GSM 무선 단말 국제규격 및 HW 기술

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문성훈

2005-10-11

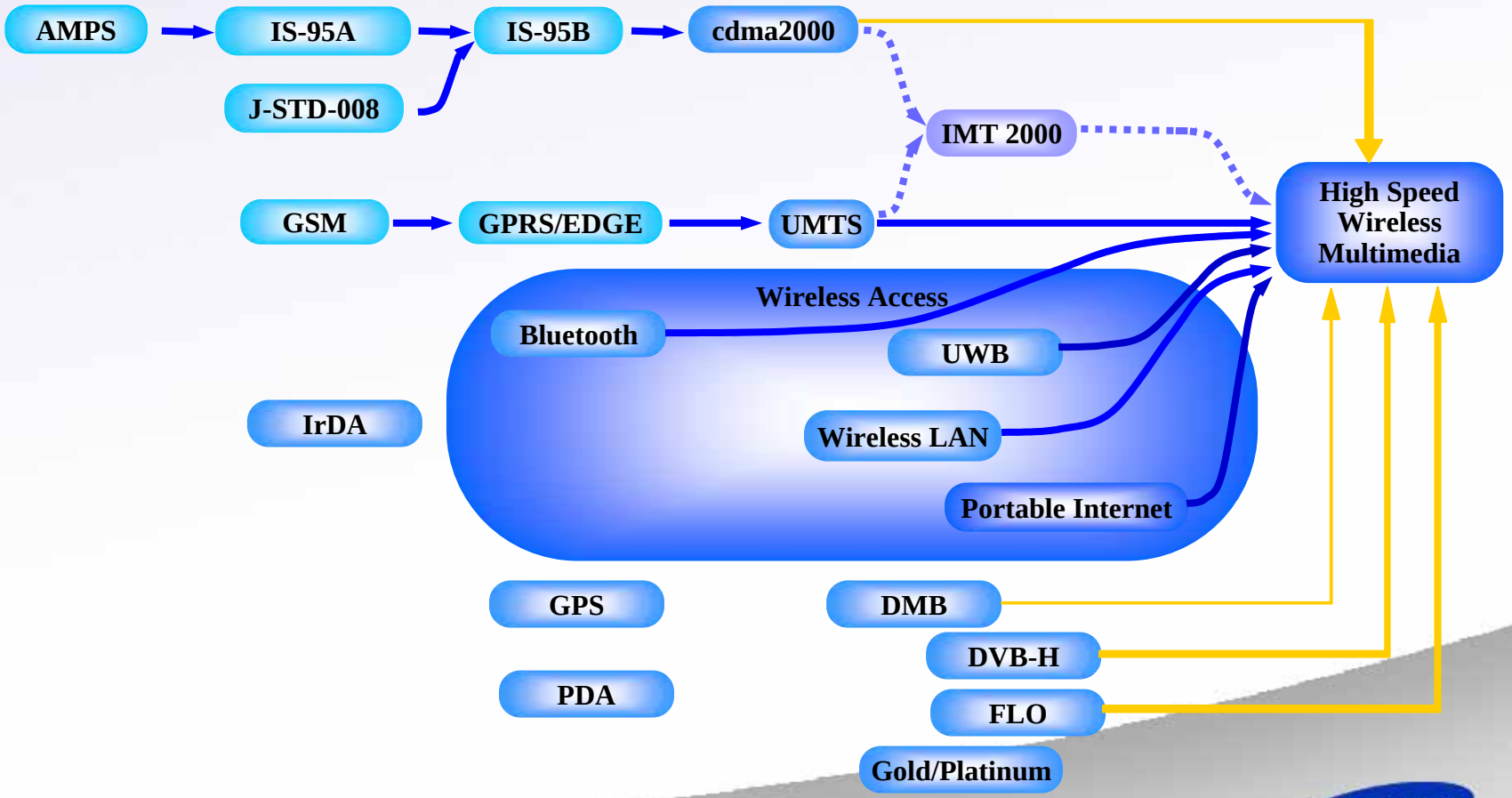
SAMSUNG DIGITall
everyone's invited™

Contents

- 무선단말 기술 동향
- GSM 송수신 방식 및 국제 규격
- GSM/GPRS/EDGE 변조

Evolution of Cellular Mobile Communication

1G (1980's)	2G (1990's)	2.5G (1999~)	3G (2001~)	4G (2010~)
Analog	Digital	Data SVC	Multimedia	High Speed Multimedia



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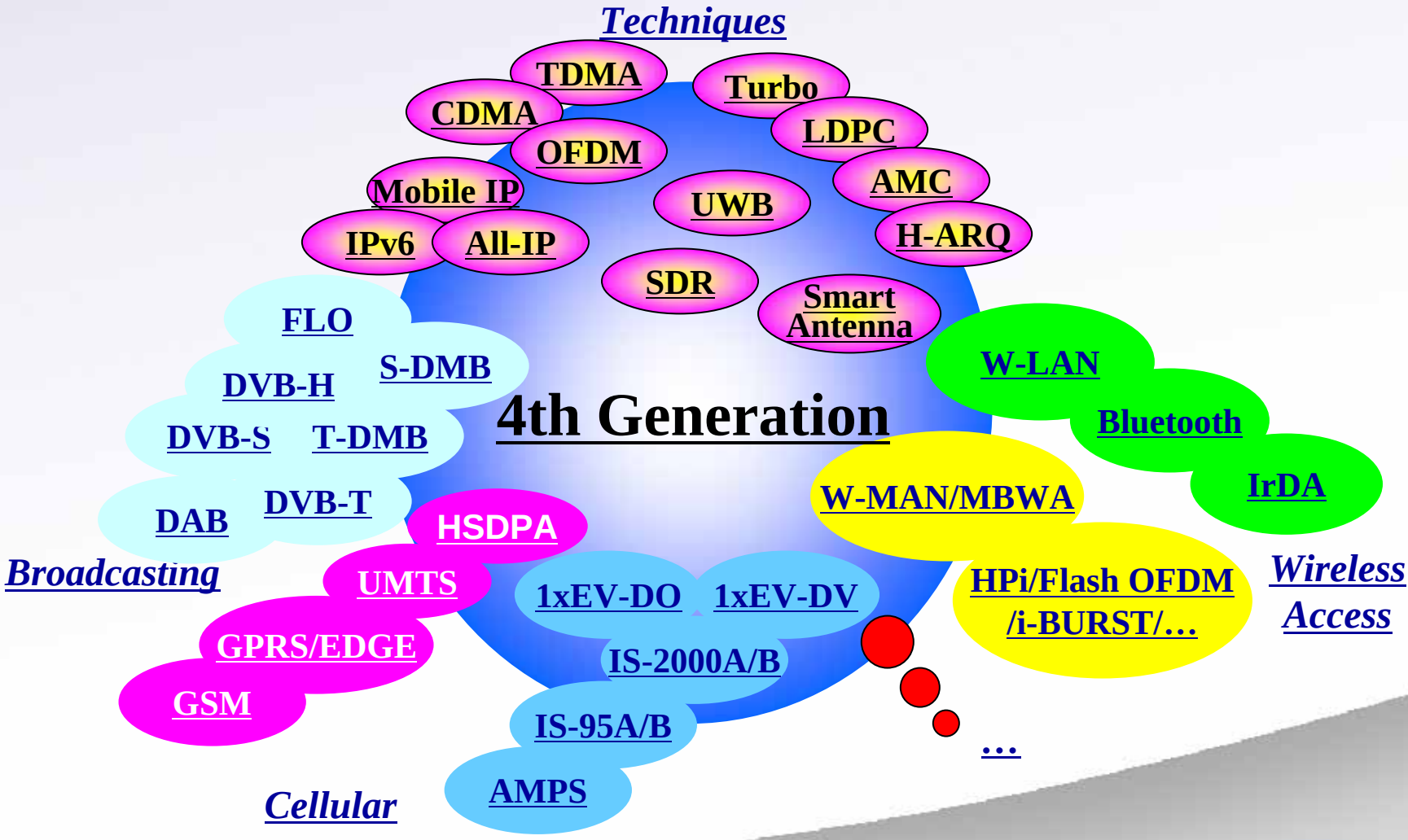
4G Cellular Mobile Communication



Camera-Phone Trends

- 국내 카메라폰의 발전

SCH-X290
2002.3.
외장카메라

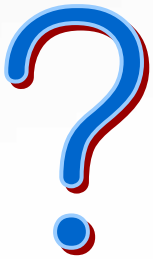
SCH-X590
2002.5.
11만화소(내장)

SCH-V420
2003.10.
100만화소

SPH-V4400
2004.6.
200만화소

SPH-S2300
2004.7.
300만화소

SCH-S250
2004.10.
500만화소



IrDA

- 적외선을 이용하여 데이터 송수신

High Speed
Standard Power


Notebook PC


Printer


Digital Camera


Desktop / Dongle


Watch


Vending m/c


Mobile Phone


Dongle


PDA


Pager


Toy


Scanner

Short Messages
Low Power

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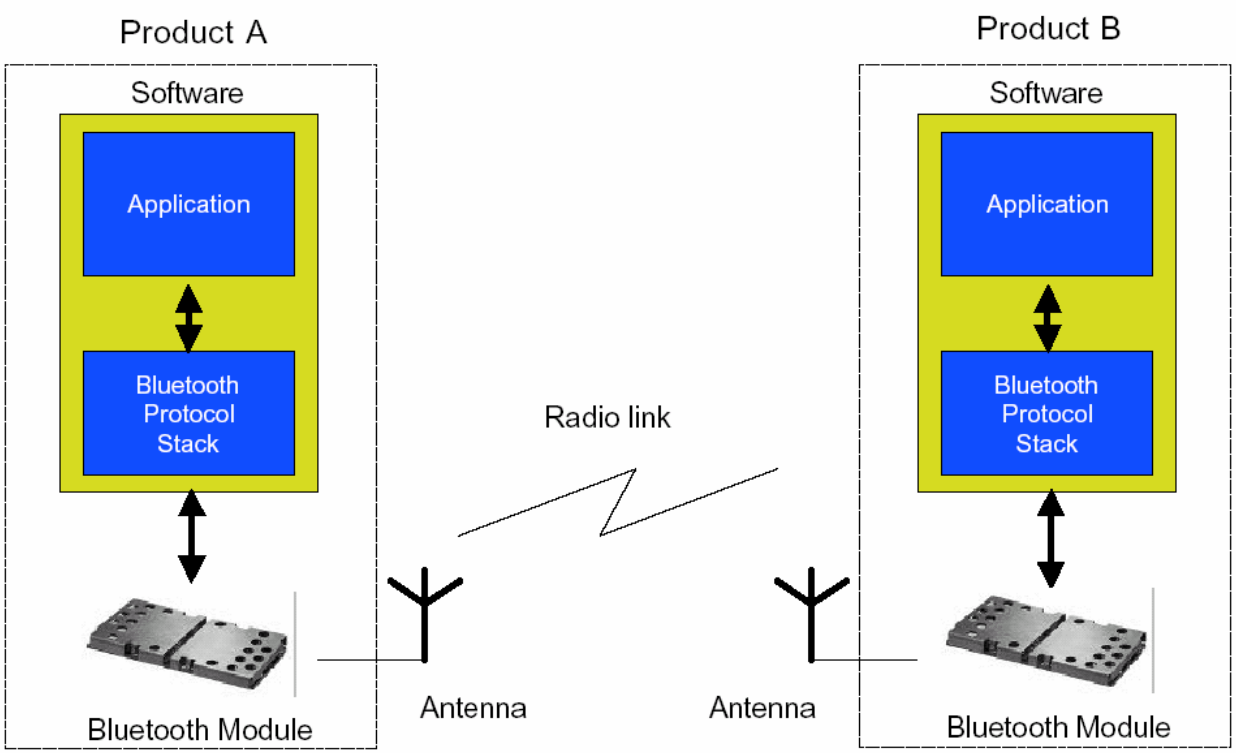
Bluetooth

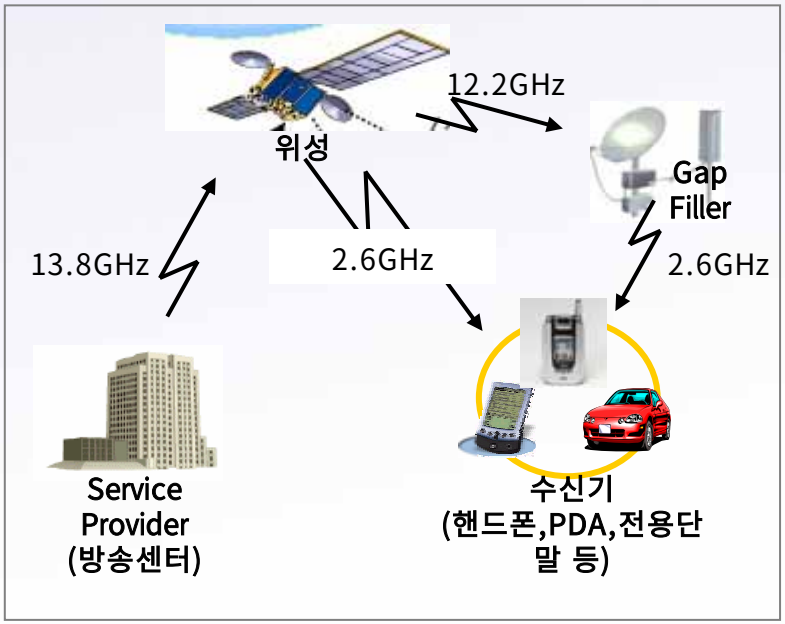
- 작고(0.5평방인치), 저렴한 가격(5달러), 적은 전력소모(100mW)로 휴대폰, 휴대용 PC등과 같은 휴대장치들, 네트워크 액세스 포인트들, 기타 주변장치들 간 작은 구역(10m~100m) 내의 무선 연결(Radio Link, 2.4GHs ISM Open Band)을 위한 기술



