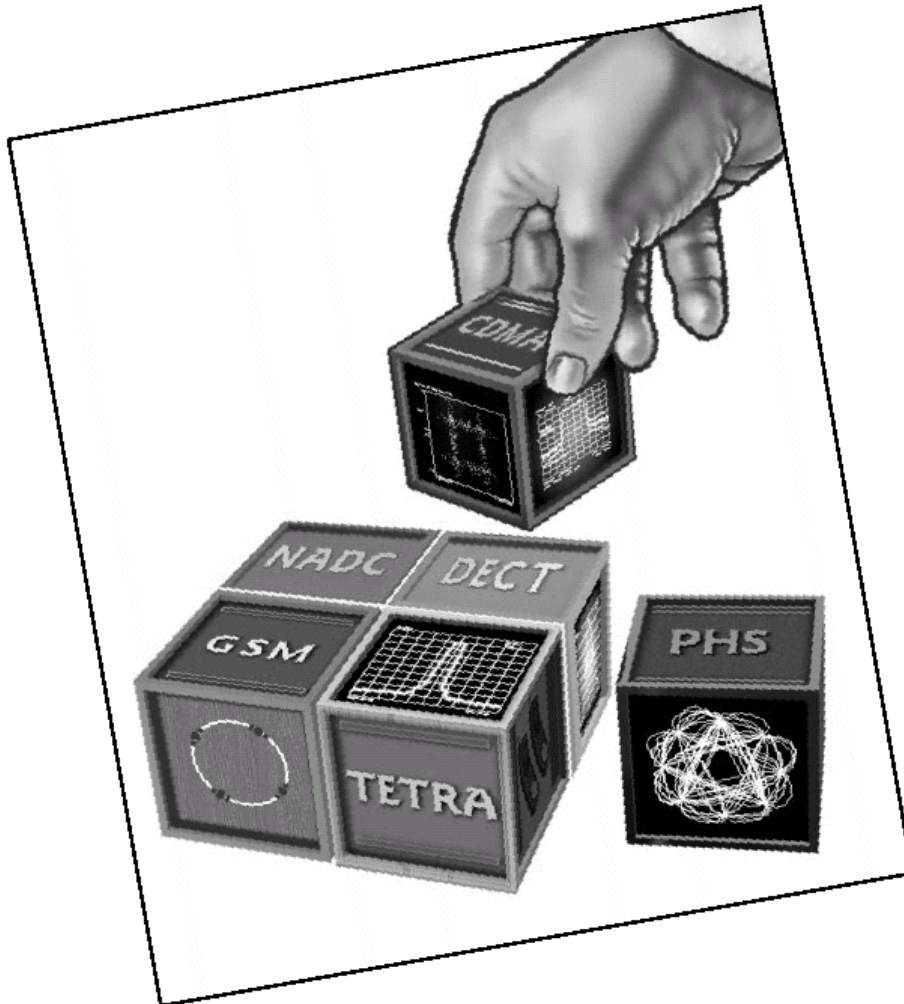


Digital Modulation in Communications Systems – () An Introduction

Application Note 1298



2003.4.23

Translated by &

trade-off

가 (, ,)

가

가 가

가

가

가

(, ,) 가 가

가

가

가

가

가

가 가

RF

trade-off

in-phase(I) quadrature(Q)

()

가

RF

key specification

RF

1. 가?
 - 1.1 Simplicity trade-off
 - 1.2

2. I/Q ()
 - 2.1
 - 2.2
 - 2.3 -
 - 2.4
 - 2.5 I/Q
 - 2.6 I Q
 - 2.7 I Q
 - 2.8 I Q

3.
 - 3.1
 - 3.1.1
 - 3.1.2 ()
 - 3.1.3
 - 3.2 (PSK)
 - 3.3 (FSK)
 - 3.4 (MSK)
 - 3.5 (QAM)
 - 3.6
 - 3.7
 - 3.8 I/Q offset
 - 3.9
 - 3.10 constant amplitude

4.
 - 4.1 Nyquist raised cosine filter

- 4.2 - matched filter
- 4.3 Gaussian filter
- 4.4 Filter bandwidth parameter alpha
- 4.5 Filter bandwidth effects
- 4.6 Chebyshev equiripple FIR filter
- 4.7

5. 가

- 5.1
- 5.2 Constellation diagrams
- 5.3 Eye diagrams
- 5.4 Trellis diagrams

6.

- 6.1 - Frequency
- 6.2 - Time
- 6.3 - Code
- 6.4 - Geography
- 6.5
- 6.6 Penetration vs Efficiency

7. 가

- 7.1
- 7.2

8. RF

- 8.1
- 8.1.1
- 8.2
- 8.2.1
- 8.3
- 8.4
- 8.5 Error Vector Magnitude(EVM)
- 8.6 EVM troubleshooting
- 8.7 Magnitude vs Phase error
- 8.8 I/Q phase error vs Time

8.9 EVM vs Time

8.10 Error Spectrum(EVM vs Frequency)

9.

10.

11.

1. 가?

가

RF

가

가

가

가

1.1 Simplicity

trade-off

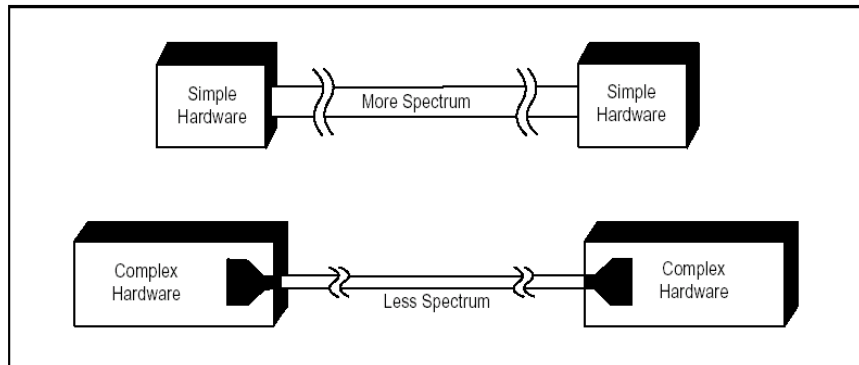
trade-off가

가

가

trade-off

Figure 1.
The Fundamental Trade-off



1.2

가

(AM)

/

(FM/PM)

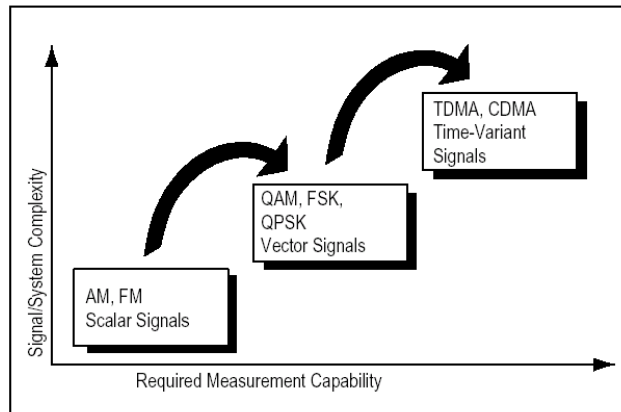
QPSK()

FSK()

MSK()

QAM()

Figure 2.
Trends in the Industry



가 TDMA() CDMA()
가

2.

I/Q

2.1

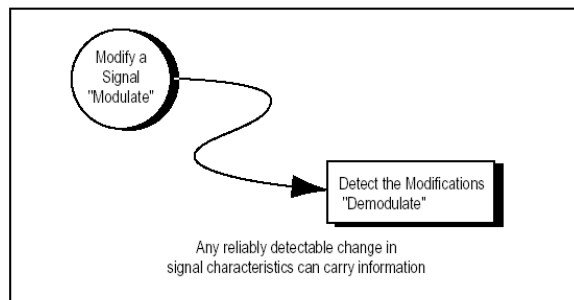
가 가

1.

2.

3.

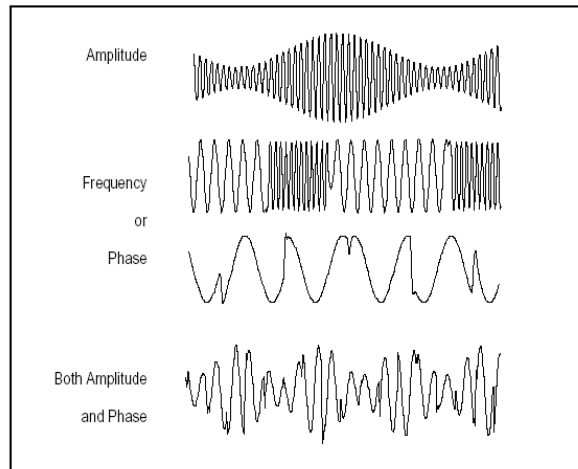
Figure 3.
Transmitting...
(Analog or Digital)



2.2

가 : , ,

Figure 4.
Signal Characteristics
to Modify



AM

(FM)

