Discover What's Possible™ Anritsu

TECHNICAL NOTE

MX268x30A / MX860x30A

Wireless LAN Measurement Software

ANRITSU CORPORATION

Wireless LAN

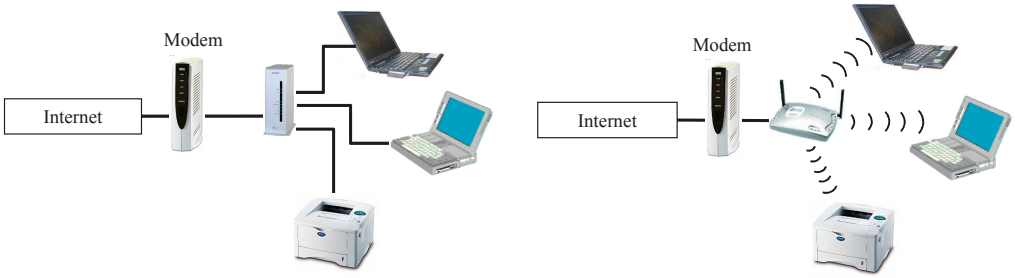
Features and Measurements based on IEEE802.11a/11b

Wireless Measurement Solutions
Anritsu Corporation

V1.0

What is Wireless LAN?

Wireless LAN literally means the LAN without wires (cables). Signals are transmitted via radio wave, infrared light or laser. This document describes the Wireless LAN via radio wave regulated in IEEE.

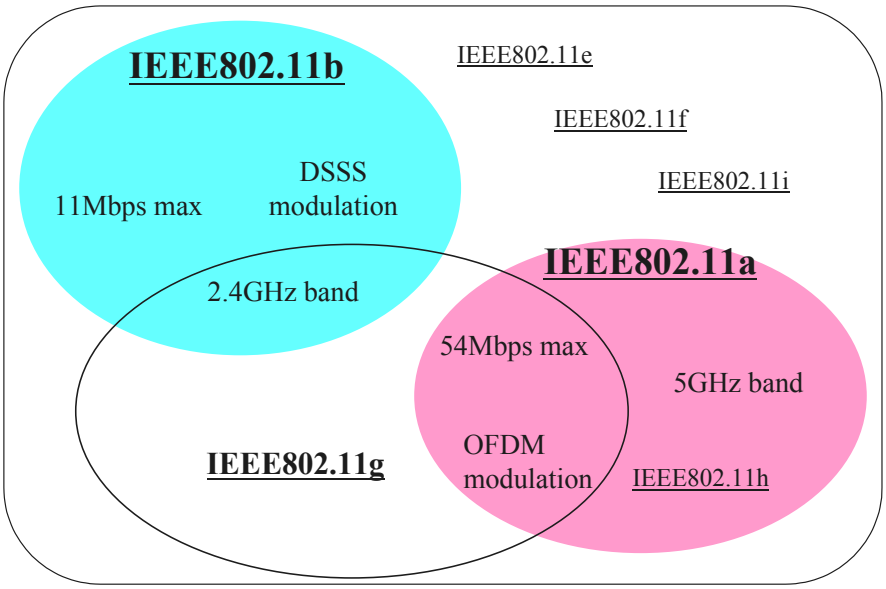


IEEE802.3: Ethernet

IEEE802.11: Wireless LAN

Institute of Electrical and Electronics Engineers

IEEE802.11x Family



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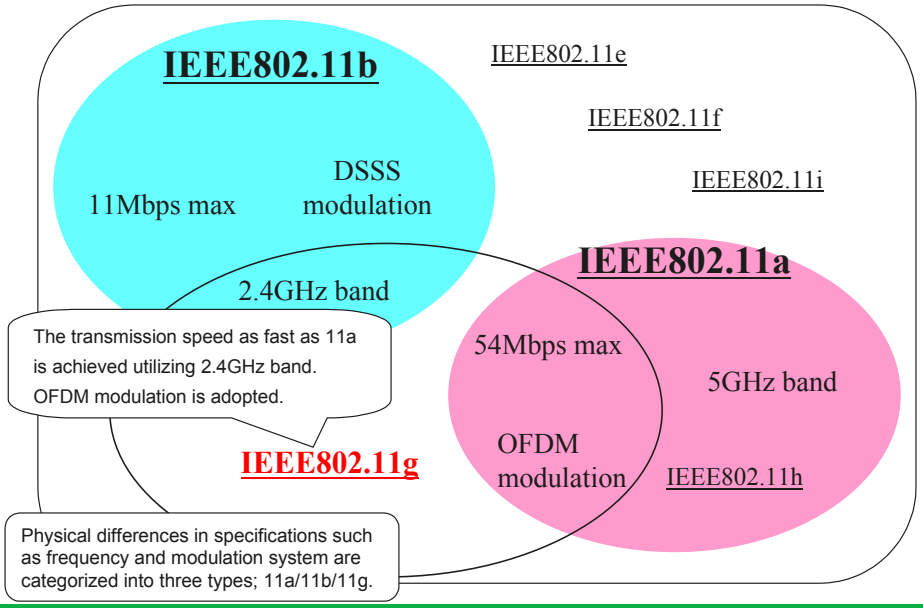
IEEE802.11x Family



