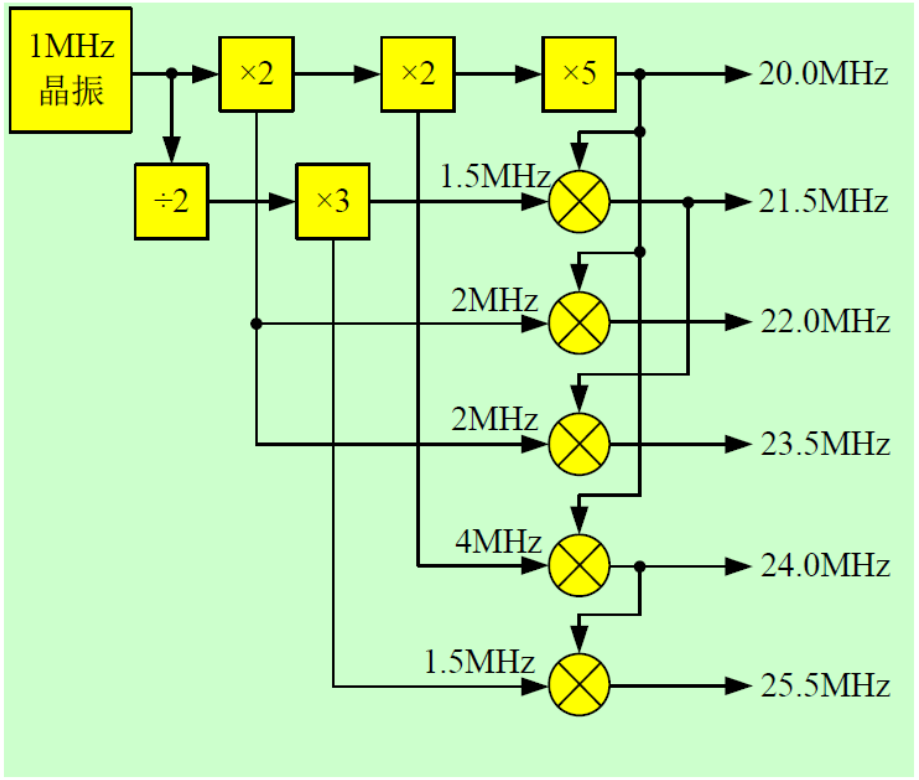
CW Source Specifications

Frequency Synthetic Technology



CW Source Specifications

Direct Frequency Synthesis

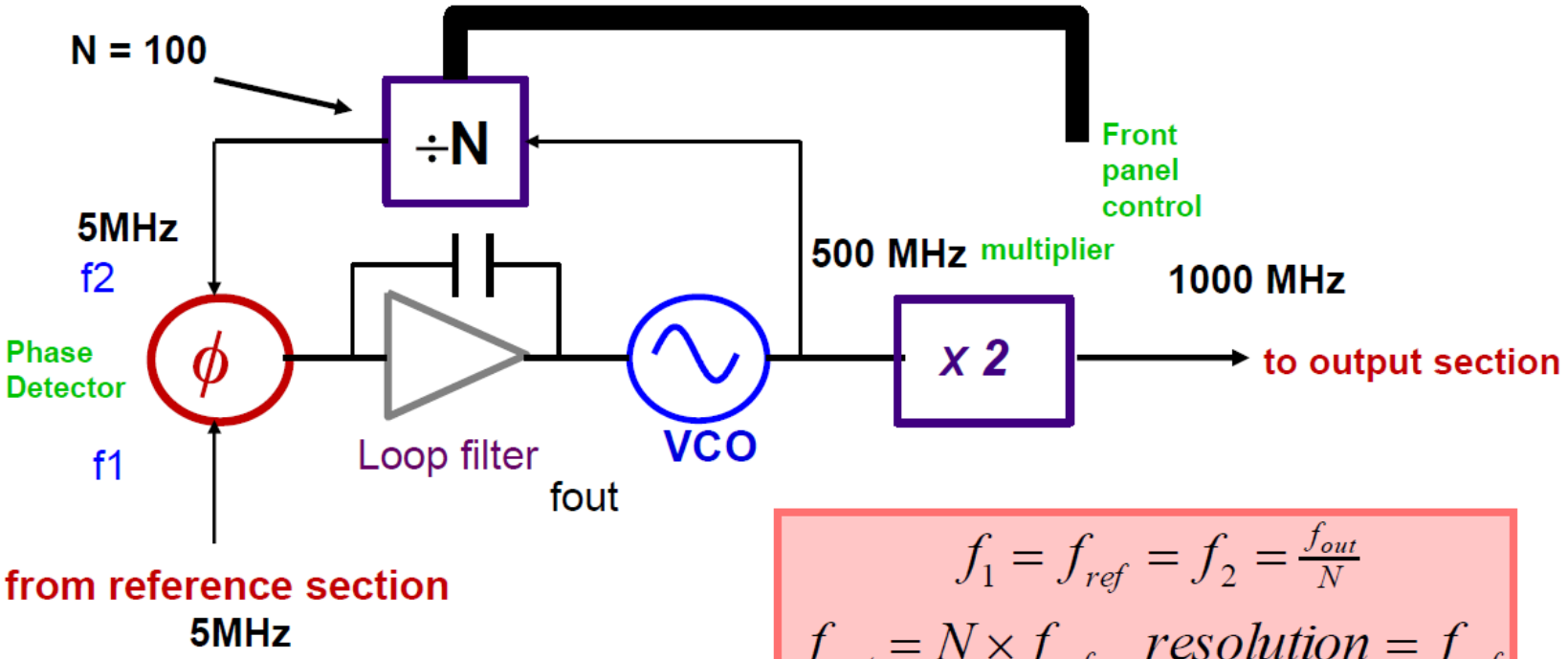


分频-混频-倍频式合成器

- 一个参考频率经过倍频、分频、混频
- 6个输出频率可以同时输出，最小频率间隔0.5MHz
- 输出信号的频率稳定度较高
- 输出信号的频率无法调整

CW Source Specifications

Indirect Frequency Synthesis

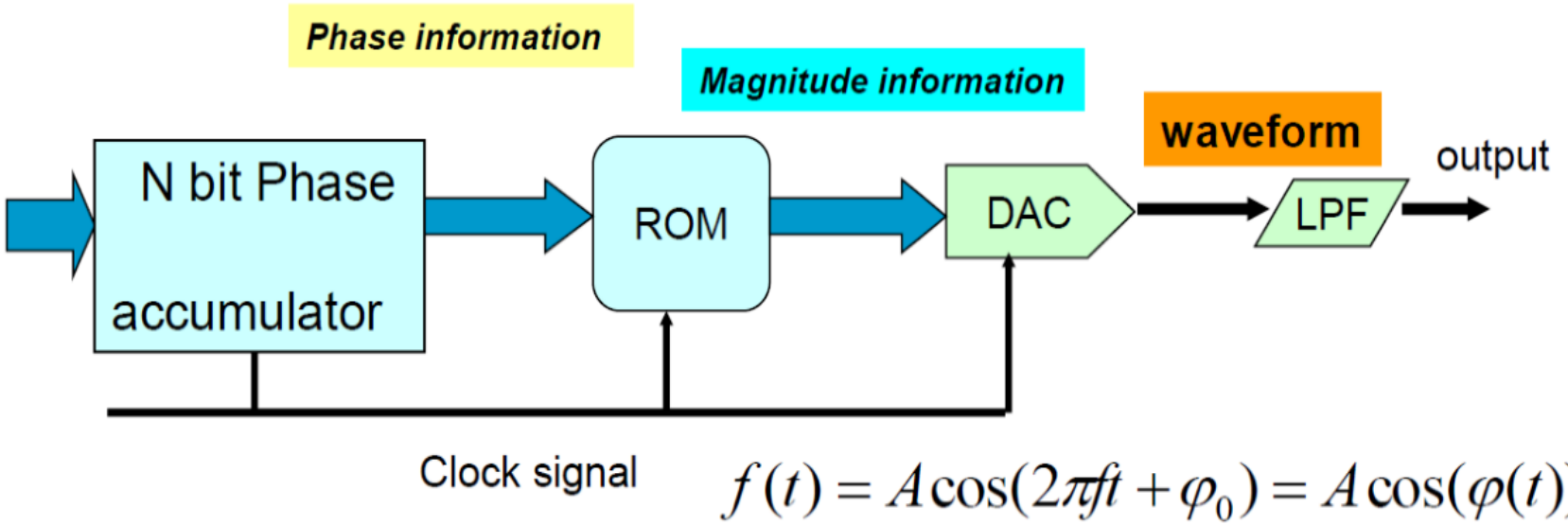


$$f_1 = f_{ref} = f_2 = \frac{f_{out}}{N}$$

$$f_{out} = N \times f_{ref} \quad resolution = f_{ref}$$

CW Source Specifications

Direct Digital Synthesizer (DDS)



CW Source Specifications

Summary of Synthesis

频率合成方法	关键技术	优点	缺点	主要应用
直接频率合成	振荡器（晶体振荡器；介质振荡器等）	频率稳定度高	输出频率固定	▪ 参考源 ▪ 单频系统 ▪ 频率捷变系统
间接频率合成	锁相环	✓输出频率范围宽 ✓高频率分辨率 ✓频率稳定度好 ✓灵活	▪分辨率指标和相位噪声指标折衷 ▪频率切换速度有限	电子系统本振
直接数字频率合成	数字电路技术；DAC	✓很高的频率分辨率 ✓频率捷变 ✓复杂波形合成	▪输出频率范围有限 ▪频谱杂散指标	频率捷变系统

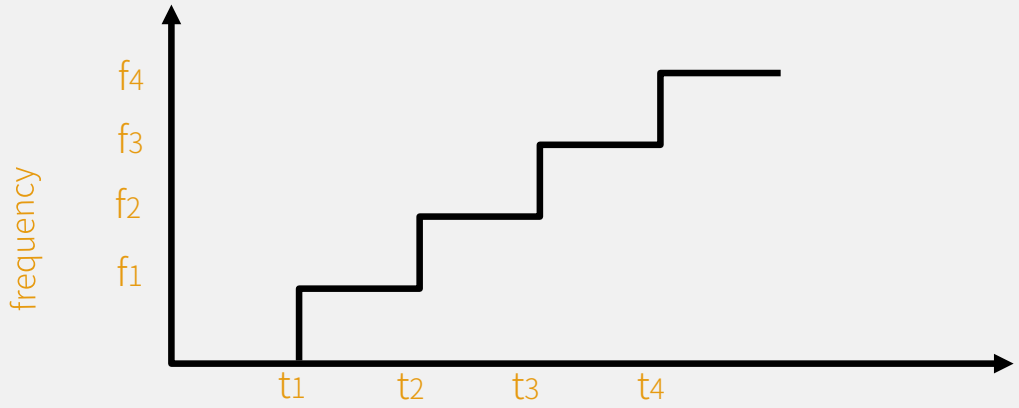
Agenda——Signal Generator

- **Generating Signals**
  - Continuous Wave (CW)
  - **Sweep Signal**
  - Analog Modulation
  - Digital Modulation
- Signal Generator Architecture
- Basic Applications
- Applications in Modern Wireless Communications

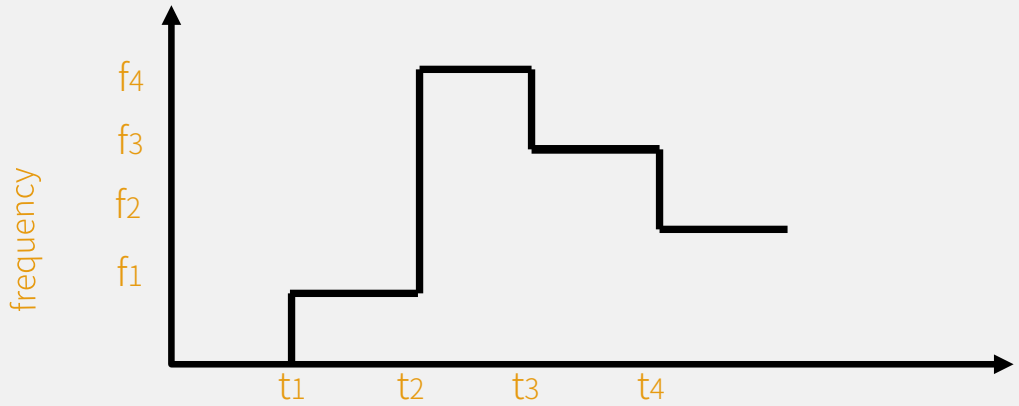
Sweep Source Specifications

Frequency

- Step Sweep
  - Accuracy
  - number of points
  - switching time



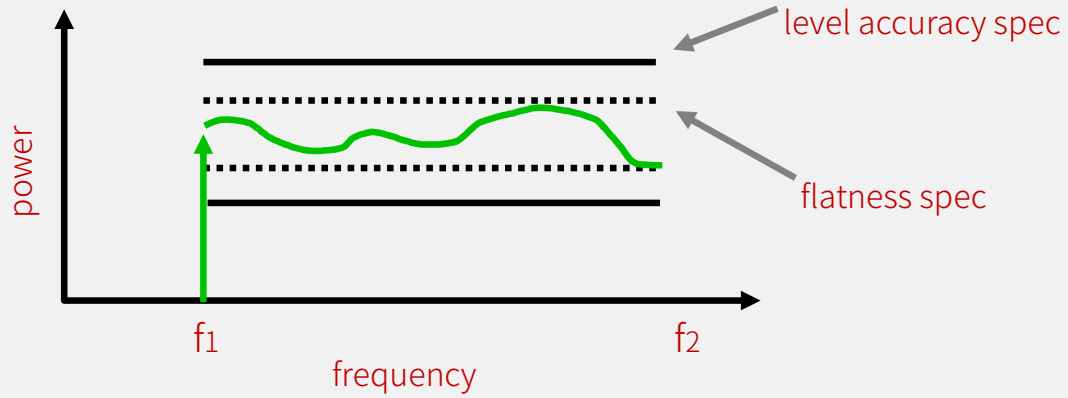
- List Sweep
  - Accuracy
  - switching time
  - dwell time



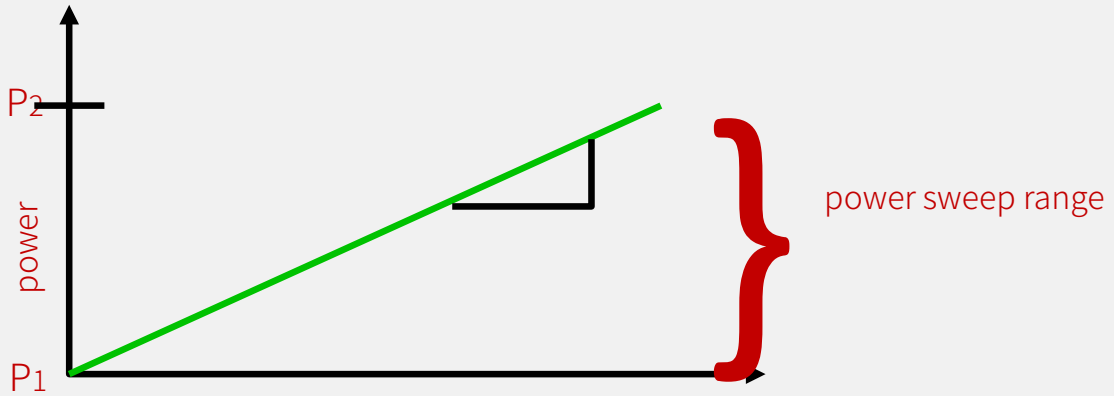
Sweep Source Specifications

Amplitude

- Frequency Sweep
  - Level Accuracy
  - Flatness
  - Source Match (SWR)



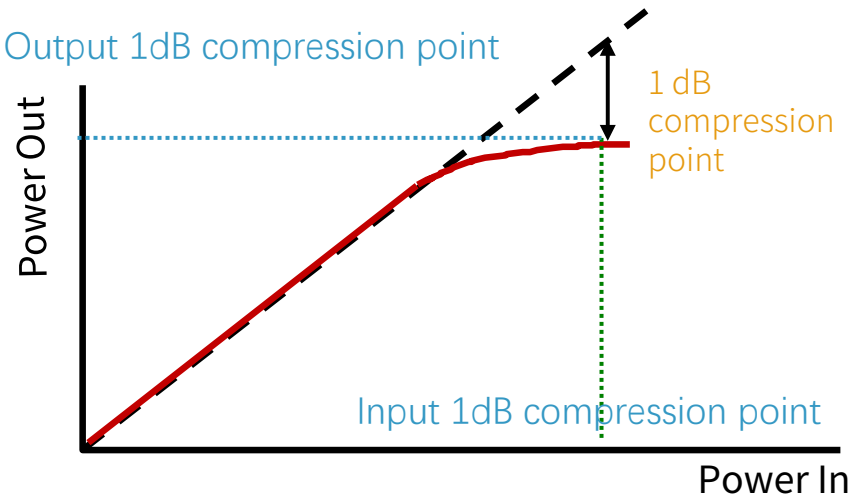
- Power Sweep
  - Power Sweep Range
  - Power Slope Range
  - Source Match (SWR)



Sweep Source Specifications

Applications & Critical Specifications

- Frequency Response
  - Level Accuracy
  - Output Power (Level)
  - Flatness
  - Speed
  - residual FM
- Amplifier Compression
  - Power Range