가

. FM

가

가

가

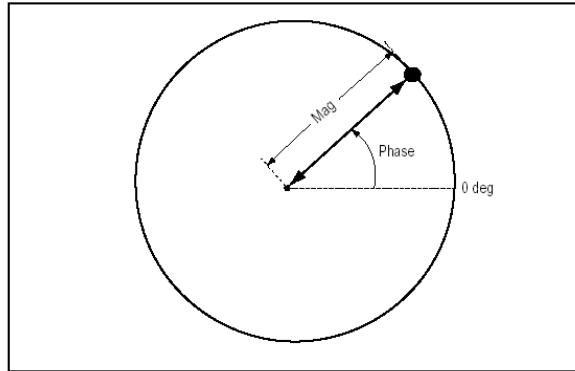
set(I(In-phase) Q(Quadrature))

2.3

)

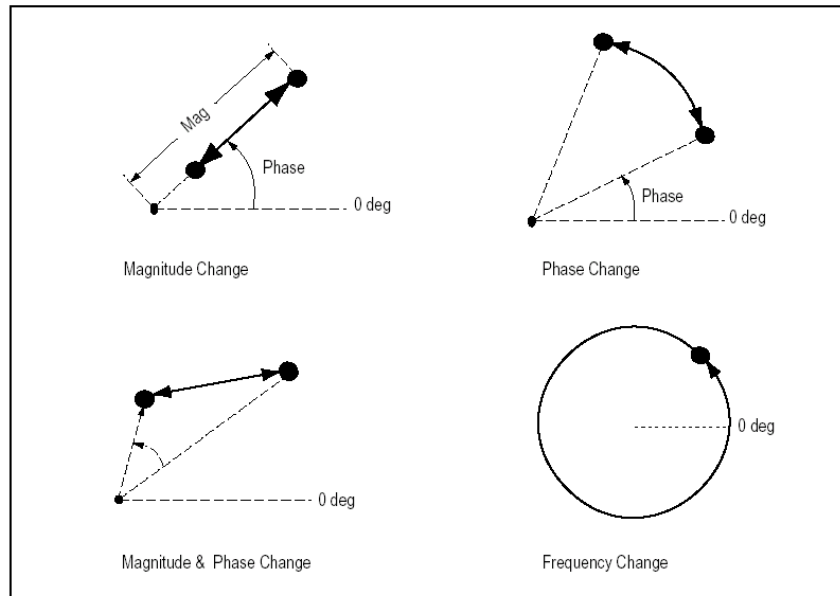
I(In-phase) Q(Quadrature)

Figure 5.
Polar Display -
Magnitude and Phase
Represented Together



2.4

Figure 6.
Signal Changes or
Modifications



(AM)

(PM)

(FM)

가

RF

가

AM

(履歷)

가

가

2.5 I/Q

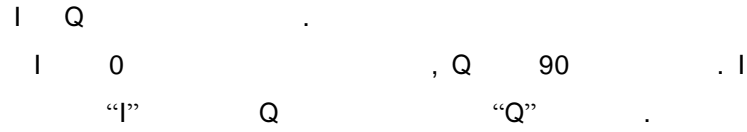
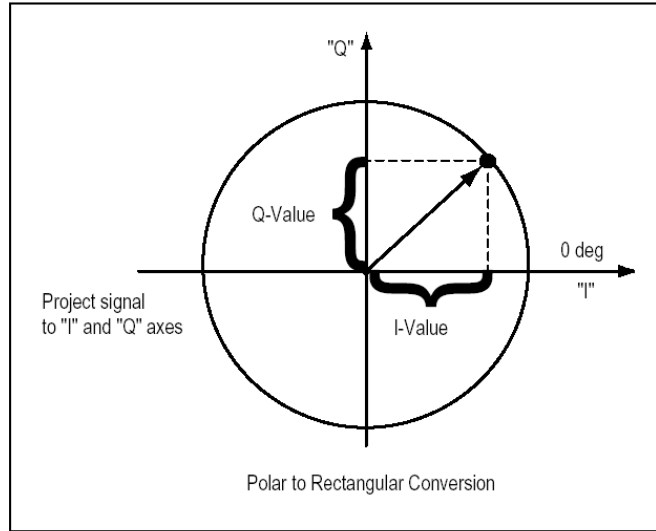


Figure 7. "I-Q" Format



2.6

I/Q

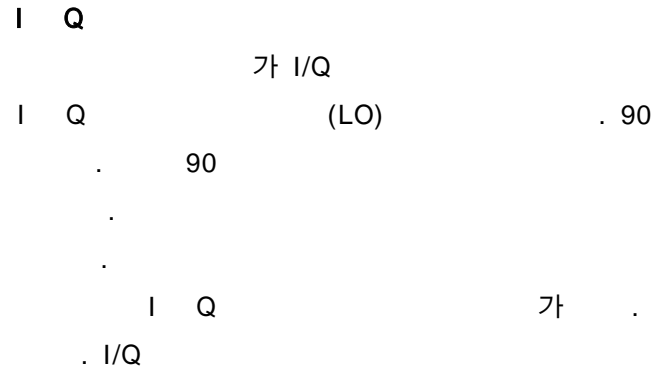
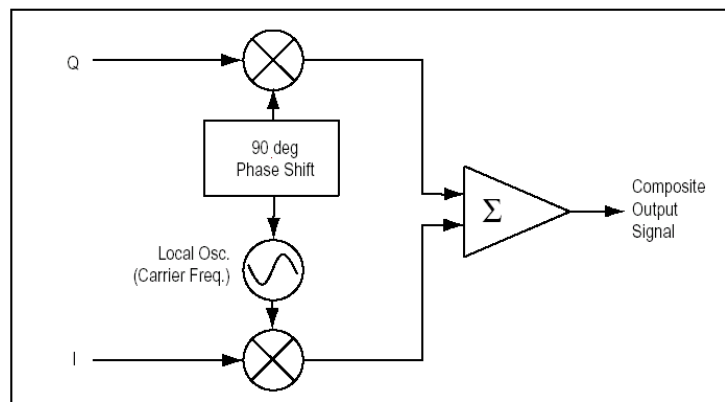


Figure 8. I and Q in a Practical Radio Transmitter



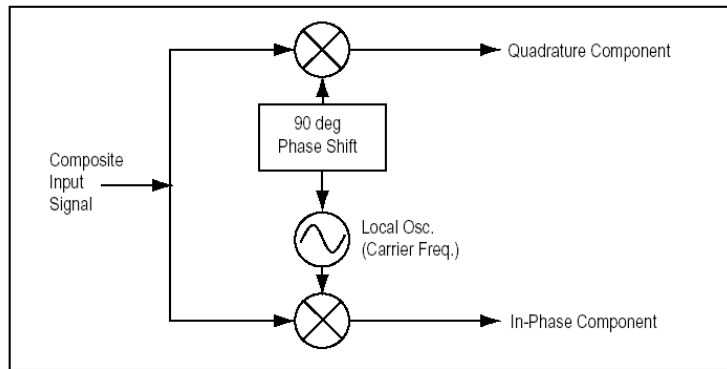
2.7



가
 90
 in-phase, I quadrature, Q 가 ()

in-phase quadrature mixing
 2 가

Figure 9.
I and Q in a Radio Receiver



2.8 I Q 가?

I/Q 가 I/Q
 constellation 가
 가 가
 () AM() PM()
) I/Q I Q 가 wrap I Q
 가

3.

3.1

MSK, GMSK	GSM, CDPD
BPSK	,
QPSK, $\pi/4$ DQPSK	, CDMA, NADC, TETRA, PHS, LMDS, DVB-S, (return path), , TFTS
OQPSK	CDMA,
FSK, GFSK	DECT, paging, RAM mobile data, AMPS, CTI, ERMES, ,
8, 16 VBS	TV(ATV), ,
8 PSK	, ,
16 QAM	, , DVB-C, DVB-T
32 QAM	, DVB-T
64 QAM	DVB-C, , , MMDS
256 QAM	, DVB-C(), ()

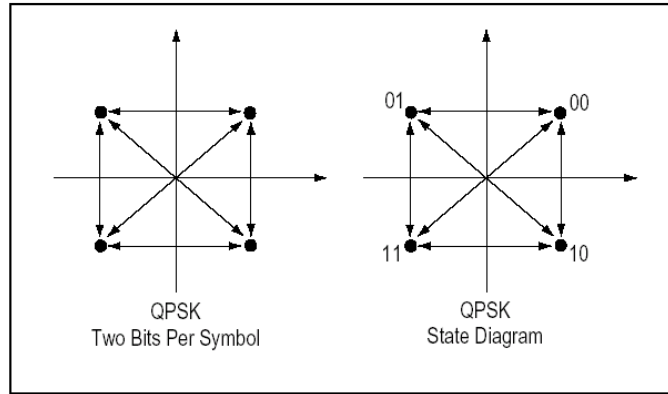
가

3.1.1

symbol rate = bit rate / the number of bits transmitted with each symbol

8 10K (, 10kHz
) 8 가, 80kbps가

Figure 10.
Bit Rate and Symbol
Rate



10

(QPSK)

0 1

가

(BPSK),

80kbps

가

(QPSK),

40kbps가

가

가

RF

3.1.2 ()

가

eight-state Phase

Shift Keying(8PSK)

PSK

(異形)