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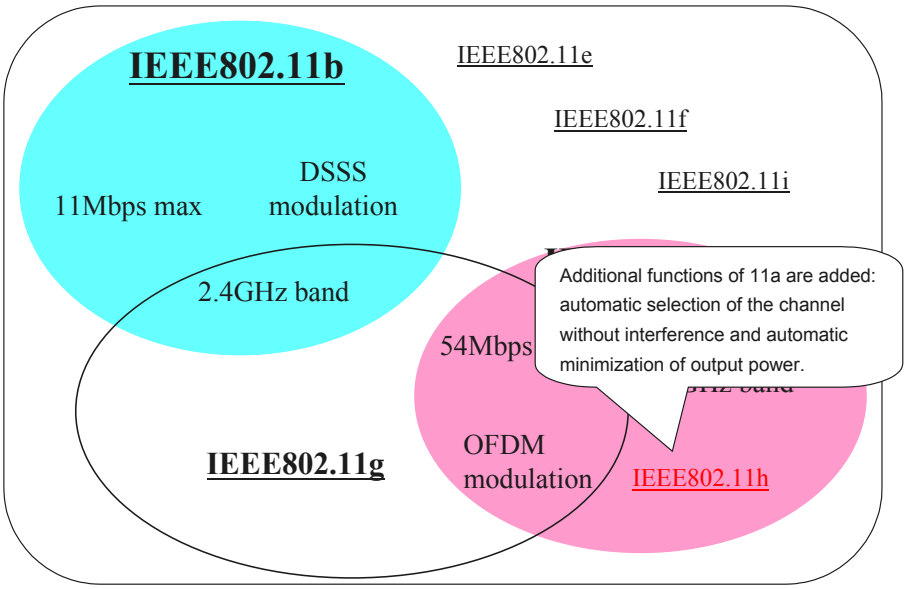
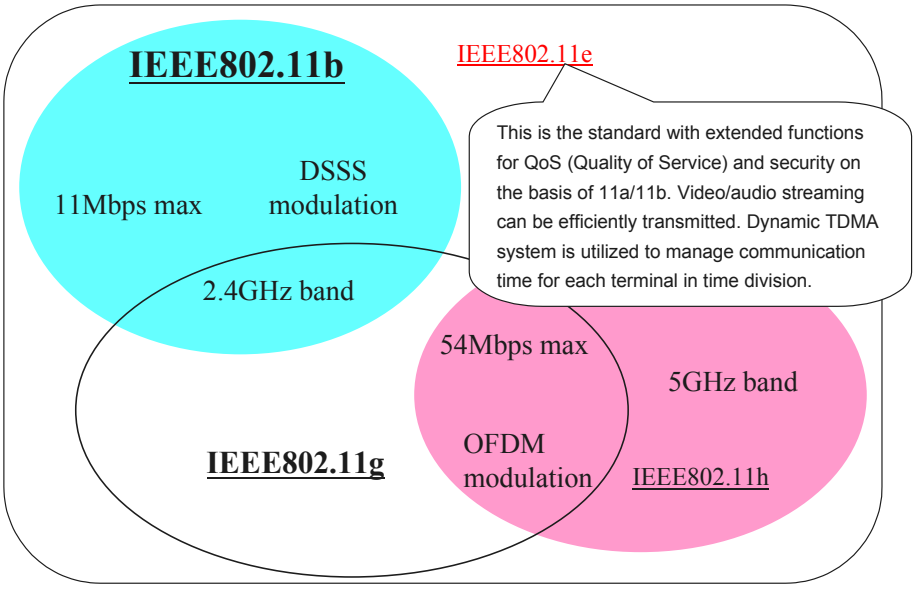
IEEE802.11x Family



IEEE802.11x Family



Access Control

CSMA/CA (Carrier Sense Multiple Access with Collision Avoidance)

Access control system for 11a/11b

In starting communication,

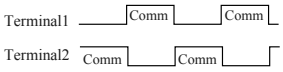
1. Confirm that other terminals are not in communication.
2. Wait other terminals to end the communication.
3. Start communication (transmit the data) in none-communication state of other terminals.
4. Receiver sends the confirmation of reception (ACK) to transmitter after receiving transmitted data.
5. Transmitter waits until receiving the confirmation. Receiving the confirmation completes the communication.

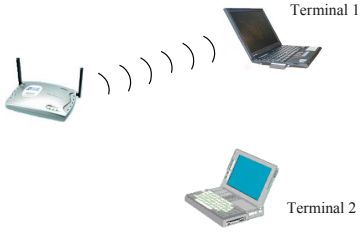
If two terminals start communication simultaneously, the communication is restarted after random time wait..

Dynamic TDMA(Time Division Multiple Access)

Access control system for 11e

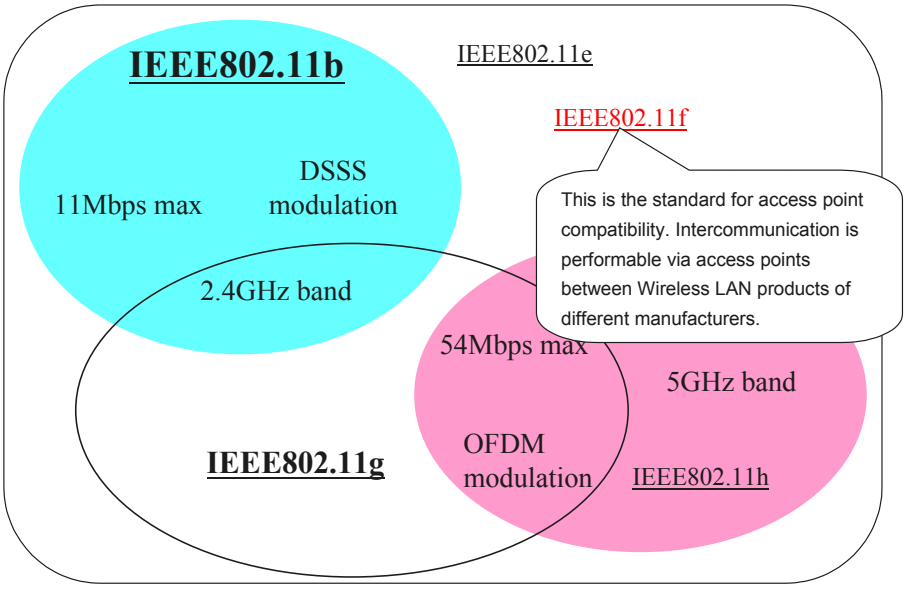
Communication time is coordinated between terminals and communication is sequentially performed at regular intervals.



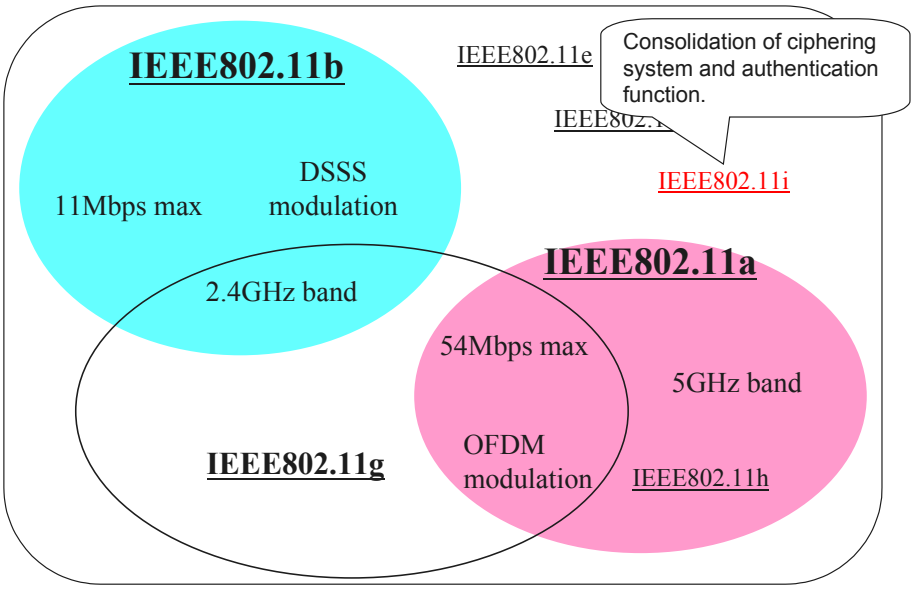


Communication speed is assured.