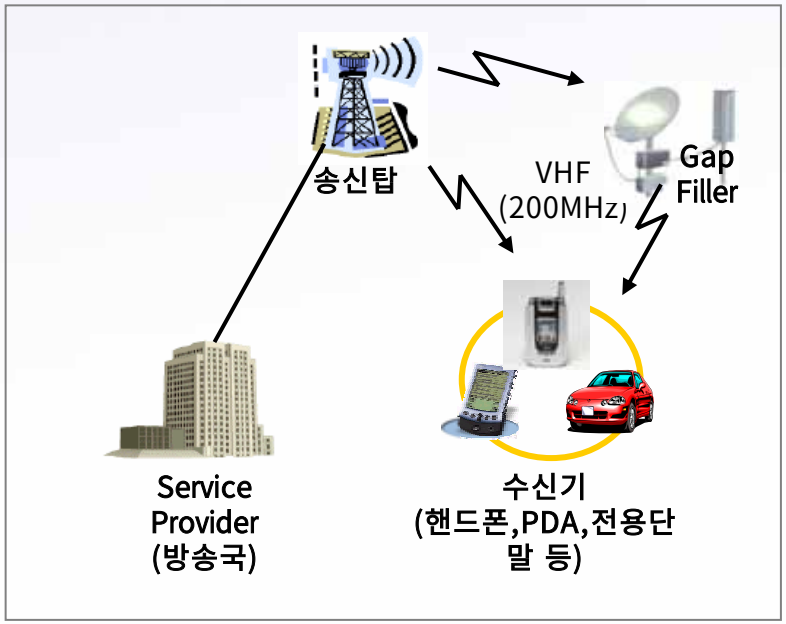
DMB

이동 중 AV, Data 등의 수신이 가능한 Digital Multimedia Broadcasting

위성 DMB



지상파 DMB



S-Band (2.6 GHz 대)	수신 주파수	VHF Ch12, Ch8 (200 MHz 대)
25 MHz	대역폭	1.5 MHz
CDM / H.264	규격	DAB기반 / H.264

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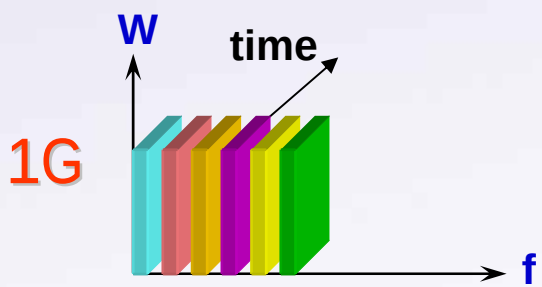
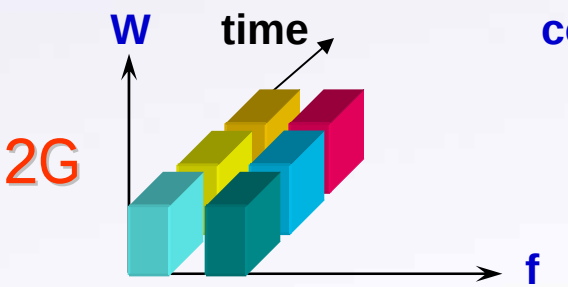
Evolution of Mobile Communication Systems



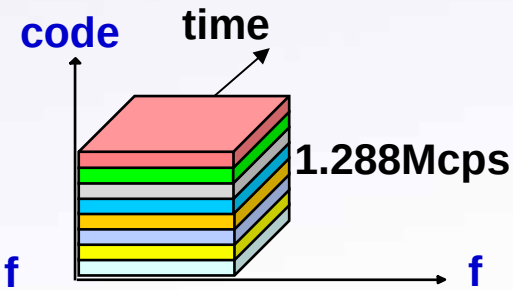
FDMA

[AMPS]



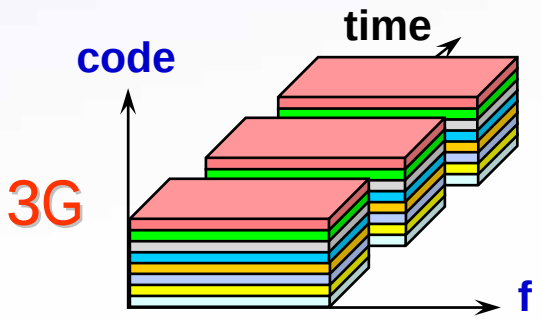
TDMA

[GSM, IS-136, PDC]

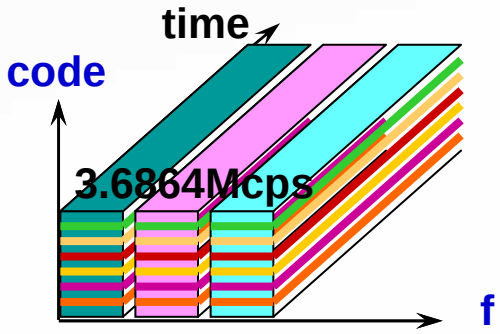


CDMA

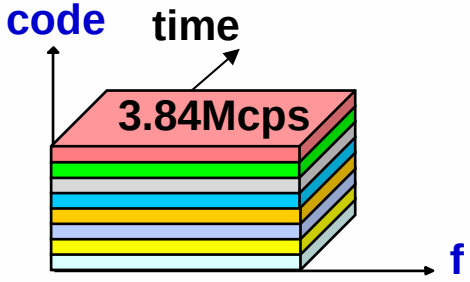
[IS-95A, B]



[TD-CDMA]



[cdma2000 MC]
(3GPP2)



[W-CDMA]
(3GPP)

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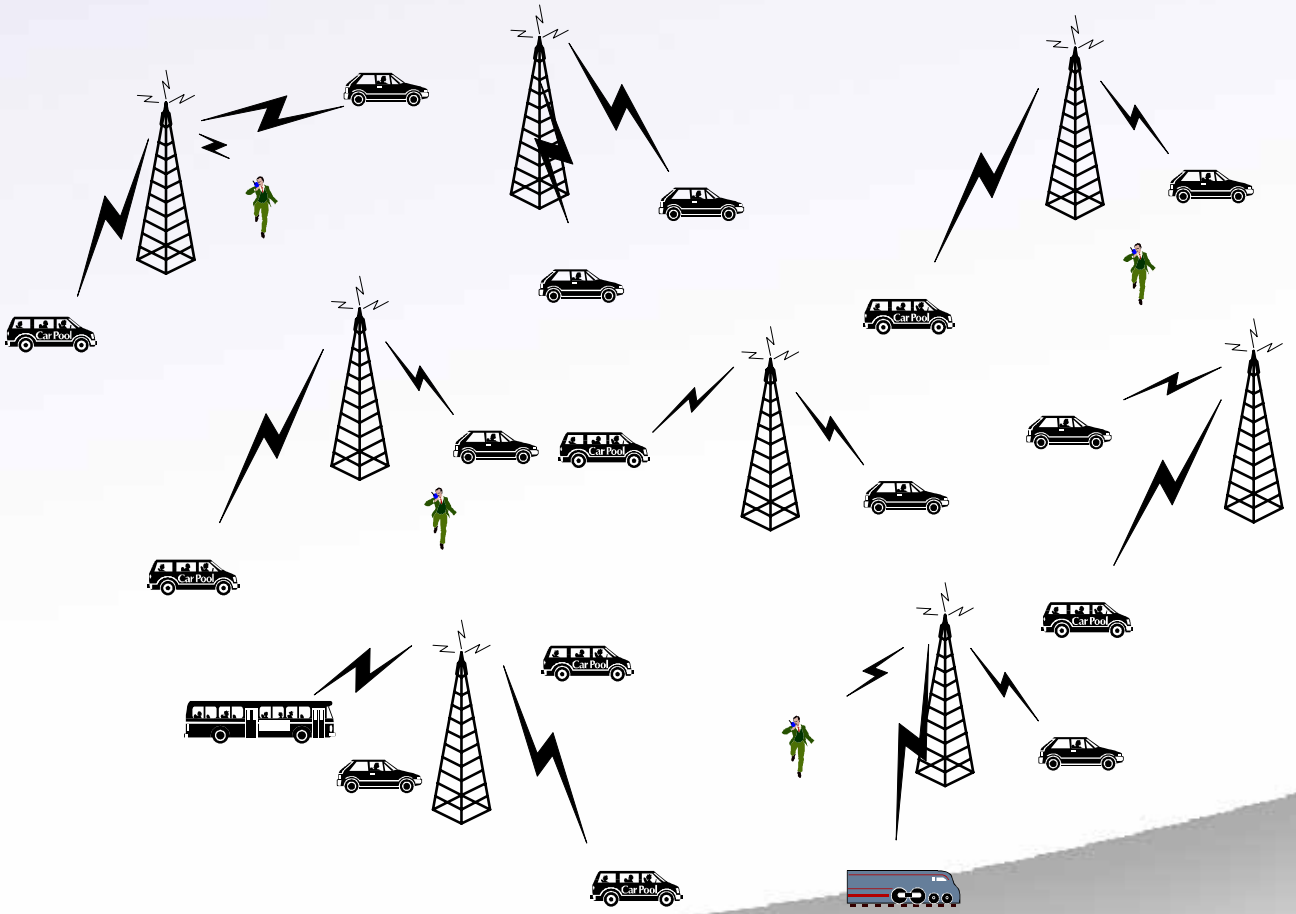
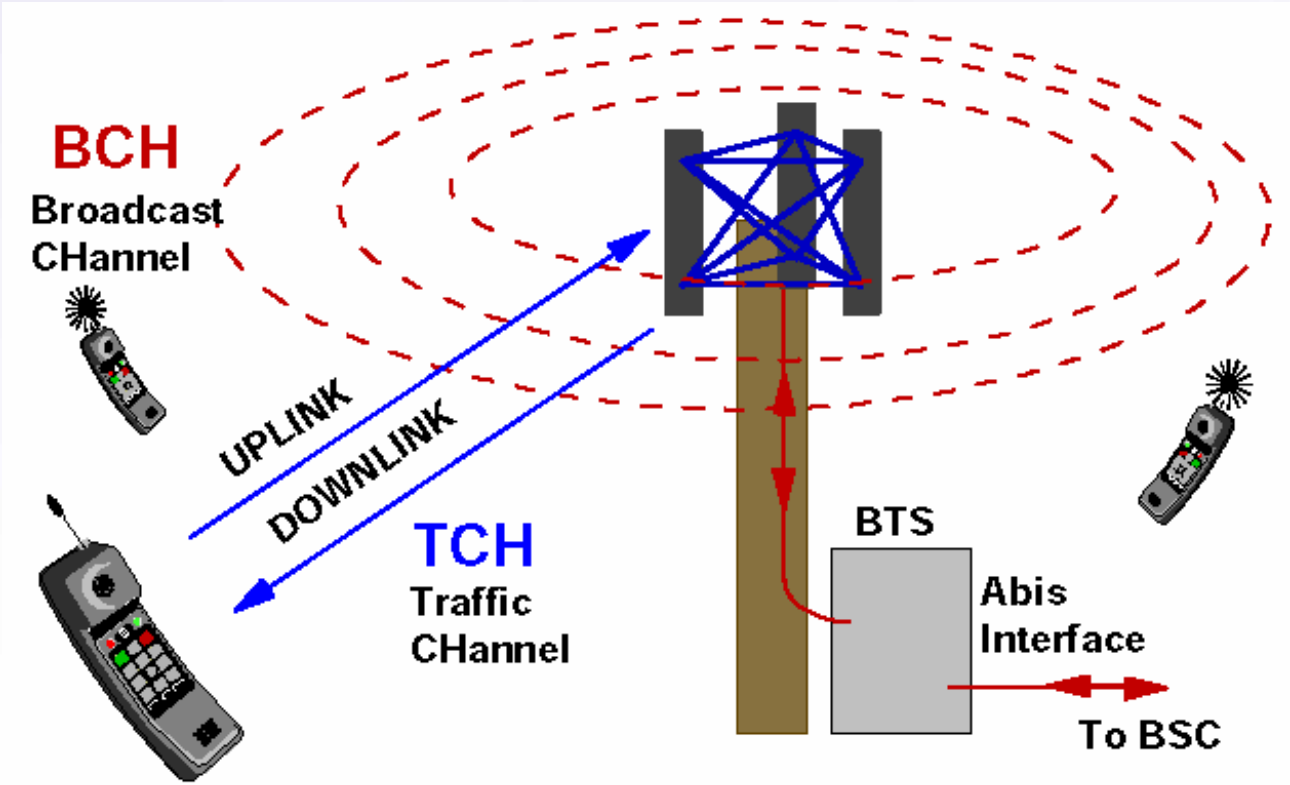
Cellular System Concept



1. GSM Air interface

♦ **A GSM Cell** ♦



- **Max Cell Radius is up to 35km**

64bit x $(3x10^8)$ = 64 x $(3.69x10^{-6})$ $(3x10^8)$ = 70.8km

Timing Advance

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♦ GSM Air Interface (1) ♦

- **Separate Bands for Uplink and Downlink**
- **TDMA & FDMA Multiplex**
  - *124 Frequency Channels (ARFCN) for GSM850*
  - *124 Frequency Channels (ARFCN) for GSM900*
  - *373 Frequency Channels (ARFCN) for DCS1800*
  - *298 Frequency Channels (ARFCN) for PCS1900*
  - *200 kHz Channels*
  - *8 Mobiles share ARFCN by TDMA*
- **0.3 GMSK Modulation**
  - *270.833 kbits/sec. rate*
- **Variable Tx Power and Timing**

♦ GSM Air Interface (2) ♦

	GSM850	GSM900 Phase I	GSM900 Phase II	GSM1800	PCS1900
Uplink	824 to 849 MHz	890 to 915 MHz	880 915 MHz	1710 to 1785 MHz	1850 to 1910 MHz
Downlink	869 to 894 MHz	935 to 960 MHz	925 to 960 MHz	1805 to 1880 MHz	1930 to 1990 MHz
ARFCN range	128 to 251	1 to 124	1 to 124, 975 to 1023	512 to 885	512 to 810
TX/RX Spacing (Freq.)	45 MHz	45 MHz	45 MHz	95 MHz	80 MHz
TX/RX Spacing (Time)	3 Timeslots	3 Timeslots	3 Timeslots	3 Timeslots	3 Timeslots
Modulation Data Rate	270.833 kbit/s	270.833 kbit/s	270.833 kbit/s	270.833 kbit/s	270.833 kbit/s
Frame Period	4.615 ms	4.615 ms	4.615 ms	4.615 ms	4.615 ms
Timeslot Period	576.9 us	576.9 us	576.9 us	576.9 us	576.9 us
Bit Period	3.692 us	3.692 us	3.692 us	3.692 us	3.692 us
Modulation	0.3 GMSK	0.3 GMSK	0.3 GMSK	0.3 GMSK	0.3 GMSK
Channel Spacing	200 kHz	200 kHz	200 kHz	200 kHz	200 kHz
TDMA Mux	8	8	8	8	8
MS Max Power	8W	20W (8W is max in use)	8W	4W	2W
MS Min Power	13 dBm	13 dBm	5 dBm	0 dBm	0 dBm
MS Power Control Steps	0 to 15	0 to 15	2 to 19	0 to 15	0 to 15
Voice Coder Bit Rate	13 kbit/s	13 kbit/s	13 kbit/s, 5.6 kbit/s	13 kbit/s, 5,6 kbit/s	13 kbit/s