가

8

가

가

8

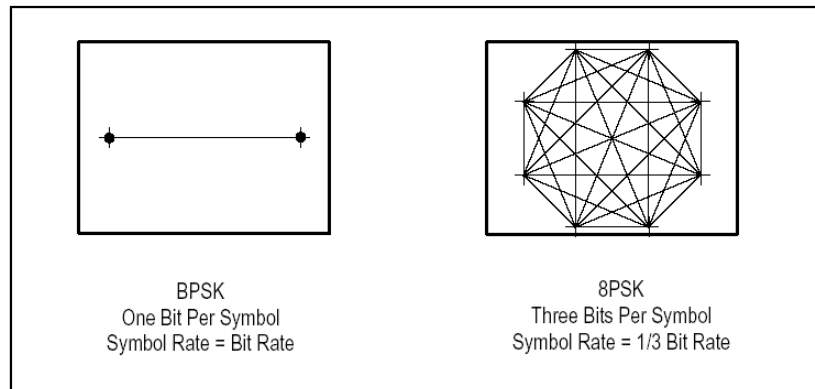
$2^3=8$

3

가

1/3

Figure 11.
Spectrum
Requirements



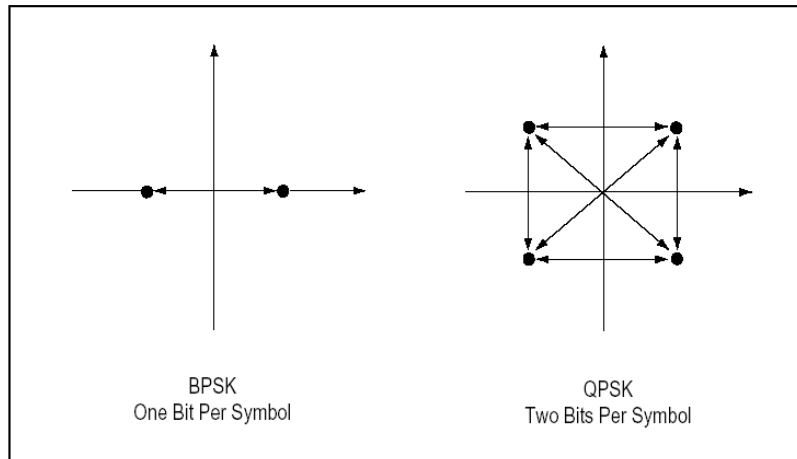
3.1.3

(Constellation) I/Q(/)

3.2 Phase Shift Keying()

가 binary Bi-Phase Shift Keying(BPSK)
 가 Constant amplitude
 0 180 . I Q I
 가 . 가 가 , 0 1
 1 .

Figure 12. Phase Shift Keying



Quadrature Phase Shift Keying(QPSK)

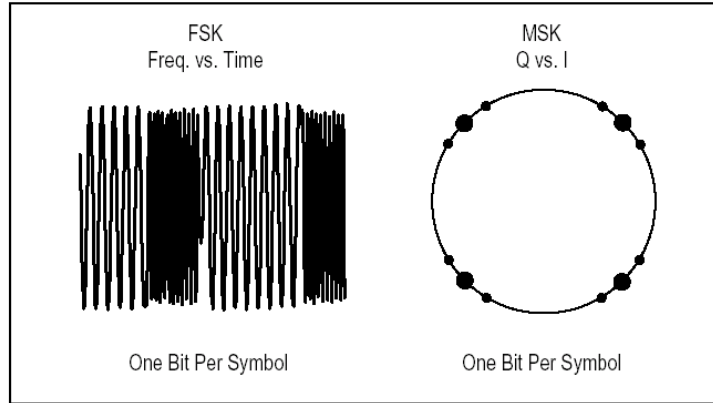
CDMA(Code Division Multiple Access) cellular service, wireless local loop, Iridium(/) DVB-S(digital video broadcasting satellite)

. Quadrature 가 90
 45 135 , -45 , -135 90 가 . I/Q
 bit 가 . $2^2=4$ 가 가 .
 BPSK

3.3 Frequency Shift Keying()

. +1Hz
 360 (2 rad/sec)

Figure 13.
Frequency Shift
Keying



FSK paging

DECT(Digital Enhanced Cordless Telephone) CT2(Cordless Telephone 2)

FSK , ()
 . Binary FSK(BFSK 2FSK) , "1"
 "0"

3.4 Minimum Shift Keying()

가 (advancing) (retarding) ,
 sampling . $(2N+1) / 2$
 I/Q 가 , I polarity
 Q polarity . I
 Q ,
 . I Q $+ - / 2$
 (90) FSK MSK(
) 90
 MSK GSM Communications cellular standard . +90
 가 1 -90 0 . MSK peak-to-peak
 1/2

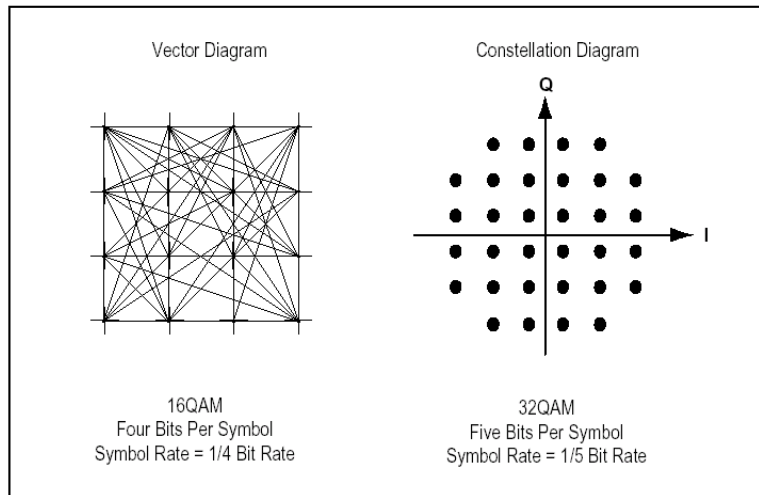
FSK MSK 가 constant envelope .
 ,
 regrowth, . 가
 constant envelope
 . MSK FSK 가 ,
 slew rate 가 ,

가 , 가
 가 . 가
 가 MSK GMSK(Gaussian MSK)

3.5 Quadrature Amplitude Modulation()

QAM . QAM , DVB-C,

Figure 14.
 Quadrature
 Amplitude Modulation



16-state QAM(16QAM) 4 I 4 Q 16
 가 symbol time

. $16=2^4$, 4bits가 I 2bits
 Q 2bits . 1/4 .

. BPSK, QPSK, 8PSK . QPSK

4QAM .

(異形) 32QAM . 36 가 6

I 6 Q . 2 (36 가

가 2 32). 4 (가

) . 가 peak power

. $2^5=32$ 5bits가 1/5 .

512 1024QAM
 256QAM . 256QAM 256 가 16 I 16 Q

. $2^8=256$ 8 . 8

256QAM . 가

가 . 가

3.1.1 (10kHz 8)
 256QAM vs BPSK . BPSK 1
 80Ksymbols가 . 256QAM 8
 10Ksymbols가 . 256QAM BPSK 1/8
 BPSK 8 .
 trade-off가 . 가
 , QAM
 QPSK 가 . degradation()
 가 .
 , 가 ,
 . 가
 , , . Degradation ,
 , , .
 I Q ,
 . QPSK
 가 가 . QPSK 4
 가 . QPSK
 QAM .

3.6

가

Modulation format	Theoretical bandwidth efficiency limits
MSK	1 bit/second/Hz
BPSK	1 bit/second/Hz
QPSK	2 bits/second/Hz
8PSK	3 bits/second/Hz
16 QAM	4 bits/second/Hz
32 QAM	5 bits/second/Hz
64 QAM	6 bits/second/Hz
256 QAM	8 bits/second/Hz

가 () 가 ,

(GSM) .

(先)

NADC, PDC

raised cosine filter , PHS

3.7

가 .

North American Digital Cellular(NADC)