Agenda——Signal Generator

- **Generating Signals**
  - Continuous Wave (CW)
  - Sweep Signal
  - **Analog Modulation**
  - Digital Modulation
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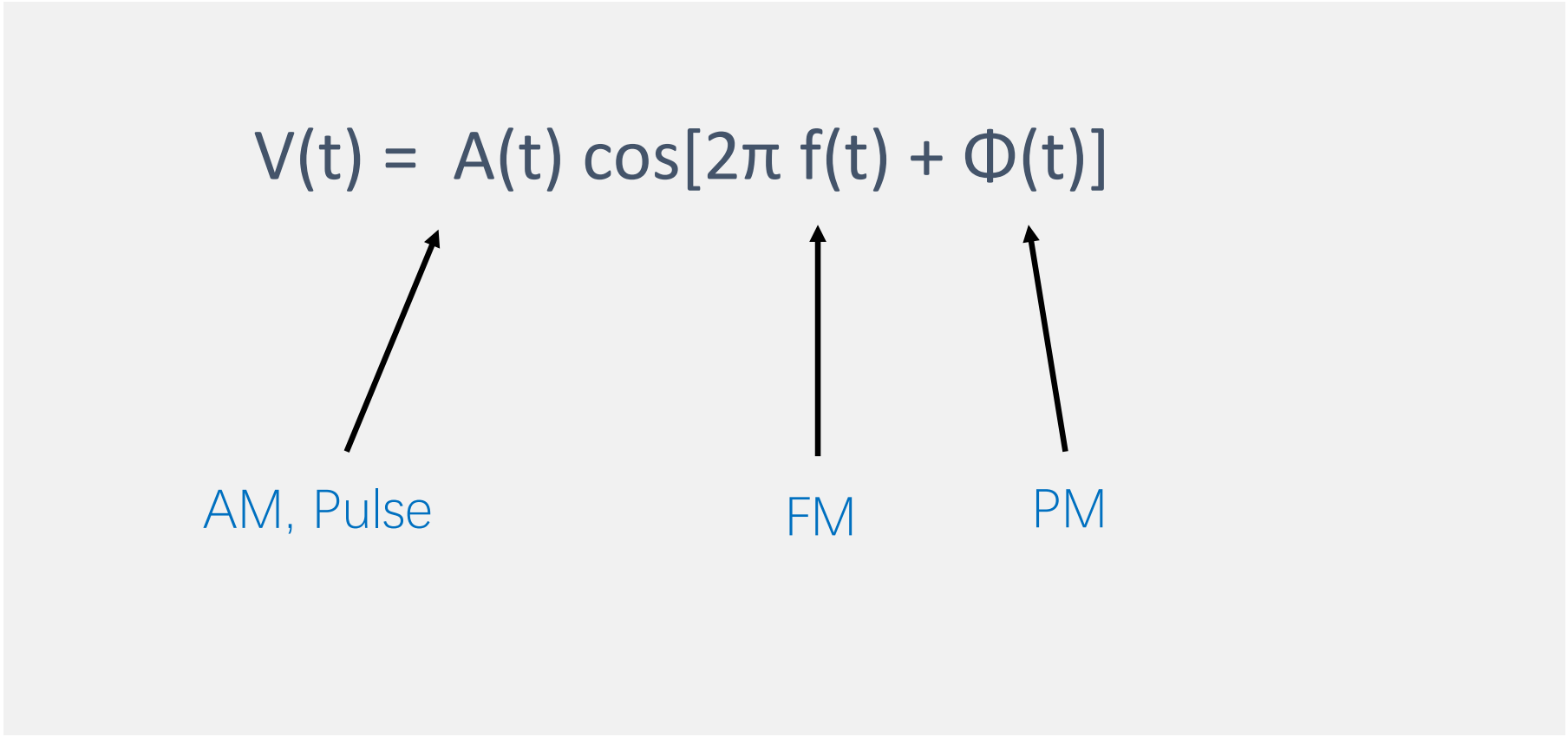
Generating Signals - Modulation

Where The Info is?



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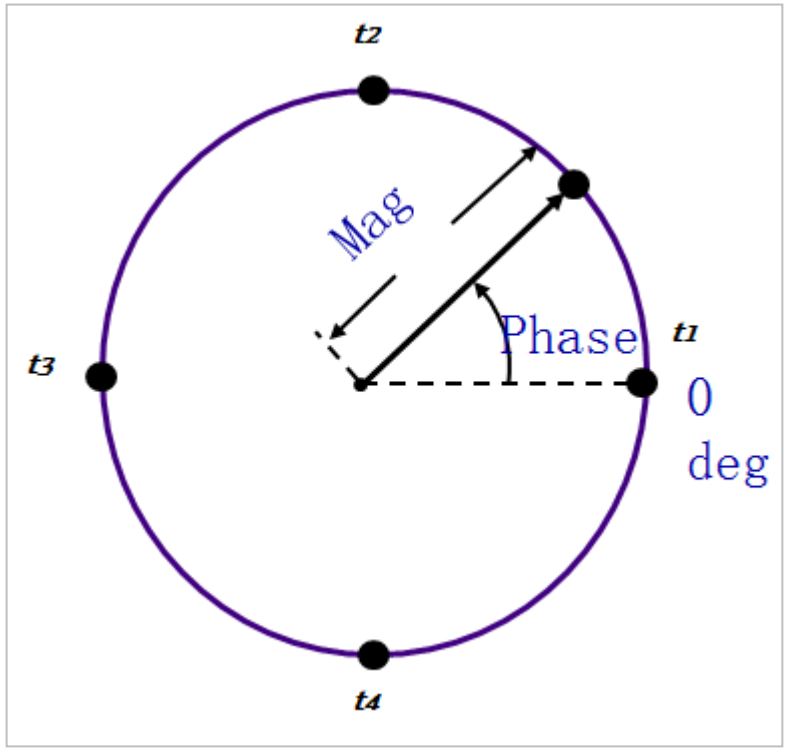
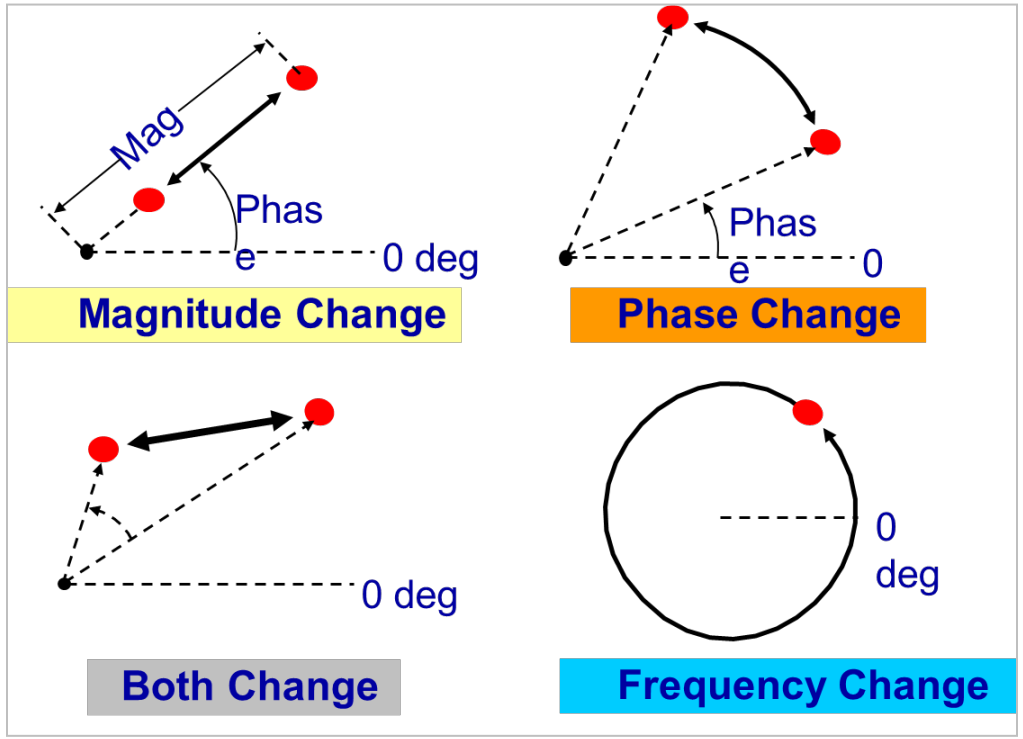
Generating Signals - Modulation

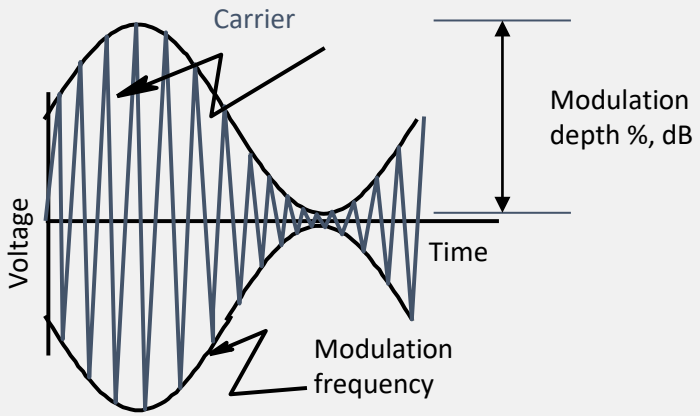
What Can Be Changed?





Generating Signals - Analog Modulation

Amplitude Modulation



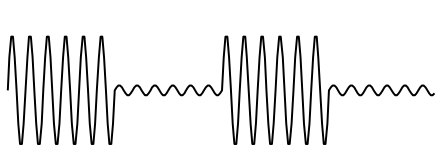
Where are AM signals used?

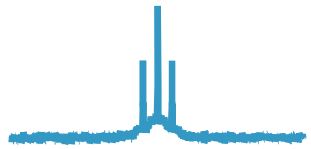
- AM Radio
- Antenna scan
- ASK (early digital 100101)

Important Characteristics

for Amplitude Modulation

- **Modulation frequency (rate)-**rate the modulating signal varies the amplitude of the Carrier
- **Depth of modulation (Mod Index)** – ratio of the peak of Modulating signal to the carrier signal amplitude Vpeak mod / Vcarrier
- Distortion %





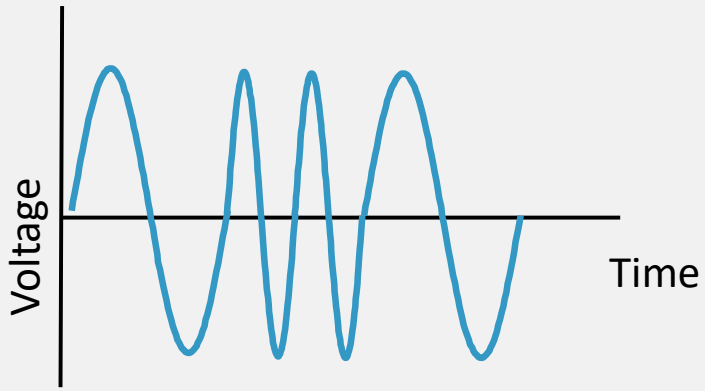
Generating Signals – Analog Modulation

Frequency Modulation

$$V(t) = A \cos[2\pi f_c t + \beta \sin 2\pi F_m t]$$

β is the modulation index, where β

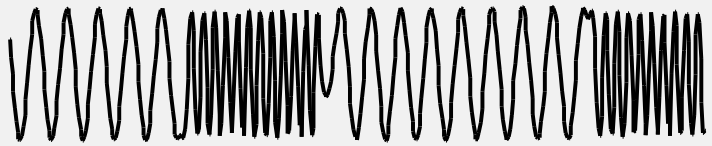
= ΔFdev /Fm



Important Characteristics

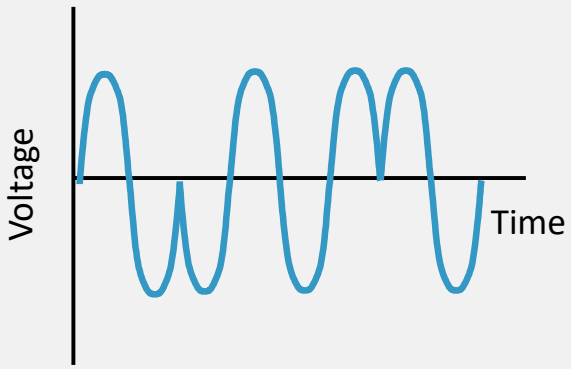
for Frequency Modulation

- **Frequency Deviation (ΔFdev)**-Amplitude of Modulating signal determines how far in Frequency the carrier signal will shift
- **Modulation Frequency (Fm)**-Determines how quickly carrier will shift from one frequency to another
- Accuracy
- Resolution
- Distortion (%)
- Sensitivity (dev/volt)



Generating Signals – Analog Modulation

Phase Modulation



$$V(t) = A\cos[2\pi f_c t + \beta 2\pi F_m t]$$

Where $\beta = \Delta\theta$, the peak phase deviation

Important Characteristics

for Phase Modulation

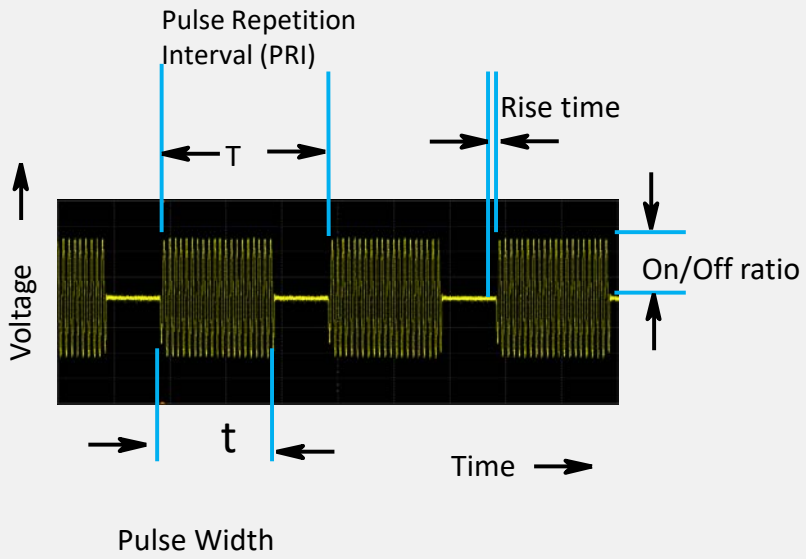
- **Phase deviation (Δθ)-**amplitude of modulating signal determines the amount of phase deviation.
- **Modulation Rate (Fm)-** determines how quickly carrier will shift from one phase to another.
- Accuracy

Where are Phase Modulated signals used?

- PSK (early digital 1010)
- Radar (pulse coding)

Generating Signals – Analog Modulation

Pulse Modulation



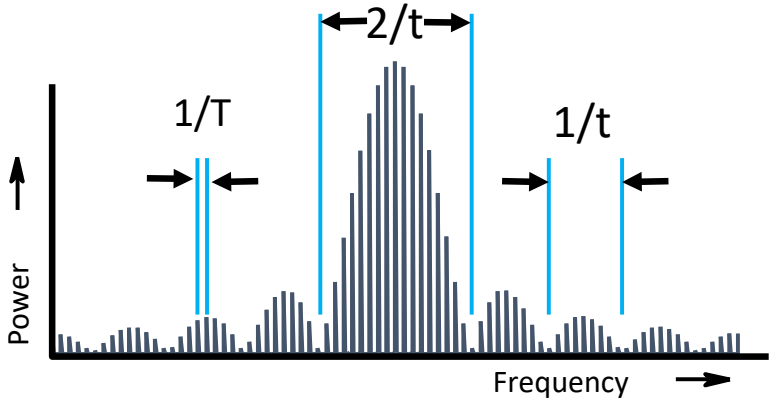
Where are Pulse Modulated signals used?

- Radar
- High Power Stimulus/Response
- Communications

Important Characteristics

for Pulse Modulation

- Pulse width (t)
- PRF (1/T)
- Duty cycle (t/T)
- On/Off ratio (dB)
- Rise time (ns)



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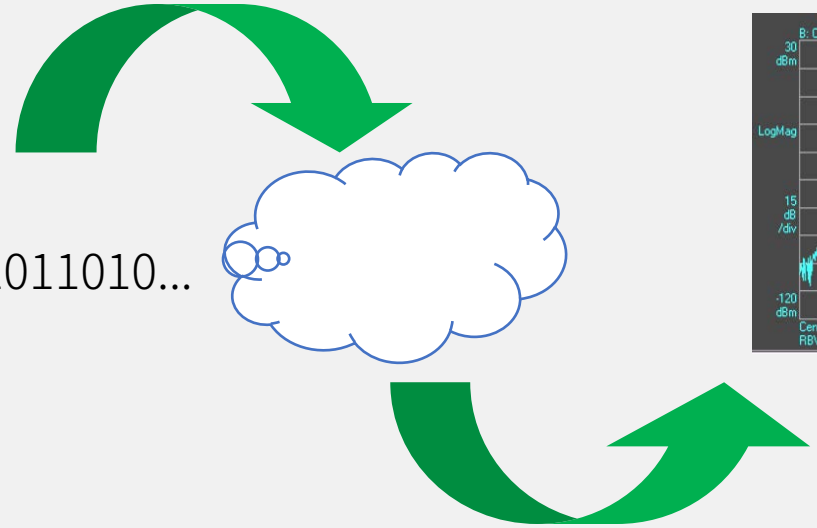
Generating Signals - Digital Modulation

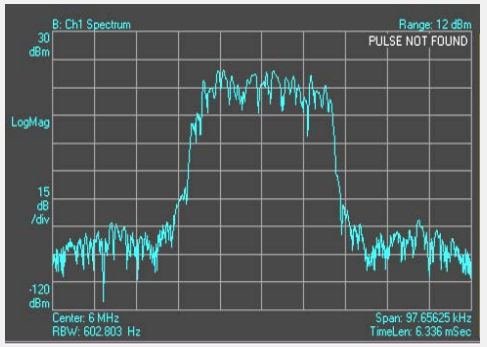
From Bits to Modulated Signal

Now we are going to show how information is transmitted by digital modulation.

Our example is a QPSK transmitter.

