

2450 MHz O-QPSK Tx/Rx Test Solution

MS2830A
Signal Analyzer

MG3710A
Vector Signal Generator

2450 MHz O-QPSK Tx/Rx Test Solution

IEEE Std 802.15.4™ - 2011

Low-Rate Wireless Personal Area Networks

Note) For detail, refer to the IEEE standard.

Version 2.00

Oct. 2014

Anritsu Corporation

*References:

- IEEE Std 802.15.4 - 2011

[For details, refer to each reference.](#)

IEEE 802.15.4 O-QPSK PHY Measurements

These materials explain the PHY layer measurements supported by IEEE 802.15.4 **O-QPSK**.

Test items of IEEE 802.15.4 (O-QPSK)		MS2830A	MG3710A	
TX	10.3.2 Transmit power spectral density (PSD) mask	√	---	
	10.3.3 Symbol rate	√	---	
	10.3.8 Error vector magnitude (EVM)	√	---	*1
	10.3.9 Transmit center frequency tolerance	√	---	*2
	10.3.10 Transmit power	√	---	
	10.3.6 TX-to-RX turnaround time			*3
	10.3.7 RX-to-TX turnaround time			*3
RX	10.3.4 Receiver sensitivity	---	√	
	10.3.5 Receiver interference rejection	---	√	*4
	10.3.11 Receiver maximum input level of desired signal	---	√	

*1: The limit value of the EVM measurement depends on the signal quality of DUT.
(Measured example: approximately 20% or less)

*2: The limit value of the Frequency Error measurement is approximately 15-ppm.

*3: The spectrum analyzer will not be used in this measurement item.

*4: The MG3710A can add two different signals and output them from the RFx1 port.
The frequency (recommended range: ± 60 MHz) and level (CN: ± 80 dB) can also be set at the screen.

MS2830A
Signal Analyzer



+

MX269017A
Vector Modulation
Analysis Software

MG3710A
Vector Signal Generator



+

MX370102A
TDMA IQproducer

► Operating frequency range



PHY [MHz]	Frequency Band [MHz]	Chip rate [k chip/s]	Bit rate [k bps]	Symbol rate [k symbol/s]	Channel Specing [MHz]
780	779 to 787	1000	250	62.5	2
868*	868 to 868.6	400	100	25	---
915*	902 to 928	1000	250	62.5	2
2450	2400 to 2483.5	1000	250	62.5	5

*: optional

► Total power, Out-of-band spurious emission

Shall conform with local regulations.

► Receiver sensitivity definitions

Packet Error Rate: Average measured over random PSDU data.

Receiver sensitivity:

- PSDU length = 20 octets
- PER = 1%
- Power measured at antenna terminals

► Packet Format

PPDU Format for O-QPSK

SHR		PHR		PHY payload
Preamble	SFD	Frame length (7 bits)	Reserved (1 bit)	PSDU

Preamble: 8 symbols (4 octets), all 0

0000 0000 0000 0000 0000 0000 0000 0000 [BIN]
0 0 0 0 0 0 0 0 [DEC]

SFD:

Bit	0	1	2	3	4	5	6	7
BIN	1	1	1	0	0	1	0	1
DEC	7				10			

PSDU: MPDU for Tx

Random data for
Rx(PER)

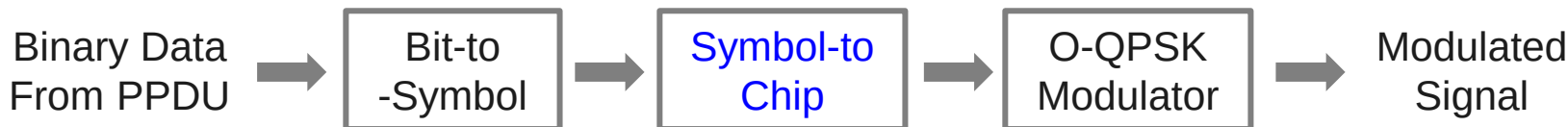
PHR: PSDU Frame length: 9 to 127

e.g. 20 octets : 0 0 1 0 1 0 0 [BIN]

Reserved: 0

Bit	0	1	2	3	4	5	6	7
BIN	0	0	1	0	1	0	0	0
DEC	4				1			

► Reference modulation diagram



► Symbol-to-Chip mapping for the 2450 MHz band

Data symbol	Chip values [BIN]	Chip values [HEX]
0	11011001110000110101001000101110	D9C3522E
1	11101101100111000011010100100010	ED9C3522
2	00101110110110011100001101010010	2ED9C352
3	00100010111011011001110000110101	22ED9C35
4	01010010001011101101100111000011	522ED9C3
5	00110101001000101110110110011100	3522ED9C
6	11000011010100100010111011011001	C3522ED9
7	10011100001101010010001011101101	9C3522ED
8	10001100100101100000011101111011	8C96077B
9	10111000110010010110000001110111	B8C96077
10	01111011100011001001011000000111	7B8C9607
11	01110111101110001100100101100000	77B8C960
12	00000111011110111000110010010110	077B8C96
13	01100000011101111011100011001001	6077B8C9
14	10010110000001110111101110001100	96077B8C
15	11001001011000000111011110111000	C96077B8

e.g. SFD

1110 0101 [BIN]
7 10 [DEC]

7=9C3522ED
10=7B8C9607

O-QPSK PHY RF requirements 1/13

Tx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.2 Transmit power spectral density (PSD) mask

Test conditions:

- RBW = 100 kHz
- Reference Level = ± 1 MHz, Highest average spectral power

Limit:

Frequency(f)	Relative limit	Absolute limit
f - f _c : 3.5 MHz	-20 dB	-30 dBm

for the 2450 MHz band



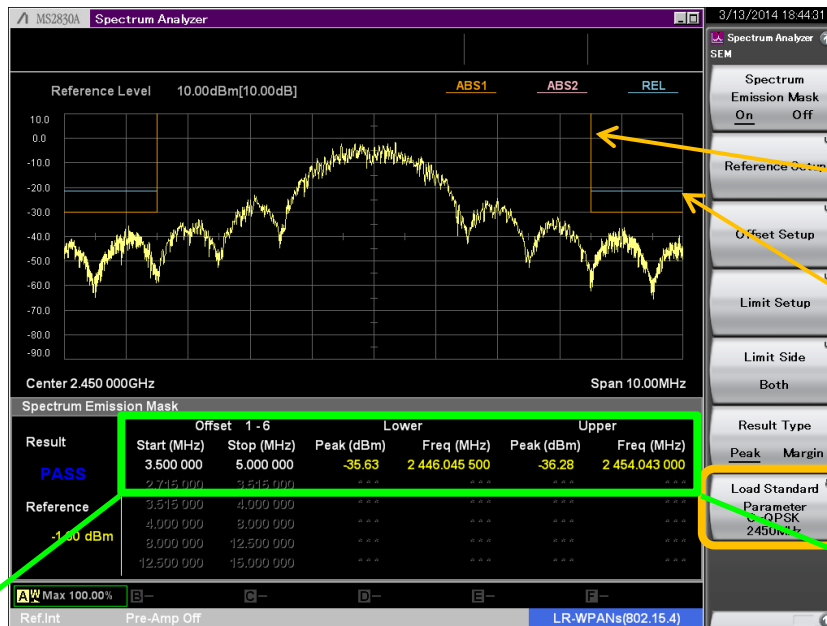
O-QPSK PHY RF requirements 2/13

Tx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.2 Transmit power spectral density (PSD) mask

Spectrum Emission Mask Function [pre-installed]



Template for Mask



Absolute limit (Red line)

Relative limit (Blue line)

Offset 1 - 6		Lower		Upper	
Start (MHz)	Stop (MHz)	Peak (dBm)	Freq (MHz)	Peak (dBm)	Freq (MHz)
3.500 000	5.000 000	-35.63	2 446.045 500	-36.28	2 454.043 000
2.715 000	3.515 000	***	***	***	***

O-QPSK PHY RF requirements 3/13

Tx Evaluation

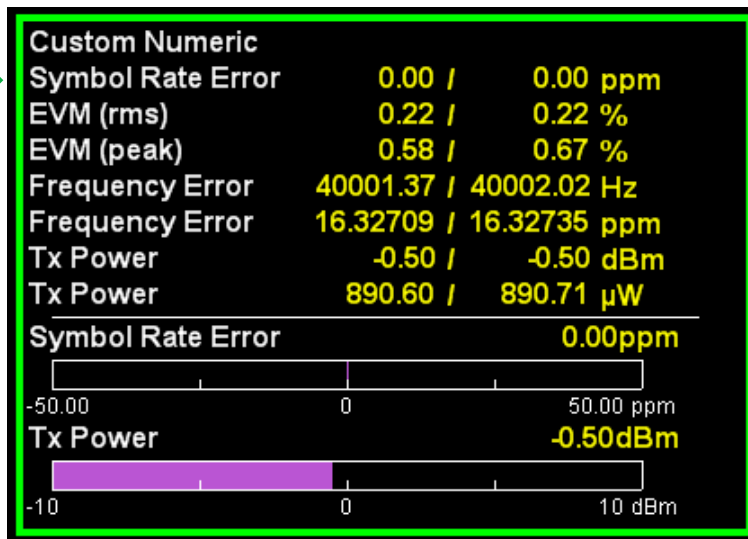
Note) For detail, refer to the IEEE standard.