TDMA version

30kHz

48Kbits

, 1.6bits/sec/Hz

/4 DQPSK

2

2bits/sec/Hz

1.6bits/sec/Hz

16QAM

QPSK

가

line-of-sight microwave link

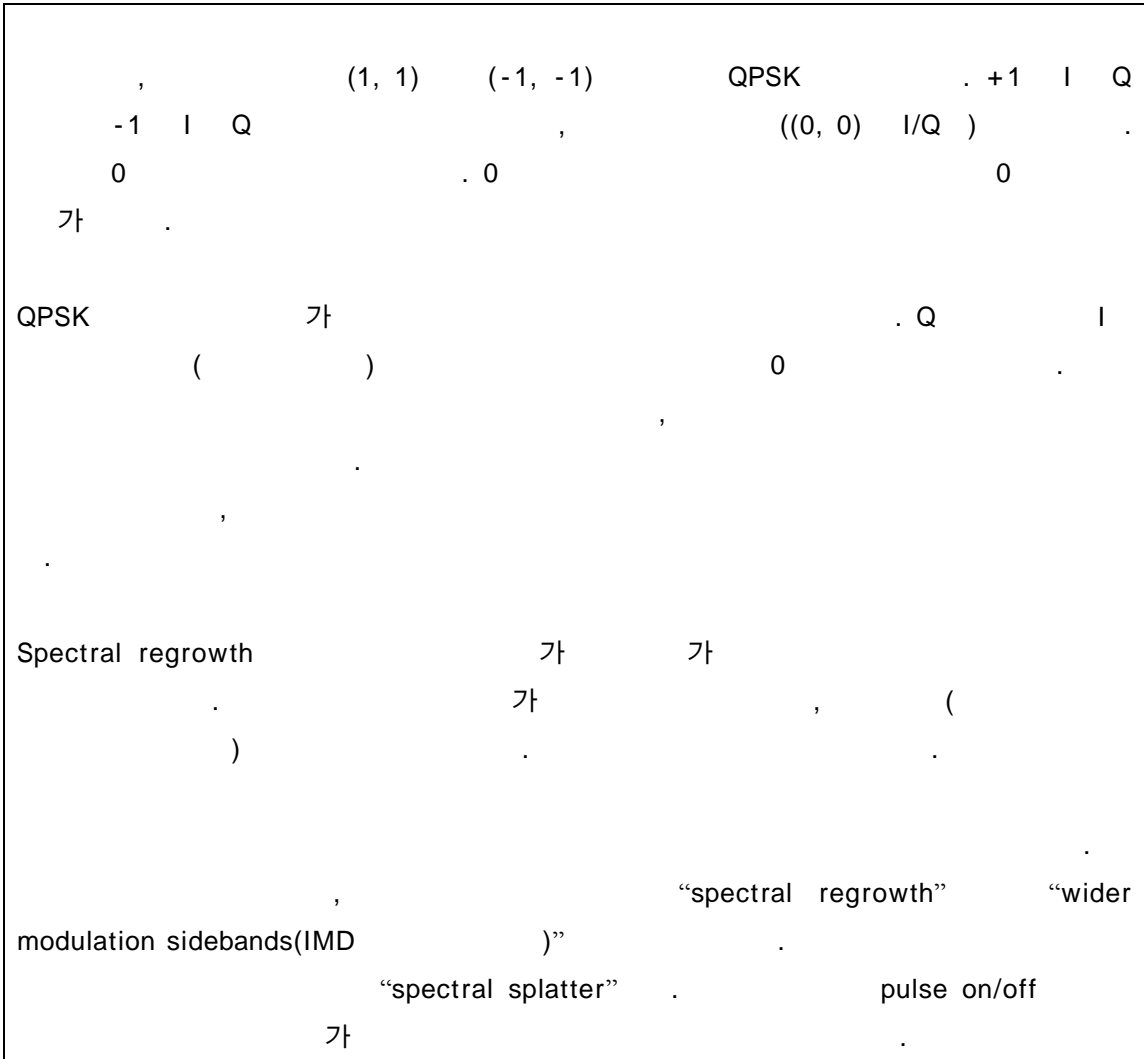
52.5MHz

140Mbits

line-of-

sight

가



– (異形)

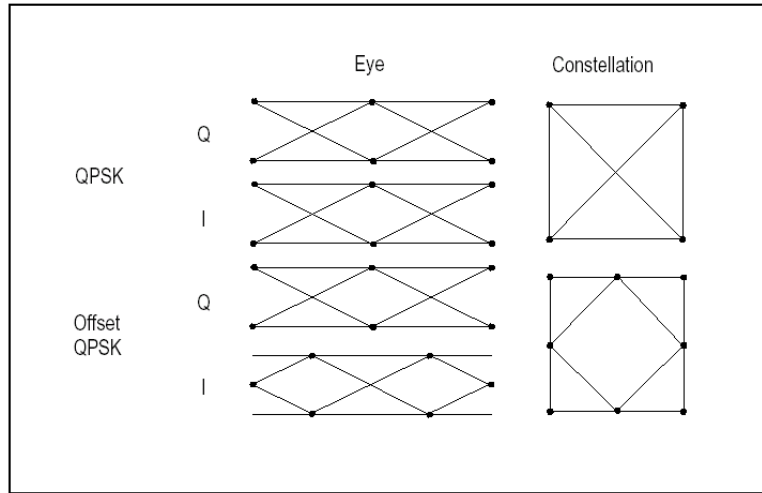
3.2 3.4

가 (異形) : I/Q offset , differential , constant envelope .

3.8 I/Q offset

(異形) offset . 가 Offset QPSK(OQPSK) .
 () CDMA .

Figure 15.
I-Q "Offset"
Modulation



QPSK , I Q . , I Q digital signal clock
 . Offset QPSK(OQPSK) , I Q 1 ()
 1/2) . offset .
 . I Q 가 offset ,
 constellation .
 I/Q . OQPSK
 clock offset (constellation)
 (QPSK 30 40dB OQPSK
 3dB) RF power amp가 .

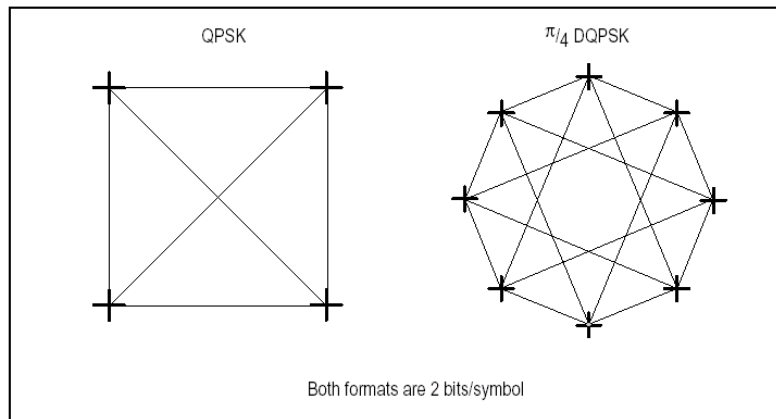
3.9 Differential modulation

(異形) Differential QPSK(DQPSK) Differential 16QAM(D16QAM)
 Differential modulation . Differential 가
 . 가
 /4 DQPSK . DQPSK
 . /4 DQPSK

- Cellular
 - NADC-IS-54(North American Digital Cellular)
 - PDC(Pacific Digital Cellular)
- Cordless
 - PHS(Personal Handyphone System)
- trunked radio
 - TETRA(Trans European Trunked Radio)
- /4 DQPSK 45 (/4) QPSK constellation offset

constellation constellation
 constellation
 /4 DQPSK 가
 가 root raised cosine filtering
 /4 DQPSK GMSK,

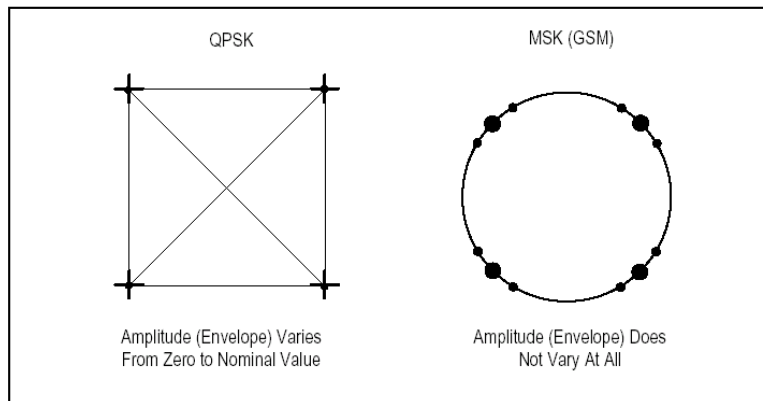
Figure 16.
 "Differential"
 Modulation



3.10 Constant amplitude modulation()

(異形) constant-envelope GSM 0.3GMSK

Figure 17.
 Constant Amplitude
 Modulation



Constant-envelope

degradation()

C 가

constant-envelope

BPSK QPSK

constant-envelope 가

MSK(3.4) peak-to-peak 1/2
FSK

GMSK Gaussian filter
MSK Gaussian filter

GMSK
constant-envelope, BER 가

4.

가 가

raised cosine
square-root raised cosine
Gaussian filters

(I Q) FDMA
가

가 trade-off가 가
Nyquist

가 가

()

trade-off

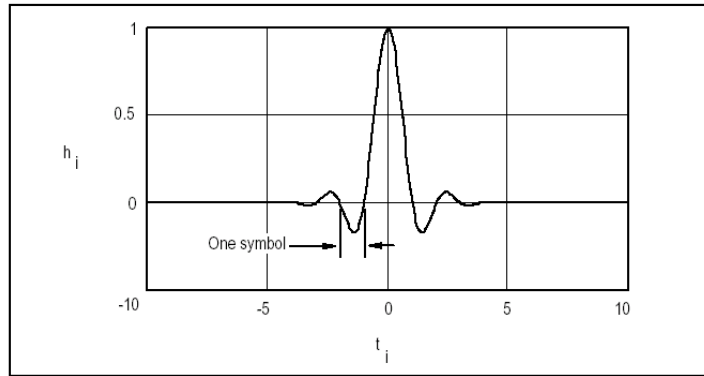
Inter-Symbol Interference(ISI)

가

4.1 Nyquist raised cosine filter

raised cosine filter, Nyquist filter 가
 . Nyquist filter
 가

Figure 18.
 Nyquist or Raised
 Cosine Filter



0

. Nyquist filter

Inter-Symbol Interference

. Inter-Symbol Interference ()