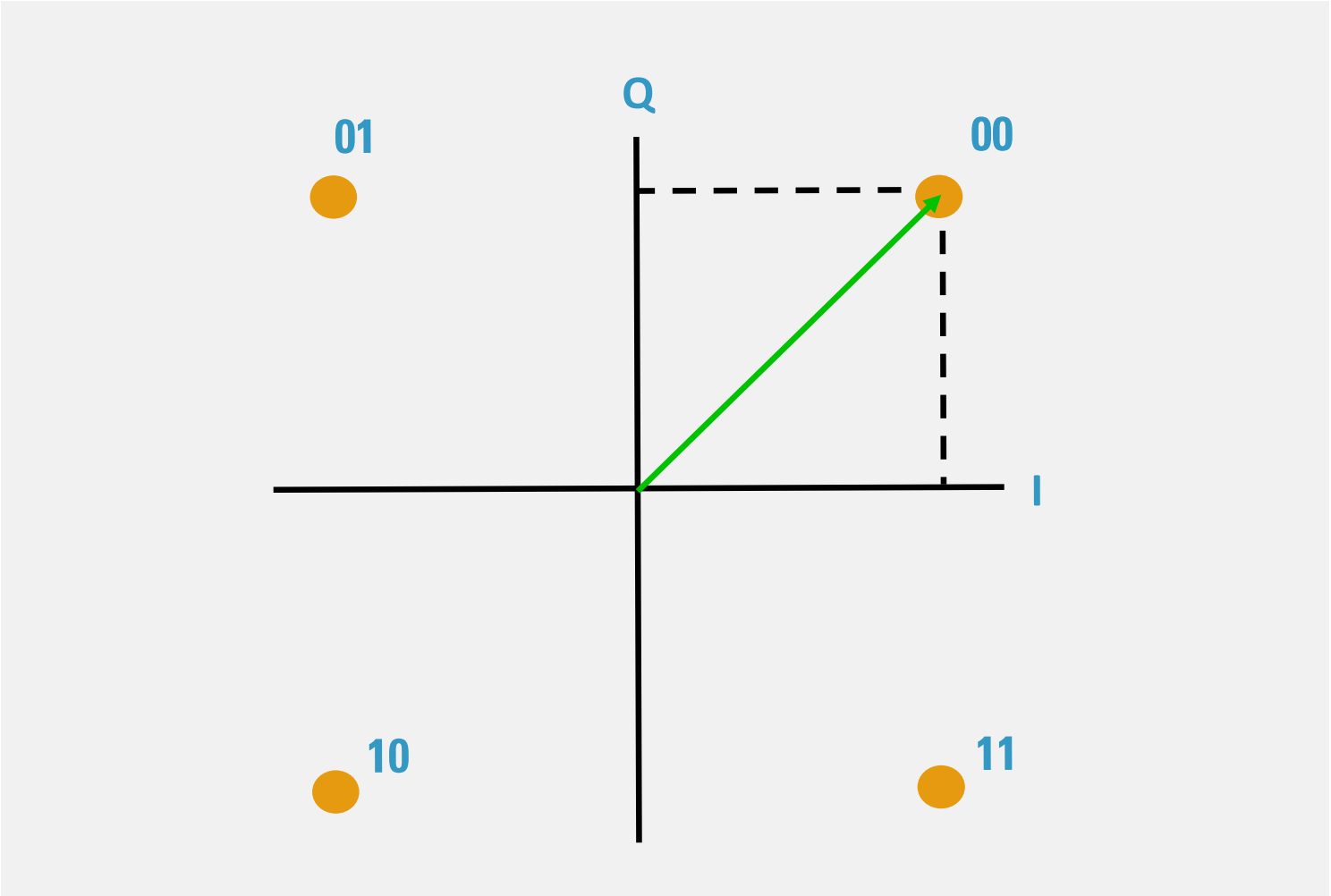


111001011010...



Generating Signals - Digital Modulation

QPSK Constellation Diagram



Generating Signals - Digital Modulation

Serial Bit Stream

Suppose these are the bits we want to send:

0110110001...

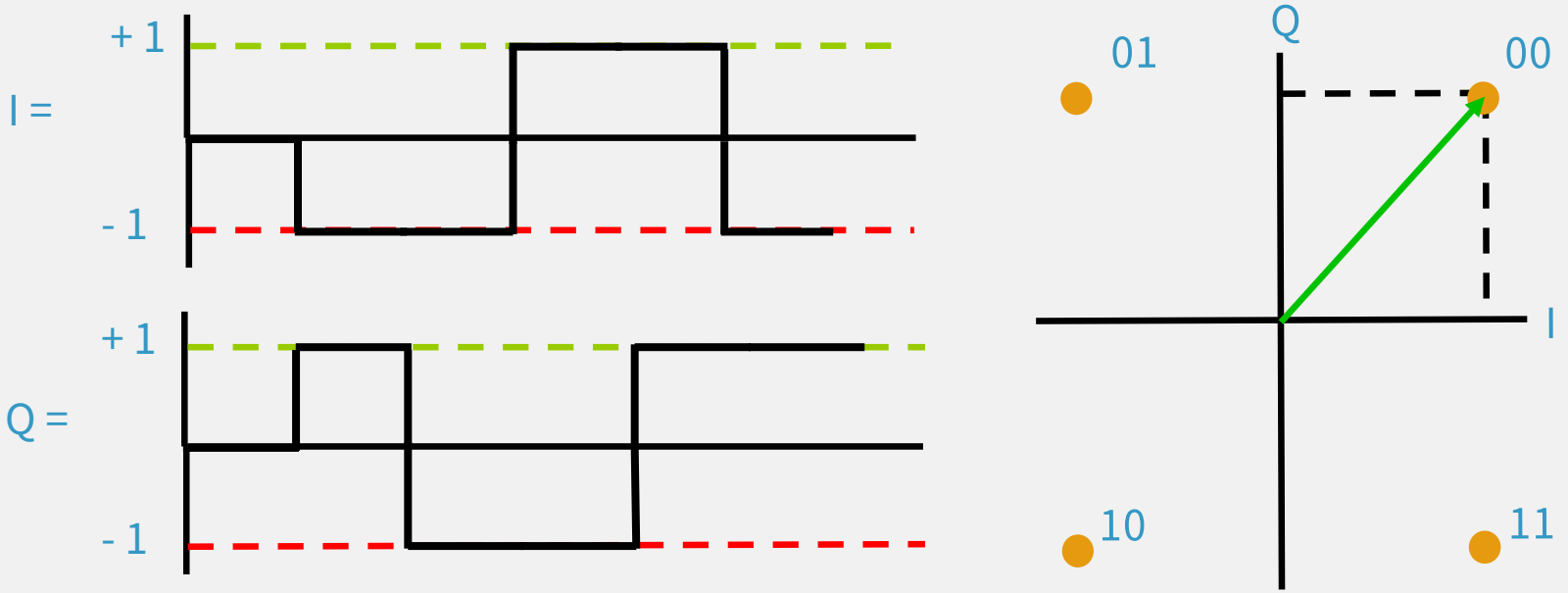
So we group them into 2-bit symbols:

01 10 11 00 01 ...

Generating Signals - Digital Modulation

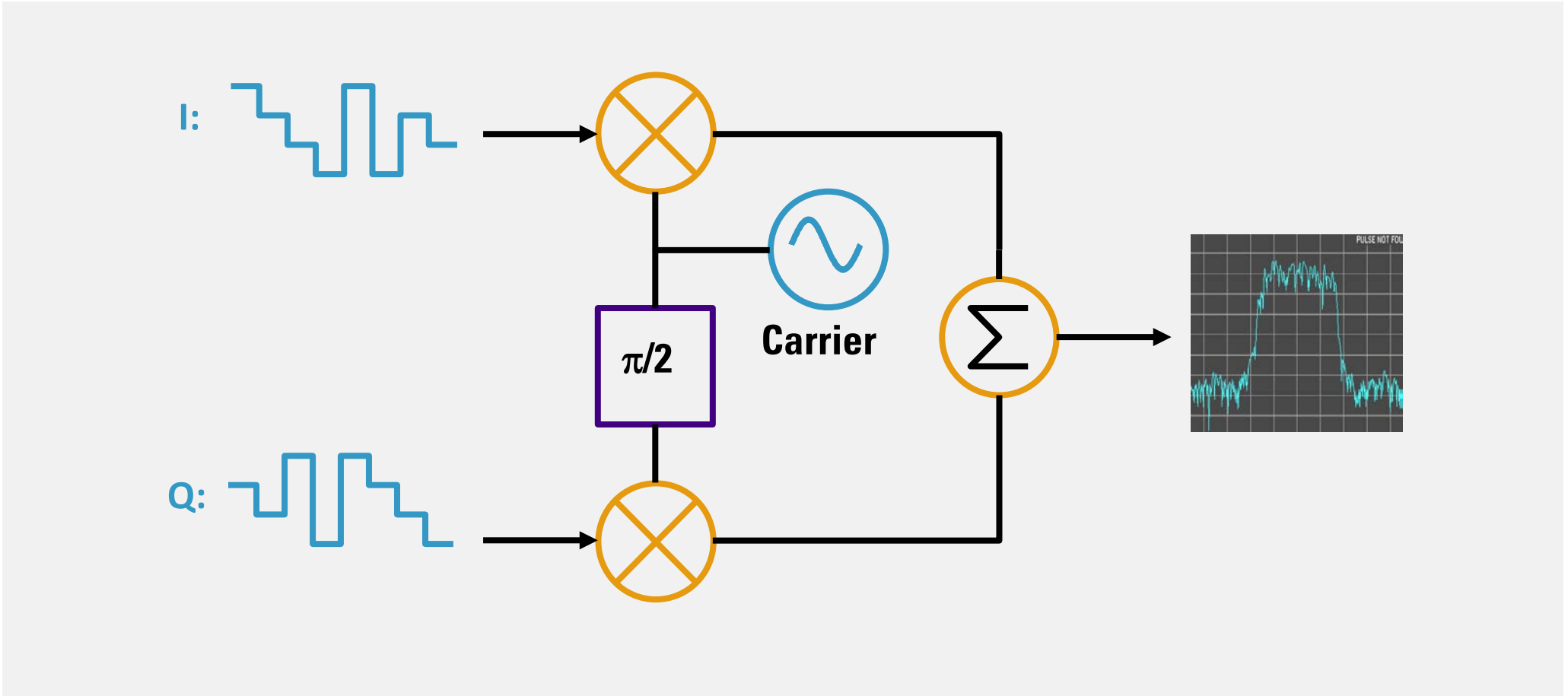
Two Waveforms

I and Q voltages represent 01 10 11 00 01 . . .