10.3.3 Symbol rate

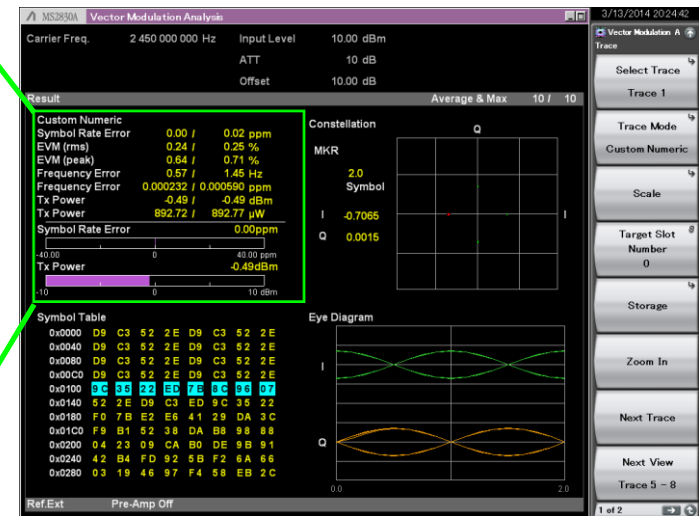
Test conditions:

- Symbol Rate = 62.5 ksp/s for the 2450 MHz band

Limit: ± 40 ppm



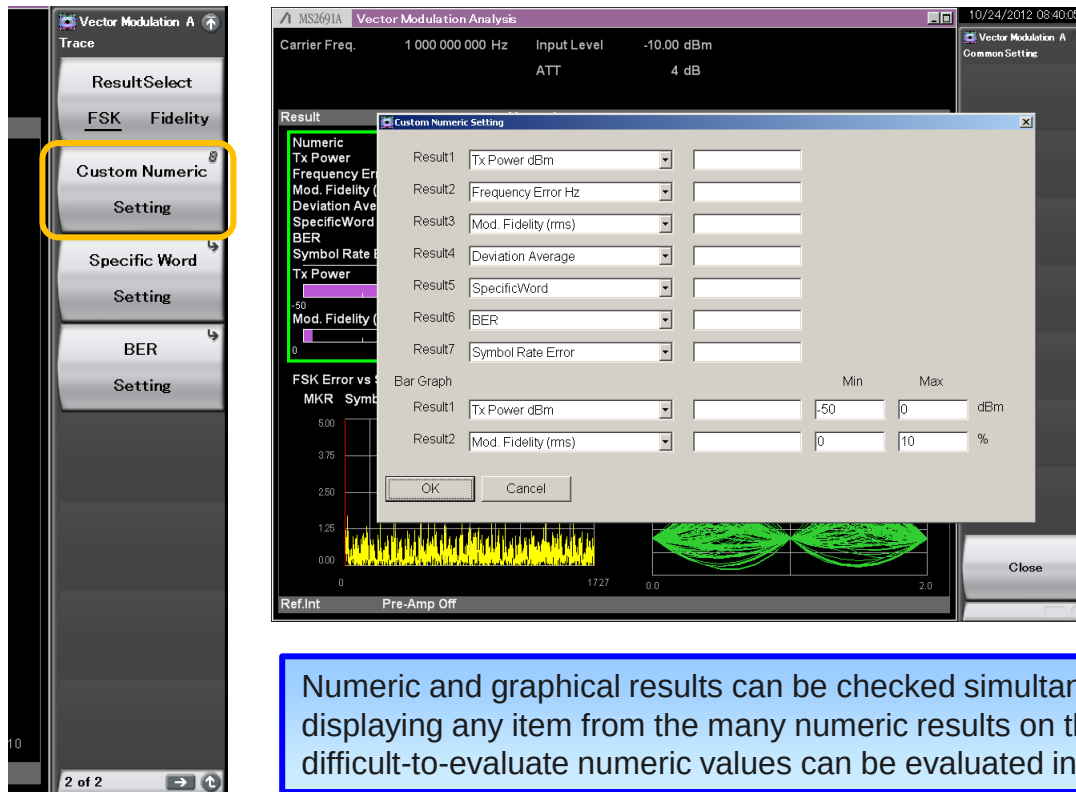
Vector Modulation Analysis Software [MX269017A]



O-QPSK PHY RF requirements 4/13

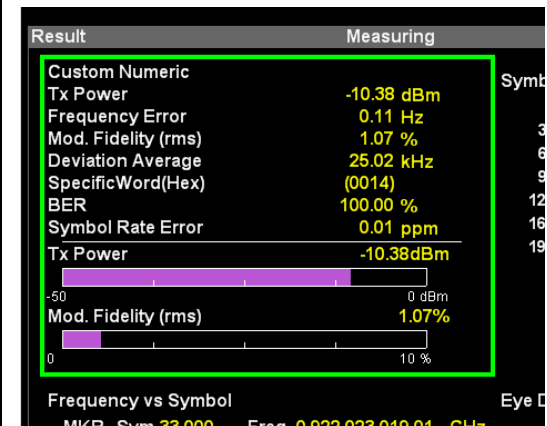
“Custom Numeric” of MX269017A

Any of 7 types of numeric measurement results or two types of graphical results can be selected for display at the Custom Numeric screen. (Note: The Custom Numeric screen does not support Zoom.)



[Trace]

> (page 2) [F2: Custom Numeric Setting]



Numeric and graphical results can be checked simultaneously on 4 sub-screens by displaying any item from the many numeric results on the Numeric screen. Moreover, difficult-to-evaluate numeric values can be evaluated intuitively from bar graphs.

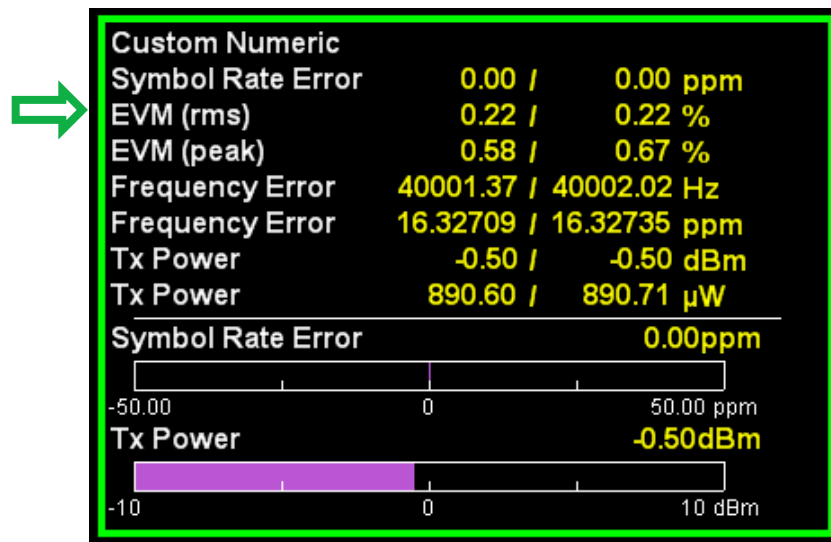
O-QPSK PHY RF requirements 5/13

Tx Evaluation

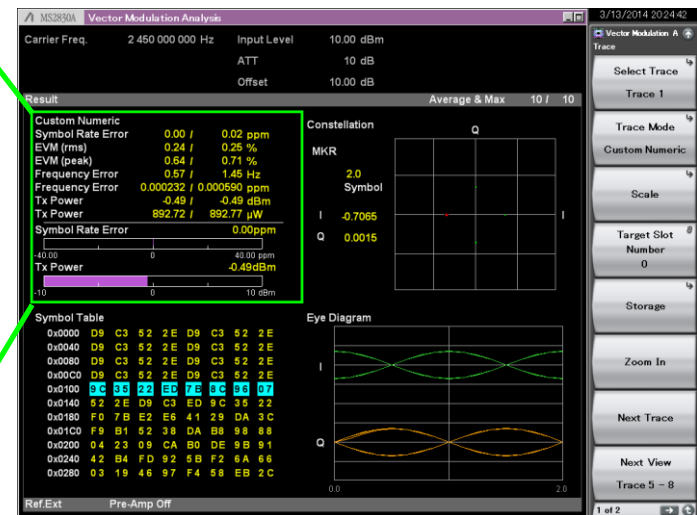
Note) For detail, refer to the IEEE standard.

10.3.8 Error vector magnitude (EVM)

Limit: 35% (when measured for 1000 chips)



Vector Modulation Analysis Software [MX269017A]



Note:

The limit value of the EVM measurement depends on the signal quality of DUT.
(Measured example: approximately 20% or less)

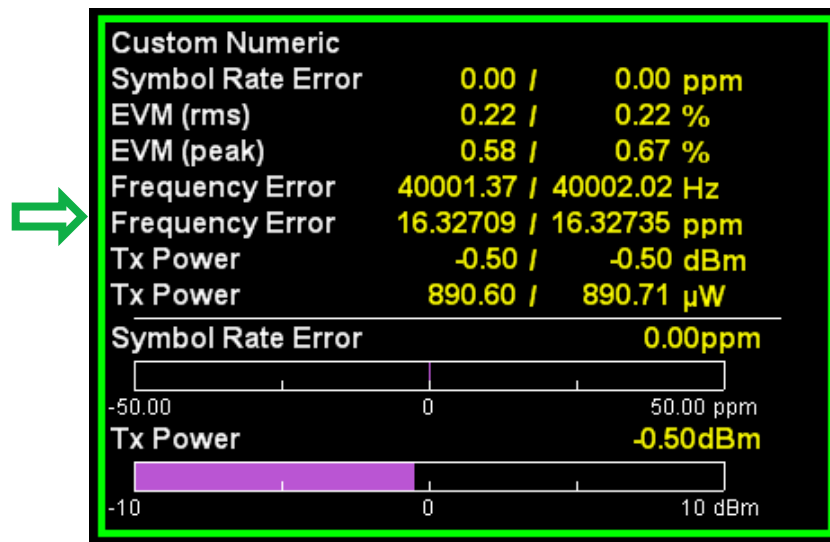
O-QPSK PHY RF requirements 6/13

Tx Evaluation

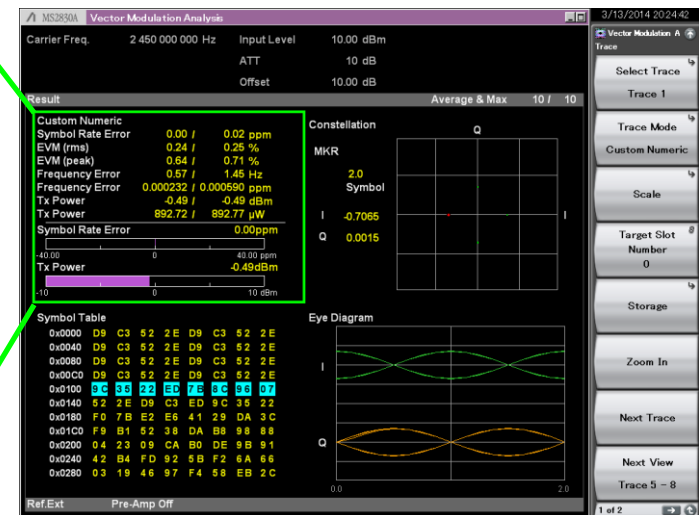
Note) For detail, refer to the IEEE standard.