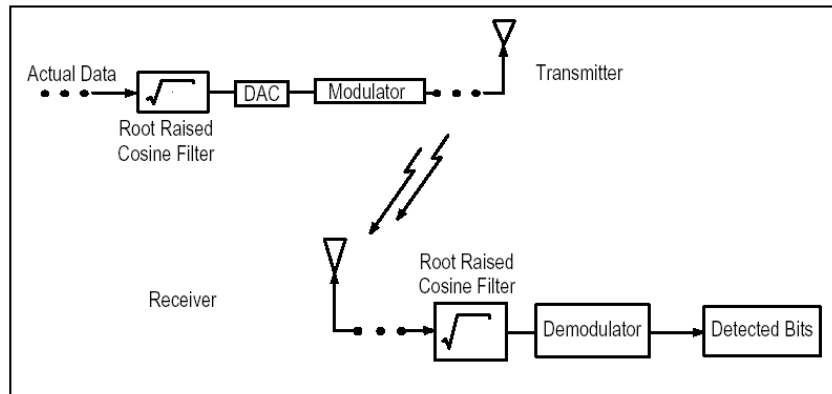
root Nyquist filter(root raised cosine)

Nyquist filter

4.2 / matched filter

가

Figure 19.
Transmitter-Receiver
Matched Filters



0 Inter-Symbol Interference(ISI)

full Nyquist filter가

root-Nyquist filter가 Nyquist x Nyquist = Nyquist

Matched filter Gaussian filtering

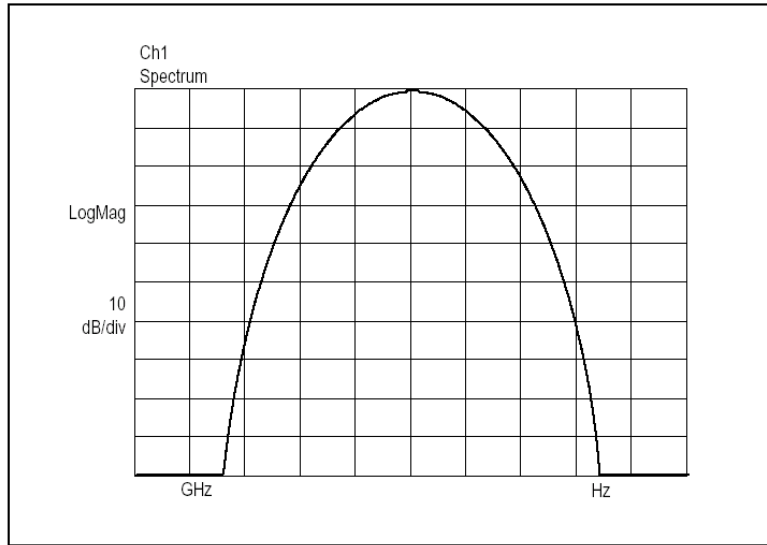
4.3 Gaussian filter

GSM GSM Gaussian filter가 0 Inter-Symbol Interference 가

17

Inter-Symbol Interference가

Figure 20.
Gaussian Filter



Gaussian filter

. Gaussian filter

cosine filter

, ,

Gauss

GSM

raised

(ISI).

4.4 filter bandwidth parameter alpha

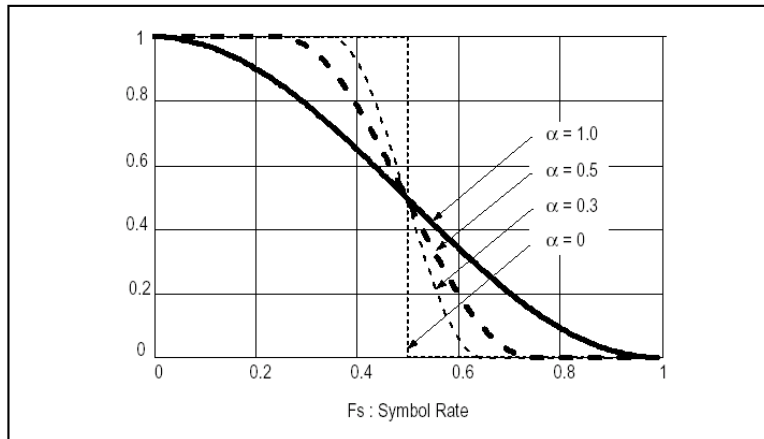
raised cosine filter 가 () alpha . Alpha

$$\text{Occupied bandwidth} = \text{symbol rate} \times (1 + \alpha)$$

가 0 alpha brick wall 가

for alpha=0, occupied bandwidth = symbol rate x (1+0) = symbol rate

Figure 21.
Filter Bandwidth
Parameters "α"



0 alpha 가

Alpha

가 alpha "excess bandwidth factor"

, 1 alpha 가 (가)

For alpha=1, occupied bandwidth = symbol rate x (1+1) = 2 x symbol rate

Alpha가 1 0 2 , 0.2 alpha 가

0.11 alpha 0.35 0.5 Gaussian filter BT(bandwidth time product) Gaussian filter

BT 0 0.3 0.5 BT

4.5

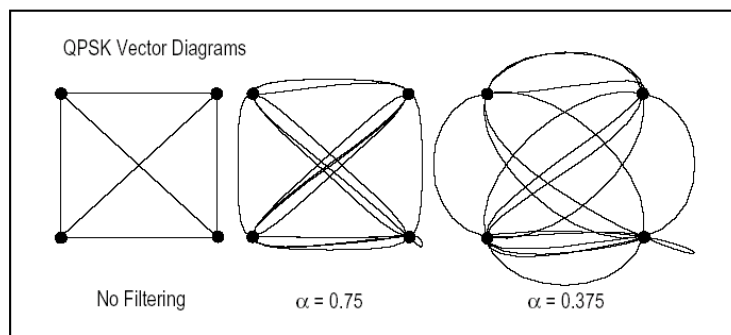
가 , QPSK alpha

가 가

가 가

alpha가

Figure 22. Effect of Different Filter Bandwidth



. 가 alpha가 0.75

alpha가 0.375 . 0.75

0.375 alpha

가

alpha

alpha

가

NADC(IS-54) /4 DQPSK . 1.0 alpha ,
 alpha
 . Alpha가 0.5 , 가 2
 1.5 . 25%
 alpha
 constellation

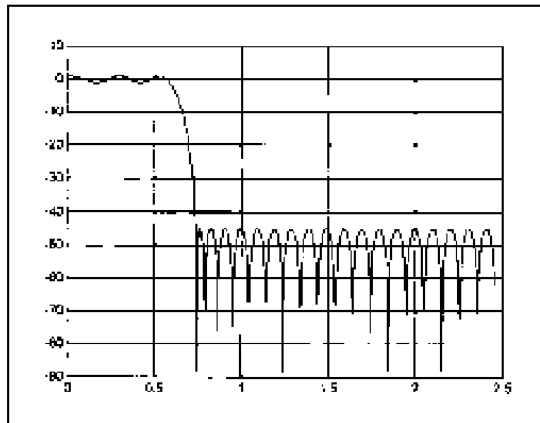
Alpha가 0.2 , ,
 . Nyquist filtering
 QPSK 0.2 alpha 5dB .
 3 .

QPSK, offset QPSK, DQPSK 16QAM, 32QAM, 64QAM, 256QAM
 QAM 가
 FSK, MSK constant-envelope

4.6 Chebyshev equiripple FIR(finite impulse response) filter

Chebyshev equiripple FIR(finite impulse response) filter IS-95 CDMA baseband
 filtering . IS-95 CDMA 1.25MHz,
 1.2288MHz RF . 0.113
 alpha shape factor 가
 . Equiripple () “rippled”
 magnitude frequency-response envelope . FIR
 shape factor Nyquist filter . IS-95 FIR filter
 0 Inter-Symbol Interference(ISI) . CDMA ISI
 64chips correlation
 . “coding gain” ISI .

Figure 23.
Chebyshev Equiripple
FIR Filter



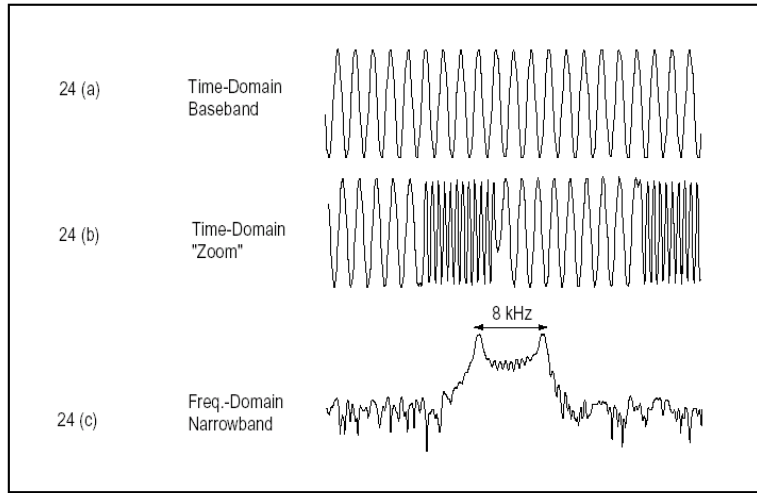
4.7

RF
가
가 narrower filter 가
alpha narrower filter ISI 가
RF 가
constant-envelope 가 C
가 , , , , ,

5.