Generating Signals - Digital Modulation

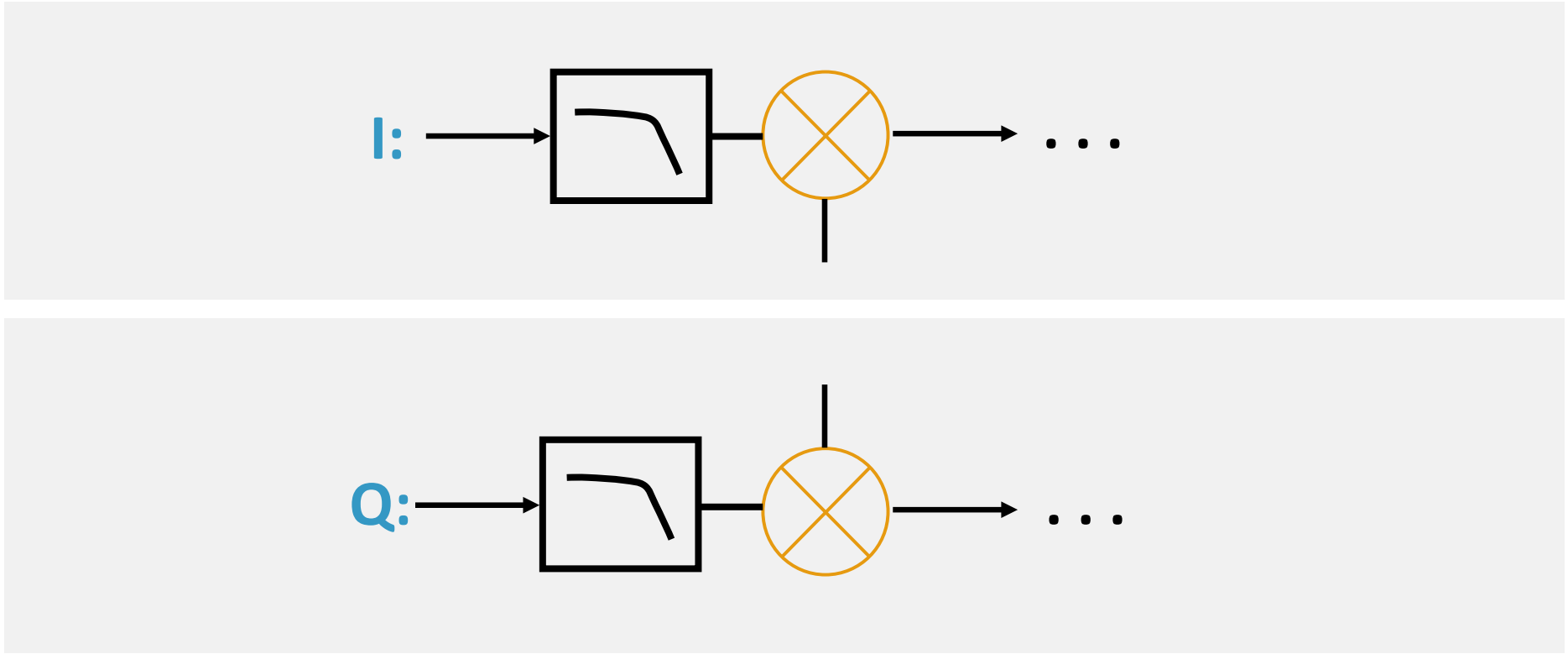
I-Q Modulator



Generating Signals - Digital Modulation

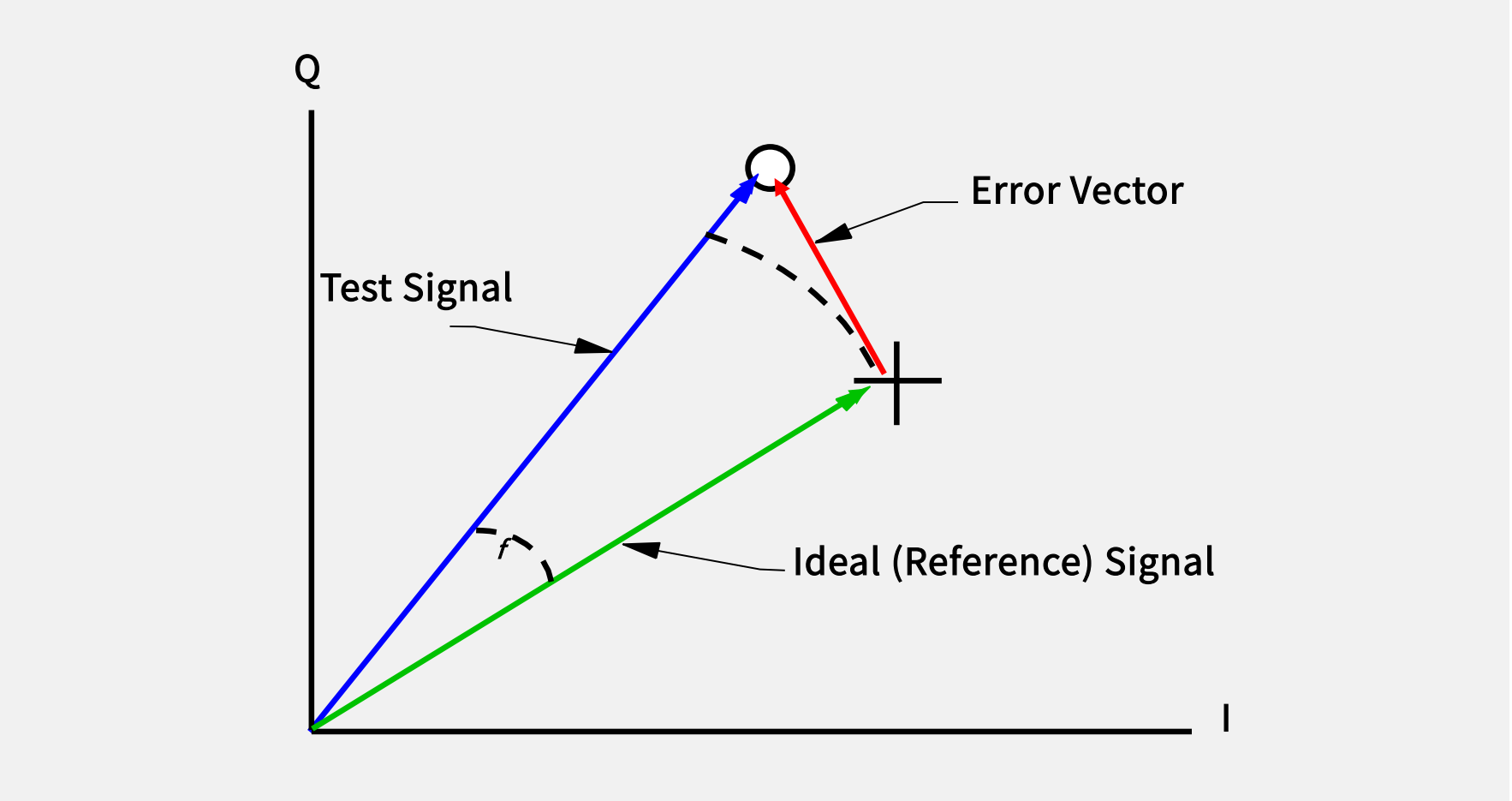
Limiting Bandwidth

Low pass filters are added at inputs



Generating Signals - Digital Modulation

Modulation Accuracy - EVM



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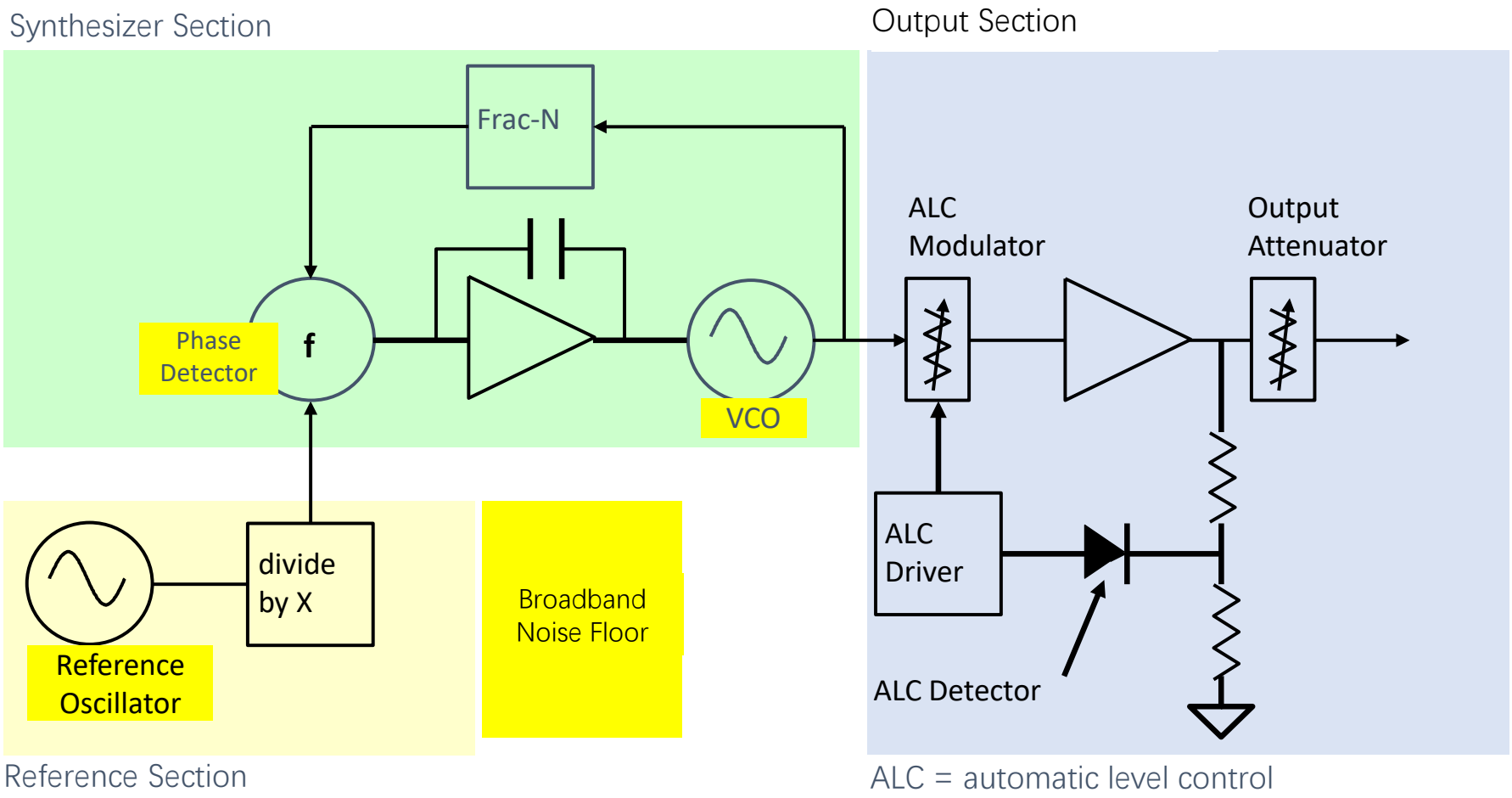
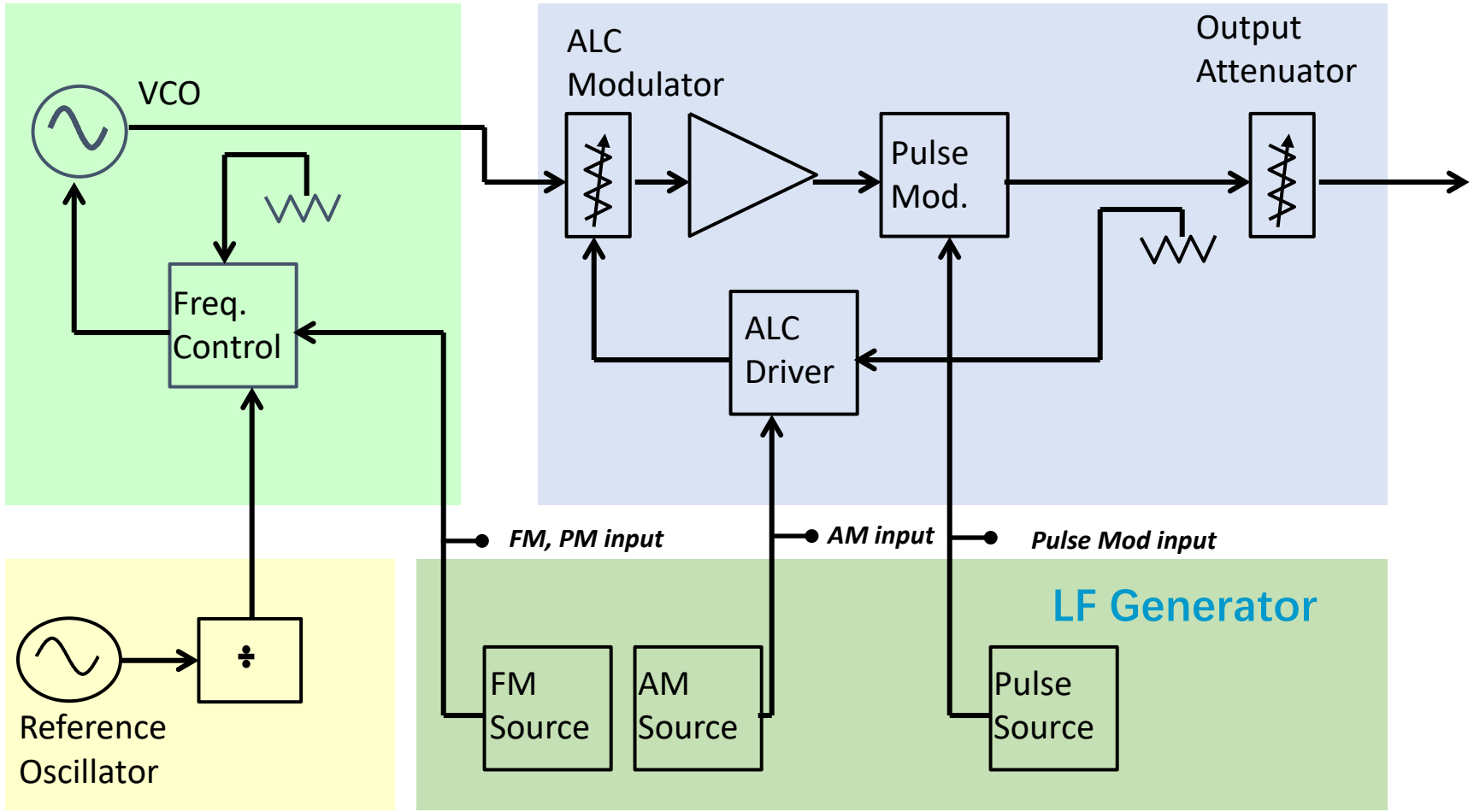
CW Signals – Block Diagram

Basic Building blocks of RF Source: Four Phase Noise Contributors



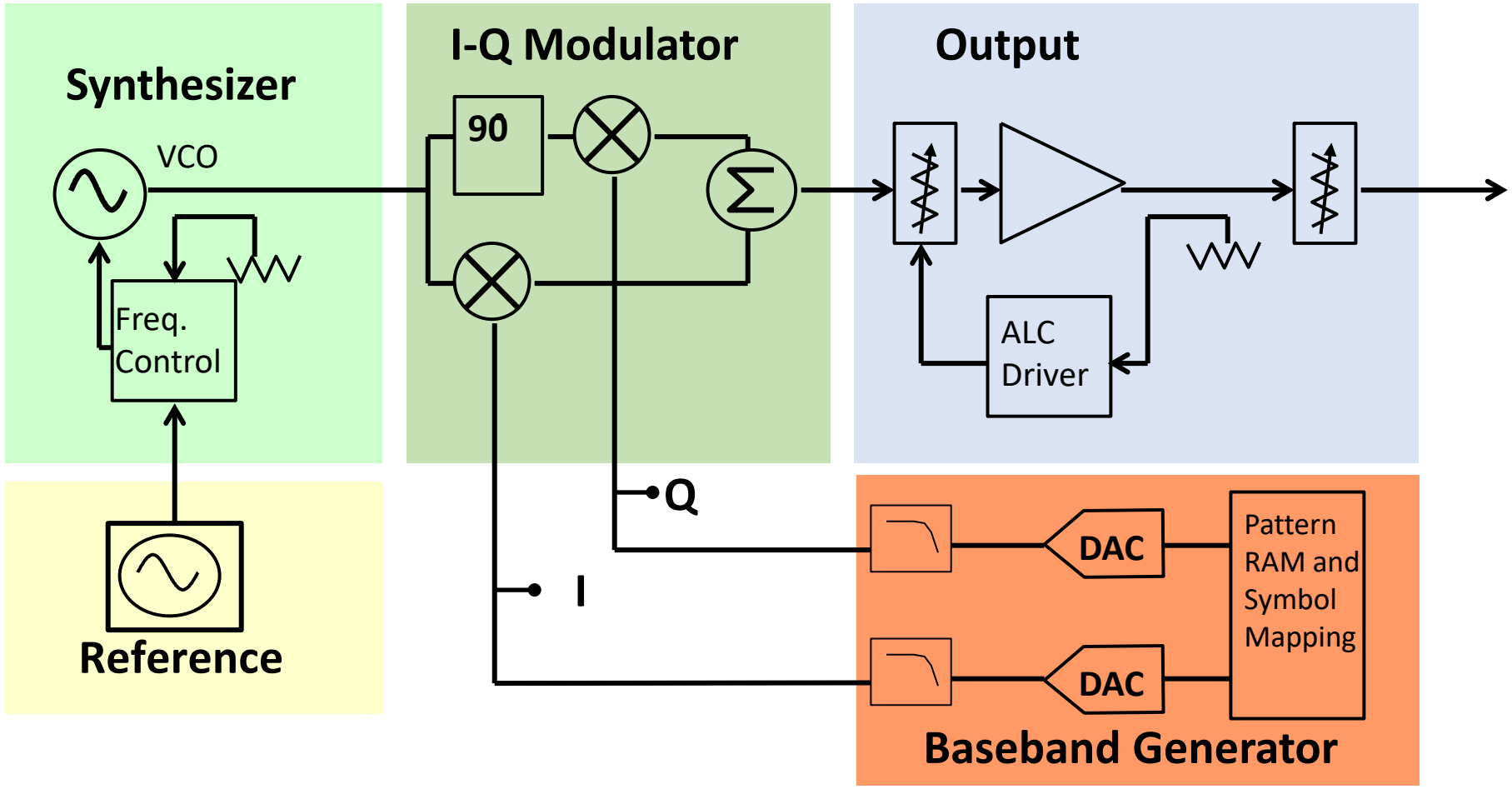
Signal Generator– Modulation

Generation of AM, FM, PM & Pulse Signal



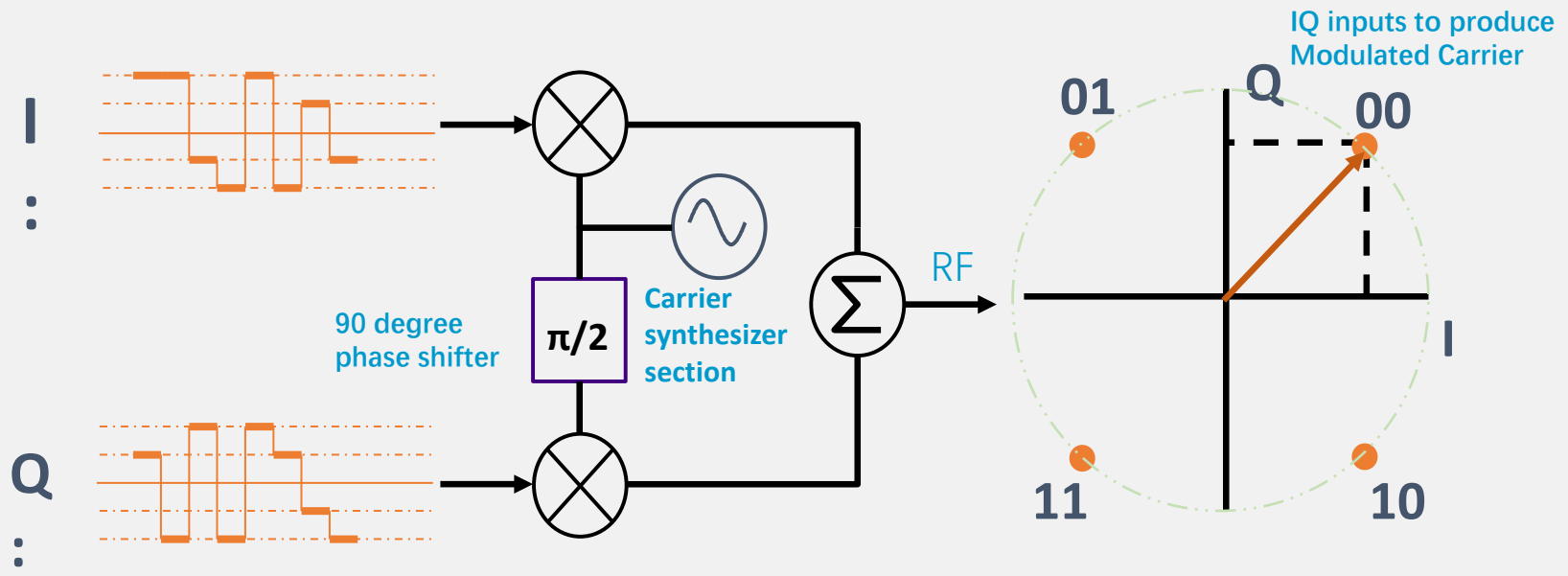
Vector Signals – Block Diagram

Adding an internal Baseband Generator



Vector Signals – Block Diagram

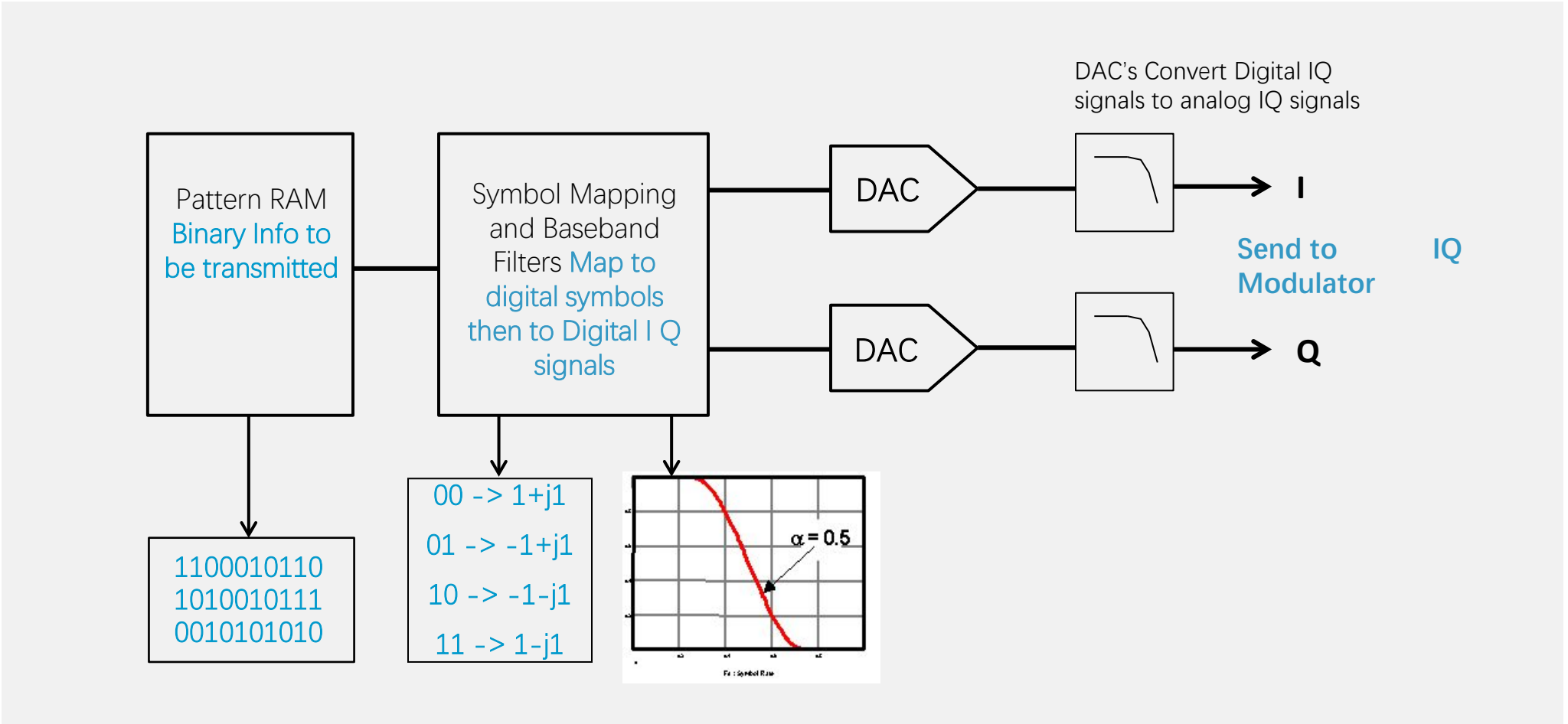
IQ Modulator



- Good Interface with Digital Signals and Circuits
- Can be Implemented with Simple Circuits
- Fast, accurate state change