IEEE802.11x Family



IEEE802.11x Family



IEEE802.11x Family

HiSWANa

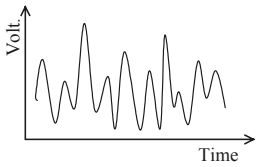
The Wireless LAN standard for 5GHz band and OFDM modulation developed by NTT.
Corresponding to IEEE802.11a + 11h
ARIB open standard (ARIB STD-T70)

HiperLAN2

The European standard equal to HiSWANa.

Analog Modulation

Base-band signal
Audio or Video signal



For further transmission of base-band signal...

⇩

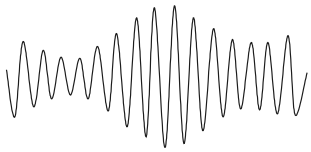
Modulation

The information of base-band signal (audio or video signal) is imposed on higher frequency (RF) and then transmitted.

Base-band signal

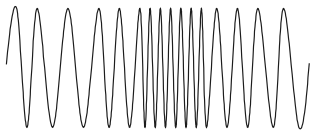
AM modulation

The amplitude of RF signal is varied.



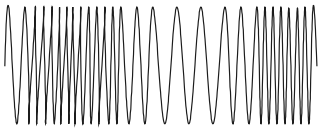
FM modulation

The frequency of RF signal is varied.

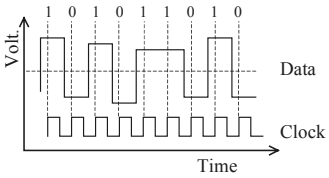


ϕM modulation

The phase of RF signal is varied.



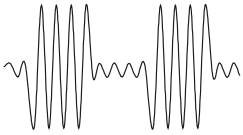
Digital Modulation



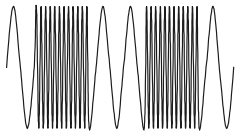
Similarly to the system of analog modulation, the information of digital signal is imposed on RF signal and then transmitted.

Digital signal (data)

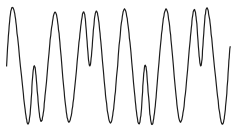
ASK(Amplitude Shift Keying)
The amplitude of RF signal is varied.



FSK(Frequency Shift Keying)
The frequency of RF signal is varied.



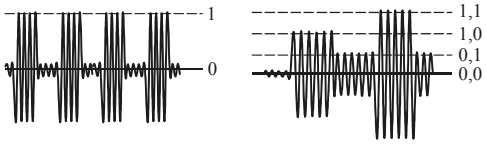
PSK(Phase Shift Keying)
The phase of RF signal is varied.



Multiple Digital Modulation

Comparing with the modulation by bit (1,0) processed by two pieces of data information, the modulation using more pieces of data information enables to transmit various pieces of information at a time.

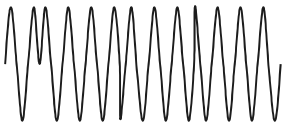
Conversion from bit to symbol



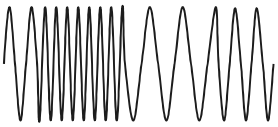
ASK
Modulation by bit (1,0)

QASK(4-value ASK)
Modulation by symbol (4 state)

QPSK(4-value PSK)



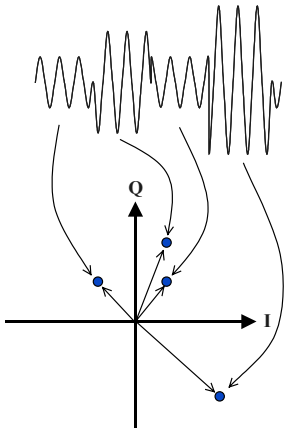
QFSK(4-value FSK)



QAM Modulation

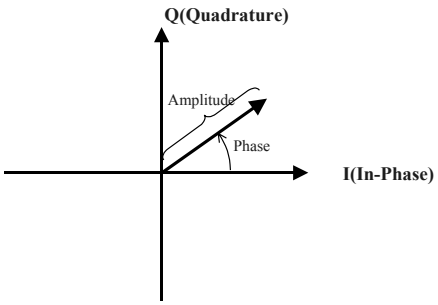
Amplitude and phase are independent one another, therefore one carrier signal can be simultaneously modulated, enabling to transmit various pieces of information at a time.

QAM(Quadrature Amplitude Modulation)
QASK and QPSK are simultaneously modulated.



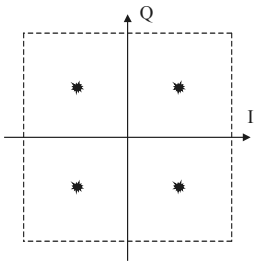
Constellation

The amplitude and phase of modulation signal are displayed on the same plane.

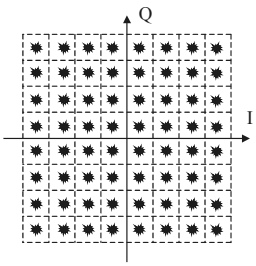


QAM Modulation

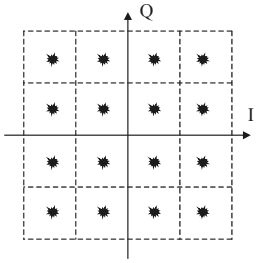
QPSK(4QAM)
1 symbol=2bit



64QAM
1 symbol=6bit



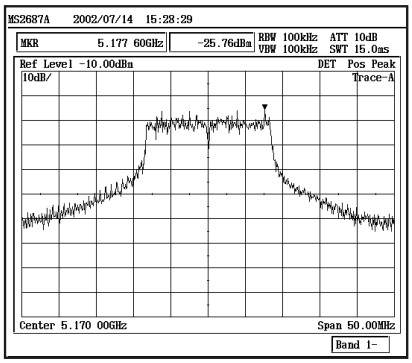
16QAM
1 symbol=4bit



About IEEE802.11a

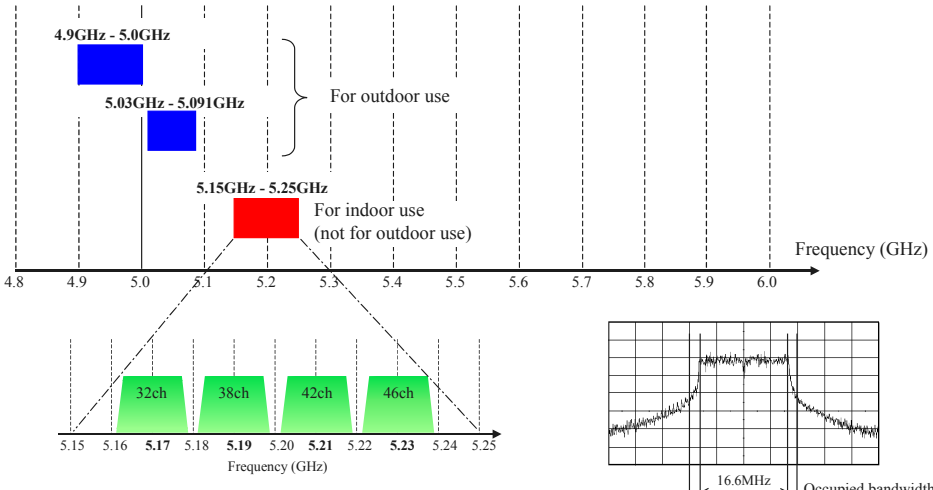
Representative performance of IEEE802.11a