가 가 , 930.004MHz
RF pager signal . Pager two-level FSK 8kHz
930.000MHz 930.008MHz
930.004MHz 24(a)
930MHz 930MHz + 8kHz period
가 가

Figure 24.
Time and Frequency
Domain View



Pager receiver IF baseband down conversion
 , 930.004MHz FSK 930.002MHz mix FSK
 930.000MHz 930.008MHz
 -2kHz +6kHz 가 baseband signal -2kHz
 +6kHz

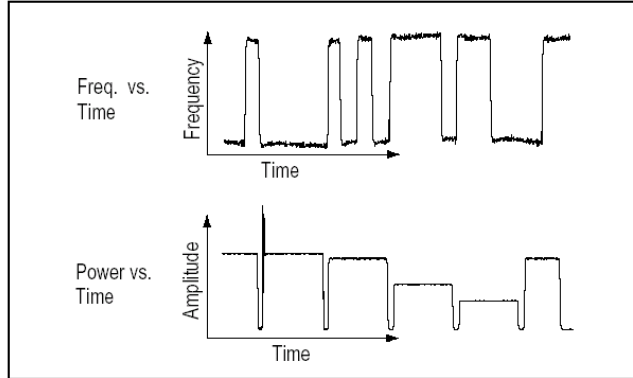
“zoom” time IF time
 IF baseband band-converted signal IF time IF
 가 representation 24(c) bits
 two-level FSK scheme FSK pager
 / 가 가

5.1

가 가 가 turn on off
 , power-versus-time pulsed bursted carrier
 power level ,
 regrowth “splatter”
 on
 turn on burst bit error rate 가,
 peak power average power level

compression clipping
 spectrum regrowth

Figure 25.
 Power and Frequency
 View



5.2 Constellation diagram

, rectangular I/Q diagram

2

rectangular

in-

phase(I) quadrature(Q)

AM PM

가

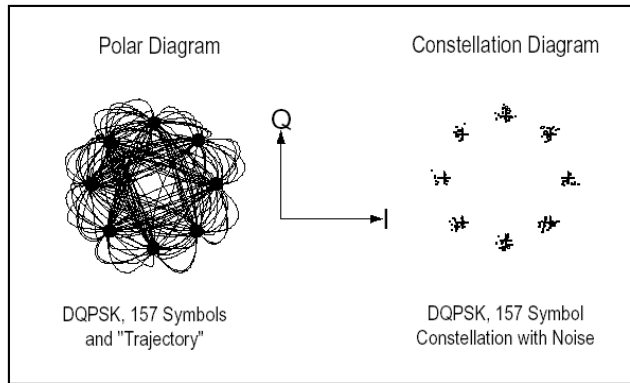
rectangular, linear set of values(I

set Q

set)

가

Figure 26.
 Constellation Diagram



NADC TDMA standard

/4 DQPSK

157-symbol DQPSK burst

symbol time

(I/Q /)

Constellation diagram

burst

. Constellation diagram

(display) 가
 Constellation diagram power level, filtering , ISI

Constellation bit per symbol

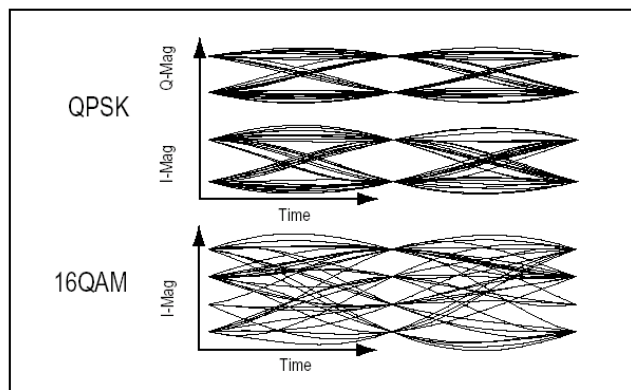
$M=2^n$, M constellation , n bits/symbol, $n = \log_2 M$

가 constellation

5.3 Eye diagrams

eye diagram . Eye diagram I Q . Eye diagram I Q . I Q . I Q . QPSK Quadrant() . I Q . I Q . eye . I/Q . I Q . eye . scheme trace가 . 가 “eyes” . 가 16QAM . Eye . “good” . 가 wide open eyes .

Figure 27. I and Q Eye Diagrams

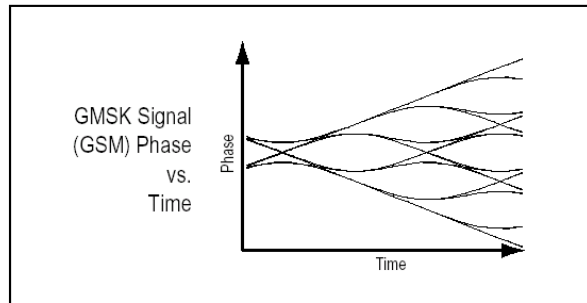


5.4 Trellis diagrams

“trellis” diagram . Trellis diagram X , Y . 가 GSM GSM 90 + 가 0 , 90 .

가 , trellis diagram (I/Q) missing transitions, missing codes, blind spot

Figure 28. Trellis Diagram



6.

RF

()
 ()
 frequency, time, code geography

6.1 - Frequency

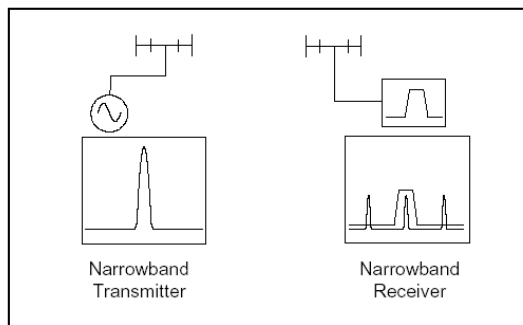
FDMA

가

1900

가

Figure 29. Multiplexing - Frequency



6.2

- Time

가

Time Division Duplex(TDD)

, TDD ()

Simple two-way radio

. CT2 DECT

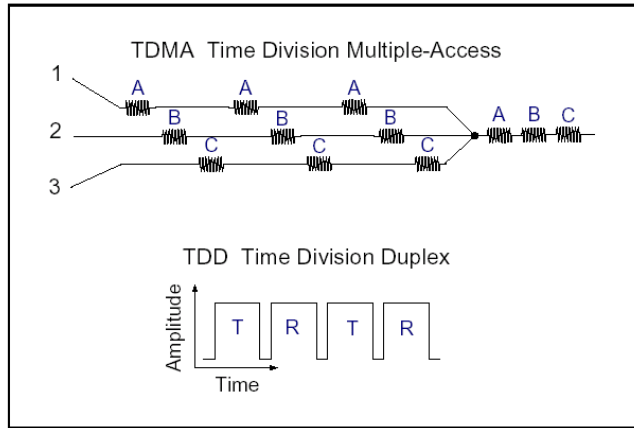
TDD

. TDMA

. TDMA GSM

US NADC-TDMA

Figure 30. Multiplexing - Time



6.3 - Code

CDMA 가

가

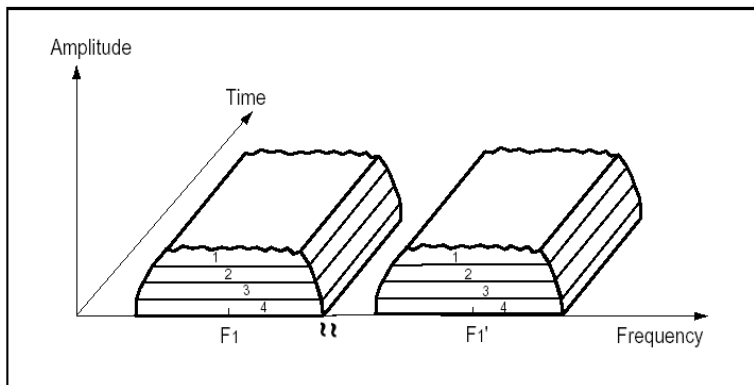
1.23MHz

. US CDMA

가

가

Figure 31. Multiplexing - Code



CDMA

가 terminal

correlation

64

6.4 - geography

geographical cellular

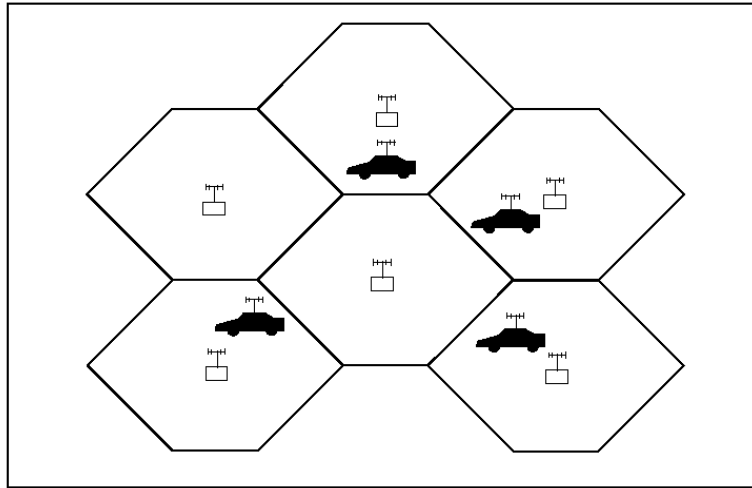
/

. Geographic

. Clear-

channel international broadcast stations, amateur stations,
geographic 가

Figure 32.
Multiplexing
- Geography



6.5

, GSM FDMA, TDMA, FDD, Geographic . DECT FDMA, TDD,
Geographic . 10

6.6 Penetration vs Efficiency

Penetration

Pager() vs . ,
가
) two-level FSK 가 () ,
가

, Pager signal penetration .
(500 1200) . 270,833 (8kHz) GSM
ASCII pager 가 가 .
/4 DQPSK 0.3GMSK