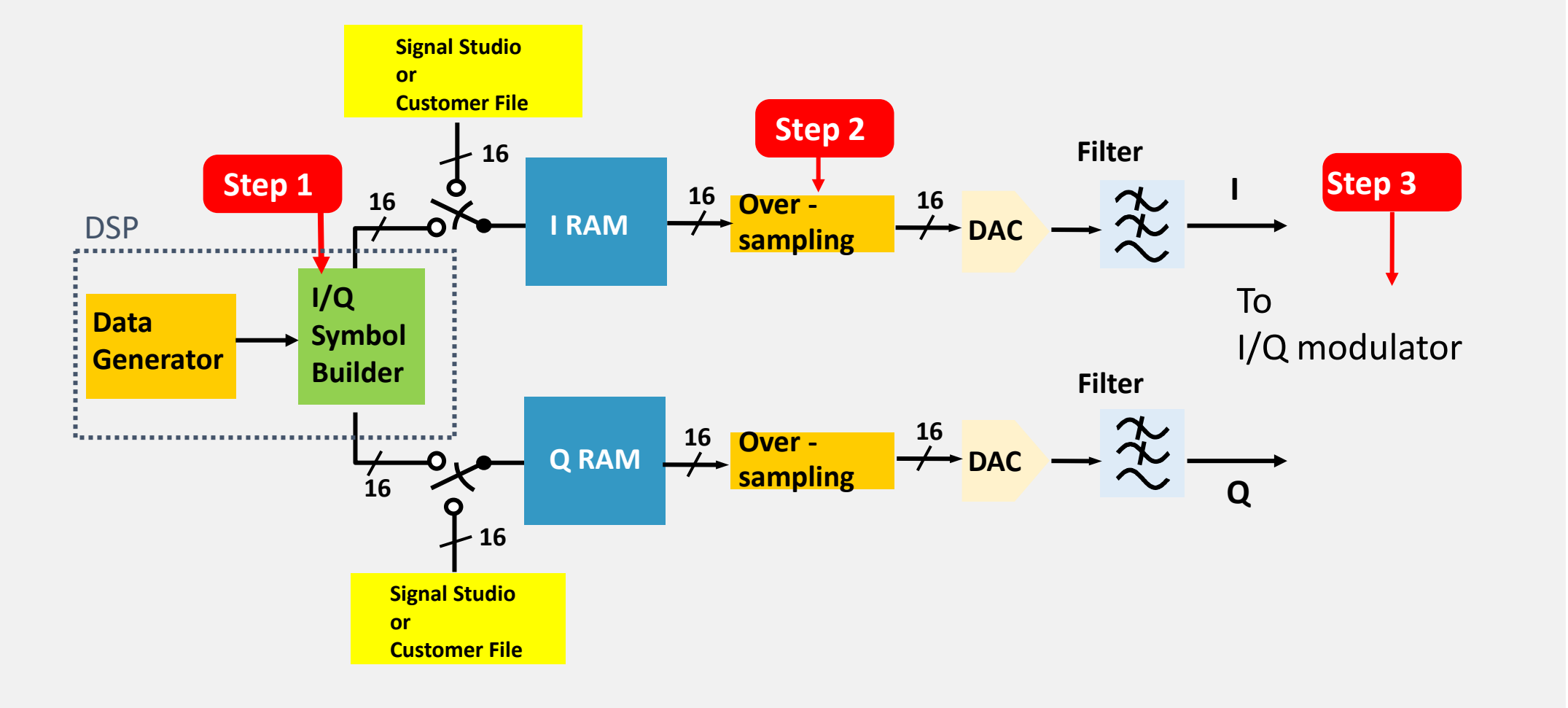
Vector Modulation Signals – BBG Block Diagram

Baseband IQ signal generation- Contains information to be transmitted



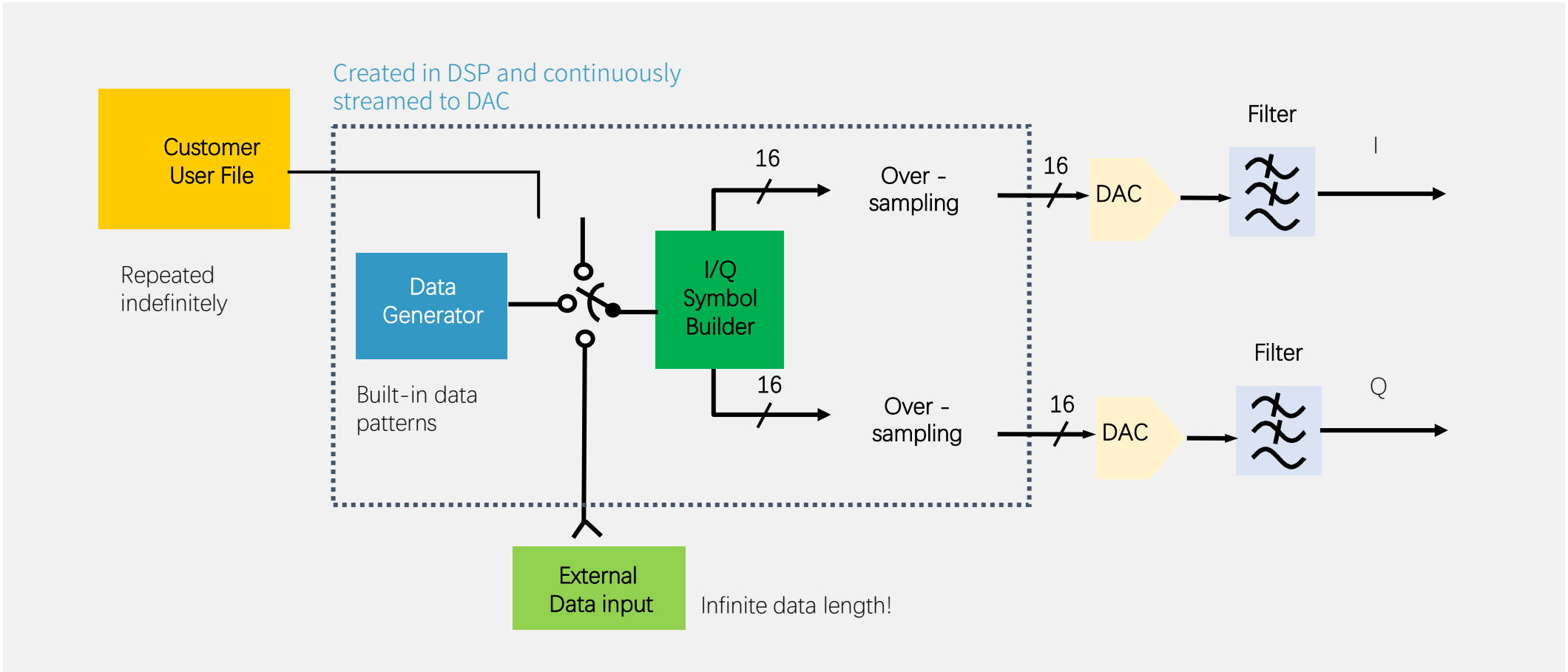
Vector Modulation Signals – BBG Block Diagram

Arbitrary waveform generator



Vector Modulation Signals – BBG Block Diagram

Real-time waveform generator

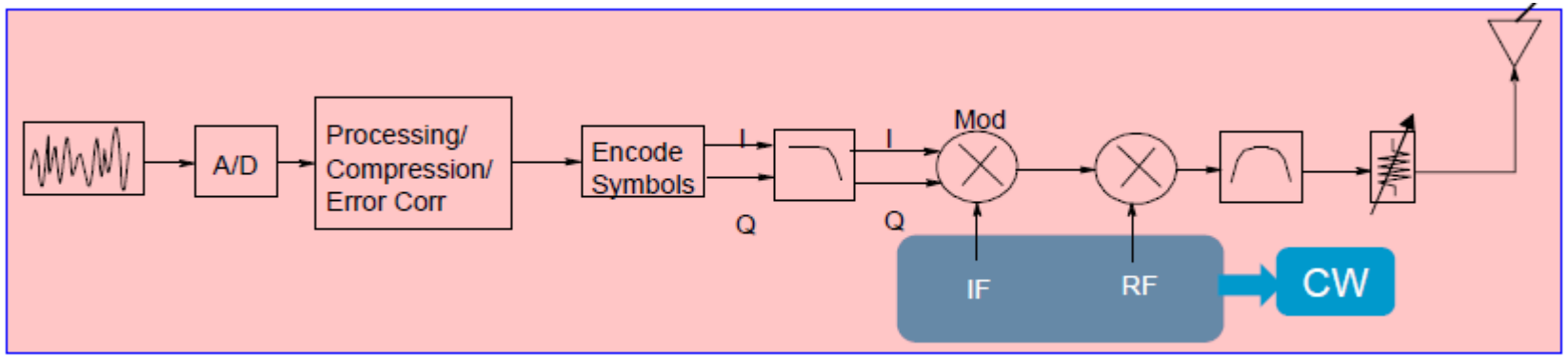


Agenda——Signal Generator

- Generating Signals
  - Continuous Wave (CW)
  - Sweep Signal
  - Analog Modulation
  - Digital Modulation
- Signal Generator Architecture
- **Basic Applications**
- Applications in Modern Wireless Communications

Basic Applications

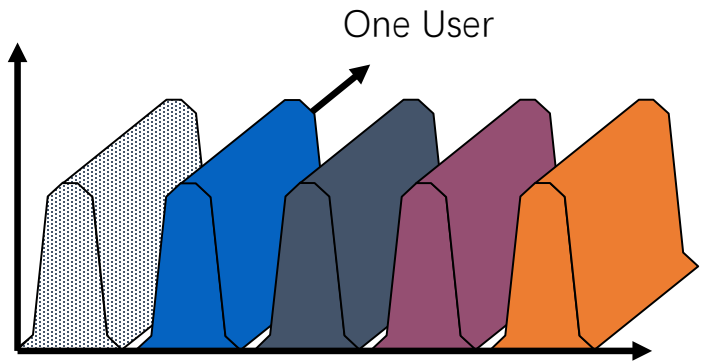
Serve as an Oscillator



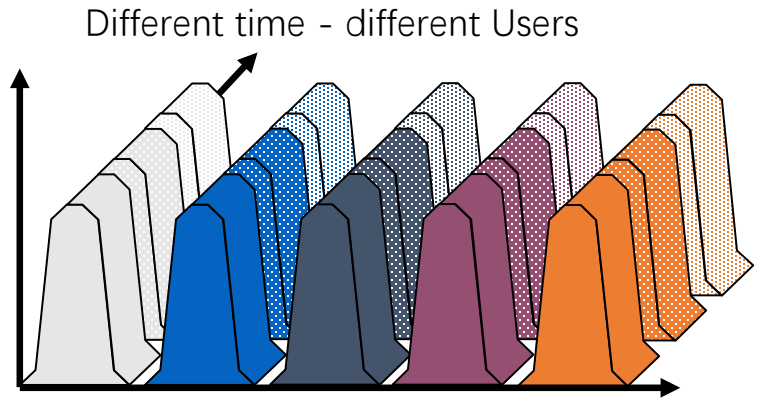
- Enhanced phase noise performance
- High stability time base
- Lower aging rate

Basic Applications

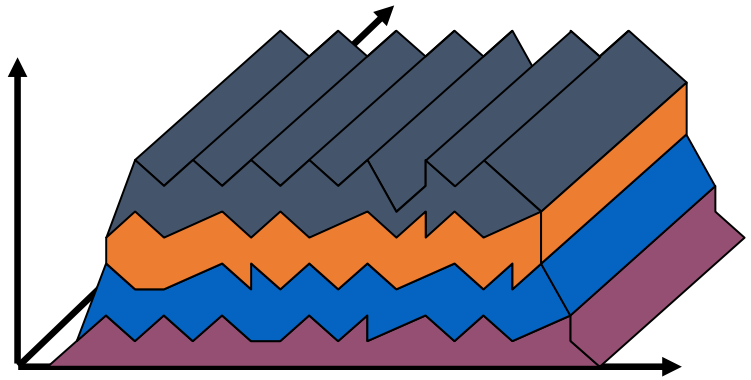
Digital Format Access Schemes



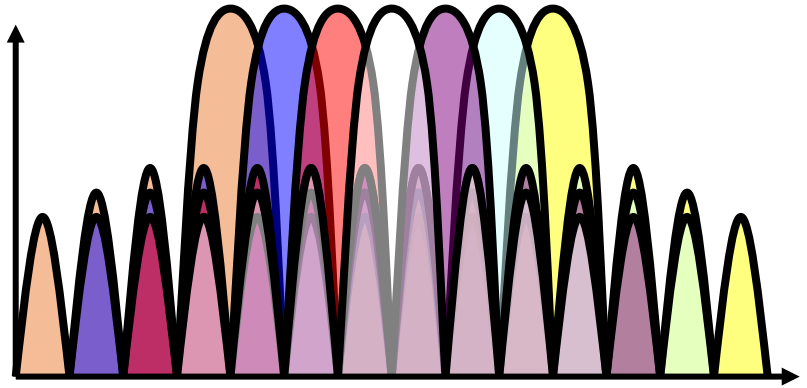
FDMA Differ channel - different Users



TDMA Different time - different Users



CDMA Same channel – many users

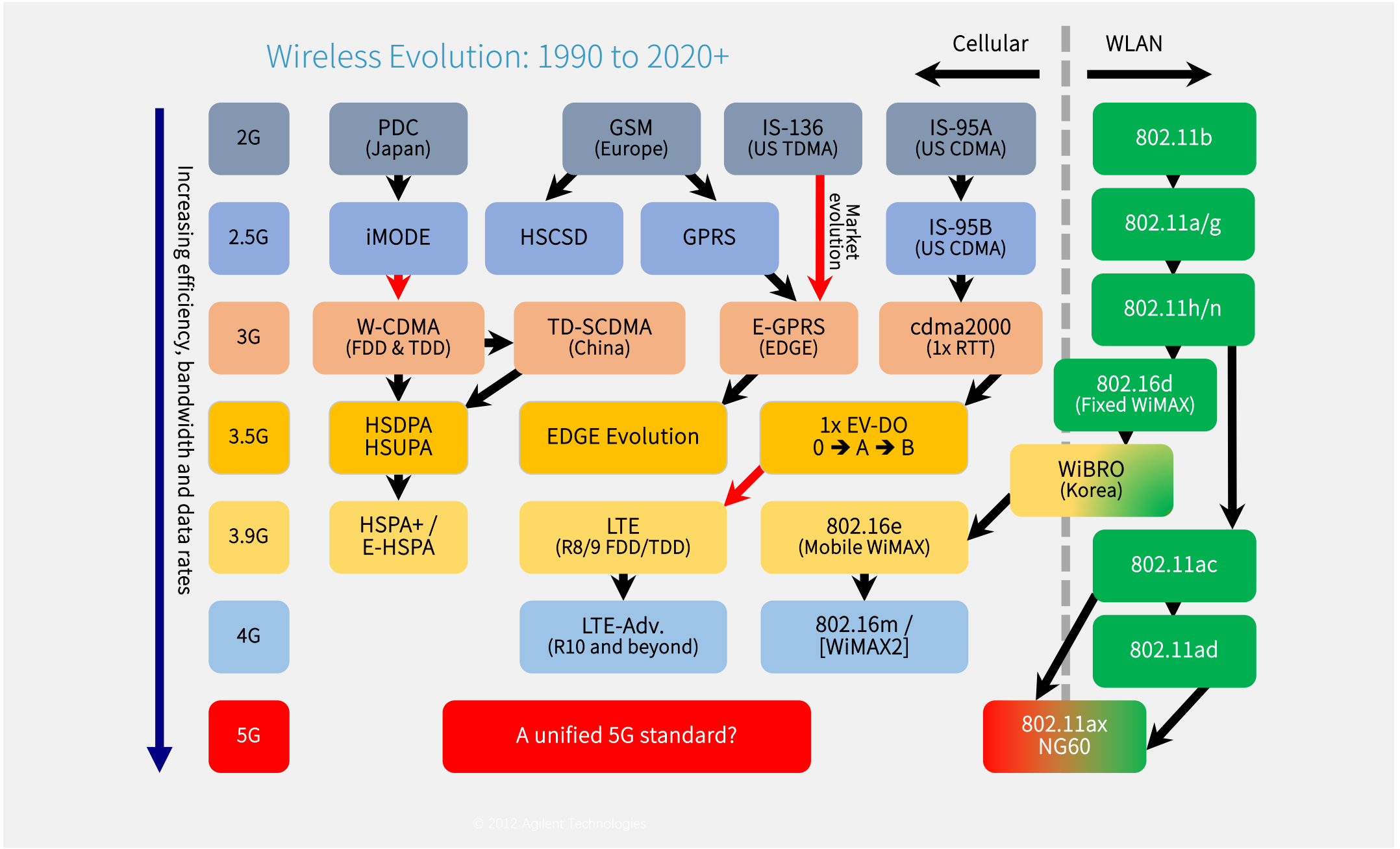


OFDM

Agenda——Signal Generator

- Generating Signals
  - Continuous Wave (CW)
  - Sweep Signal
  - Analog Modulation
  - Digital Modulation
- Signal Generator Architecture
- Basic Applications
- **Applications in Modern Wireless Communications**