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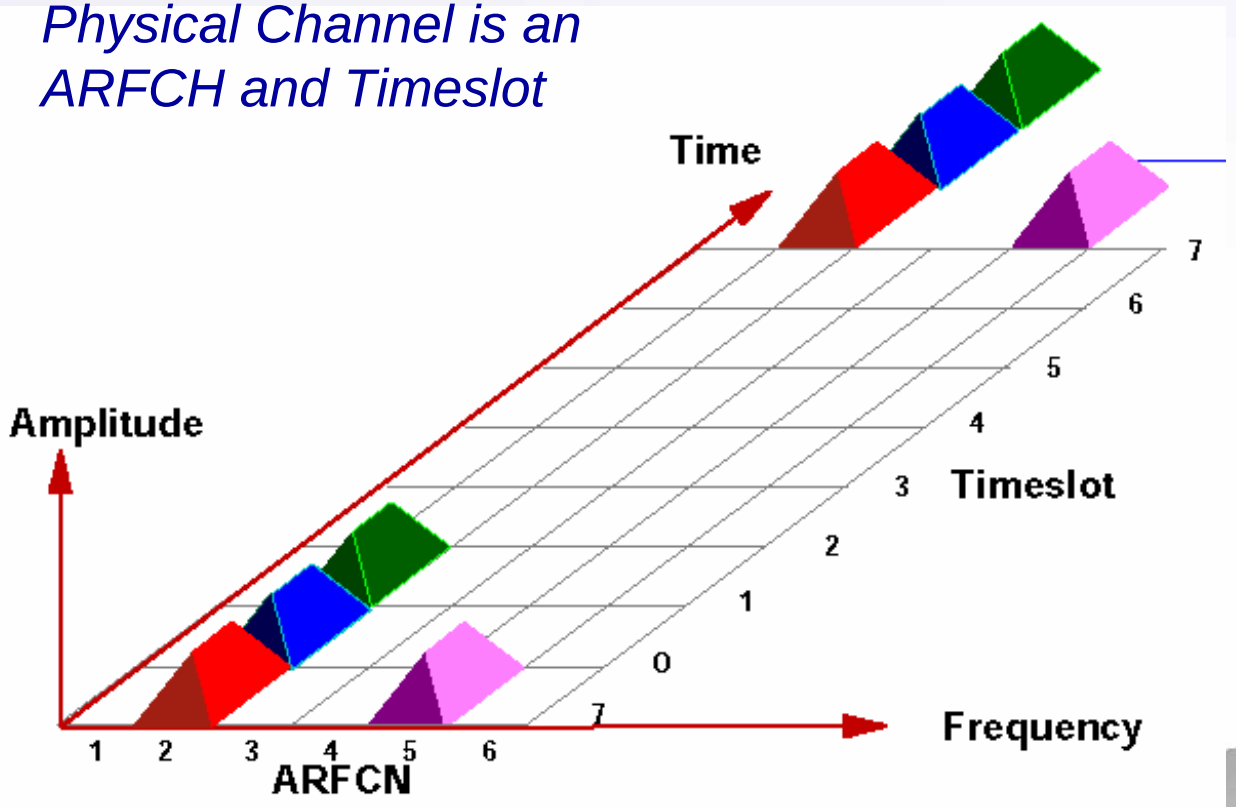
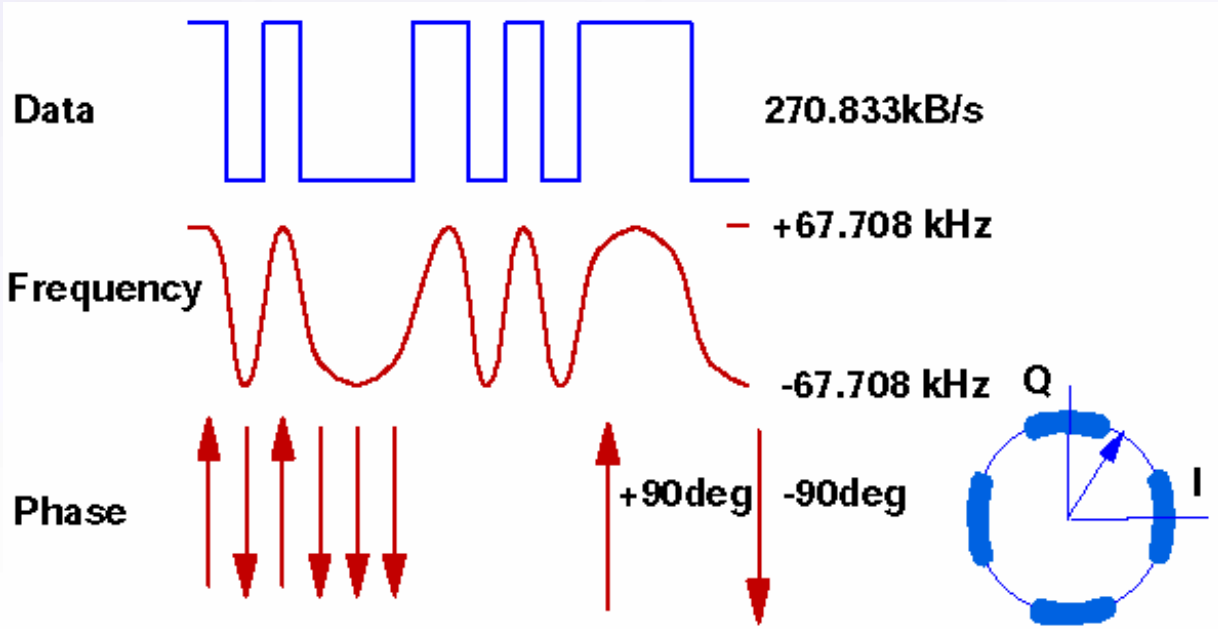
2. GSM Radio 주요 특성

♦ TDMA and FDMA ♦

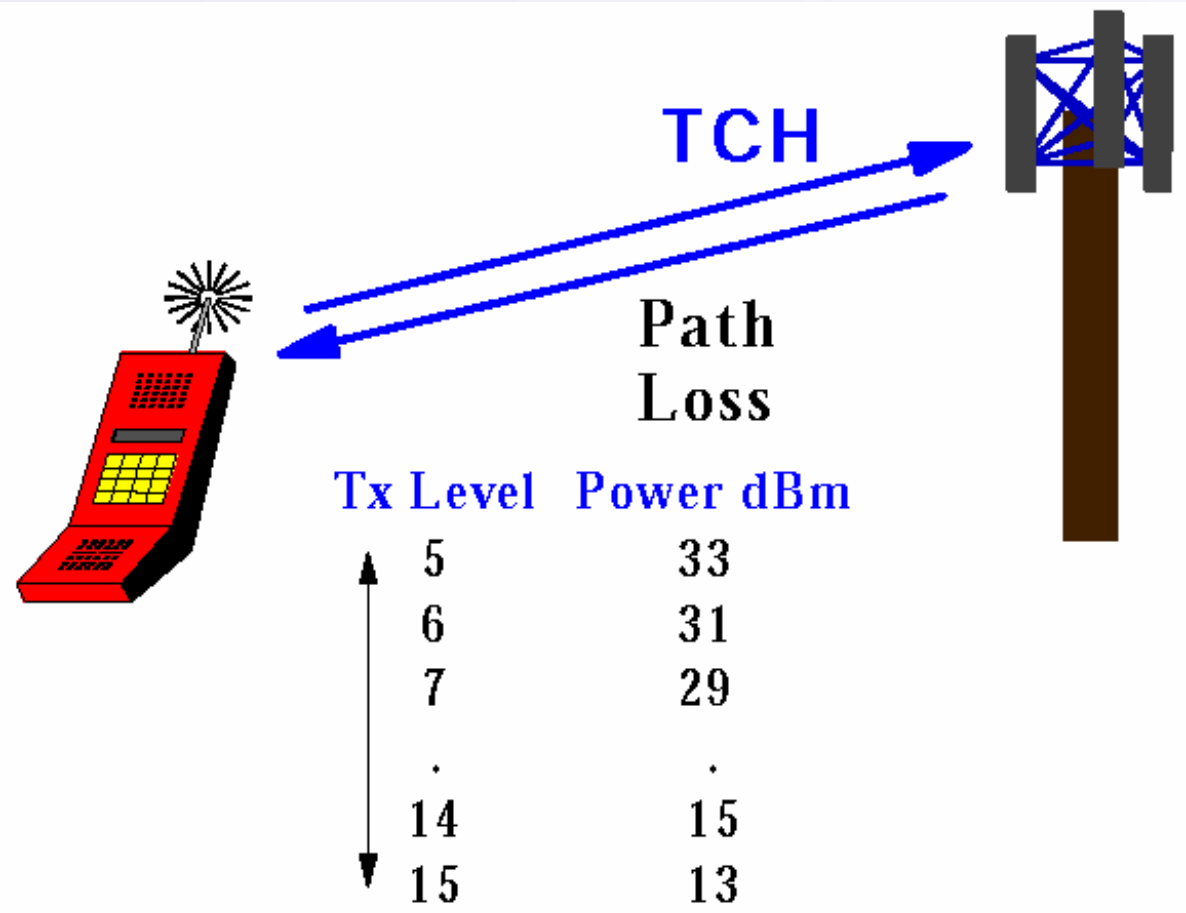
Physical Channel is an ARFCH and Timeslot



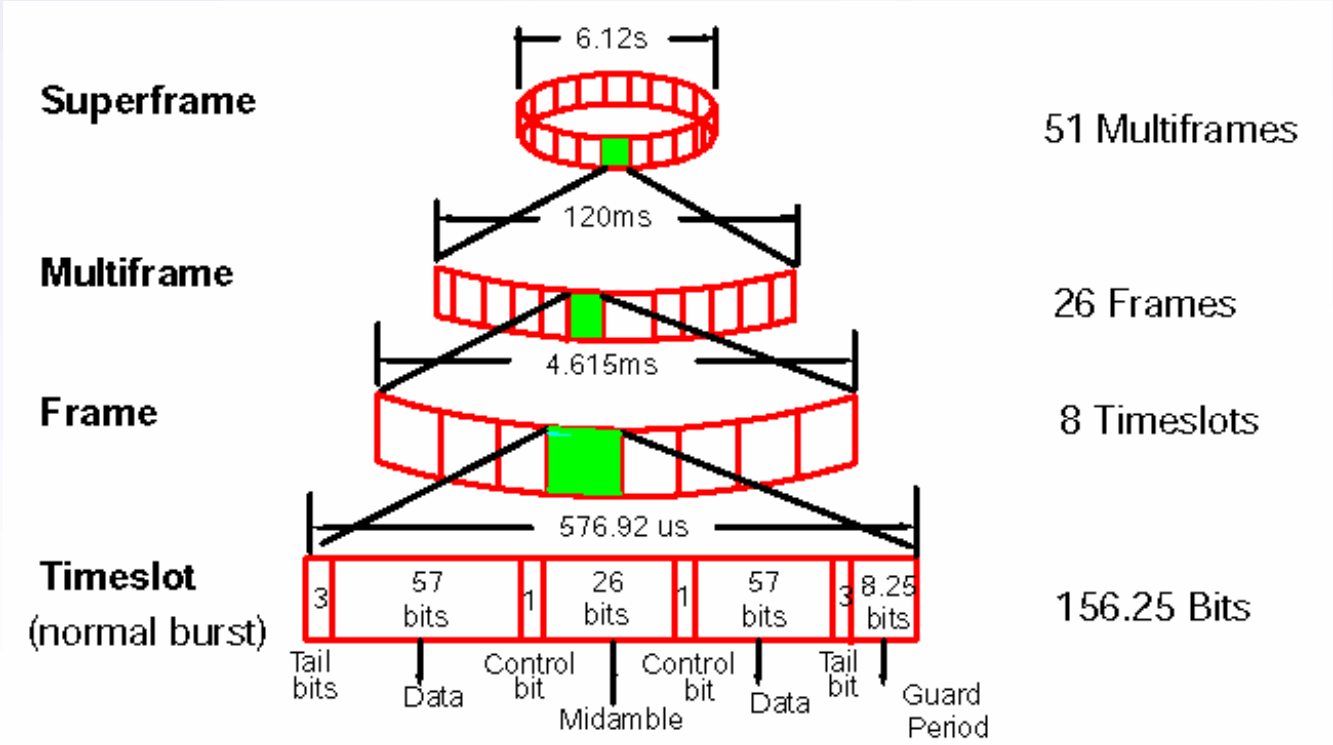
♦ 0.3 GMSK Modulation ♦



♦ TX levels ♦



♦ Frames and Multiframes ♦



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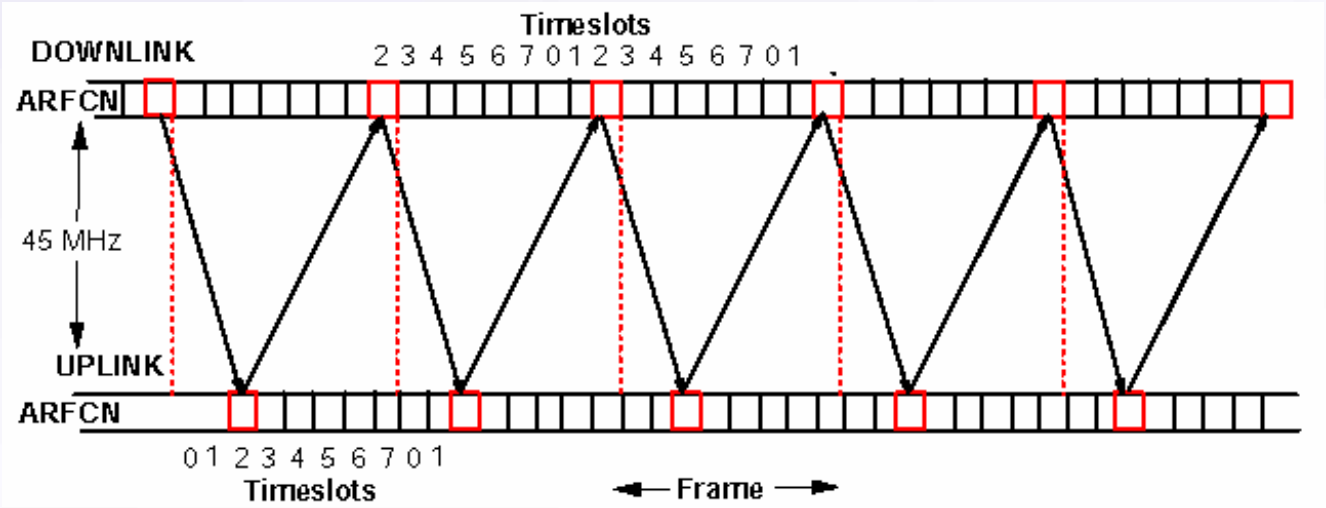
♦ Downlink and Uplink ♦