10.3.9 Transmit center frequency tolerance

Limit: ± 40 ppm



Vector Modulation Analysis Software [MX269017A]



Note:

The limit value of the Frequency Error measurement is approximately 15 ppm.

O-QPSK PHY RF requirements 7/13

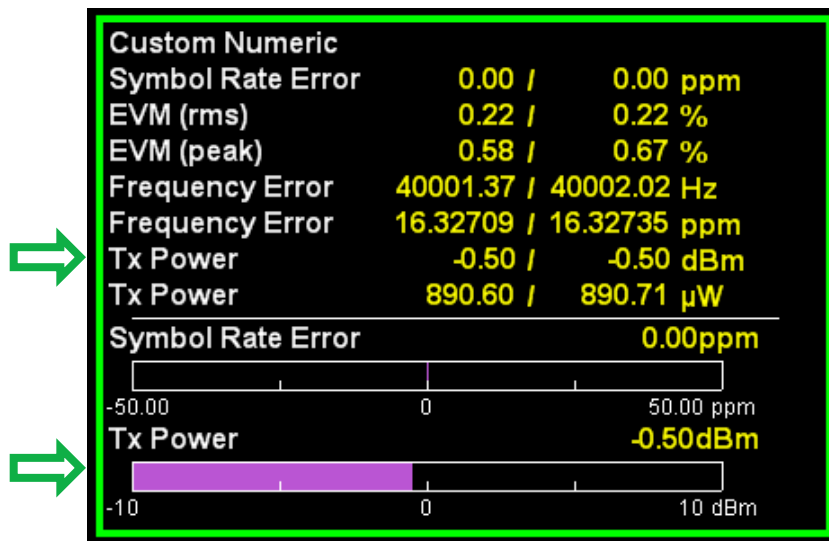
Tx Evaluation

Note) For detail, refer to the IEEE standard.

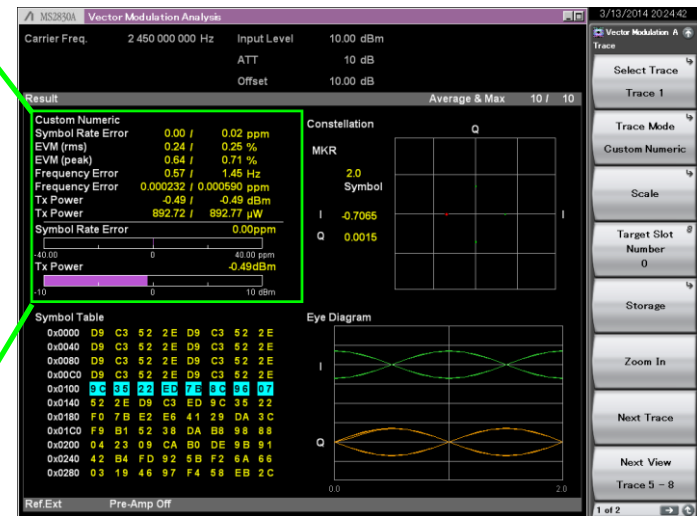
10.3.10 Transmit power

Limit: Shall be capable of transmitting at a power level of least -3 dBm.

(Total Power: Shall conform with local regulations.)



Vector Modulation Analysis Software [MX269017A]

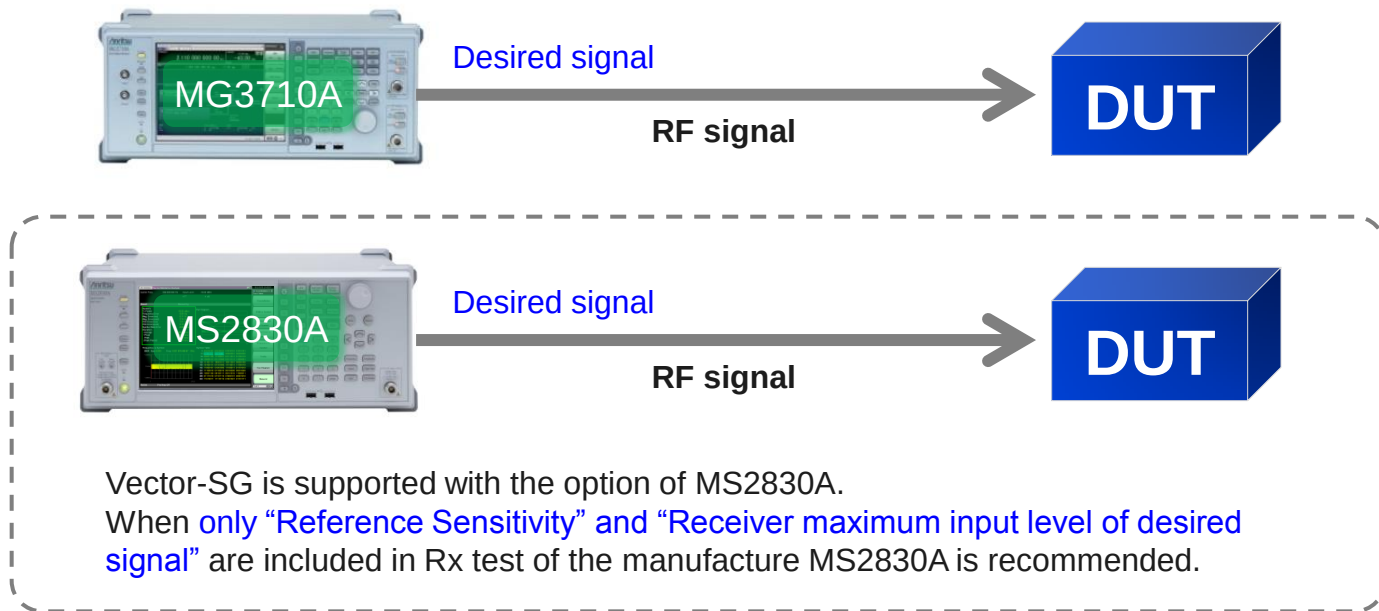


O-QPSK PHY RF requirements 8/13

Rx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.4 Receiver sensitivity



Expected Value: PER 1%

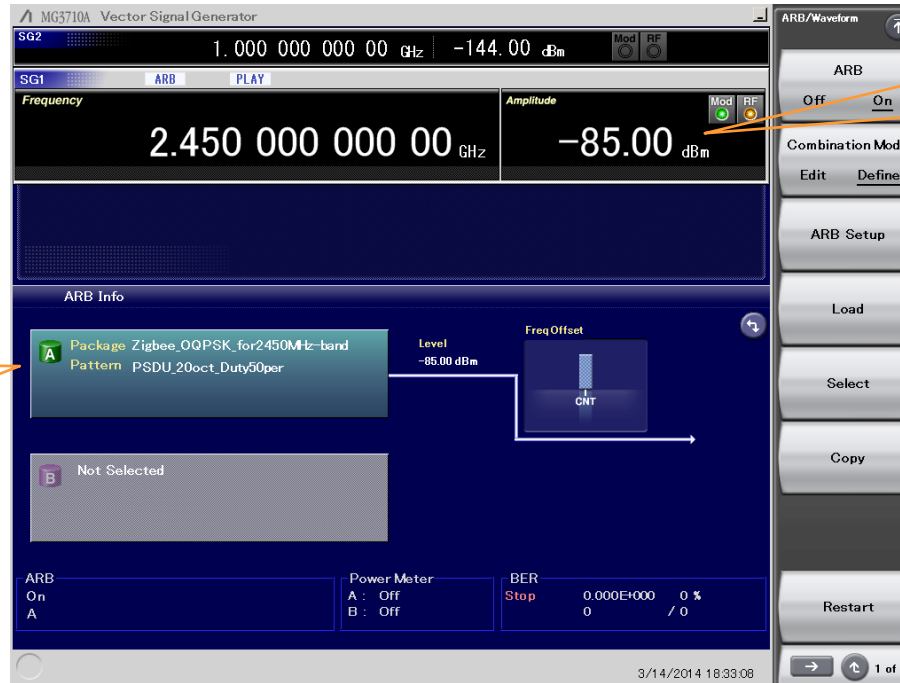
Limit: Shall be capable of achieving a receiver sensitivity of -85 dBm or lower.

O-QPSK PHY RF requirements 9/13

Rx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.4 Receiver sensitivity



Wanted Signal
(Static)

Setting Range

Std: -110 to +17 dBm

Opt: -144 to +30 dBm

*: See data-sheet for detail

Choose ZigBee signal
you want from the list.