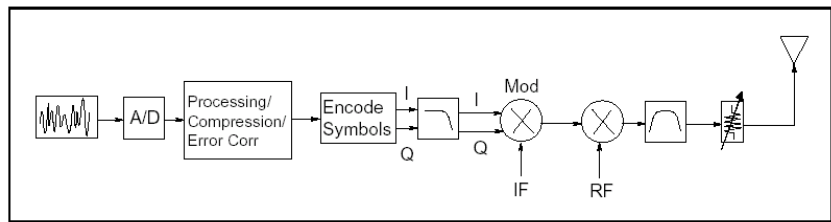
penetration

가
가

7. 가

7.1

Figure 33.
A Digital Transmitter



가

가

traing sequence

(

(constellation)

I/Q(, /)

가 (

)

가

가

가 . I Q

I Q

I

Q

가

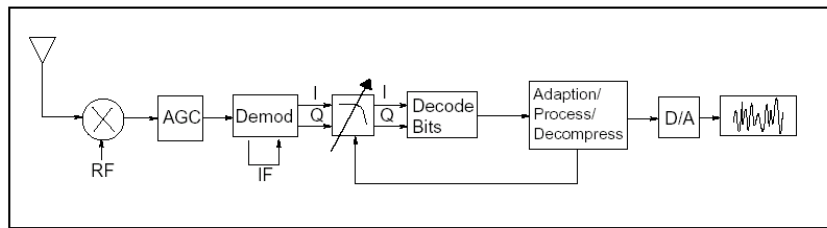
가 . I Q

Up conversion (RF) (IF) 가 / (RF)

7.2

(RF) (IF) down conversion 가 , competing ,

Figure 34. A Digital Receiver



1. (carrier lock)
2. (symbol lock)
3. I Q
4. I Q ("slicing")
5. Decoding de-interleaving
6. Original bit stream
7. -

가 () ()

10101010101010

Pulsed carrier

turn-on

8. RF

interference-free, trade-off가 trade-off RF

BER

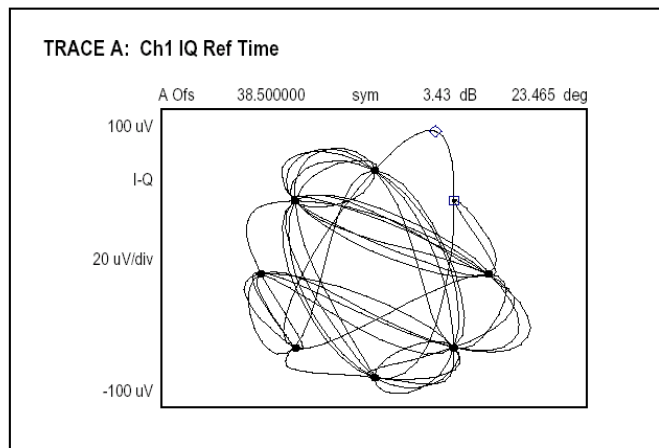
RF

가

8.1

(PSD) (PSD) PSD
1Hz

Figure 35. Power Measurement

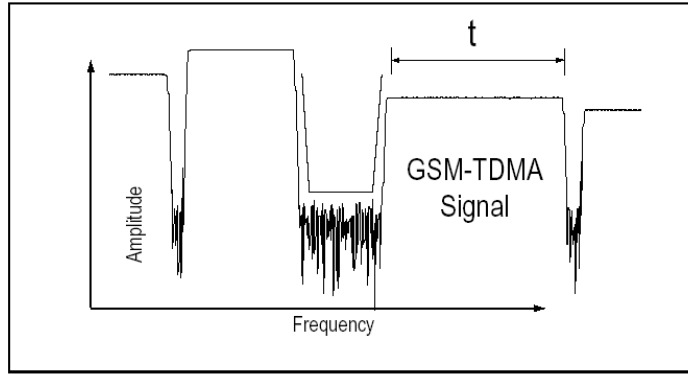


8.1.1

RF

(dB)

Figure 36.
Power and Timing
Measurements

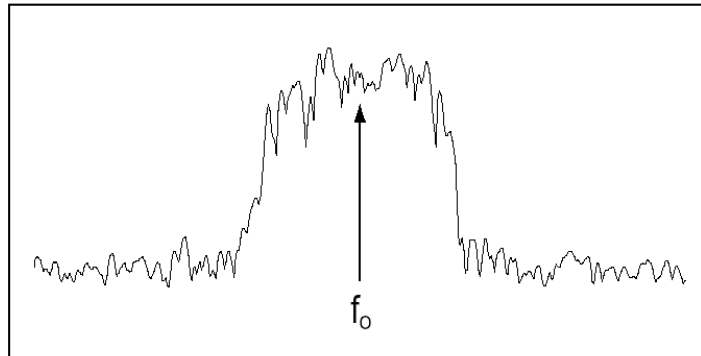


Pulsed system(TDMA) , 가 ,
가 . Burst power profile(power versus time) turn-on turn-off times
가 on on/off cycle

8.2

() 가
가
가

Figure 37.
Frequency
Measurements



8.2.1

(BW) (本) 가
Hz
,
99% (integrated band power)
99% 30kHz 가 99%
30kHz

Constellation diagram

(BPSK, 16QAM, /4 DQPSK)

phasor

ideal, "reference" phasor

phasor

EVM

38 EVM
phasor end point

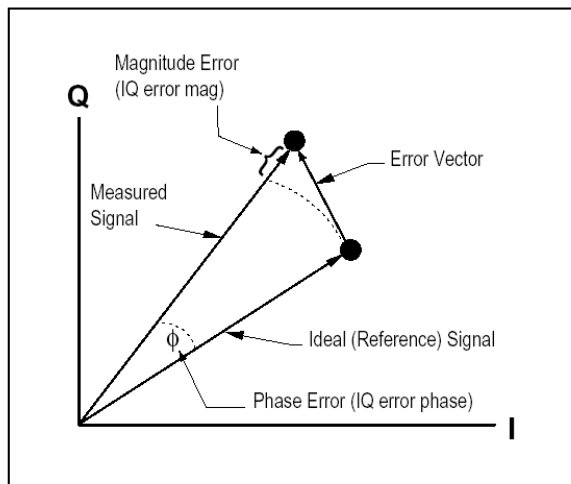
가 (項)

, EVM

scalar ((差) vector)

ideal version

Figure 38.
EVM and Related
Quantities



NADC-TDMA(IS-54)

, EVM

. /4

DQPSK

. IS-54

EVM

EVM

64QAM

. EVM

(가)

가 ()

가

가

turn out

(

) constellation

(

)

phasor

phasor (I/Q) ()
) 가 , I-Q
 . Standard EVM -
 root-mean-square(RMS)

8.6 Error vector

Error Vector Magnitude ,

degradation

error-vector-magnitude

product note 89400-14

5965-

2898E

EVM

NADC PHS

8.7 Magnitude vs Phase error

(, ,)

(38)

()가 ()

frequency reference, phase-locked loops,

, spurious cross-coupling

AM

8.8 I/Q phase error vs Time

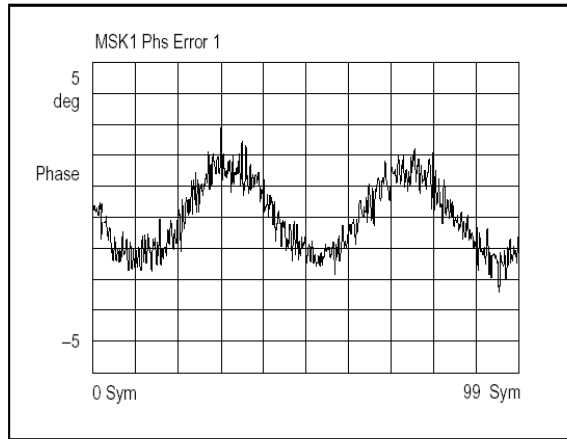
) ,

PM

가

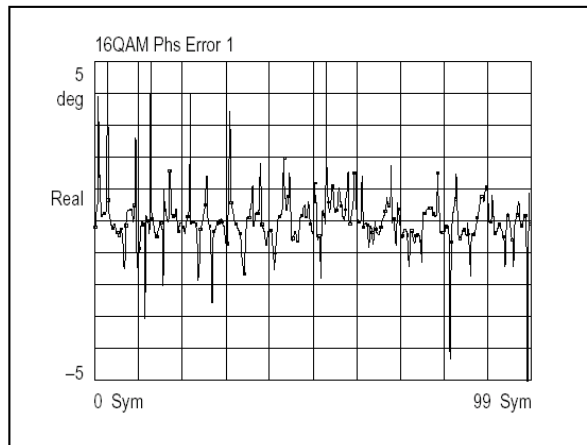
(random jitter, PM/FM)

Figure 39.
Incidental (inband)
PM sinewave is
clearly visible even at
only three degrees
peak-to-peak.



uniform constellation 가 . I/Q
constellation “square” , Q 가 I
. Quadrature() constellation “tilt”
I Q 가 90 가 .