Item	Specification
Frequency	5GHz band
Output	10mW/MHz
Modulation (transmission speed)	BPSK-OFDM(6Mbps,9Mbps) QPSK-OFDM(12Mbps,18Mbps) 16QAM-OFDM(24Mbps,36Mbps) 64QAM-OFDM(48Mbps,54Mbps)
Sub carrier	52
OFDM symbol length	4us
Guard interval	0.8us
Sub-carrier interval	312.5kHz
Occupied bandwidth	16.6MHz



Spectrum Waveform

Frequency



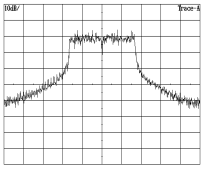
• The frequency range from 5.15 to 5.25GHz is not utilizable for outdoor due to the interference by weather radar.

Modulation System

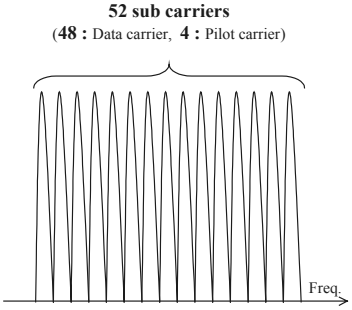
• What is **OFDM**(Orthogonal Frequency Division Multiplexing)?

A type of frequency division multiplexing (FDM).

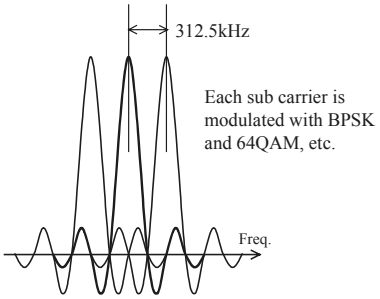
The orthogonality of each sub carrier enables close allocation of bands, overlapping one another.



Actual OFDM spectrum



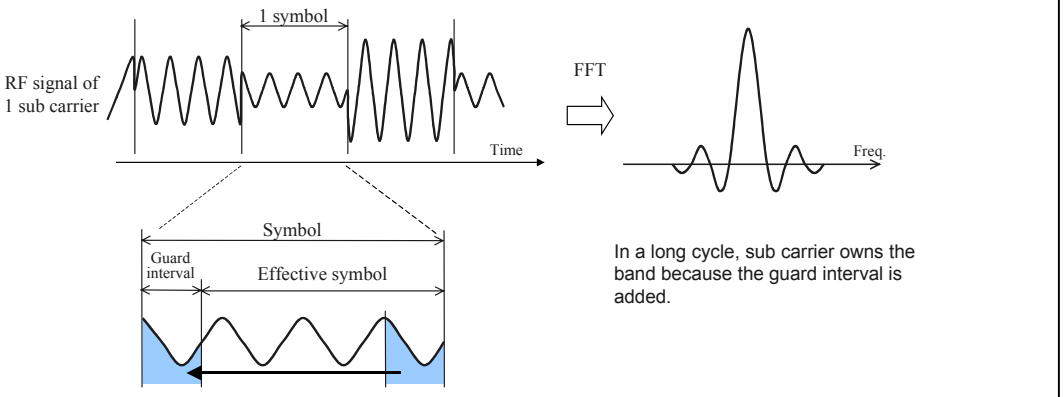
OFDM spectrum concept



Sub-carrier expansion

Modulation System

• What is **Orthogonal**?

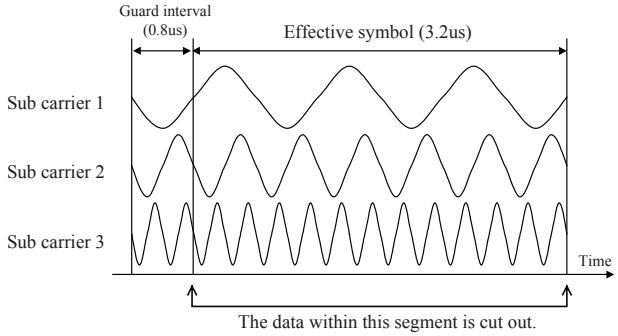


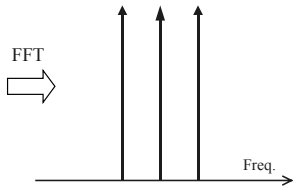
In a long cycle, sub carrier owns the band because the guard interval is added.

Partial effective symbol in the rear is moved and attached to the front, regarded as guard interval.

Modulation System

• What is **Orthogonal**?





If the waveform of integral multiple cycle is included within the time segment to cutout the data (effective symbol length), it is demodulated (FFT) into single sinusoidal wave.

All sub-carrier frequencies must be integral multiple of inverse number for effective symbol length.

The center frequency of 32ch is

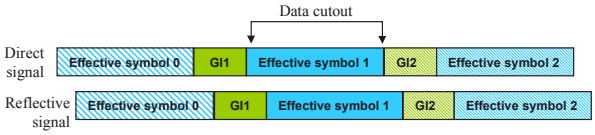
$5170\text{MHz} = 16544 \times \frac{1}{3.2 \times 10^{-6}}$ (Hz)

Sub carriers are allocated at 312.5kHz ($\frac{1}{3.2 \times 10^{-6}}$) intervals, centered on this frequency.

OFDM Features (1)

• **Less interference of delayed signal**

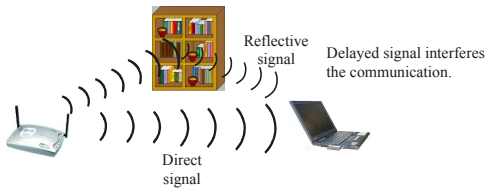
Guard interval is able to reduce the interference of delayed signal because of long symbol length.



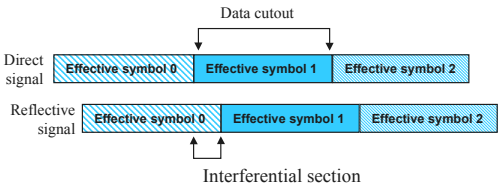
The guard interval is a part of effective symbol, so there is no influence of delayed signal if the overlapped section of delayed signals is within the guard interval.