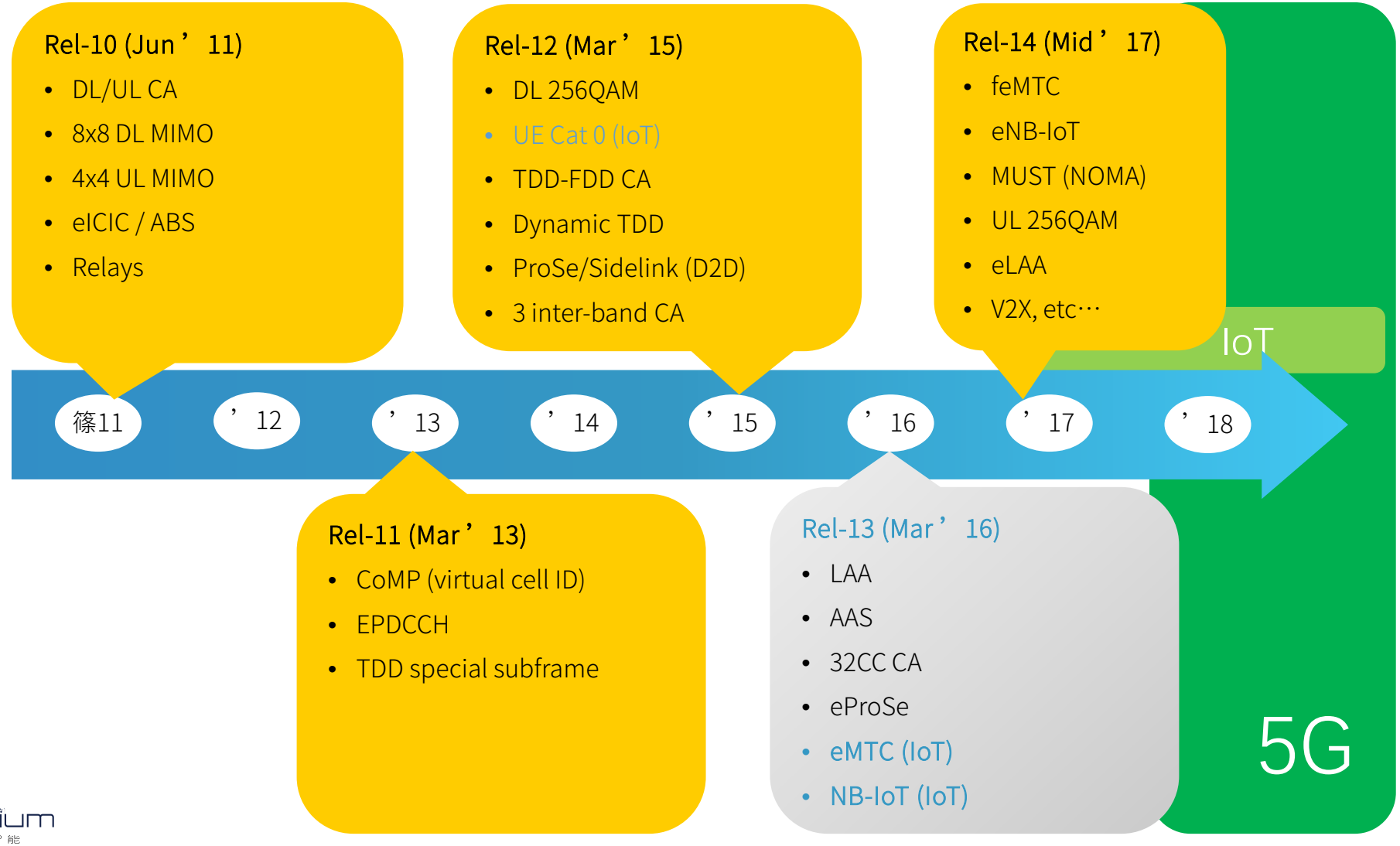
类脑智能 驱动未来



类脑智能驱动未来

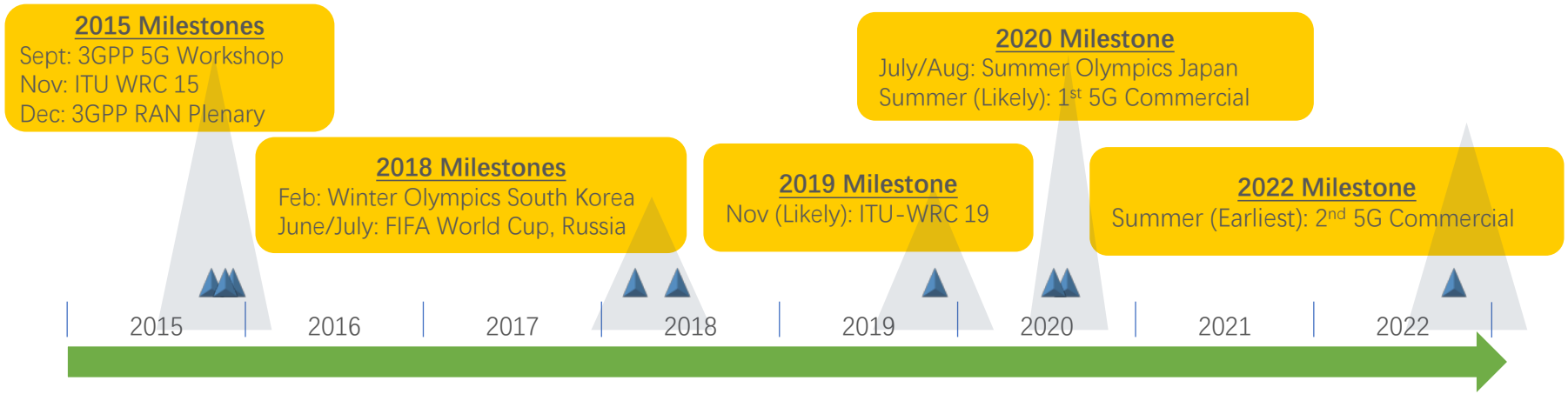
3GPP LTE/LTE-Advanced Evolution…

Introduction



5G Standardization Timeline

Industry rallying around these cardinal dates



- Mid/Late 2020: commercialization focused below 6GHz (standard must be complete before end 2018). 2022 or later for mmWave commercialization (technology, spectrum)
- 2018 and 2020 Olympics will showcase 5G.
- 3GPP Workshops & Plenary in Sept and Dec 2015 is official start to 5G standards work

Application in LTE- N7624B/N7625B

N7624(5)B Signal Studio Basic Waveform for LTE and LTE-Advanced FDD (TDD) Component Testing

- Create spectrally-correct LTE and LTE-Advanced FDD signals for ACLR and spectral mask type testing
- Predefined setups for E-UTRA test models (E-TM) and reference measurement channels (RMC)
- Set parameters such as channel power and modulation type for modulation quality testing

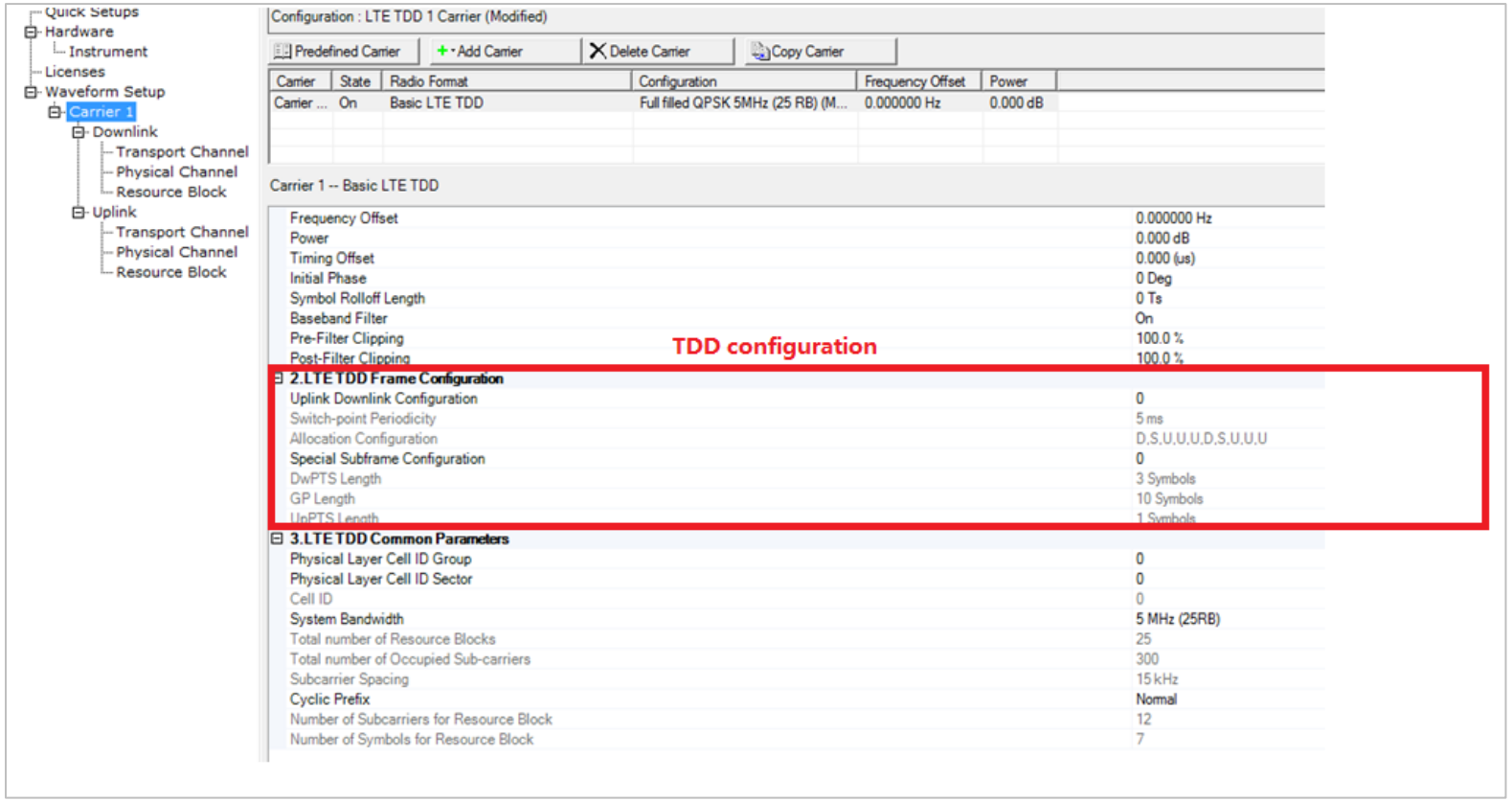
N7624B Signal Studio Advanced Capability, Real-time Signal Generation, LTE FDD eNB Receiver Testing

- Choose a pre-defined fixed reference channel (FRC) configurations
- Create PUSCH sounding reference signals (SRS), including frequency hopping and UCI multiplexing
- Use the PUCCH wizard to create multi-user configurations
- Customize RV index sequence for HARQ retransmission
- Create real-time uplink LTE signals for closed-loop HARQ and timing adjustment testing

N7624B Signal Studio Advanced Waveform for LTE and LTE-Advanced FDD UE Receiver Testing

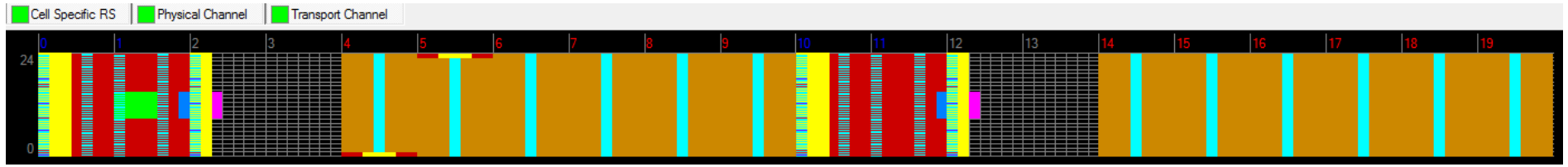
Application in LTE　Basic TDD Carrier

- Basic : use waveform playback mode to create and customize waveform files needed to test components and transmitters – E-TM (Test Model Wizard)
- Advanced: address applications in LTE receiver test, including the verification of baseband designs and the integration of the baseband and RF modules. – FRC



Application in LTE –Basic TDD Downlink

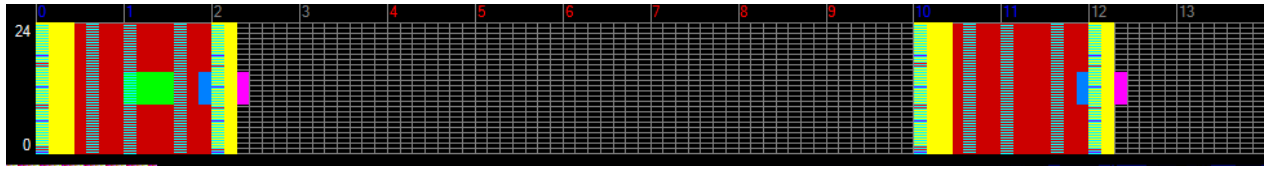
1. Cell Parameters	
State	On
Antenna Port	0
Total Number of Antennas	1 Antenna
Power Definition Type	Total Power
Reference Signal Transmit Power (RSTP)	-34.77 dBm
OFDM Symbol Transmit Power (OSTP)	-10.00 dBm
2. Cell Specific Reference Signal	
Cell Specific Reference Signal Power	0.000 dB
Cell Specific Reference Signal Frequency Shift	Cell ID mod 6
PDSCH Cell Specific Ratio	pB/pA=1
3. Synchronization Signals	
Primary Synch Signal State	On
Primary Synch Signal Power	0.000 dB
Secondary Synch Signal State	On
Secondary Synch Signal Power	0.000 dB
P-SS/S-SS Transmit Antenna Port	Port 0



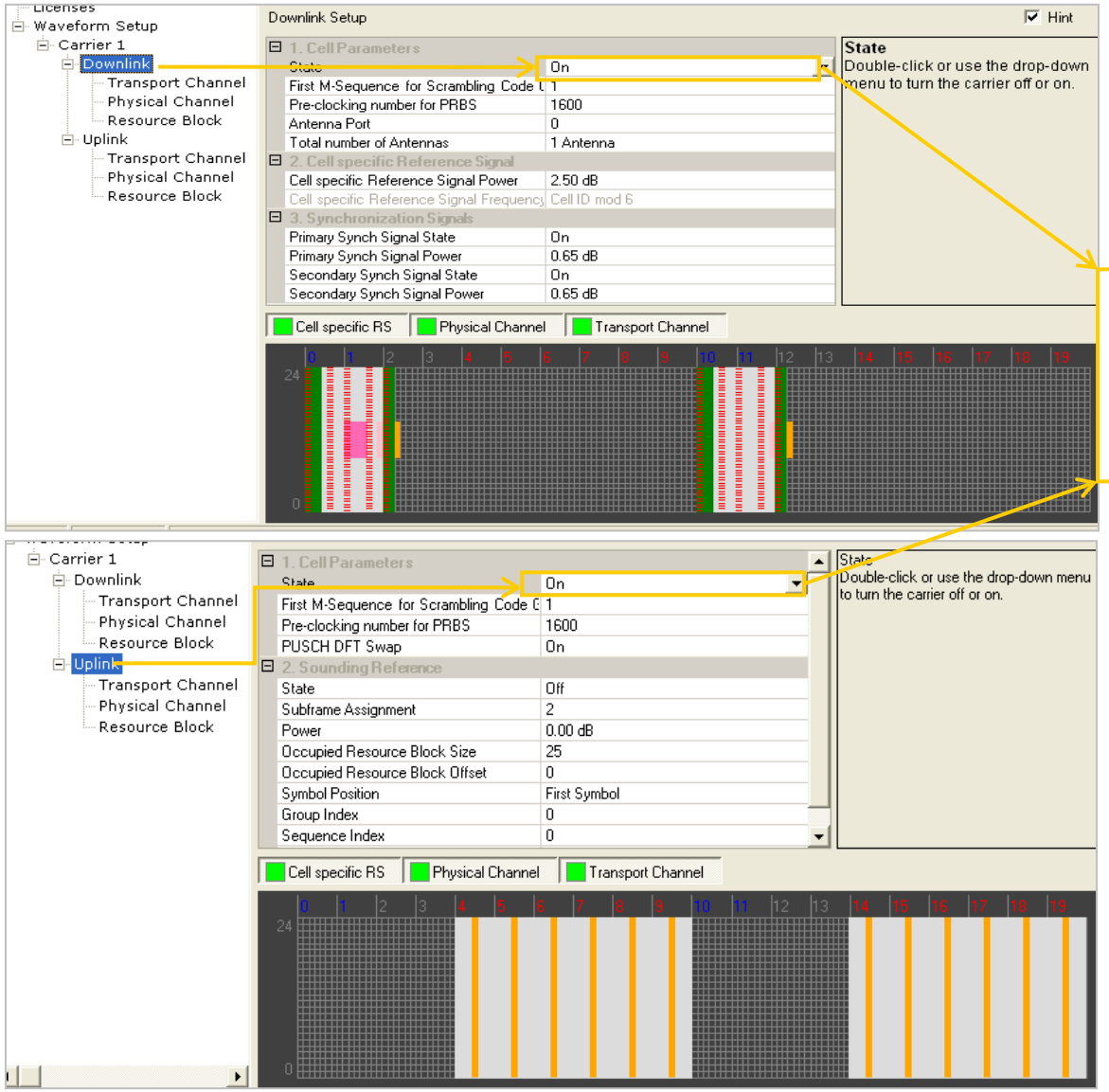
Application in LTE –Advanced TDD Downlink

#	Channel	State	Power	Data	Higher Layer	Resource Block Collection
1	PBCH	On	0.000	Higher Layer	CH2:BCH	-
2	PDCCH	On	0.000	-	-	-
3	PDSCH	On	0.000	Higher Layer	CH1:DL-SCH	1,2
4	PDSCH	On	0.000	Higher Layer	CH1:DL-SCH	3,4
5	PCFICH	On	0.000	-	-	-
6	PHICH	On	0.000	-	-	-

1. Cell Parameters	
State	On
Antenna Port	0
Total Number of Antennas	1 Antenna
Power Definition Type	Total Power
Reference Signal Transmit Power (RSTP)	-34.77 dBm
OFDM Symbol Transmit Power (OSTP)	-10.00 dBm
2. Cell Specific Reference Signal	
Cell Specific Reference Signal Power	0.000 dB
Cell Specific Reference Signal Frequency Shift	Cell ID mod 6
PDSCH Cell Specific Ratio	pB/pA=1
3. Positioning Reference Signals (PRS)	
State	Off
Power	0.000 dB
Antenna Mapping for Port 6	1
Number of PDCCH Symbols	2
PRS Bandwidth	5 MHz (25RB)
Number of Consecutive DL Subframes (N_PRS)	1 subframe
PRS Configuration Index (I_PRS)	0
PRS Periodicity (T_PRS)	160 (subframes)
PRS Subframe Offset (Delta_PRS)	0
PRS Muting Sequence Length	2
PRS Muting Sequence	1,1
4. Synchronization Signals	
Primary Synch Signal State	On
Primary Synch Signal Power	0.000 dB
Secondary Synch Signal State	On
Secondary Synch Signal Power	0.000 dB
P-SS/S-SS Transmit Antenna Port	Port 0