- **Uplink lags Downlink by 3 Timeslot periods**
- **Uplink and Downlink was same Timeslot Number**
- **Uplink and Downlink use same Channel Number (ARFCN)**
- **Uplink and Downlink use different bands (45 MHz apart for GSM900)**

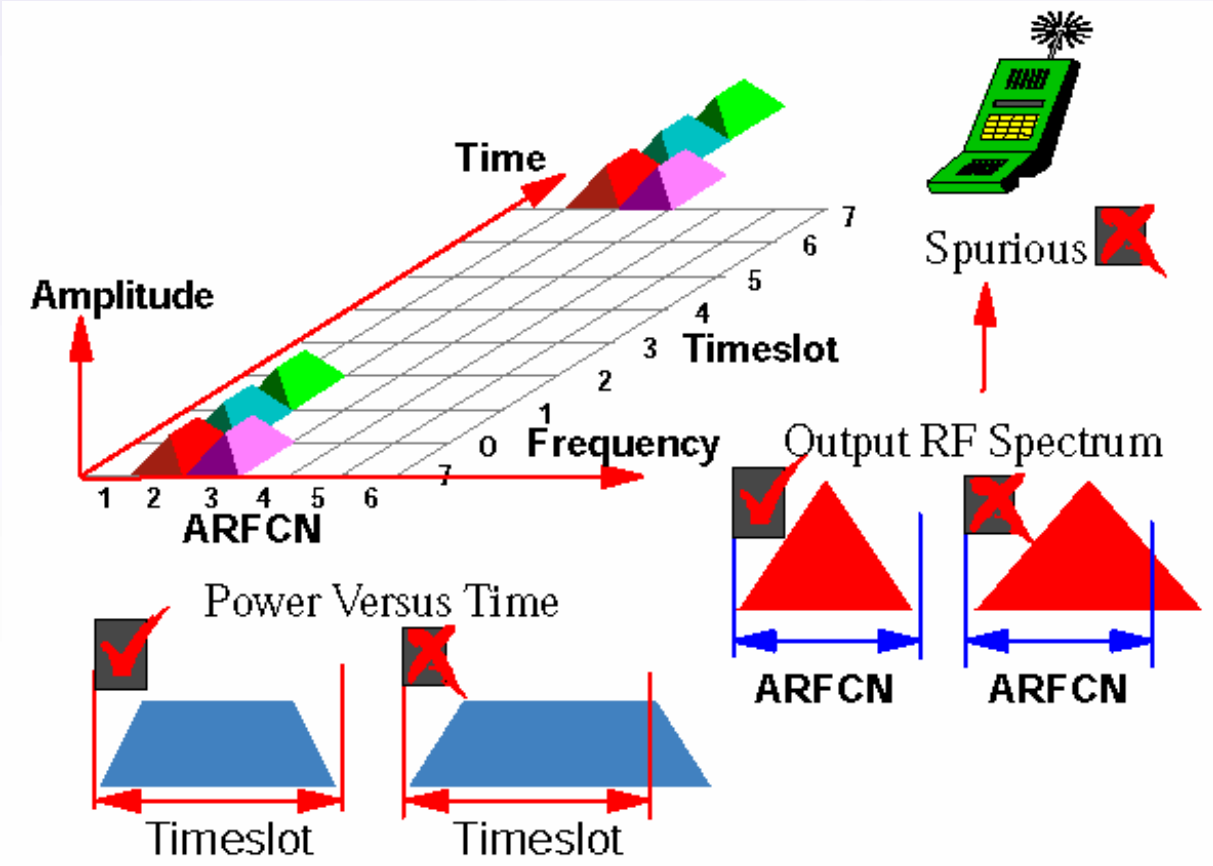
♦ S I M ♦
(Subscriber Identity Module)

- **Plugs into Every GSM Mobile**
  - Two Sizes-standard (credit card) and Micro (postage stamp)
- **Holds All Unique Subscriber Information**
  - IMSI (International Mobile Subscriber)
  - Lists of Networks Allowed For User
- **Stores Information on Last Location**
- **Stores User Information**
  - Speed Dial Lists, Memories Etc.

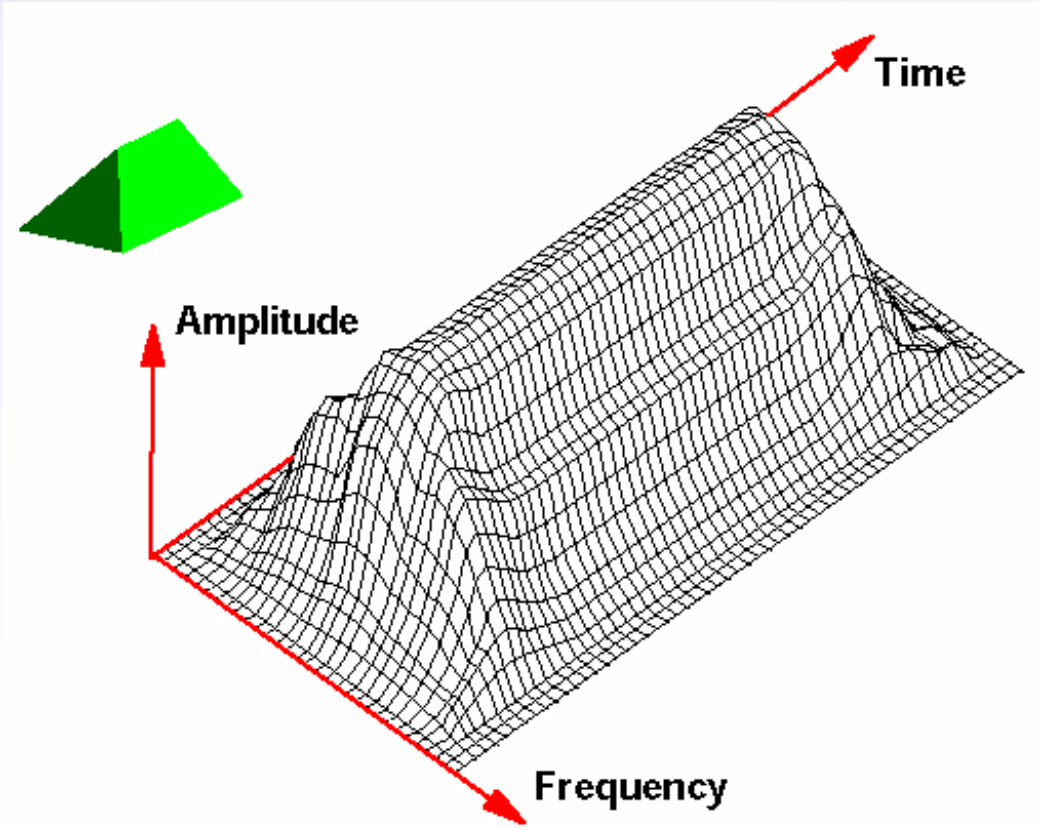
♦ Phase II Features ♦

- **Bringing GSM and DCS together**
- **Low power levels(16,17,18,19) are added**
- **E-GSM**
- **Dual Band**
- **Enhanced Full Rate Speech**
- **Half Rate Speech**
- **Fast BER Measurements**
- **Data Applications**