The effective symbol length of 64QAM-OFDM for 11a is 3.2us with 0.8us (240m in distance) of guard interval.

In transfering the same amount of data with single 64QAM, effective symbol length is 66.7ns(3.2us/48) with 16.7ns (5m in distance) of guard interval.



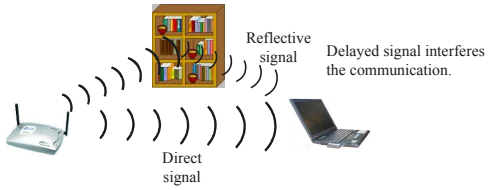
Without guard interval, delayed signal functions as interference signal.

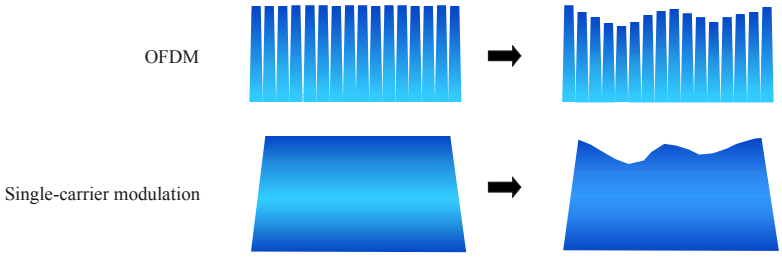


OFDM Features (2)

- Less interference of delayed signal

In OFDM, the influence of frequency band characteristic varied by delayed signal is less as the frequency bandwidth per sub carrier is narrow band so.





Ideal spectrum waveform

Spectrum waveform affected by delayed signal

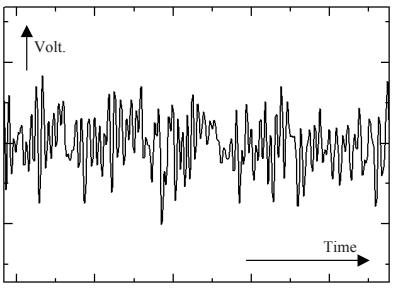
OFDM Features (3)

- Easy to be distorted

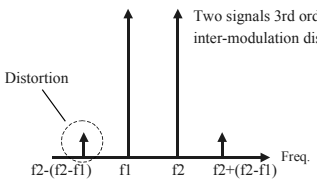
The presence of numerous sub carriers adjacently allocated at equal intervals tends to cause inter-modulation distortion.

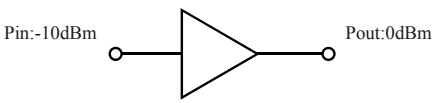
Also, amplitude probability distribution is close to white noise, which makes big difference between average power and instantaneous power.

Amplifiers and Mixers must be backed off by 10dB and more.



OFDM waveform on Oscilloscope

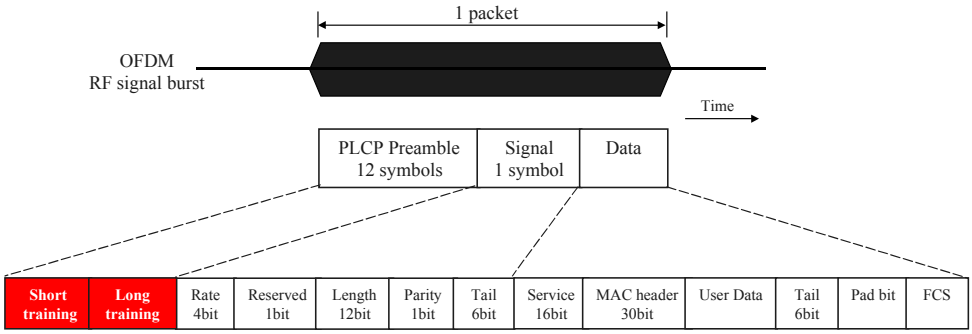




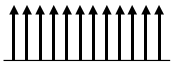
Gain: +10dB

P1dB: 0dBm

Data Structure (1)

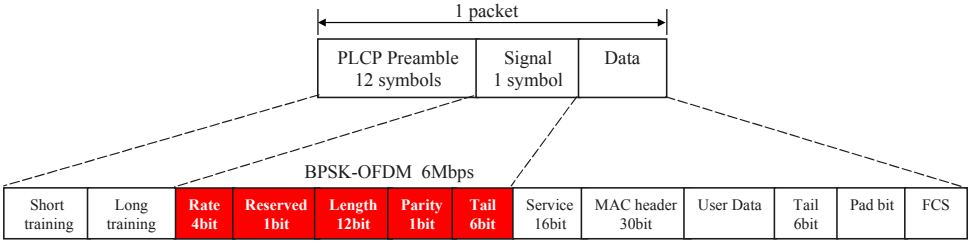


• **Short training**
12 sub carriers are used per symbol.
The sub-carrier amplitude is constant.
Repetition of 10symbols
- Rough frequency adjustment
- Diversity selection
- AGC drawing



• **Long training**
52 sub carriers are used per symbol.
The sub-carrier amplitude is constant.
Repetition of 2symbols
- Fine frequency adjustment
- Transmission route estimation

Data Structure (2)



• **Rate**
Modulation method and transmission speed in Data area
1101 : BPSK 6MHz
1111 : BPSK 9MHz
0101 : QPSK 12MHz
0111 : QPSK 18MHz
1001 : 16QAM 24MHz
1011 : 16QAM 36MHz
0001 : 64QAM 48MHz
0011 : 64QAM 54MHz

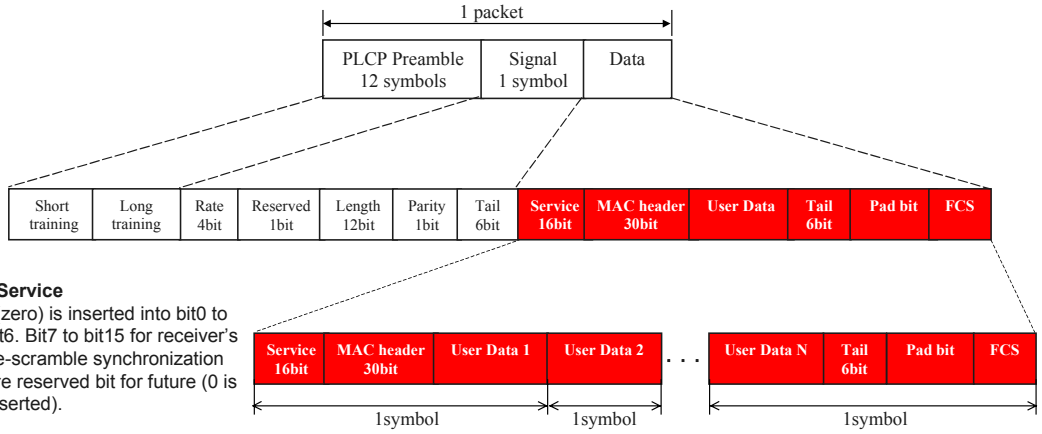
• **Reserved**
The bit reserved for future use

• **Length**
The number of byte in User Data

• **Parity**
Even parity in Rate/Reserved/Length section

• **Tail**
All 0(zero)"000000"

Data Structure (3)



• **Service**
0(zero) is inserted into bit0 to bit6. Bit7 to bit15 for receiver's de-scramble synchronization are reserved bit for future (0 is inserted).