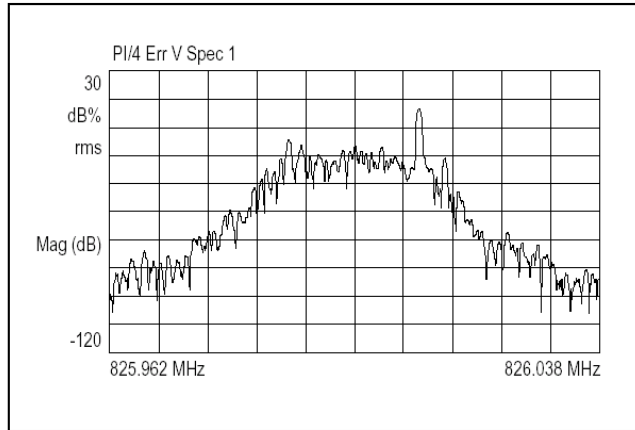
Figure 40.
Phase noise appears
random in the time
domain.



8.9 Error Vector Magnitude vs Time

EVM ideal, reference
, peak zero-crossing
. EVM () . Signal peak
Error peak compression clipping . Signal minima
error peak zero-crossing nonlinearity .

Figure 43.
Switching-power-
supply interference
appears as EVM
spur, offset from
carrier by 10kHz.



EVM product note 89400-14 “Using Error-Vector-Magnitude Measurements to Analyze and Troubleshoot”
 5965-2898E

9.

가 가
 가

trade-off

10. Overview of communications systems

	<u>GSM900</u>	<u>NADC</u>	<u>PDC</u>	<u>CDMA</u>
Geography	Europe	North America	Japan	North America, Korea, Japan
Introduction	1992	1992	1993-1994	1995-1997
Frequency Range	935-960 MHz down 890-915 MHz up EGSM 925-960 MHz 880-915 MHz	869-894 MHz down 824-849 MHz up	810-826 MHz down 940-956 MHz up 1777-1801 MHz down 1429-1453 MHz up	824-849 MHz (US) 869-894 MHz (US) 832-834, 843-846, 860-870 MHz (Japan) 887-889, 898-901, 915-925 MHz (Japan)
Data Structure	TDMA	TDMA	TDMA	CDMA
Channel per Frequency	8-16	3-6	3-6	32-64 (Dyn. adapt)
Modulation	0.3 GMSK (1 bit/symbol)	$\pi/4$ DQPSK (2 bits/symbol)	$\pi/4$ DQPSK (2 bits/symbol)	Mobile: QPSK Base: OQPSK (1 bit/symbol)
Speech CODEC	REL-P-LTP 13 Kbits/s	VSELP 8 Kbits/s EFR	VSELP 8 Kbits/s	8 Kbits/s var rate CELP 13 kbit/s var rate CELP
Mobile Output Power	3.7mW to 20W	2.2mW to 6W	.3W to 3W	10nW to 1W
Modulation Data Rate	270.833 Kbits/s (1 bit/symbol)	48.6 Kbits/s (2 bits/symbol)	42 Kbits/s (2 bits/symbol)	9600/14,400 bps data; 1.2288 Mb/s spreading
Filter	0.3 Gaussian	SQRT raised cosine $\alpha = .35$	SQRT raised cosine $\alpha = .50$	Chebyshev low pass (FIR)
Channel Spacing	200 kHz	30 kHz	50 kHz 25 kHz interleave	1.23 MHz
Number of Channels	124 frequency ch. w/8 timeslots per ch. (1000)	832 frequency ch. w/3 users per ch. (2496)	1600 frequency ch. w/3 users per ch. (4800)	19-20 frequencies
Est # of Subscribers by year 2000	15-20 million	35-40 million (8.9 million 9/92)	5 million	
Source	GSM Standard	IS-54	RCR Spec Std 27B	IS-95 spec
Service	Public Cellular	Public Cellular	Public Cellular	Public Cellular

10. Overview of communications systems

	<u>DCS1800</u>	<u>PHS</u>	<u>DECT</u>	<u>TETRA</u> Trans European Trunked Radio
Geography	Europe	Japan/China	Europe/China	Europe
Introduction	1993	1993 Private office 1995 Public	1993	1995
Frequency Range	1.7-1.9 GHz 1710-1785 MHz down 1805-1880 MHz up	1895-1918 MHz up/down 1.9, 1.93 GHz (China)	1.897-1.913 GHz 1.9, 1.93 GHz (China)	450 MHz < 1 GHz
Data Structure	TDMA	TDMA/TDD	TDMA/TDD	TDMA
Channel per Frequency	8-16	4-8	12	4
Modulation	0.3 GMSK (1 bit/symbol)	$\pi/4$ DQPSK (2 bits/symbol)	0.5 GFSK ± 202 -403 kHz dev (1 bit/symbol)	$\pi/4$ DQPSK
Speech CODEC	REL-P-LTP 13 Kbits/s	ADPCM 32 Kbits/s	ADPCM 32 Kbits/s	Includes channel & speech coding 7.2 Kbits/s
Mobile Output Power	250mW to 2W	10mW	250mW	
Modulation Data Rate	270.833 Kbits/s	384 Kbits/s	1.152 Mbit/s	19.2 Kb/s
Filter	0.3 Gaussian	SQRT raised cosine $\alpha = .50$	0.5 Gaussian	$\alpha = 0.4$ SQRT raised cosine
Channel Spacing	200 kHz	300 kHz	1.728 MHz	25 kHz
Number of Channels	3000-6000		10 carrier frequencies w/12 users per frequency (120)	
Est # of Subscribers by year 2000	4-13 million	6.5-13 million		
Source	prl-ETS 30 176 prETS 300 175-2	RCR spec Std 28 China-First News Release 8/15/96	CI Spec., Part 1, Rev 05.2e China-First News Release 8/15/96	Mobile Europe Magazine 1/92
Service	Personal Communications	Cordless Telephone Personal Communications	Wireless PBX	Trunked system Adj. ch. sel > 60 dB

11. Glossary of terms

ACP	Adjacent Channel Power
ADPCM	Adaptive Digital Pulse Code Modulation
AM	Amplitude Modulation
AMPS	Advanced Mobile Phone System
B-CDMA	Broadband Code Division Multiple Access
BER	Bit Error Rate
BPSK	Binary Phase Shift Keying
BFSK	Binary Frequency Shift Keying
BW	Bandwidth
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
COFDM	Coded Orthogonal Frequency Division Multiplexing
CRC	Cyclic Redundancy Check
CT2	Cordless Telephone - 2
DAB	Digital Audio Broadcast
DCS 1800	Digital Communication System - 1800 MHz
DECT	Digital Enhanced Cordless Telephone
DMCA	Digital MultiChannel Access, similar to iDEN
DQPSK	Differential Quadrature Phase Shift Keying
DSP	Digital Signal Processing
DVB-C	Digital Video Broadcast - Cable
DVB-S	Digital Video Broadcast - Satellite
DVB-T	Digital Video Broadcast - Terrestrial
EGSM	Extended Frequency GSM
ERMES	European Radio Message System
ETSI	European Telecommunications Standards Institute
EVM	Error Vector Magnitude
FDD	Frequency Division Duplex
FDMA	Frequency Division Multiple Access
FER	Frame Error Rate
FFSK	Fast Frequency Shift Keying
FFT	Fast Fourier Transform
FLEX	4-level FSK-based paging standard developed by Motorola
FM	Frequency Modulation
FSK	Frequency Shift Keying
GFSK	Gaussian Frequency Shift Keying
Globalstar	Satellite system using 48 low-earth orbiting satellites
GSM	Global System for Mobile Communication
GMSK	Gaussian Minimum Shift Keying
HDTV	High Definition Television
iDEN	integrated Dispatch Enhanced Network (Motorola designed system for dispatch, cellular and conference calling)

11. Glossary of terms (cont'd)

IF	Intermediate Frequency
I/Q	In phase / Quadrature
Iridium	Motorola voice/data 66-satellite system worldwide
ISI	Intersymbol Interference
IS-54	Interim Standard for US Digital Cellular (NADC)
IS-95	Interim Standard for US Code Division Multiple Access
IS-136	Interim Standard for NADC with Digital Control Channels
LMDS	Local Multipoint Distribution System
MFSK	Minimum Frequency Shift Keying
MMDS	Multichannel Multipoint Distribution System
MPSK	Minimum Phase Shift Keying
MSK	Minimum Shift Keying
NADC	North American Digital Cellular system
OFDM	Orthogonal Frequency Division Multiplexing
OQPSK	Offset Quadrature Phase Shift Keying
PACS	Personal Access Communications Service
PCS	Personal Communications System
PCM	Pulse Code Modulation
PDC	Pacific Digital Cellular System (formerly JDC)
PHS	Personal Handyphone System (formerly PHP)
PRBS	Pseudo-Random Bit Sequence
PSD	Power Spectral Density
PSK	Phase Shift Keying
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RAM	Wireless data network
RF	Radio Frequency
RMS	Root Mean Square
SQRT	Square Root
TDD	Time Division Duplex
TDMA	Time Division Multiple Access
TETRA	Trans European Trunked Radio
TFTS	Terrestrial Flight Telephone System
VSB	Vestigial Side Band
WLL	Wireless Local Loop



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