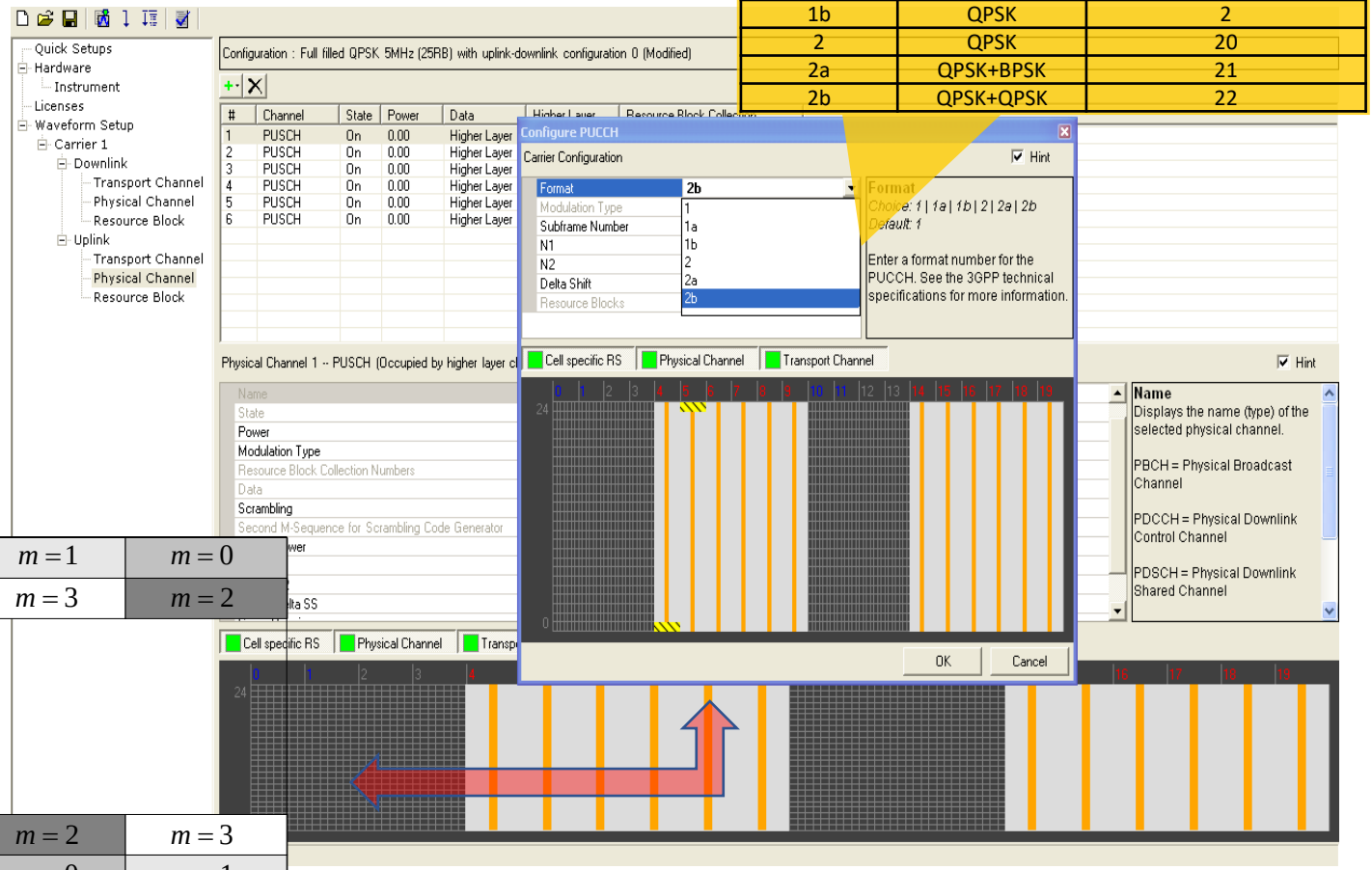
Application in LTE –Configure TDD Uplink and Downlink



Clicking the ON/OFF button to enable DL/UL signal

Application in LTE –Basic LTE TDD- Uplink PUCCH

PUCCH format	Modulation scheme	Number of bits per subframe, M_{bit}
1	N/A	N/A
1a	BPSK	1
1b	QPSK	2
2	QPSK	20
2a	QPSK+BPSK	21
2b	QPSK+QPSK	22



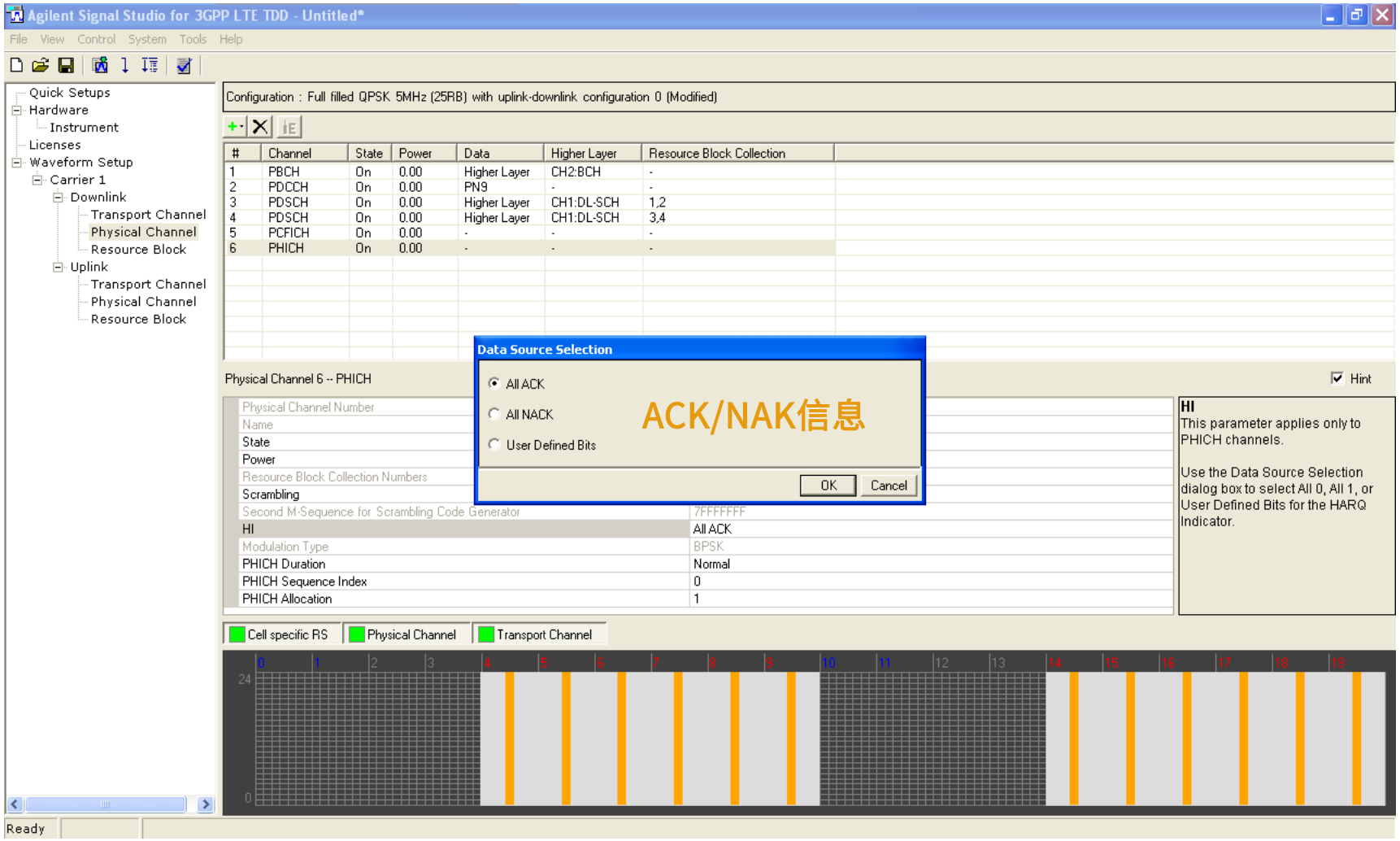
$n_{PRB} = N_{RB}^{UL} - 1$

$n_{PRB} = 0$

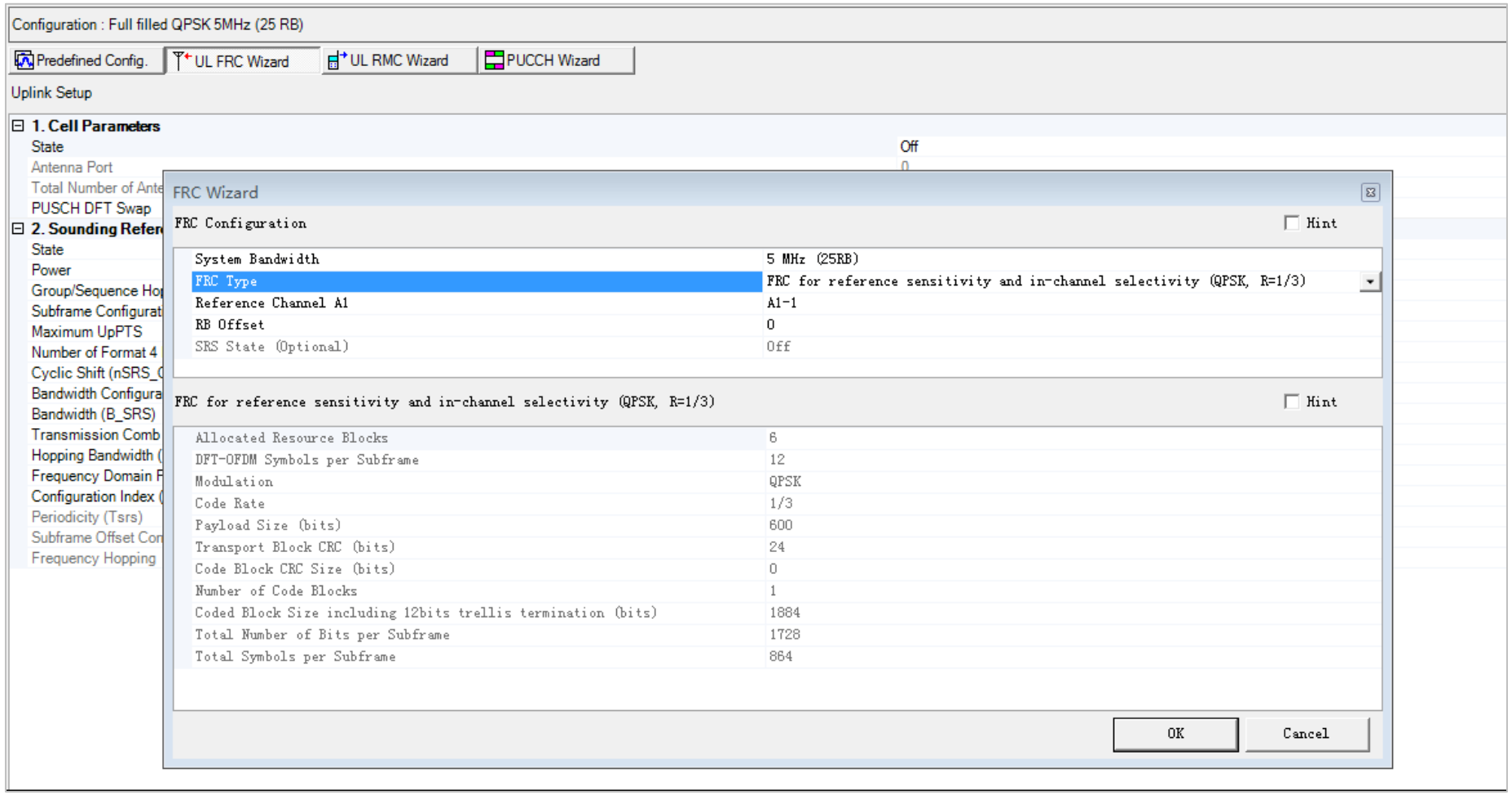
$m=1$	$m=0$
$m=3$	$m=2$
$m=2$	$m=3$
$m=0$	$m=1$

One subframe

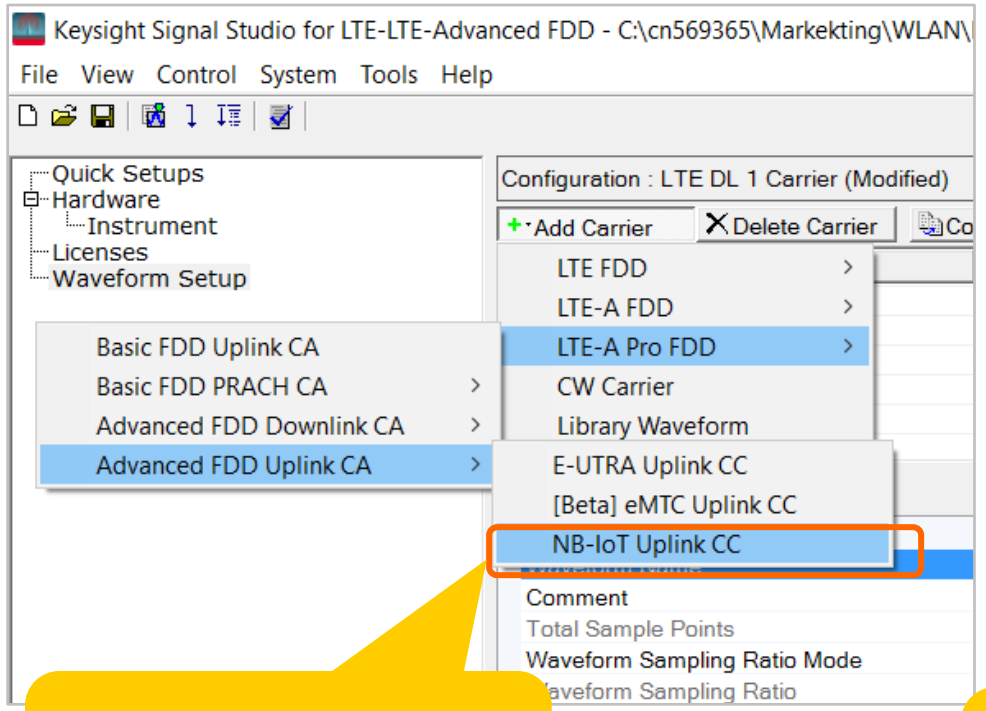
Application in LTE –Basic LTE TDD- PHICH



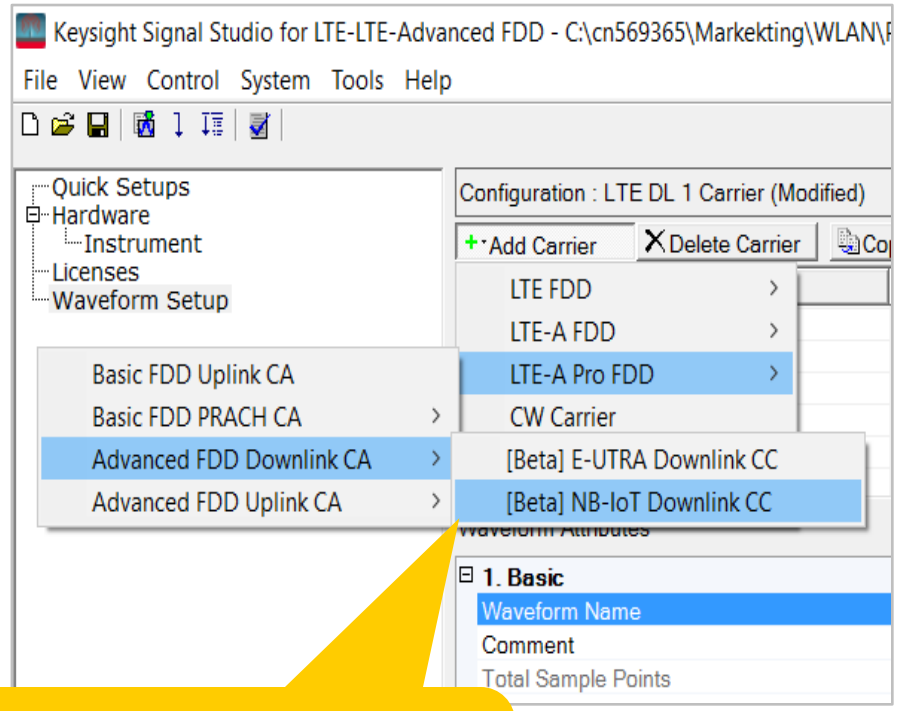
Application in LTE Advanced LTE TDD- Uplink FRC



Application in NB_IoT – NB-IoT Component Carrier



Select “NB-IoT Uplink CC” is under LTE-A Pro, Advanced FDD Uplink CA



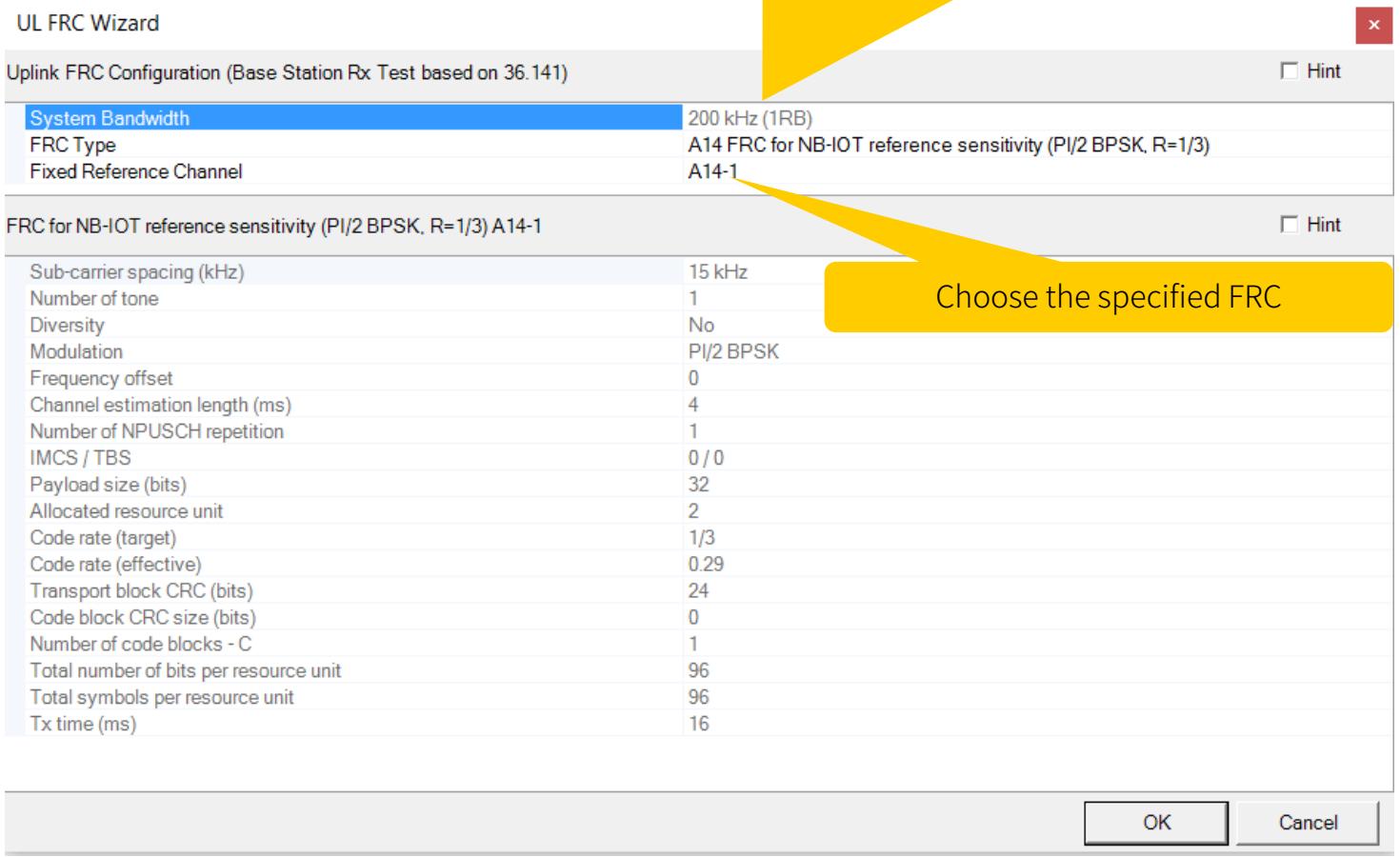
Select “NB-IoT Downlink CC” is under LTE-A Pro, Advanced FDD Downlink CA

Note: “Beta” features are included but hidden by default. Select “Show Beta Features” under View menu.