Waveform List to Play				Subitem
Packages	in Memory	A	Patterns in Package : Zigbee_OQPSK_for2450MHz-band	Status
Package Name	Pattern Name	Type	Status	
Zigbee_OQPSK_for2450MHz-b...	NoFormat-PN9	wvi	Normal	
	PSDU_20oct_Duty10per	wvi	Normal	
	PSDU_20oct_Duty20per	wvi	Normal	
	PSDU_20oct_Duty25per	wvi	Normal	
	PSDU_20oct_Duty33per	wvi	Normal	
	PSDU_20oct_Duty50per	wvi	Normal	
				Select

O-QPSK PHY RF requirements 10/13

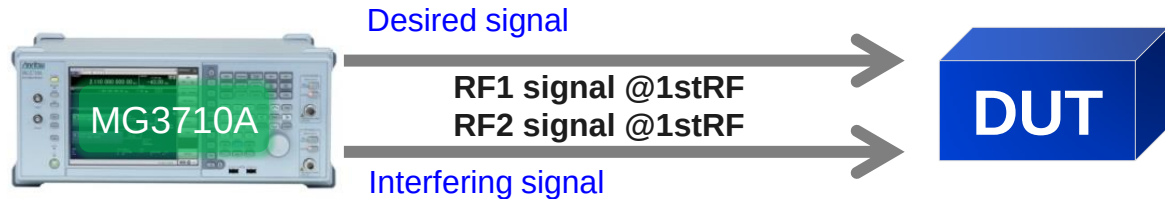
Rx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.5 Receiver interference rejection

Dual memory:

One RF-port has two memory. Two signals are output by one RF-port. The Frequency and Level can be set. This is supported only in MG3710A.

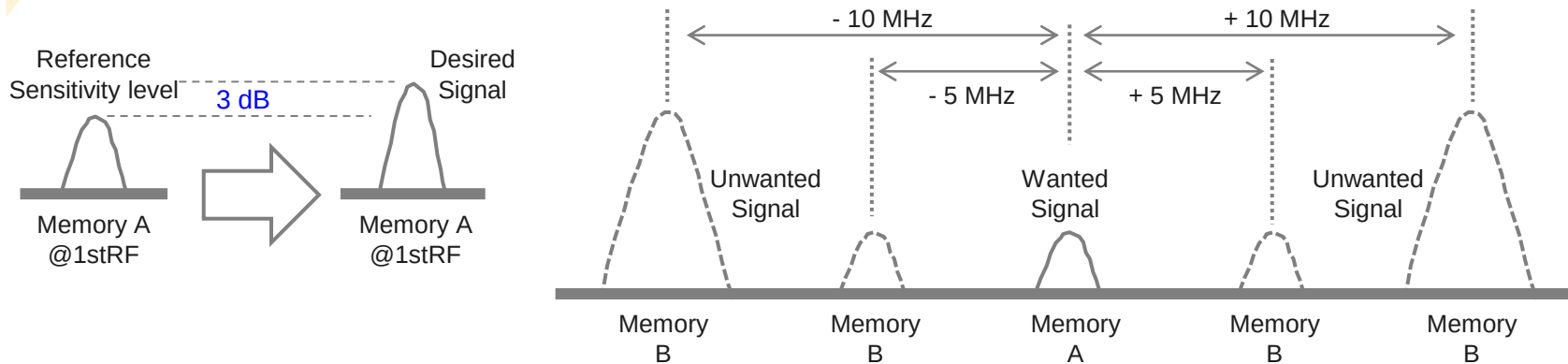


RF1 = Desired signal

- Level: 3 dB above the reference sensitivity

RF2 = Interfering signal

- Frequency: [RF1 Freq.] $\pm$ [5 MHz or 10 MHz]



Expected Value: PER 1%

Limit:

Adjacent channel rejection	Alternate channel rejection
0 dB	30 dB

O-QPSK PHY RF requirements 11/13

Rx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.5 Receiver interference rejection



Merit of Dual memory:

- Two signals of "Wanted signal" and "Unwanted signal" are output by one RF-port.
- Level setting can be made by both each level and C/N
- Frequency offset can be set by direct input.

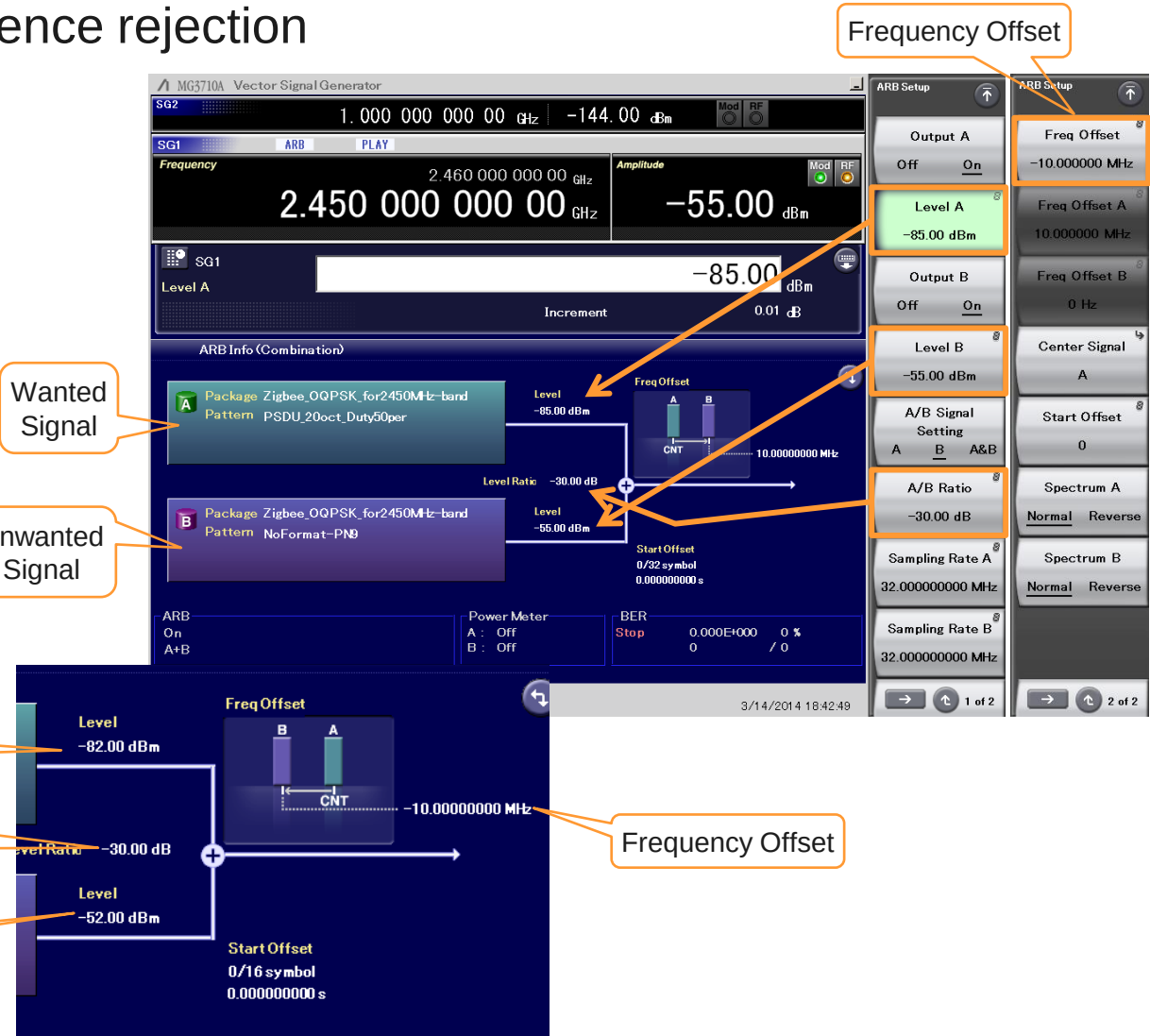
Wanted Signal

Unwanted Signal

Wanted Signal Level

Wanted/Unwanted Level Ratio

Unwanted Signal Level

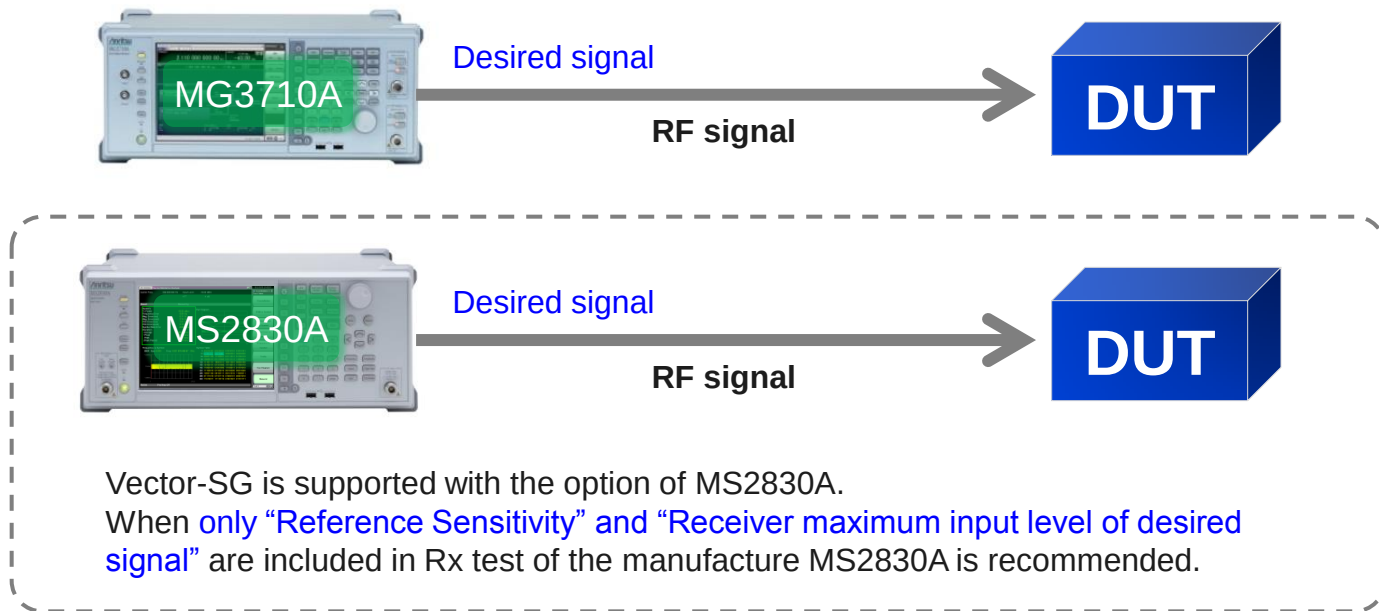


O-QPSK PHY RF requirements 12/13

Rx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.11 Receiver maximum input level of desired signal