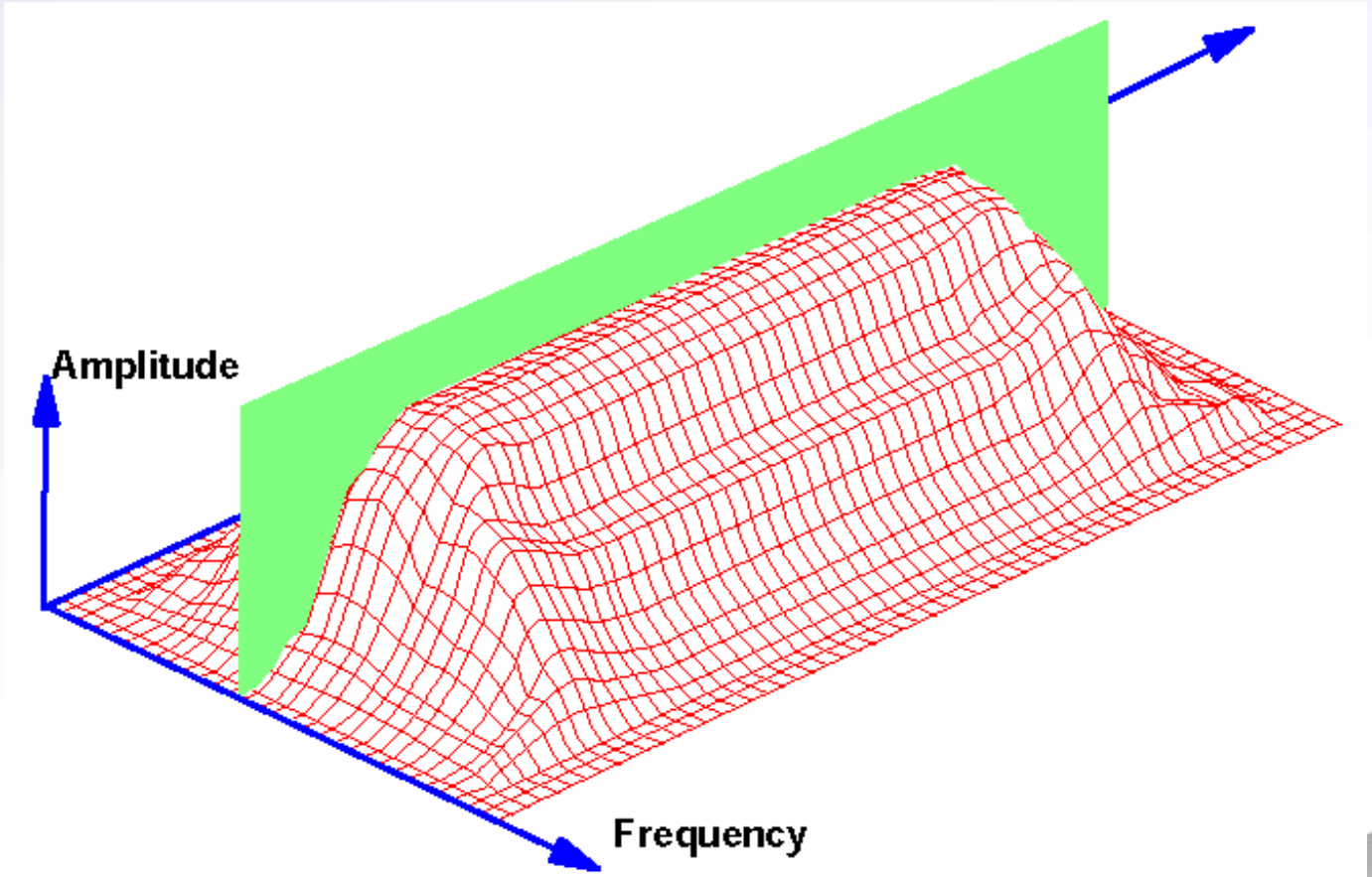
♦ Don’t interface with other users ♦



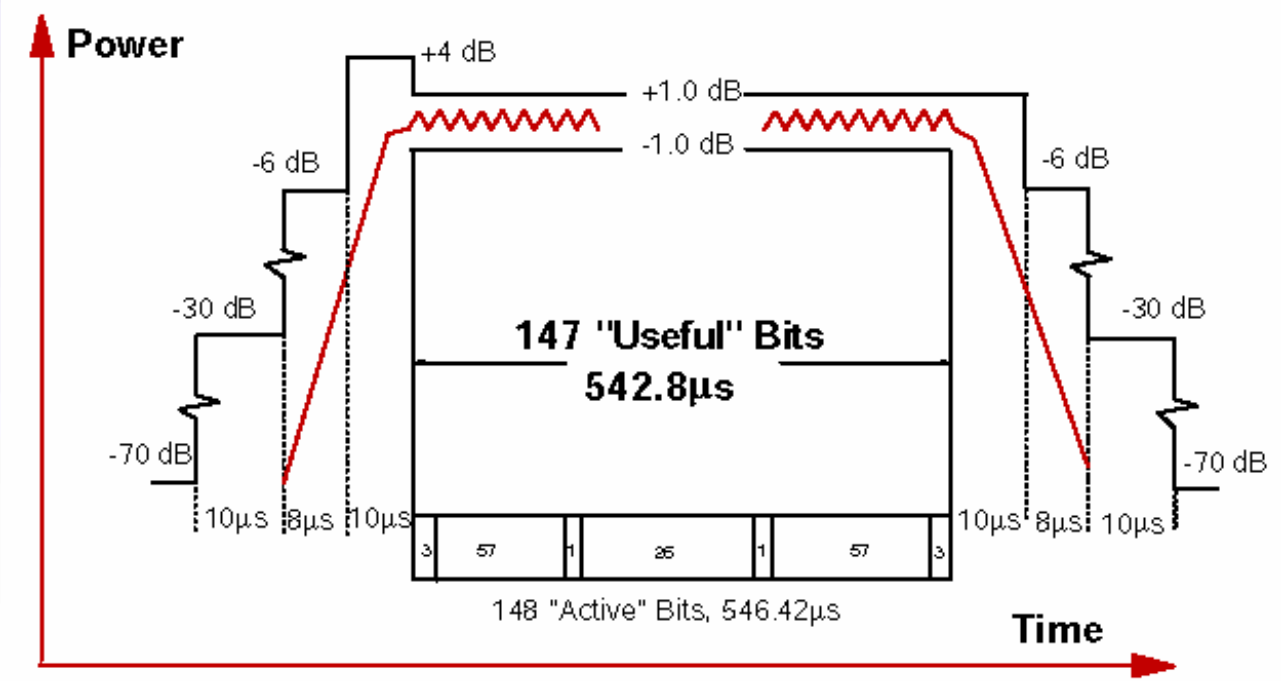
♦ The GSM Burst ♦



♦ Power versus Time ♦



♦ GSM TDMA Power Burst ♦



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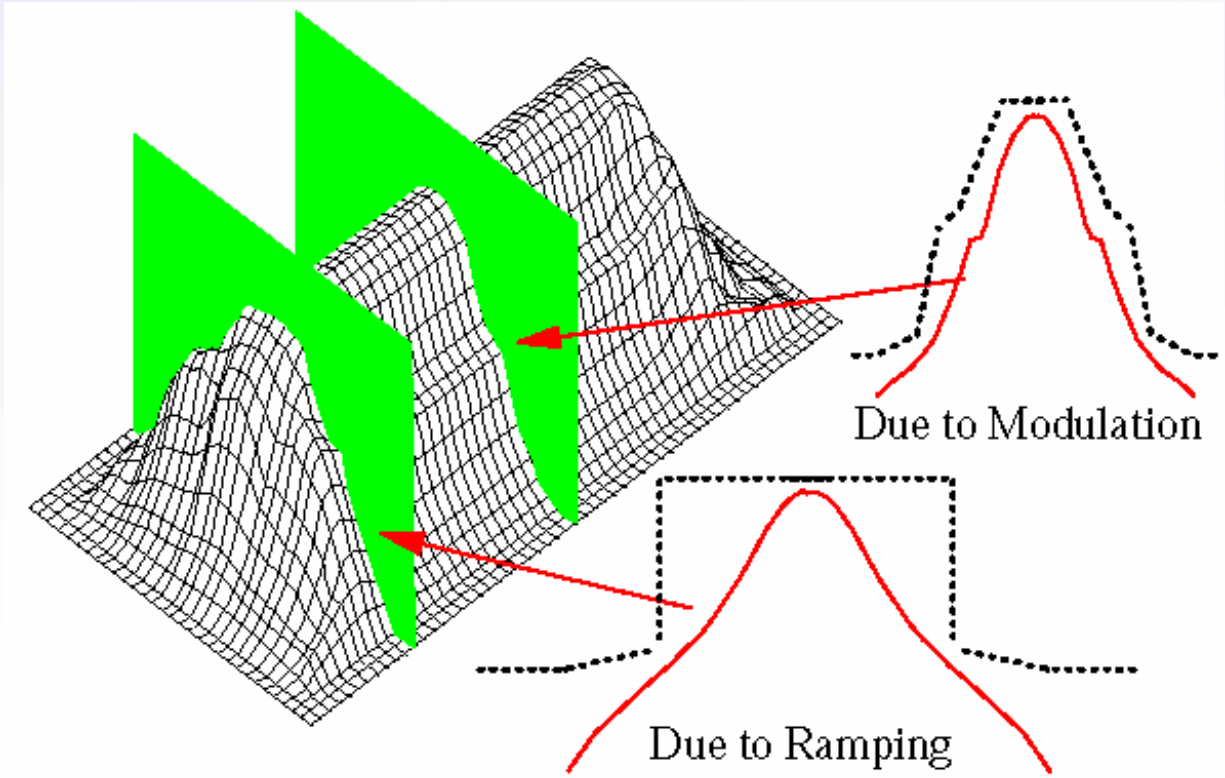
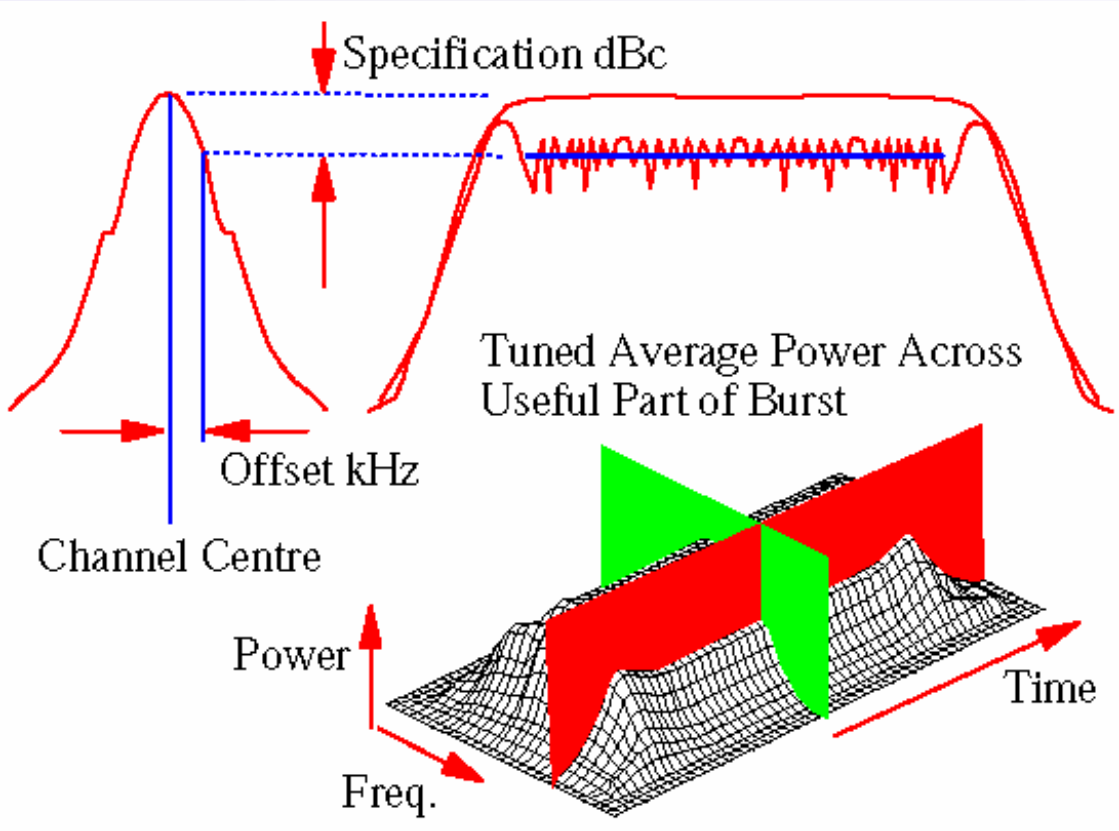
♦ Output RF Spectrum ♦



♦ Output RF Spectrum ♦

due to Modulation



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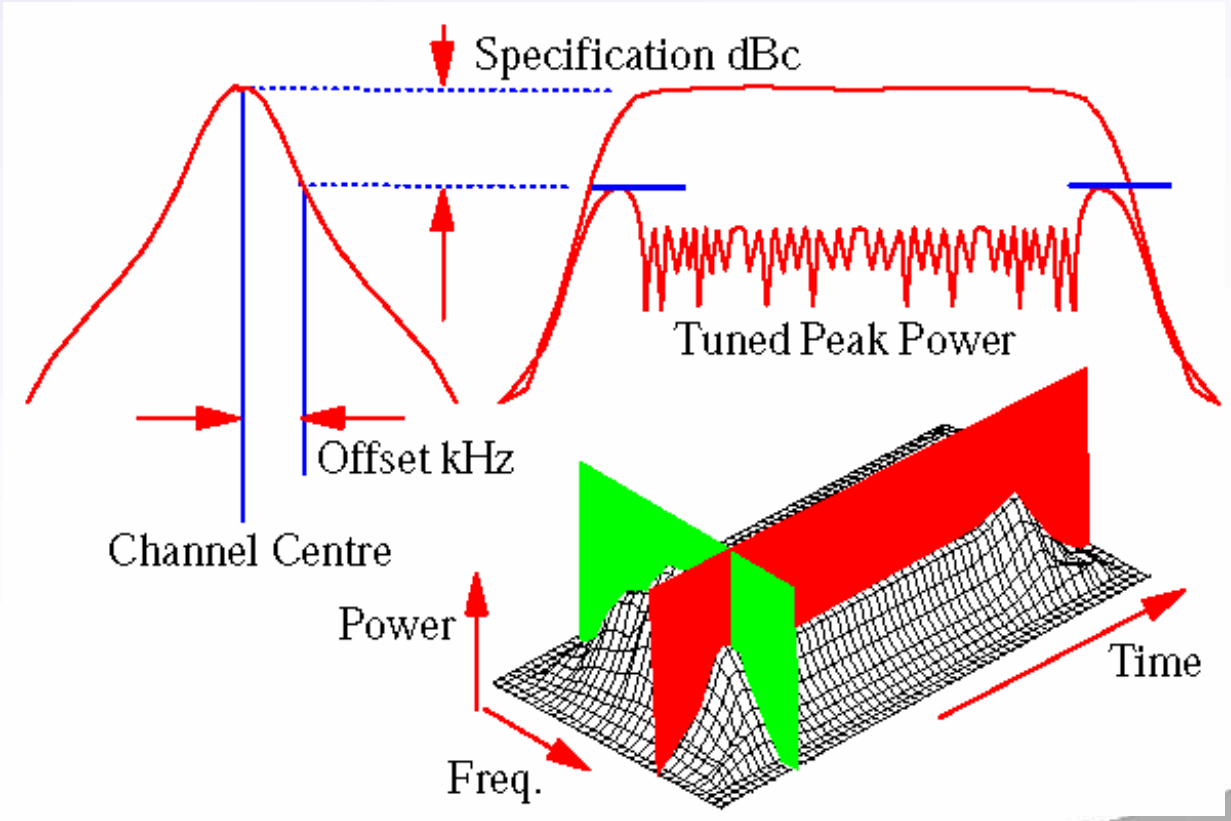
♦ ORFS due to Modulation ♦

Power Control Level	Power Level [dBm]	0 kHz	100 kHz	200 kHz	250 kHz	400 kHz	≥ 600 kHz
0	43	0 dB	0.5 dB	-30 dB	-33 dB	-60 dB	-70 dB
2	39	0	0.5	-30	-33	-60	-66
3	37	0	0.5	-30	-33	-60	-64
≥ 5	≤ 33	0	0.5	-30	-33	-60	-60