• **MAC header**
MAC addresses of transmitter and receiver are saved.

• **User Data**
User's data

• **Tail**
All 0(zero)"000000" turbo encoder is initialized.

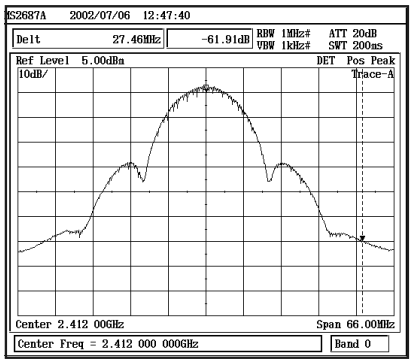
• **Pad bit**
This bit is filled with 0(zero) if the last user's data can not fill up 1 symbol.

• **FCS**
Frame check sequence
The data to detect packet errors.

About IEEE802.11b

Representative performance of IEEE802.11b

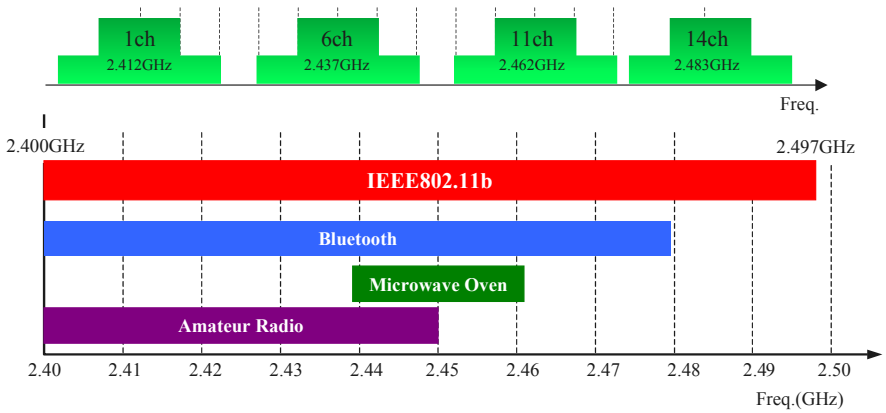
Item	Specification
Frequency	2.4GHz band
Output	10mW/MHz
Modulation (transmission speed)	DBPSK (1Mbps) DQPSK (2Mbps) CCK (5.5Mbps) CCK (11Mbps)



Spectrum Waveform

Optional PBCC is speculated as modulation system, which is omitted here.

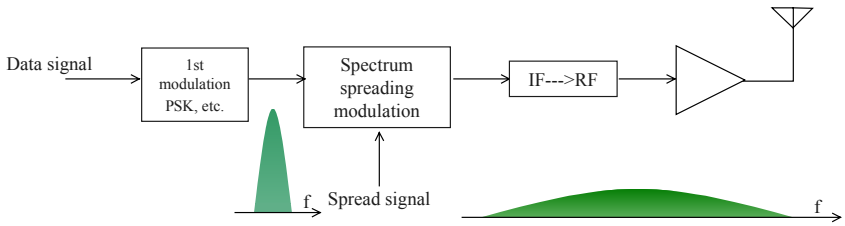
Frequency



- **ISM band** (Industry, Science and Medical Band) is utilized.
- Interference might be caused due to the frequency band shared with other systems.

Modulation System (1)

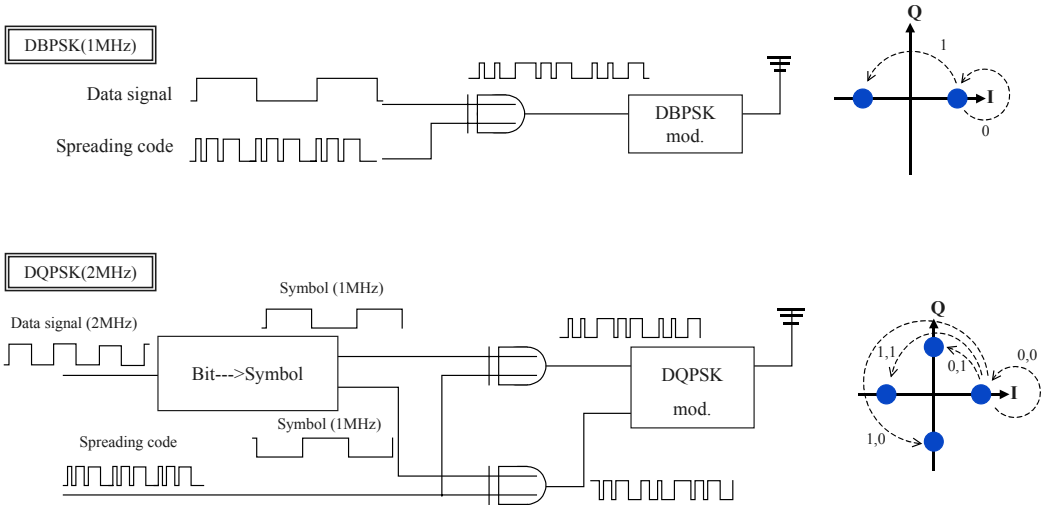
DSSS(Direct Sequence Spread Spectrum)



Spread signal > Data signal

The signal modulated by data signal is further modulated by the spread signal to widen the frequency band.
With spreading spectrum, the influence of in-band interference is lessened by averaging effect at the time of demodulation.
The use of none-correlation signal for spread signal enables multiplexing into the same frequency.
by utilizing non-relative signal for spreading signal.

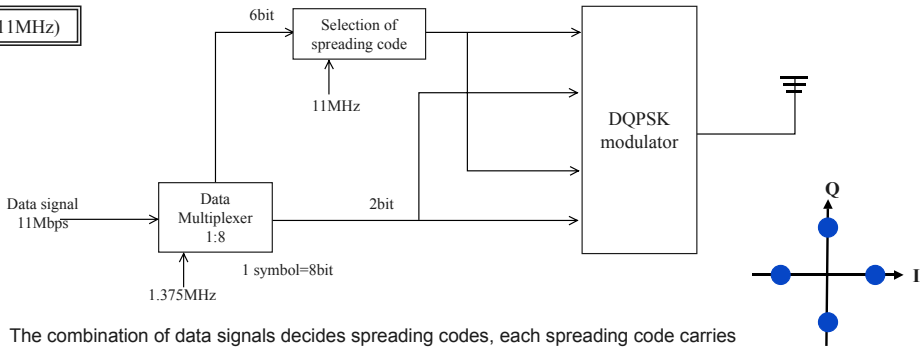
Modulation System (2)



Spreading code: 10110111000
Channels are divided for communication because of constant spreading code.