Application in NB_IoT – UL FRC Wizard

UL FRC Wizard

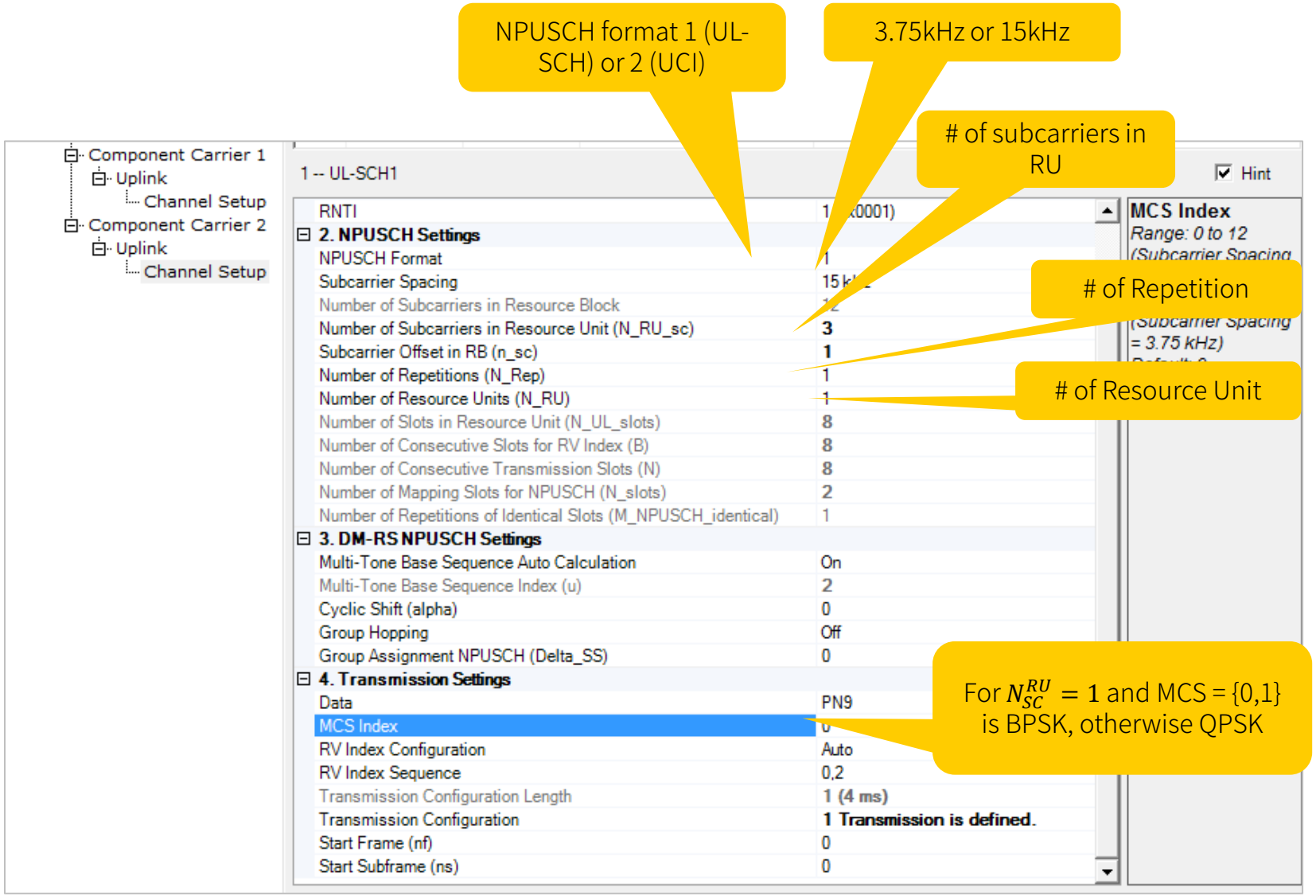
A14 FRC for NB-IoT reference sensitivity
A15 FRC for NB-IoT dynamic range
A16 FRC for NB-IoT NPUSCH format 1



Choose the specified FRC

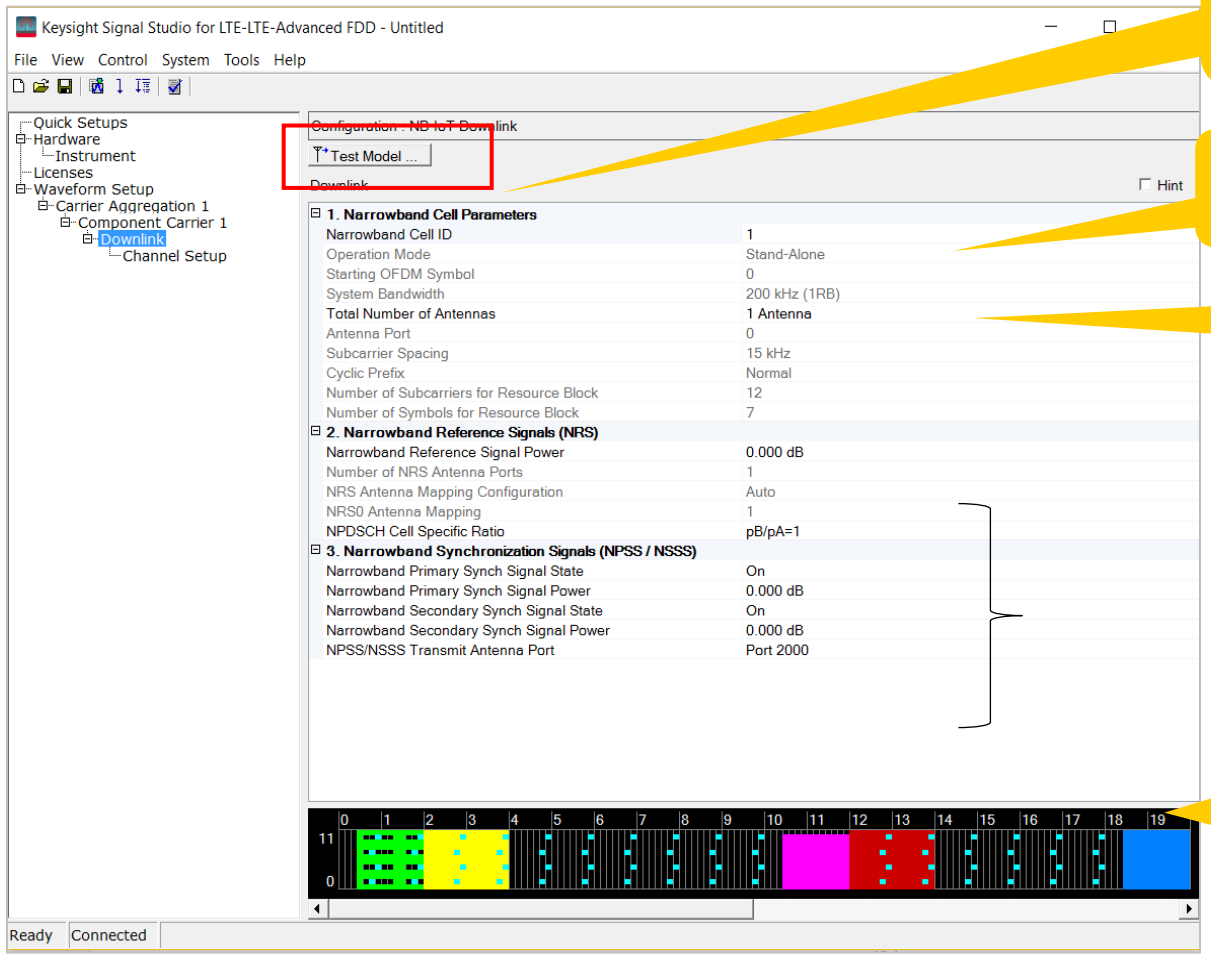
Application in NB_IoT – UL-SCH Node

UL-SCH Node



Application in NB_IoT – Downlink Configuration

NB-IoT Downlink Con guration



Configure N-TM in Test Model Wizard (Beta in Mar Release)

Standalone(/guard-band) or in-band

# of antenna (1 or 2)

Resource map shows color coded channel allocation

NeuHelium 新氦类脑智能

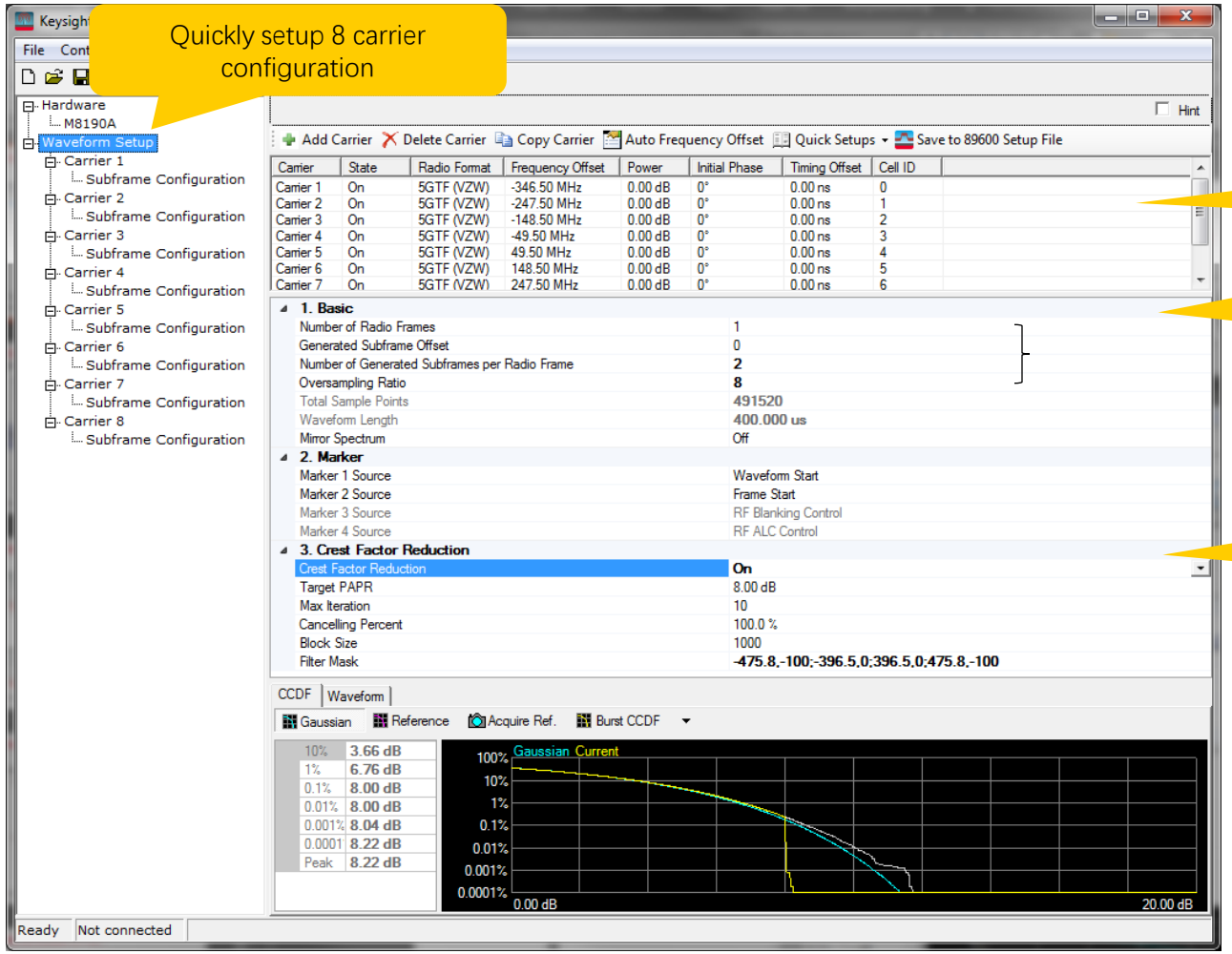
Application in Verizon 5G- Features

Signal Generation Based on VZW Pre-5G Spec

- Main PHY layer structure are implemented for signal generation
  - Support multi-user channels generation
  - Support transport channel coding for DL-SCH, UL-SCH, BCH, DCI, and UCI
    - LDPC and tail biting CC
  - DCI Auto Generation with xPDSCH and xPUSCH scheduling information
  - Multi-Antenna Transmission
    - Tx Diversity and Spatial Multiplexing
  - High Speed case for KT5G spec
- Support flexible signal configuration
  - Both single carrier and multi-carrier are supported
    - 8 Carrier Configuration Preset

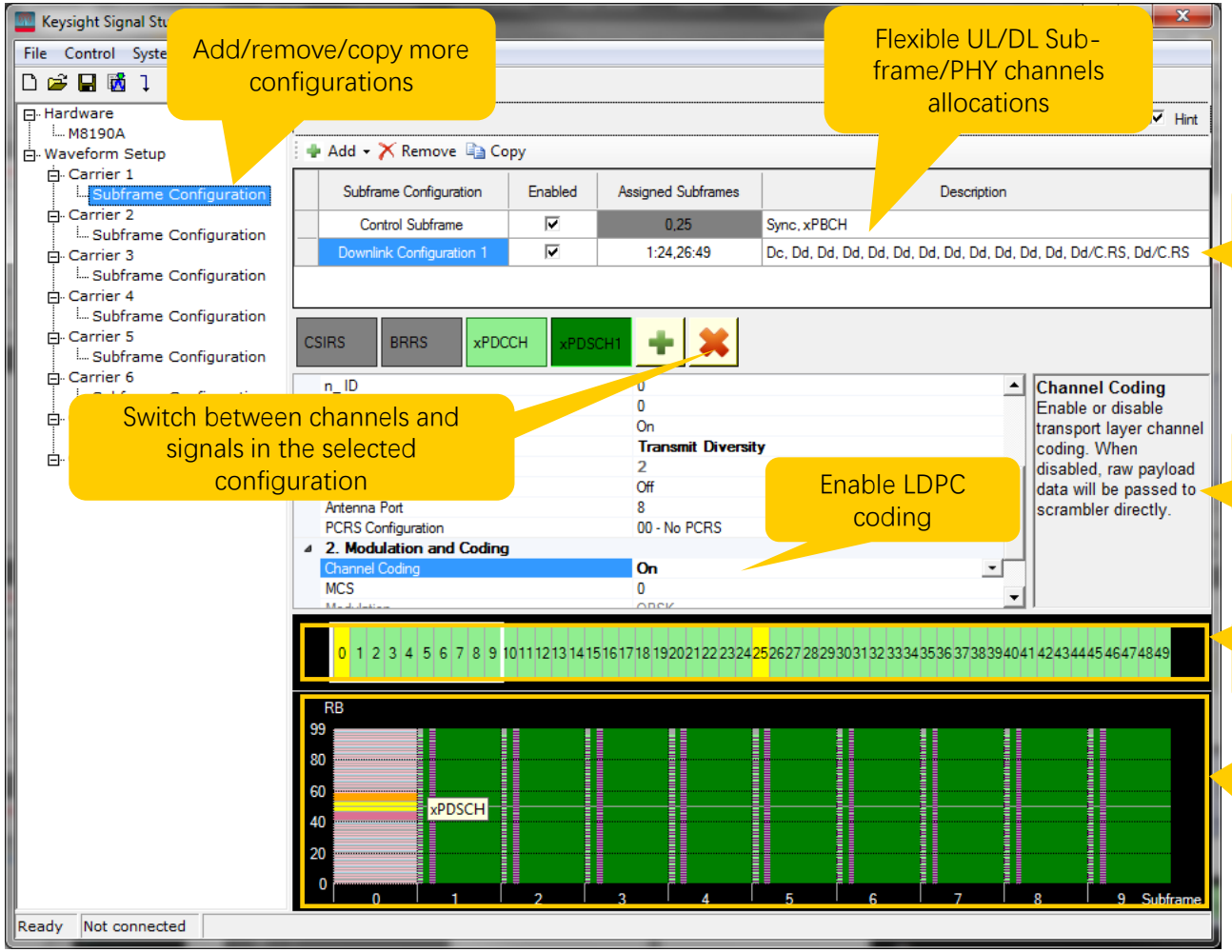
- Support flexible signal configuration (Cont’ d)
  - Graphical display for frame resource allocation
  - User can assign resource blocks to both downlink and uplink channels.
  - Support generating DL and UL signal at the same time.
  - Support partial generation of one radio frame
- Signal verification methods
  - User can export the demod setup of VSA software from Signal Studio for VSA demodulation.
    - Requires VSA Custom OFDM (89601B-BHF)

Application in Verizon 5G- User Interface



Application in Verizon 5G- Subframe Configuration

Subframe Configuration



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