♦ Output RF Spectrum ♦

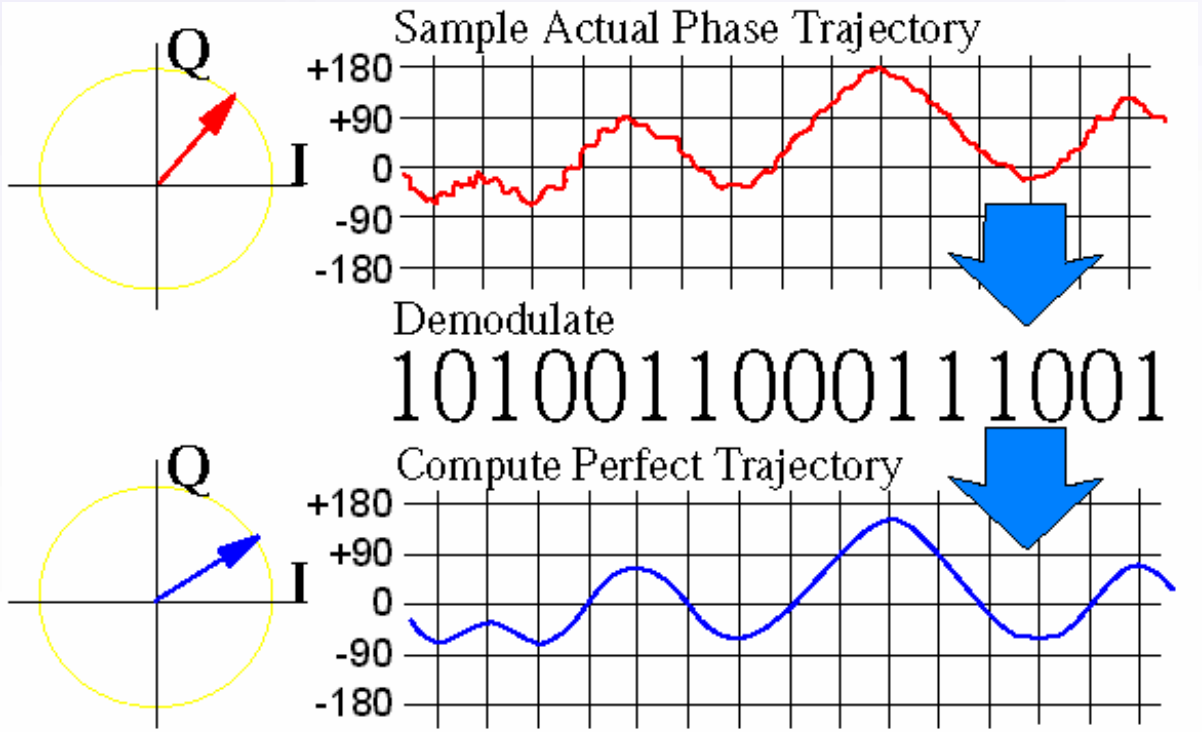
due to Ramping



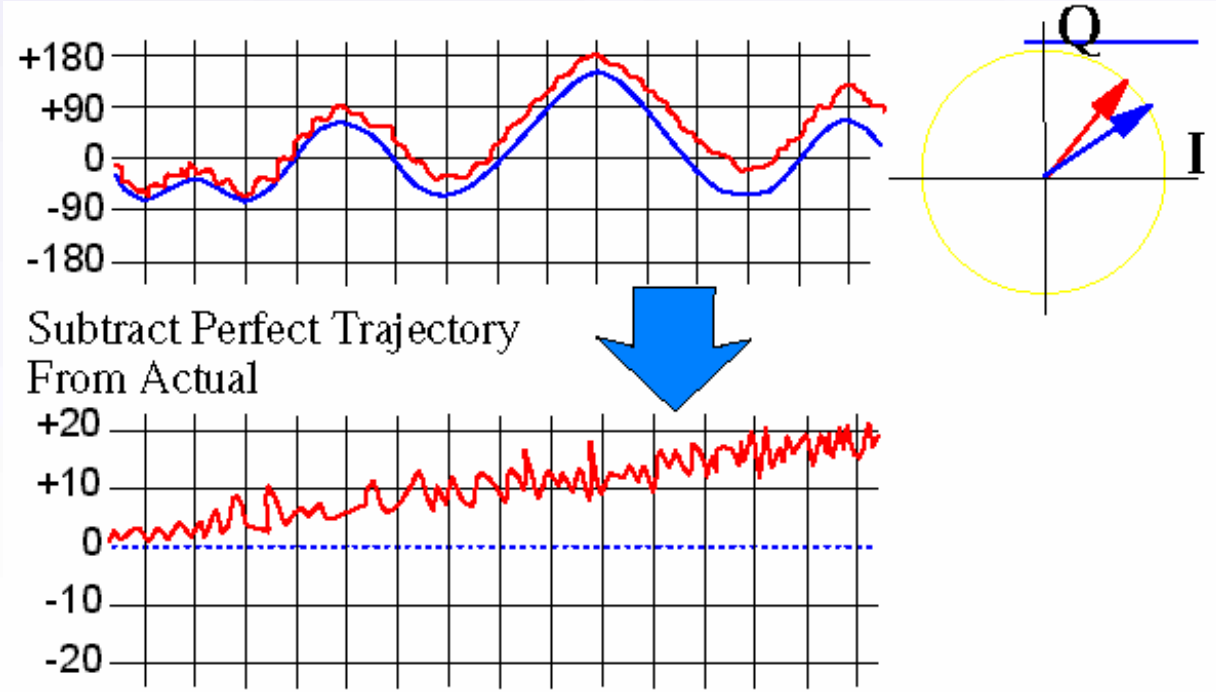
♦ ORFS due to Ramping ♦

Power Level	400 kHz	600 kHz	1200 kHz	1800 kHz
43 dBm	-9 dBm	-21 dBm	-21 dBm	-24 dBm
41	-11	-21	-21	-24
39	-13	-21	-21	-24
37	-15	-21	-21	-24
35	-17	-21	-21	-24
33	-19	-21	-21	-24
31	-21	-23	-23	-26
29	-23	-25	-25	-28
27	-23	-26	-27	-30
25	-23	-26	-29	-32
23	-23	-26	-31	-34
≤ 21	-23	-26	-32	-36

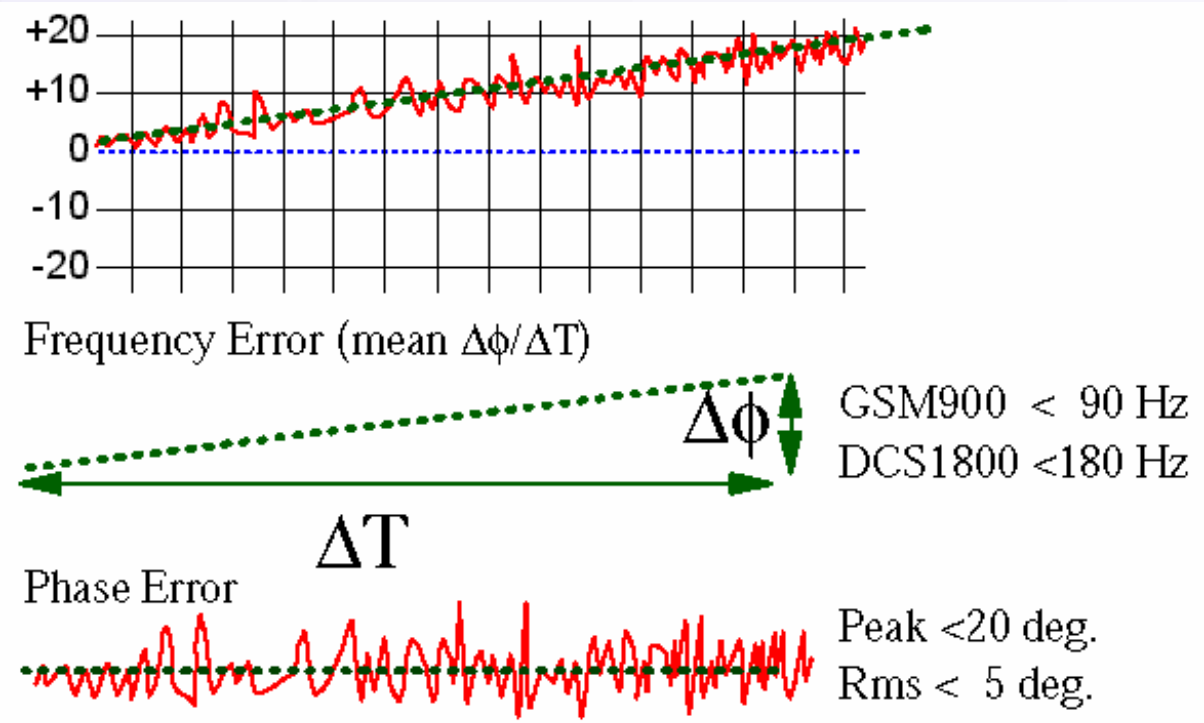
♦ Measuring Phase and Frquency Error (1) ♦



♦ Measuring Phase and Frquency Error (2) ♦



♦ Measuring Phase and Frquency Error (3) ♦



3. Dual Band and Triple Band

- **What is Dual Band ?**
- **GSM900 and DCS1800**
- **GSM900 and PCS1900**
- **GSM900, DCS1800 and PCS1900**
- **Market Drivers**
- **How does it work ?**
  - dual band handover
  - multi band measurement reporting

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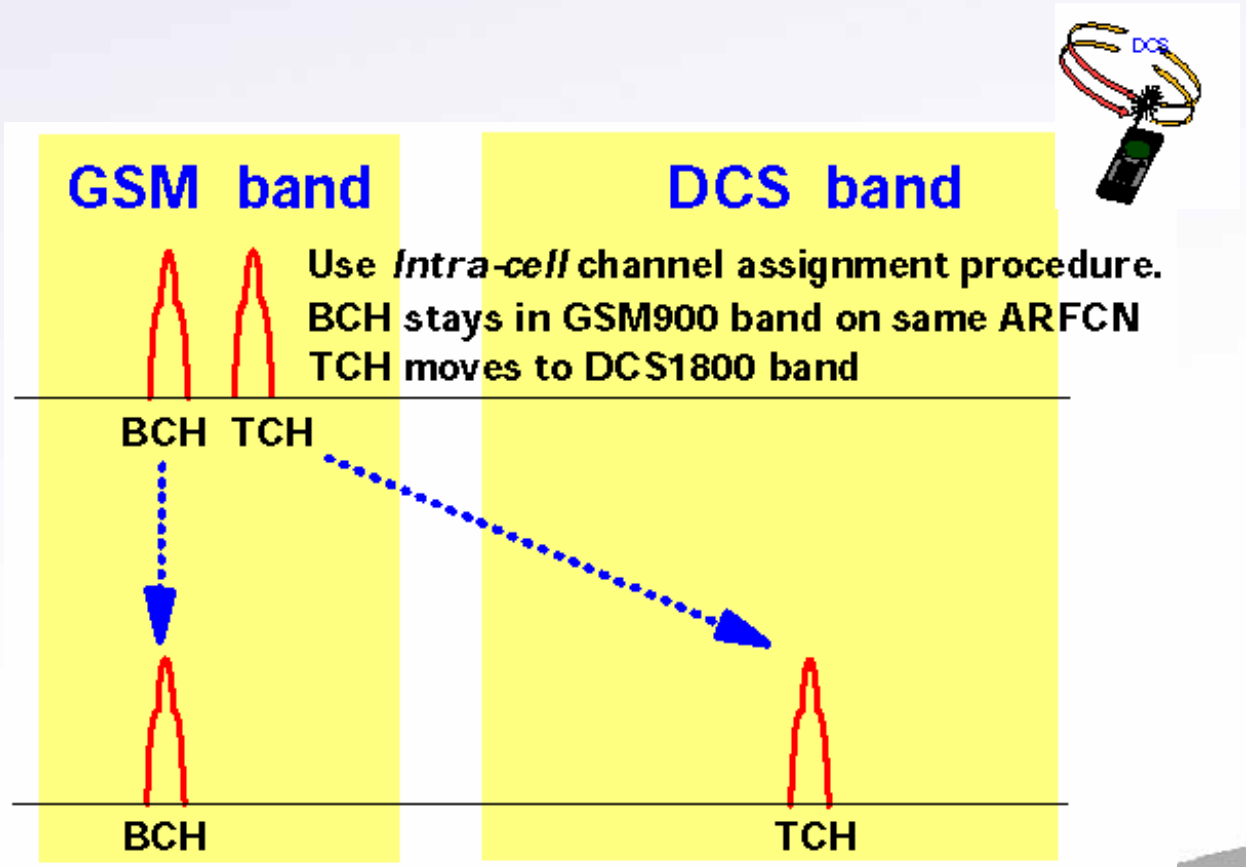
♦ How Does Dual Band Work ? ♦

- **Set up a call**
  - in GSM or DCS
- **Intra band handover**
- **Inter cell handover**

♦ Dual Band Assignment ♦



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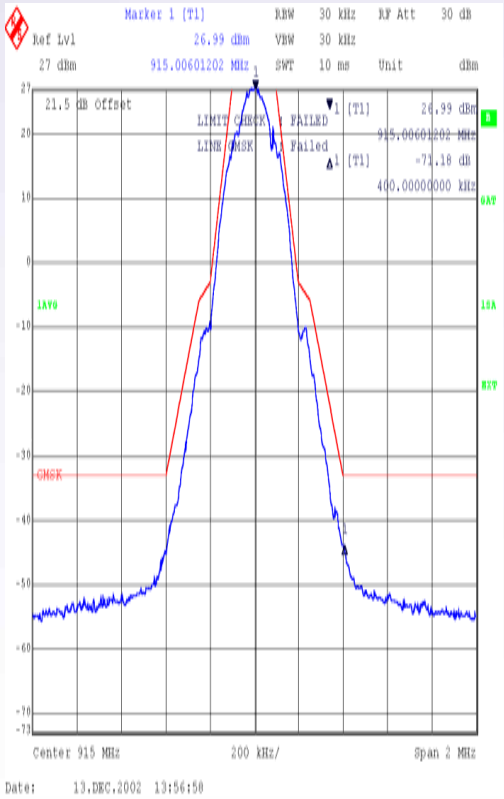
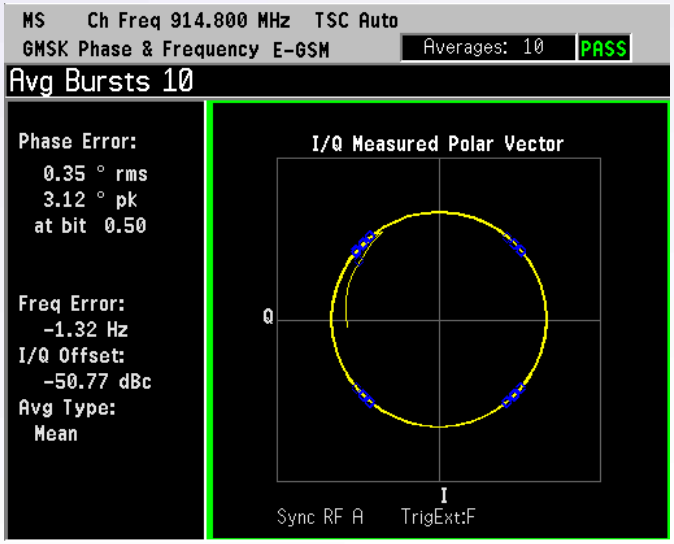
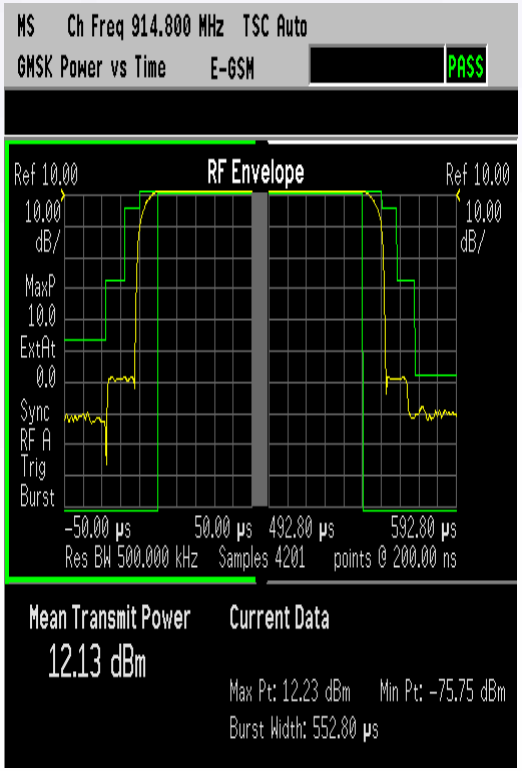
GMSK Modulation (1)







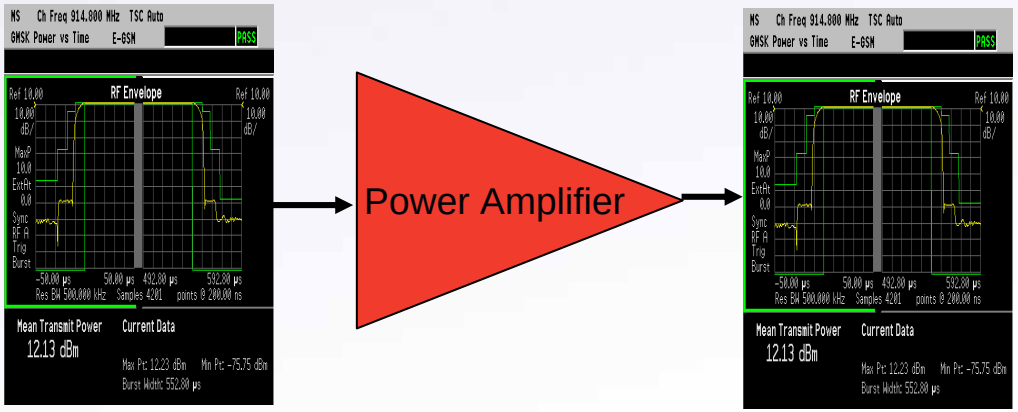
The modulation spectrum must fit in the modulation mask
The time burst must fit in the time mask