Expected Value: **PER 1%**

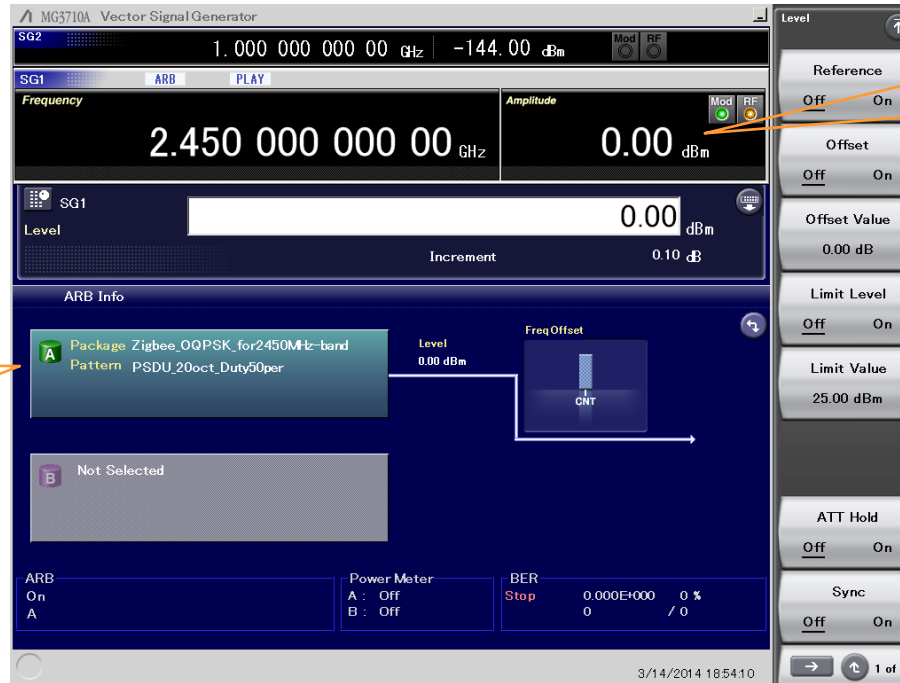
Limit: **≥ -20 dBm**

O-QPSK PHY RF requirements 13/13

Rx Evaluation

Note) For detail, refer to the IEEE standard.

10.3.11 Receiver maximum input level of desired signal



Wanted Signal
(Static)

Setting Range
Std: -110 to +17 dBm
Opt: -144 to +30 dBm

*: See data-sheet for detail

Choose ZigBee signal
you want from the list.

Waveform List to Play				Subitem
Packages	in Memory	A	Patterns in Package : Zigbee_OQPSK_for2450MHz-band	Status
Package Name	Pattern Name	Type	Status	
Zigbee_OQPSK_for2450MHz-b...	NoFormat-PN9	wvi	Normal	
	PSDU_20oct_Duty10per	wvi	Normal	
	PSDU_20oct_Duty20per	wvi	Normal	
	PSDU_20oct_Duty25per	wvi	Normal	
	PSDU_20oct_Duty33per	wvi	Normal	
	PSDU_20oct_Duty50per	wvi	Normal	
				Select

Appendix

Introduction of Waveform Pattern for ZigBee 2450 MHz-band

Pattern Name	Type	Status
NoFormat-PN9	wvi	Normal
PSDU_20oct_Duty10per	wvi	Normal
PSDU_20oct_Duty20per	wvi	Normal
PSDU_20oct_Duty25per	wvi	Normal
PSDU_20oct_Duty33per	wvi	Normal
PSDU_20oct_Duty50per	wvi	Normal

✓ Requires TDMA IQproducer license (MX370102A).

Waveform Pattern for ZigBee 2450 MHz-band

PPDU Format for O-QPSK

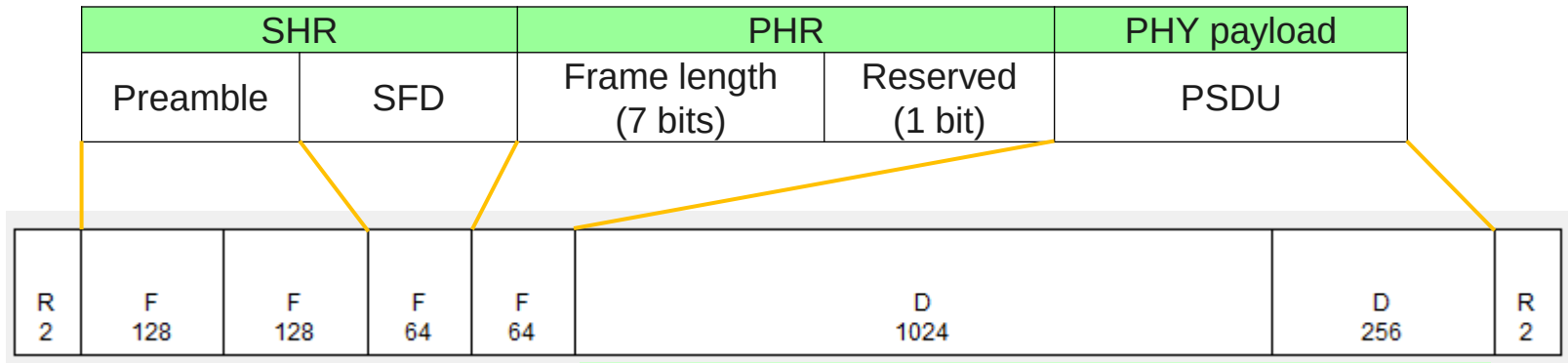


Fig.1 Field structure

PSDU Frame length: 20 octets for Rx test

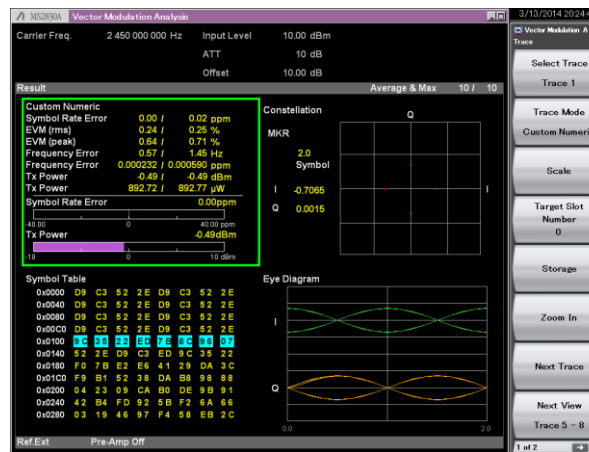
Waveform Pattern Conditions

e.g.)

Modulation Method	: O-QPSK
Symbol Rate	: 1 Msps
Frame	: Duty 50%, 33%, 25%, 20%, 10% or Continuous(NoFormat-PN9)
Field	: (fig.1) (exclude "NoFormat-PN9")
Preamble	: 32 bits / 256 chips, D9C3522E x 8 [HEX]
SHR	: 8 bits / 64 chips, 9C3522ED 7B8C9607 [HEX]
PHR	: 8 bits / 64 chips, 522ED9C3 ED9C3522 [HEX]
Payload	: 160 bits (20 octets) / 1280 chips PN9*
	*: Not Symbol-to-Chip mapping
Ramp	: 2 chips
Filter	: Half-sine

Appendix

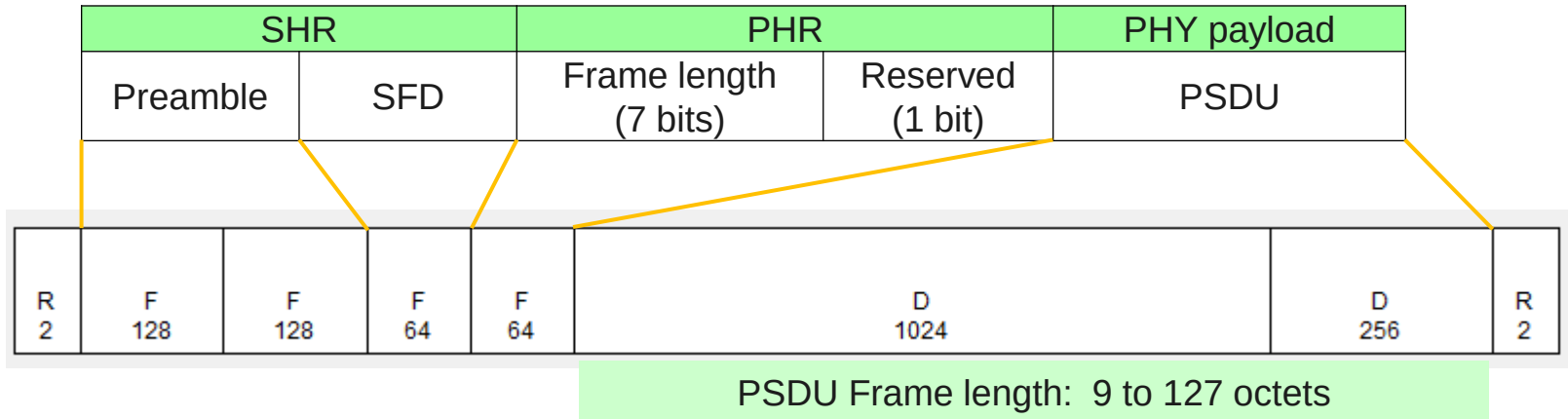
Example of parameter setting for Vector Modulation Analysis Software (MX269017A)



✓ Requires Vector Modulation Analysis Software license (MX269017A).