Modulation System (3)

CCK(11MHz)



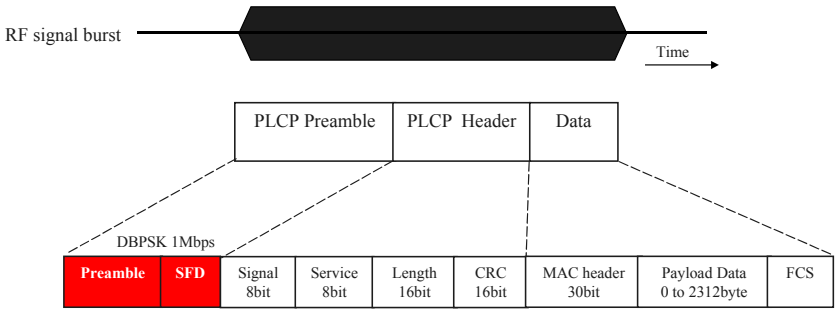
The combination of data signals decides spreading codes, each spreading code carries information.

6 bits out of 1 symbol (8 bits) are utilized to decide spread signal patterns (64 patterns), the rest 2 bits are to decide carrier signal phase.

CCK(5.5MHz)

2 bits out of 1 symbol(4bit) are utilized to decide spread signal patterns and the rest 2 bits are to decide carrier signal phase. The others are same as 11MHz.

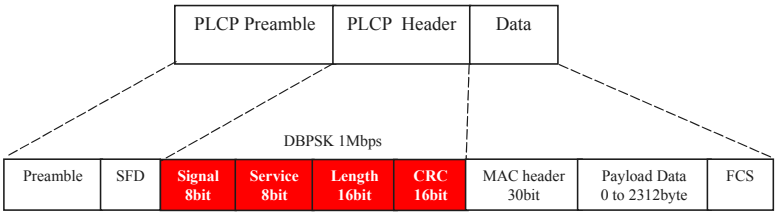
Data Structure (1)



- **Preamble**
  Long: 128bit ALL "1"
  Short: 56bit ALL "0"

- **SFD(Start of Frame Deliminator)**
  Frame starting position is indicated.
  Short: F3A0hex
  Long: 05Cfhex

Data Structure (2)



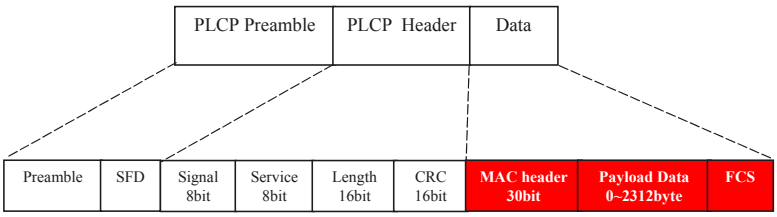
- **Signal**
  Modulation system of Data section
  0Ahex: 1Mbps
  14hex: 2Mbps
  37hex: 5.5Mbps
  6Ehex: 11Mbps

- **Service**
  bit0,1,4,5,6: Reserved bit
  bit2: Whether the carrier frequency and symbol clock are synchronized each other
  0:not 1:locked
  bit3: Modulation system
  0:CCK 1:PBCC
  bit7:
  Data transmission speed ≥8Mbps
  ---> "1"

- **Length**
  The amount of information in Data section

- **CRC**
  For the verification of frame data correctness

Data Structure



- **MAC header**
  MAC addresses of transmitter and receiver are saved.

- **Payload Data**
  User's data

- **FCS**
  Frame check sequence
  The data to detect packet errors

Measurement for IEEE802.11a/11b

What to Measure?

The influence to other channels and systems is measured.
(TELEC technical standard conformity test items)

- Frequency
- Occupied bandwidth, Spread bandwidth
- Spurious
- Antenna power
- Adjacent channel leakage power
- Out-band leakage power
- Secondary emissions

Communication state is measured.

- BER
- PER
- Modulation accuracy
- Constellation

Others

- CCDF

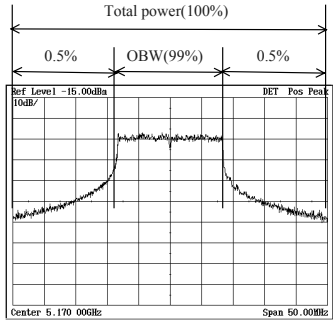
TELEC Technical Standard Conformity Test Items (1)

● Frequency

Modulation is discontinued and measurement is performed under CW state.

Allowable value ±50×10^{-6}(11a)
±20×10^{-6}(11b)

● Occupied bandwidth (OBW)



SPA's Setup
Center frequency:
Center frequency of measured signal
Span width:
2 to 3.5 times of the band
RBW: ≤3% of the band
VBW: Same as RBW
Point: ≥400 points
Detection: Positive Peak
Display: Max Hold

The frequency range for 99% of center power out of total power 100% on the measurement screen, excluding 0.5% of power at right and left edges.

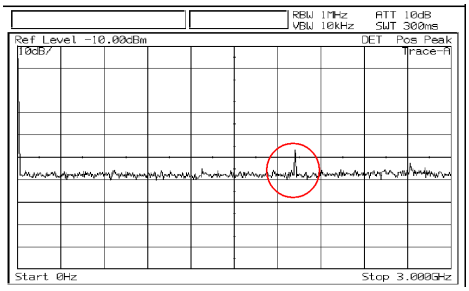
Allowable value ≤18MHz (11a)
≤26MHz (11b)

TELEC Technical Standard Conformity Test Items (2)

● Spurious

in Detection
SPA's Setup
Sweep range:
Up to 3 times of carrier frequency
RBW: 1MHz
VBW: 10kHz
Point: ≥400 points
Detection: Positive Peak
Sweep: Single Sweep
Display: Max Hold

in Measurement
SPA's Setup
Center frequency:
Spurious Frequency
Span width: 0Hz
RBW: 1MHz
VBW: 1kHz
Point: ≥400 points
Detection: Sample
Sweep: Single Sweep



Frequency resolution during detection=Span width ÷ Point
The measurement is performed with narrowed span width in order to acquire the frequency accuracy during measurement.