Frequency domain

Constellation domain

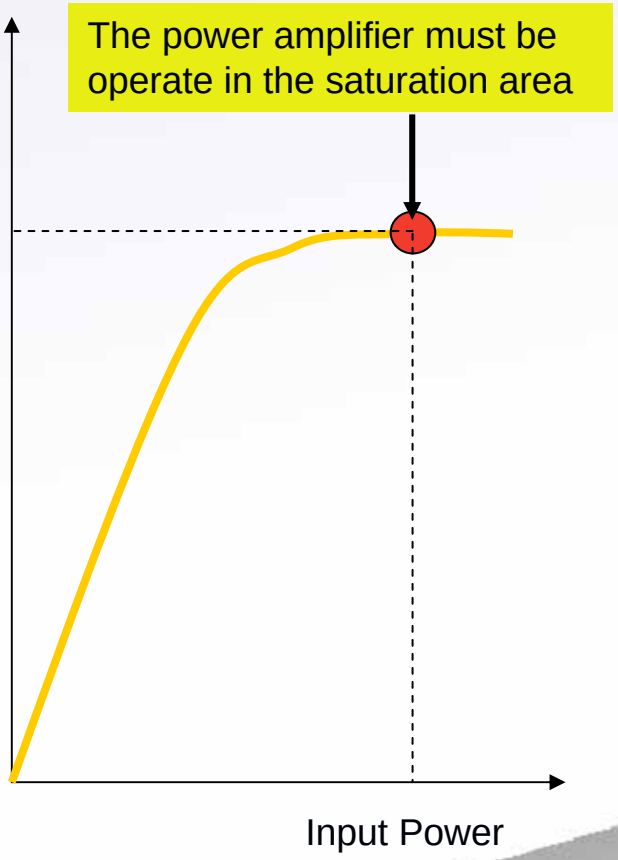
Time domain

GMSK Modulation (2)



Input Burst

Output Burst



As the information is only in the phase modulation the power amplifier must be operated saturated in order to get an optimized efficiency

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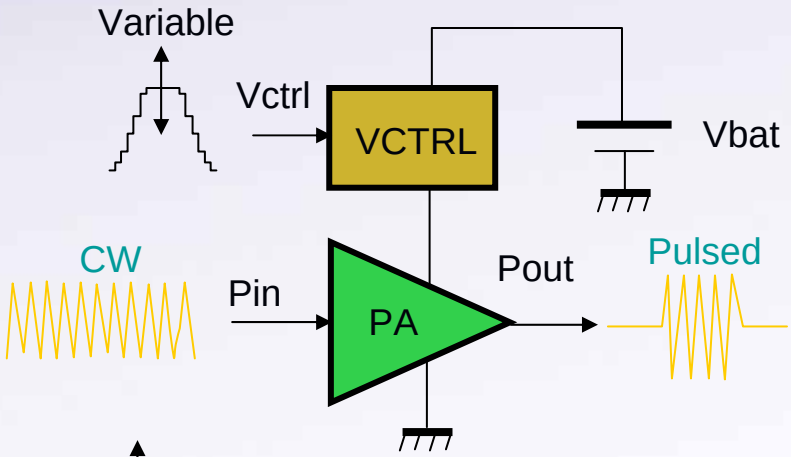
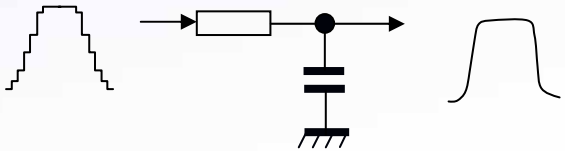
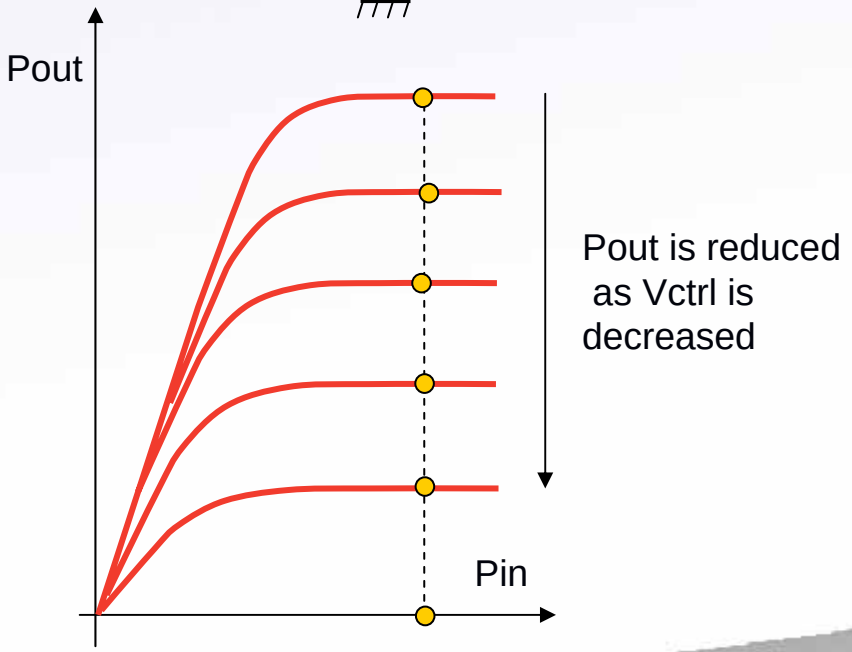
GMSK Power Control



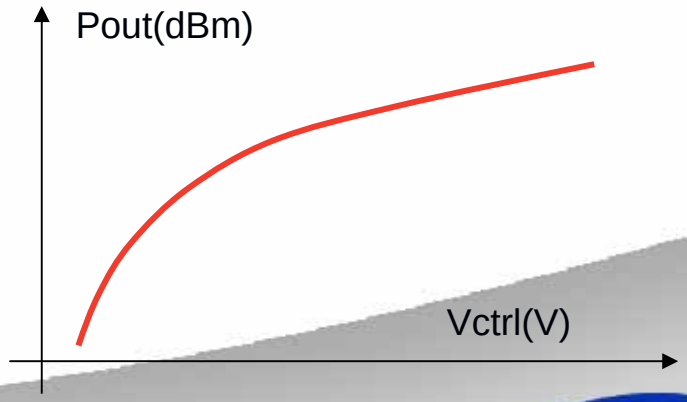
As for GMSK mode, we work with a constant envelope, we can operate the power amplifier saturated .
An easy way to control the output power is then to fix the input drive level in CW mode at a constant level and to burst the output signal with a pulsed control signal issued from the DAC .



The control signal is integrated in order to provide a smooth ramp-up & down.



Pout is reduced as Vctrl is decreased



EDGE Modulation (1)

Two modulation schemes are defined in EDGE:

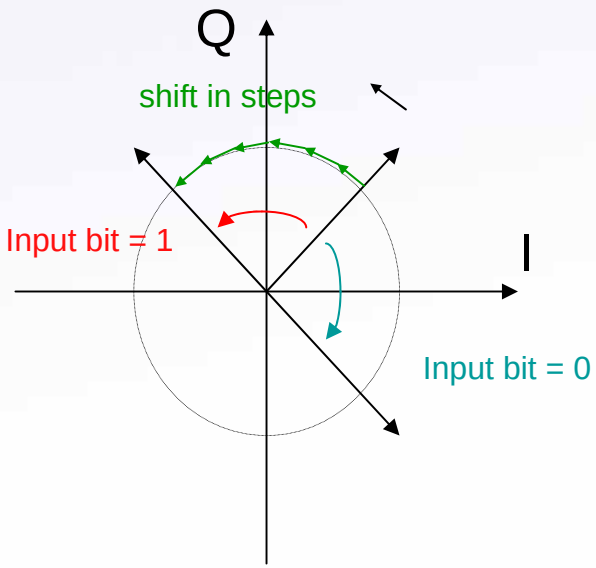
- GMSK (Gaussian Minimum Shift Keying) as in GSM and GPRS
- 8-PSK (8 Symbol Phase Shift Keying)

The chosen RF modulation depends on the quality of the actual radio link.

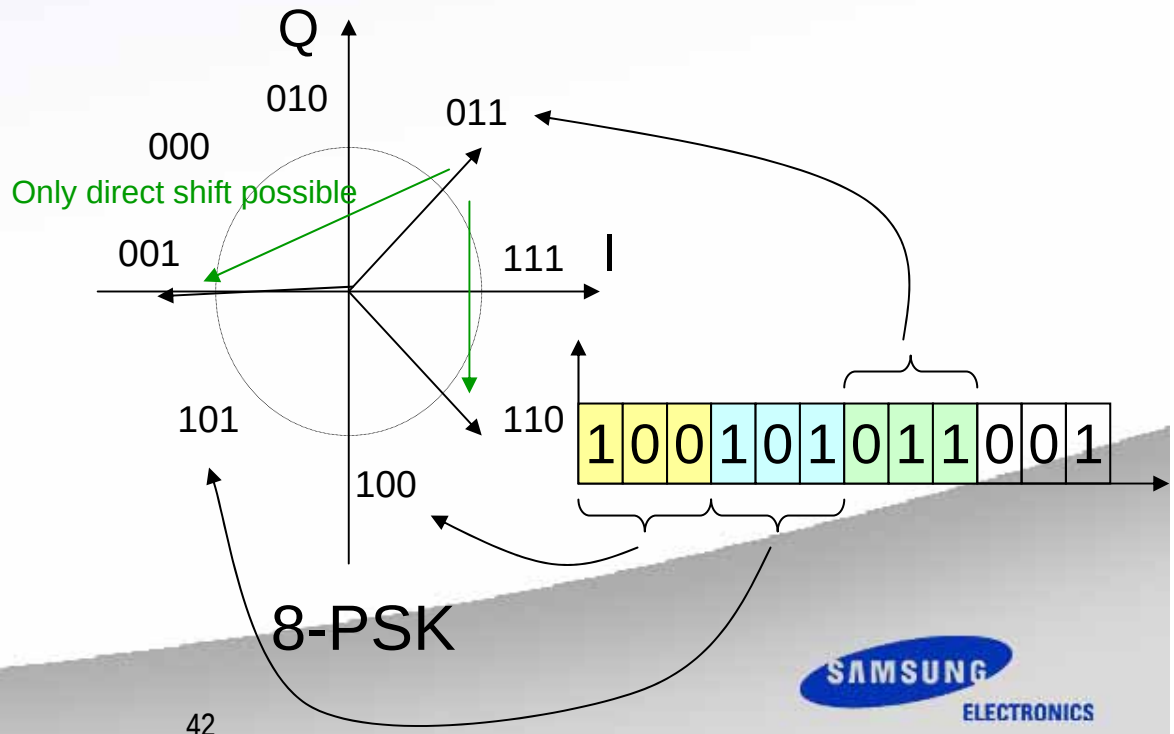
In 8-PSK, each possible combination of three inputs bits is allocated to one symbol. Thus 8 symbols (000 to 111) are defined for 8-PSK.
Each input symbol generates a phase shift to one of eight defined phase states.

EDGE Modulation (2)

Compared to GMSK, 8-PSK has three times the data throughput capacity.
However, its major disadvantage is the inconsistent envelope of modulated signal.