Example of parameter setting for VMA Software

PPDU Format for O-QPSK



Example of test signal

e.g.)

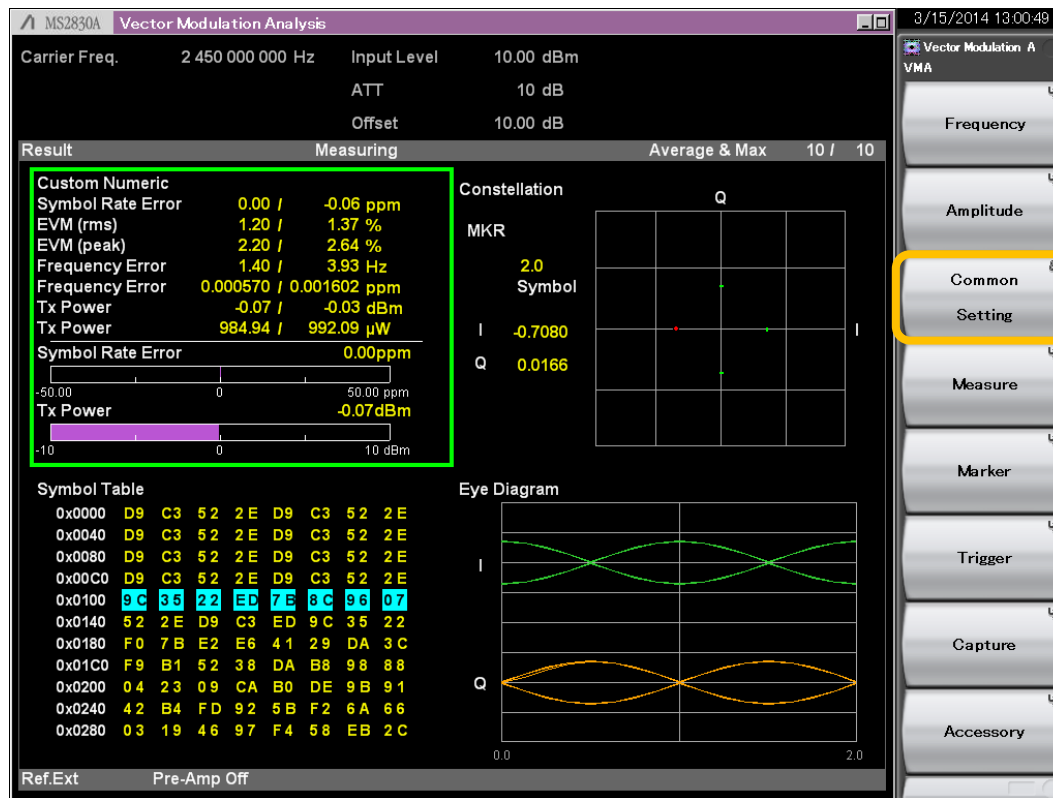
Modulation Method : O-QPSK
Symbol Rate : 1 Msps
Frame : Duty 50%, 33%, 25%, 20%, 10% or Continuous(NoFormat-PN9)
Field : (fig.1) (exclude "NoFormat-PN9")
Preamble : 32 bits / 256 chips, D9C3522E x 8 [HEX]
SHR : 8 bits / 64 chips, 9C3522ED 7B8C9607 [HEX]
PHR : 8 bits / 64 chips, 522ED9C3 ED9C3522 [HEX]
Payload : 160 bits (20 octets) / 1280 chips PN9*
*: Not Symbol-to-Chip mapping
Ramp : 2 chips
Filter : Half-sine

PHR: e.g. Frame length = 20 octets : 0 0 1 0 1 0 0 [BIN]
Reserved: 0

Bit	0	1	2	3	4	5	6	7
BIN	0	0	1	0	1	0	0	0
DEC	4				1			

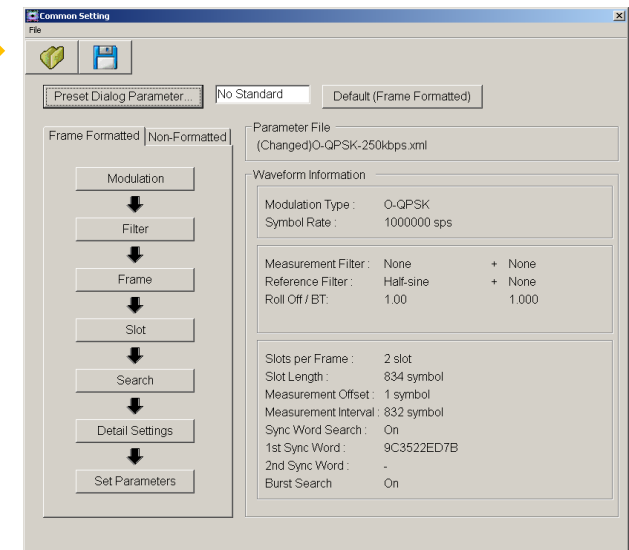
Example of parameter setting for VMA Software

Vector Modulation Analysis Software [MX269017A]



Set the carrier frequency

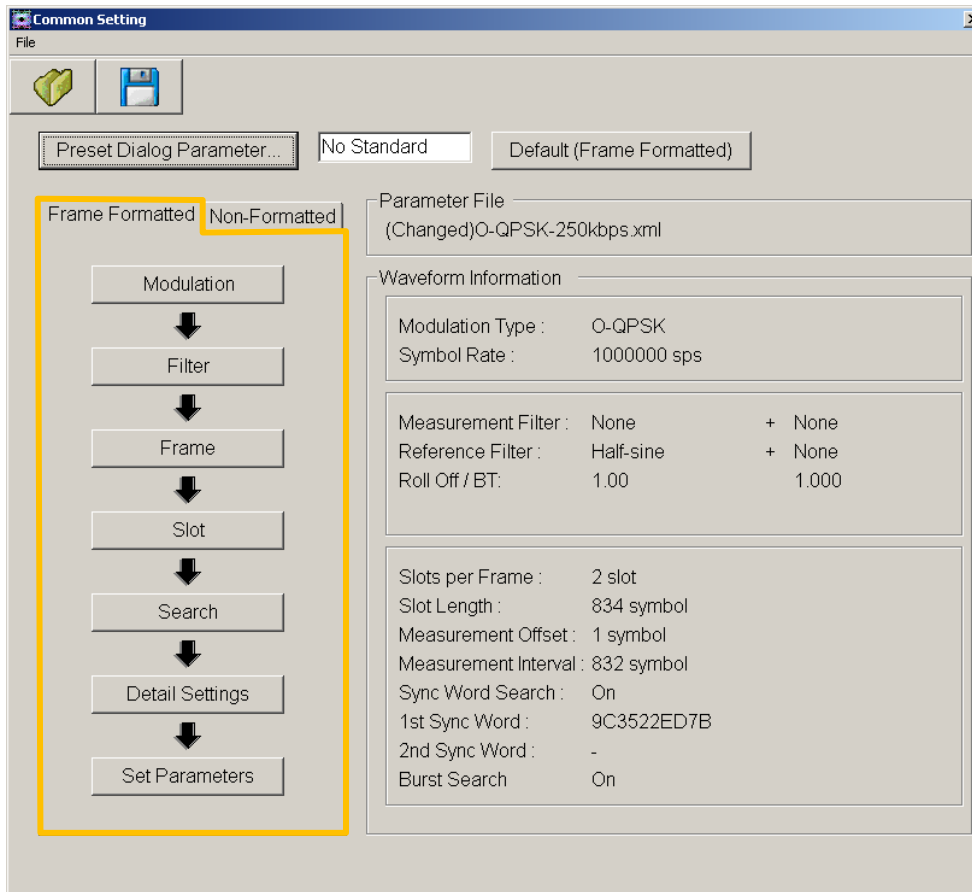
Set the input level of Signal analyzer



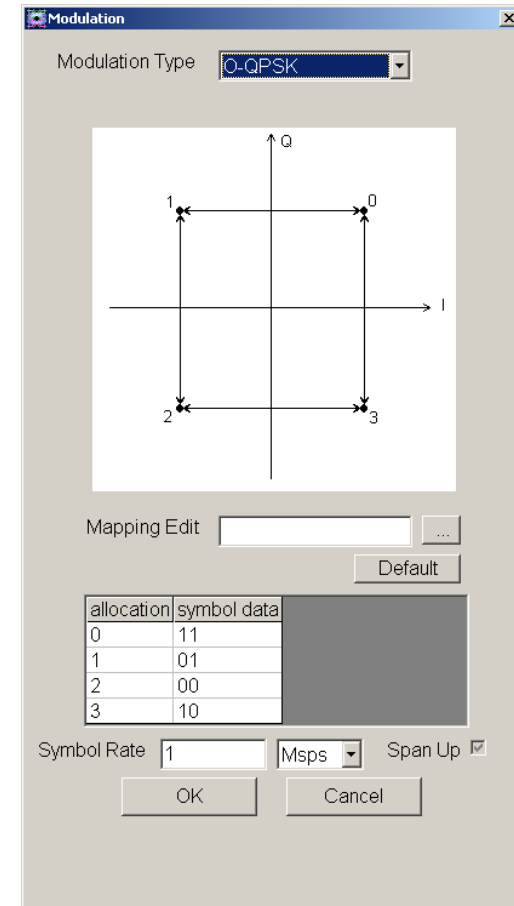
For detail parameter setting
(Refer to the following page)