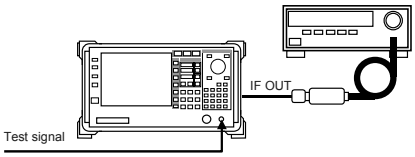
If the spurious level measured during detection is under allowable value, it is regarded as measured value. If the level is beyond allowable value, the measurement is re-performed according to the regulated method.

Allowable value	11a	11b
	≤2.5uW (<5.13GHz)	≤2.5uW (<2.387GHz)
	≤0.2uW (<5.27GHz, ≤5.342GHz)	≤25uW (2.387GHz<2.4GHz)
		≤25uW (>2.4835GHz, ≤2.4965GHz)
	≤2.5uW (>5.342GHz)	≤2.5uW (>2.4965GHz)

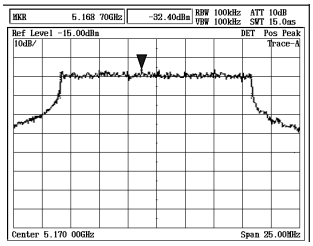
TELEC Technical Standard Conformity Test Items (3)

● Antenna power

SPA is substituted for narrow-band filter to measure the power at 1MHz band.



The in-band frequency at max.level is measured first.



SPA's setup
Center frequency:
Center frequency of the measured signal
Span width: 25MHz(11a)
50MHz(11b)
RBW: 1MHz
VBW: 3 times of RBW
Point: ≥400 points
Detection: Positive Peak
Display: Max Hold
Sweep: Continuous

Power Meter measures SPA's IF output level with the max.level frequency regarded as SPA's center frequency.

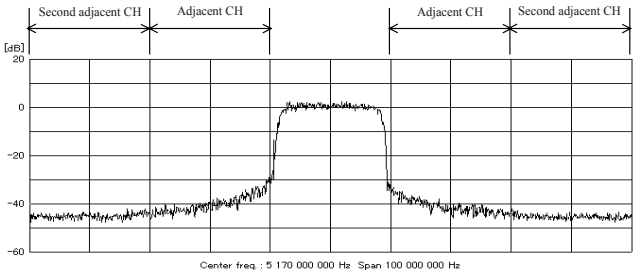
SPA's entire loss and equivalent noise bandwidth of 1MHzRBW are measured beforehand.

SPA's Setup
Center frequency:
Max. power frequency
Span width: 0Hz
RBW: 1MHz
VBW: Same as RBW
Point: ≥400 points
Detection: Positive Peak
Display: Max Hold
Sweep: Continuous

Allowable value Upper +20%
Lower -80%

TELEC Technical Standard Conformity Test Items (4)

● Adjacent channel leakage power



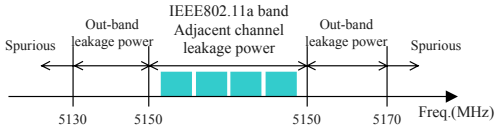
SPA's Setup
Center frequency:
Center frequency of Adjacent CH
Span width: 18MHz
RBW: 300kHz
VBW: 300kHz
Point: ≥400 points
Detection: Sample
Sweep: Continuous
Averaging

The ratio of measurement channel power to adjacent channel/second adjacent channel power is measured.
The power is measured by integrating the data at the points within measured band.

Allowable value ≥25dB within ±9MHz band at 20MHz offset
≥40dB within ±9MHz band at 40MHz offset

TELEC Technical Standard Conformity Test Items (5)

● Out-band leakage power



Out-band leakage power
The power out of the domain defined by 802.11a band and spurious

Measurement method is the same as that of adjacent channel leakage power.

SPA's Setup
Frequency sweep range:
5130 to 5142MHz
5142 to 5150MHz
5250 to 5258MHz
5258 to 5270MHz
RBW: 1MHz
VBW: 10kHz
Detection: Positive Peak
Sweep: Single Sweep

Allowable value
5130 to 5142MHz: ≤2.5uW/MHz
5142 to 5150MHz: ≤15uW/MHz
5250 to 5258MHz: ≤15uW/MHz
5258 to 5270MHz: ≤0.2uW/MHz

● Secondary emissions

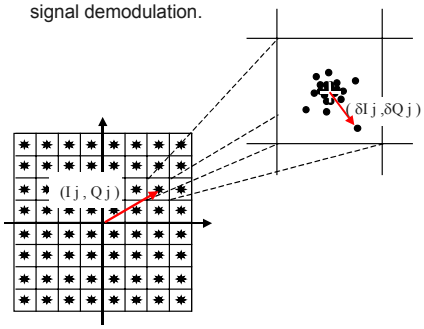
The measurement of unwanted radio emissions during signal reception.

Measurement method is the same as that of spurious measurement.

SPA's Setup
Frequency sweep range:
Up to 3 times of received frequency
RBW: 100kHz(fc<1GHz)
1MHz(fc>=1GHz)
VBW: Same as RBW
Detection: Positive Peak
Sweep: Single Sweep

BER and Modulation Accuracy

❍Modulation accuracy:
The ratio of vector error from ideal constellation point and ideal signal amplitude in the constellation of signal demodulation.



$$Modulation\ Accuracy = \sqrt{\frac{\frac{1}{N}\sum_{j=1}^{N}(\delta I_j^2 + \delta Q_j^2)}{S_{mean}^2}} \times 100\%$$

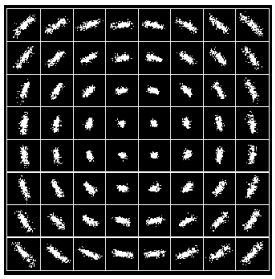
S_{mean}^2 : The average power for total sum of each symbol point.

❍Features of Modulation Accuracy
- Direct evaluation of signal quality
- Short measurement time
- EVM vs C/N characteristic is almost linear
- High C/N sections are evaluated.

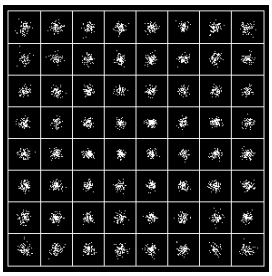
❍BER
- Normally BER itself is not measured and the margin for BER deterioration is measured by additive noise.
- Signal quality is indirectly evaluated (via receiver).
- Time-consuming measurement
- C/N features are non-linear, especially the measurement is difficult with good C/N is
- BER vs C/N characteristic is none-linear.
- High C/N sections are not evaluated.

Constellation

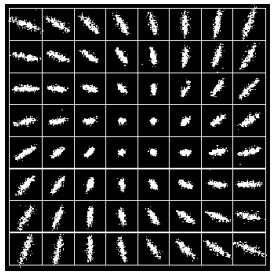
Constellation monitoring helps debugging.



Phase rotation
- Carrier frequency difference
- Symbol clock difference



Point spread
- S/N deterioration



Variation of amplitude direction
- AGC oscillation

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Specifications are subject to change without notice.

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