Example of parameter setting for VMA Software

(1) Frame Formatted signal



Modulation

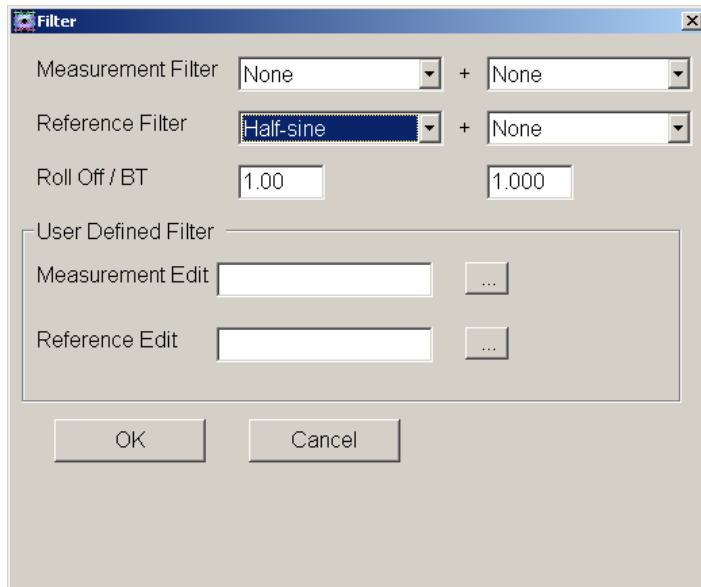


Modulation Type : O-QPSK
Symbol Rate : 1 Msps

Example of parameter setting for VMA Software

(1) Frame Formatted signal

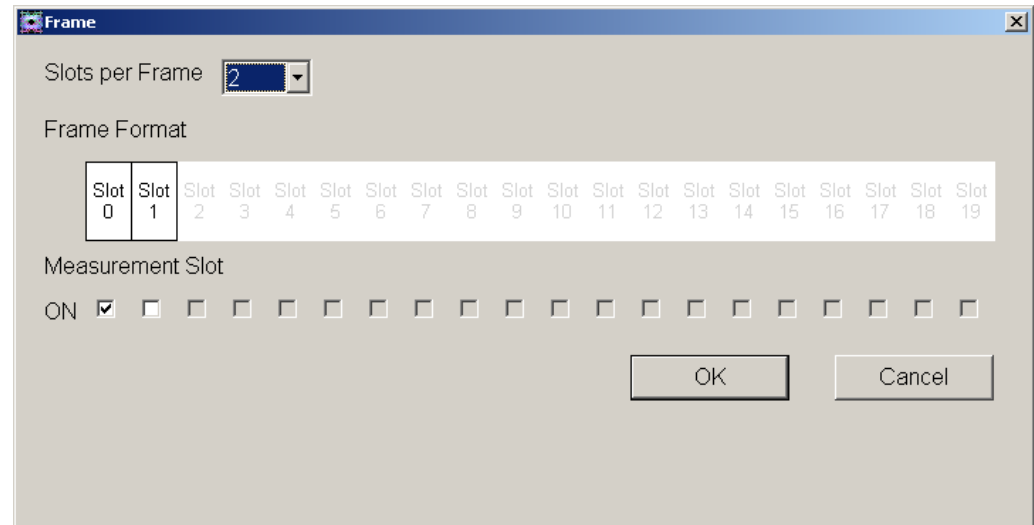
Filter



Measurement Filter : None
Reference Filter : Half-Sine
Roll Off / BT : 1.00

Frame

e.g. Duty 50%
(on = 1 slot, off = 1 slot)



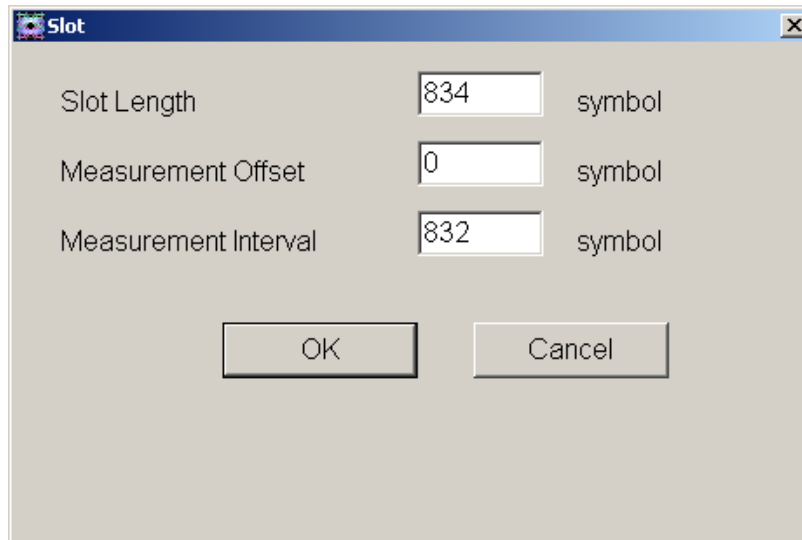
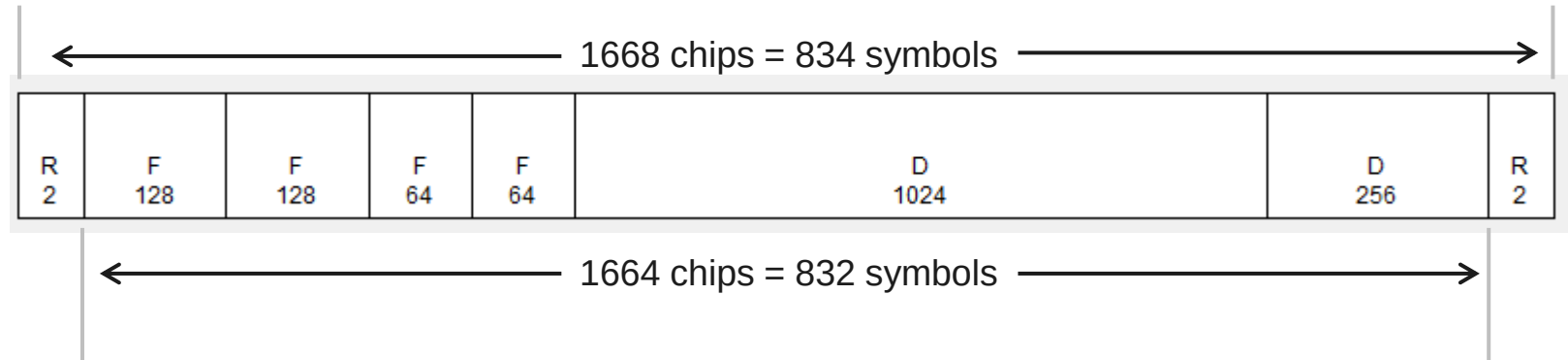
Slots per Frame : 2
Frame Format : Slot 0 = On, Slot 1 = Off

Example of parameter setting for VMA Software

(1) Frame Formatted signal

Slot

e.g. PSDU frame length = 160 bits (20 octets) / 1280 chips



Slot Length* : 834
Measurement Offset : 0
Measurement Interval : 832

*: Setting Range = 10 to 4096 symbols
(1 symbol = 2 chips)

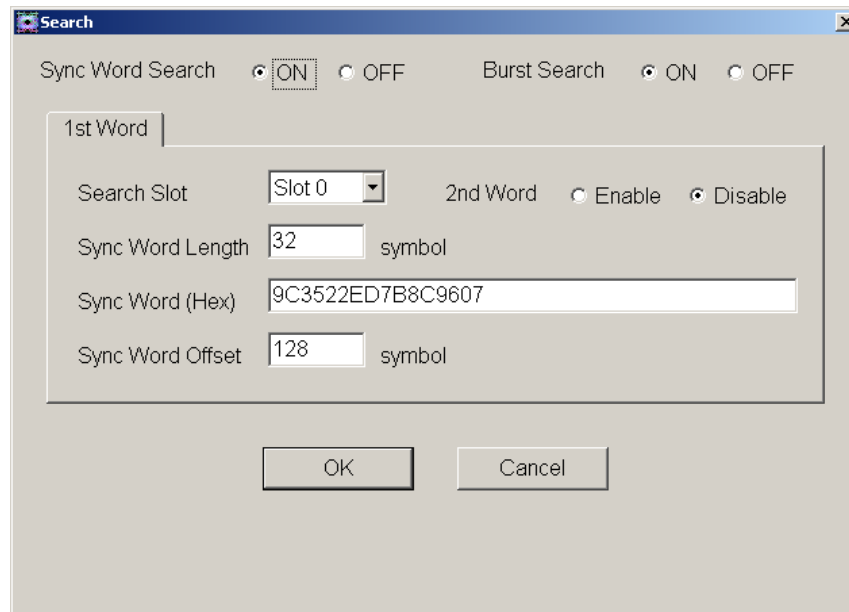
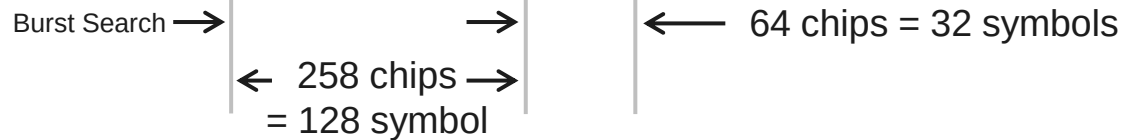
Maximum value of measured PSDU length:
= $4096 \times 2 - (2 + 256 + 64 + 64 + 2)$ [chips]
= 7804 [chips]
= 975 [bits]
= 121 octets

Example of parameter setting for VMA Software

(1) Frame Formatted signal

Search

SHR : 8 bits / 64 chips, 9C3522ED 7B8C9607 [HEX]



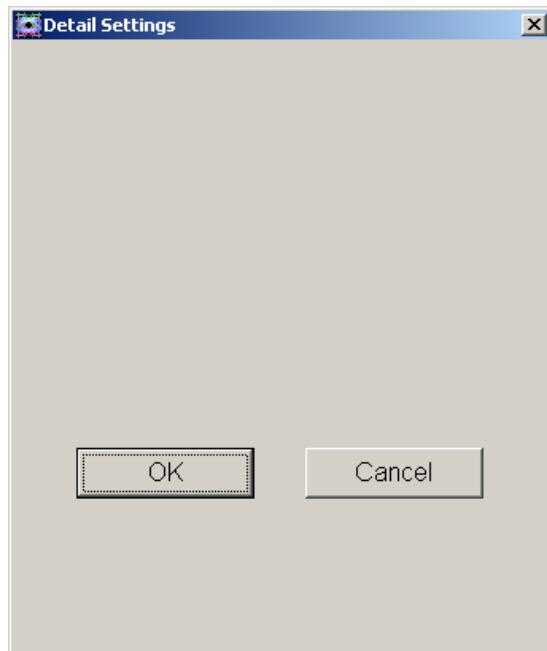
Sync Word Search : On
Burst Search : On
Search Slot : Slot 0
Sync Word Length : 32 symbol
Sync Word (Hex) : 9C3522ED 7B8C9607
Sync Word Offset : 128 symbol

Example of parameter setting for VMA Software

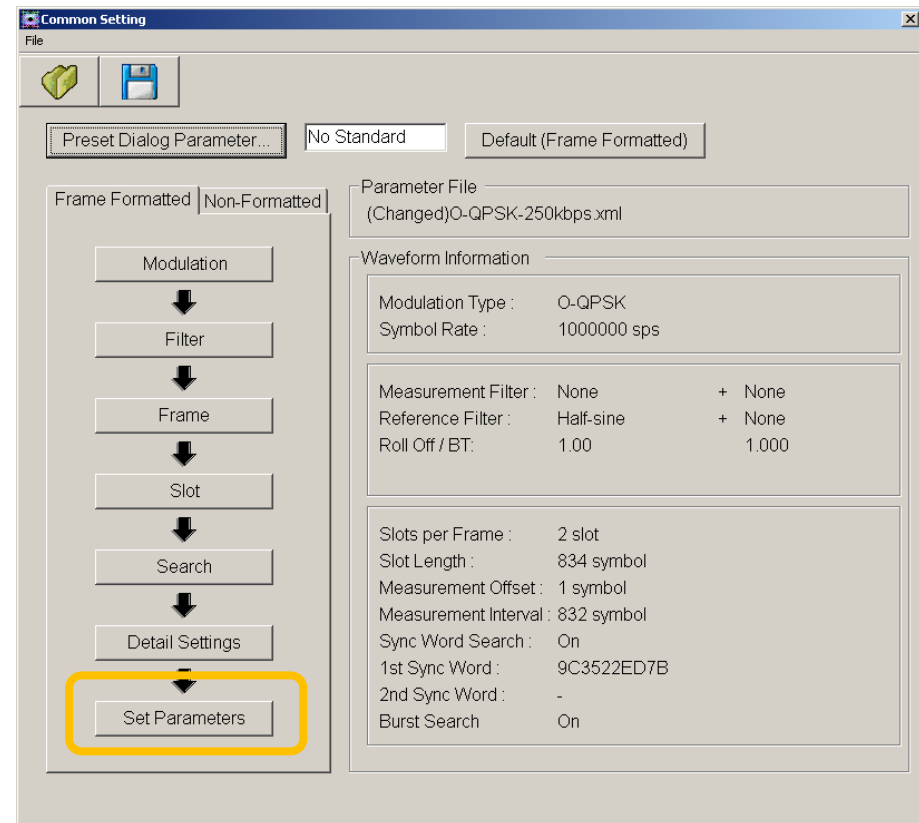
(1) Frame Formatted signal

Detail Settings

Unused parameter



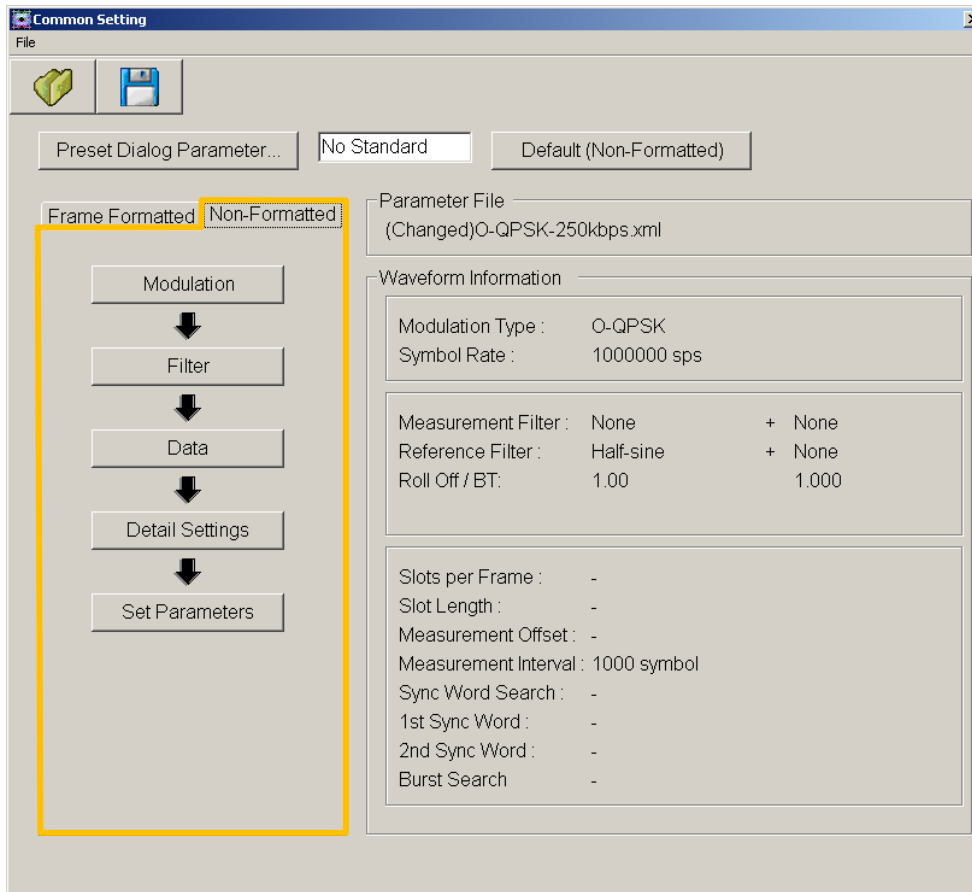
Set Parameters



After all parameters were input, push this button

Example of parameter setting for VMA Software

(2) No Formatted signal



Modulation

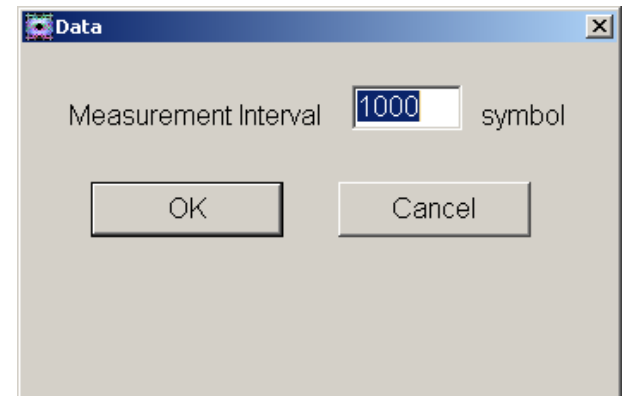
Filter

Detail Settings

Set Parameter

(Same as "Frame Formatted signal")

Data



10.3.8 Error vector magnitude (EVM)

Limit: 35% (when measured for 1000 chips)

Ordering Information

► Recommended Configuration

Model	Name
MS2830A	Signal Analyzer
MS2830A-040	3.6 GHz Signal Analyzer
MX269017A	Vector Modulation Analysis Software (Requires MS2830A-006&005)
MS2830A-005	Analysis Bandwidth 31.25 MHz (Requires MS2830A-006)
MS2830A-006	Analysis Bandwidth 10 MHz
MG3710A	Vector Signal Generator
MG3710A-032	1stRF 100 kHz to 2.7 GHz
MG3710A-048	Combination of Baseband Signal for 1stRF
MX370102A	TDMA IQproducer

	Test items of IEEE802.15.4 (O-QPSK)	MS2830A	MG3710A	
TX	10.3.2 Transmit power spectral density (PSD) mask	√	---	
	10.3.3 Symbol rate	√	---	
	10.3.8 Error vector magnitude (EVM)	√	---	*1
	10.3.9 Transmit center frequency tolerance	√	---	*2
	10.3.10 Transmit power	√	---	
	10.3.6 TX-to-RX turnaround time			*3
	10.3.7 RX-to-TX turnaround time			*3
RX	10.3.4 Receiver sensitivity	---	√	
	10.3.5 Receiver interference rejection	---	√	*4
	10.3.11 Receiver maximum input level of desired signal	---	√	

- *1: The limit value of the EVM measurement depends on the signal quality of DUT.
(Measured example: approximately 20% or less)
- *2: The limit value of the Frequency Error measurement is approximately 15 ppm.
- *3: The spectrum analyzer will not be used in this measurement item.
- *4: The MG3710A can add two different signals and output them from the RFx1 port.
The frequency (recommended range: ± 60 MHz) and level (CN: ± 80 dB) can also be set at the screen.

● United States

Anritsu Company

1155 East Collins Blvd., Suite 100, Richardson,
TX 75081, U.S.A.
Toll Free: 1-800-267-4878
Phone: +1-972-644-1777
Fax: +1-972-671-1877

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