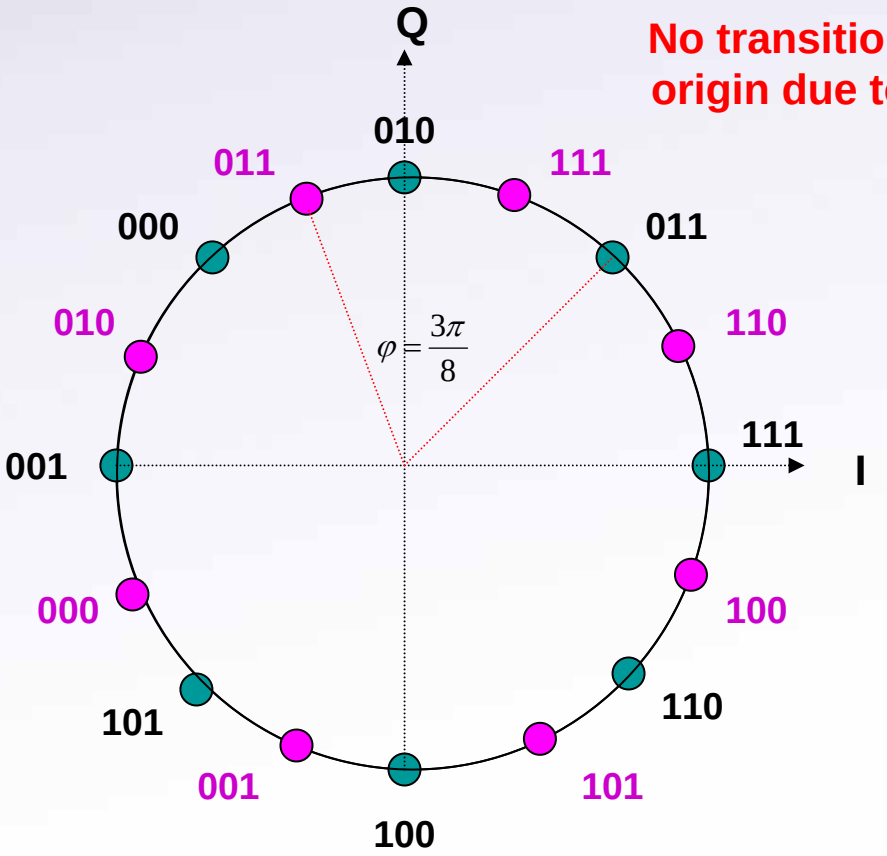


GMSK

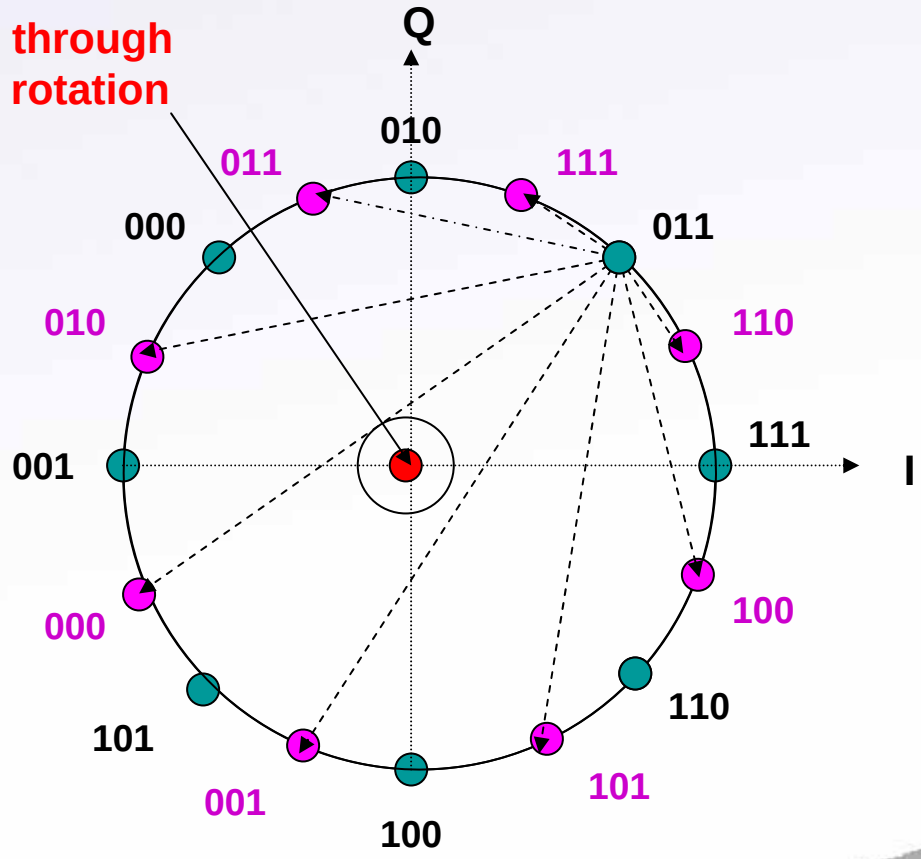


8-PSK

EDGE Modulation (3)



Between any two symbols, the symbol circle shifts by an offset angle of $\varphi = \frac{3\pi}{8}$



The figure illustrates one symbol change from blue colour state (plain 8PSK) to the mauve symbol state which is shifted by 3π/8 compare to plain 8PSK

Constellation diagram for 3π/8 Offset 8-PSK

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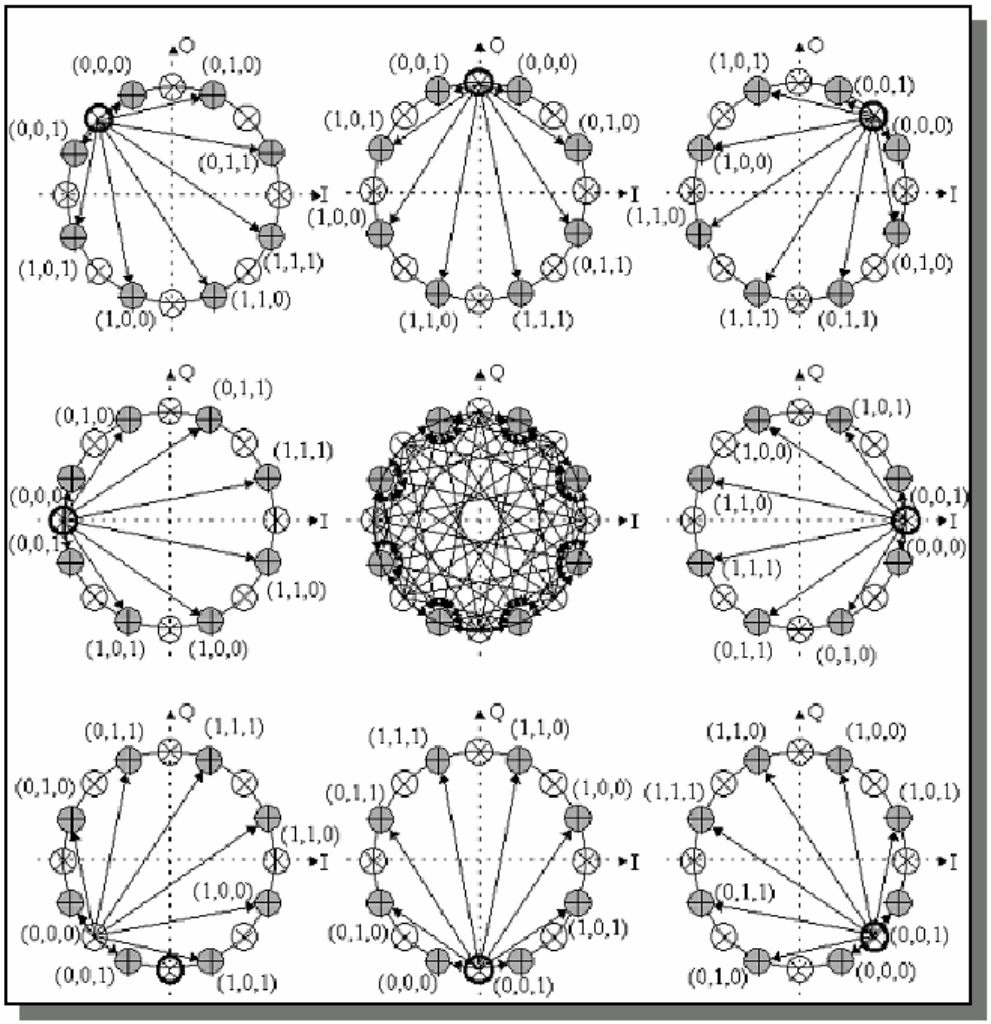
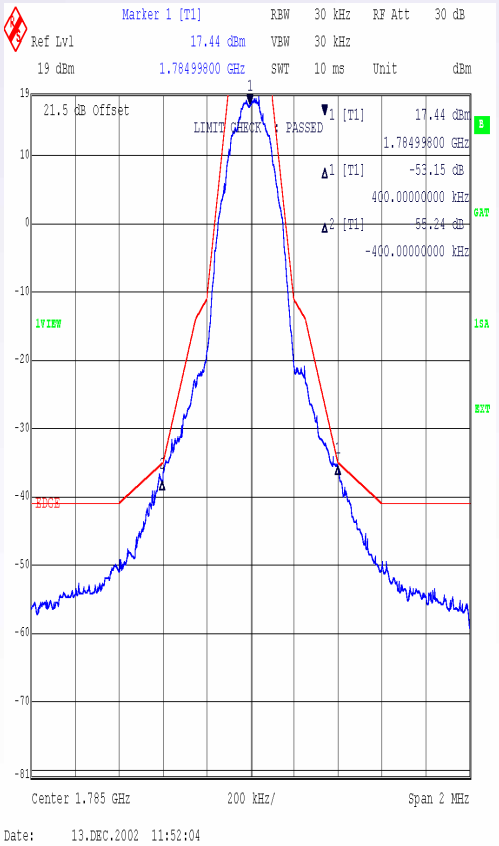
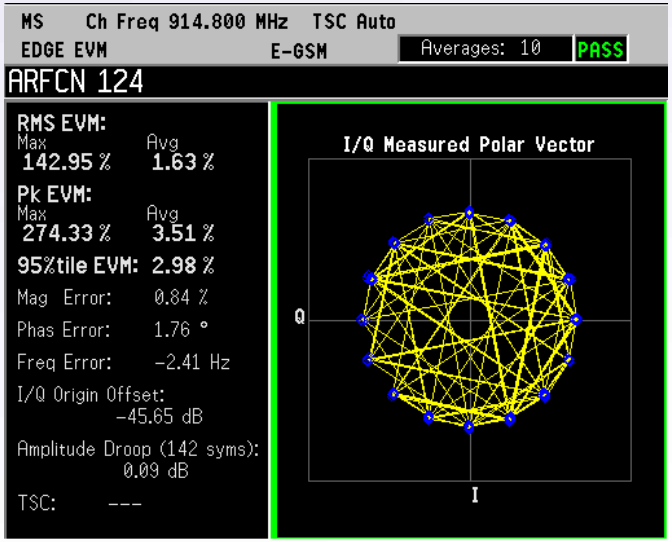
3π/8 8PSK Modulation Constellations

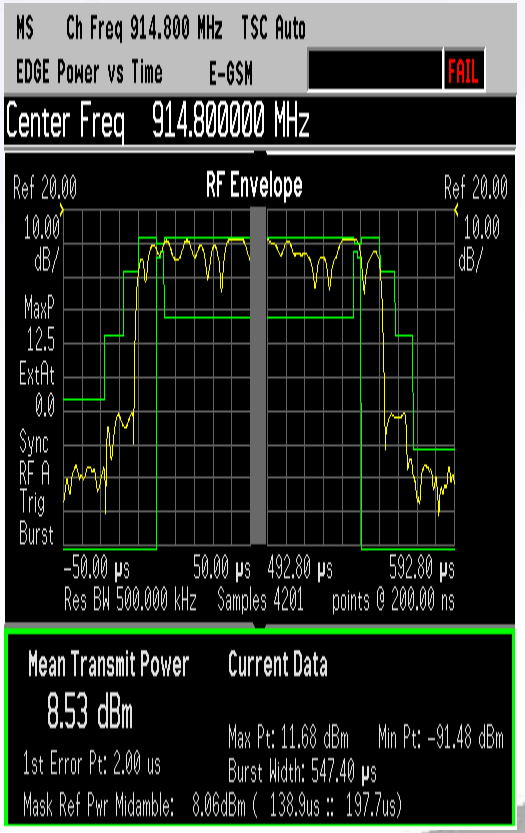
1. EDGE coding schemes MCS5-9
2. Uses 3π/8 8PSK
3. 3 bits per symbol
4. Utilises a 3π/8 rotation every symbol to avoid zero transitions
5. Power trace now varies with symbol transitions



EDGE Modulation (4)







The modulation spectrum must fit in the modulation mask.
The time burst must fit in the time mask.

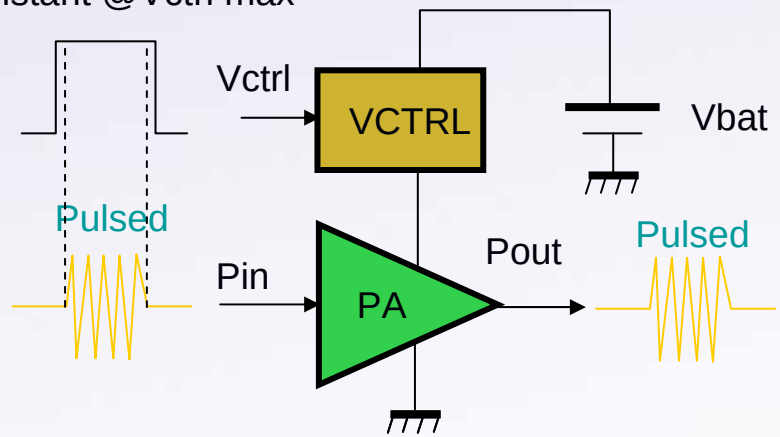
Frequency domain

Constellation domain

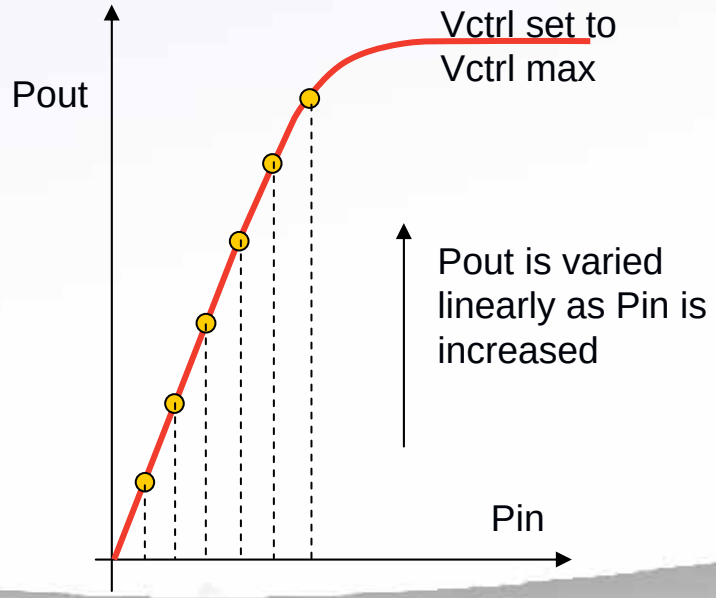
Time domain

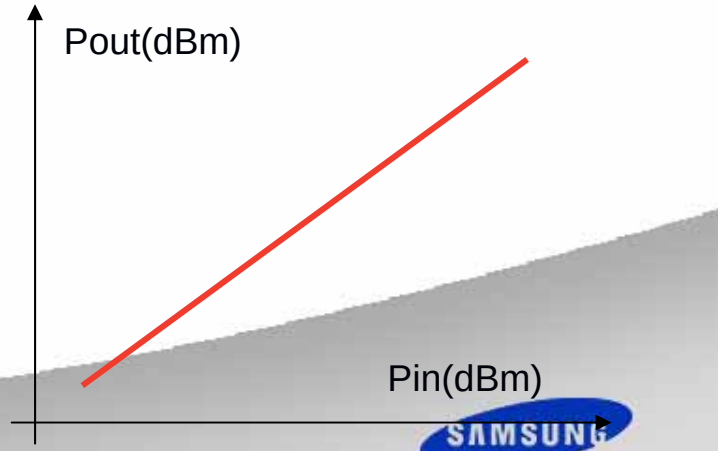
EDGE Power Control

Vctrl is kept
constant @Vctrl max



As for EDGE mode we work with a non constant envelope, due to the 8PSK modulation, the power amplifier is operated non saturated (linear mode) to allow the phase and amplitude modulation to be transmitted.
An easy way to control the output power is then to fix the control voltage to its maximum value and to pulse and vary the output power by means of the input signal
The ramp-up & down of the signal is done on the input signal.





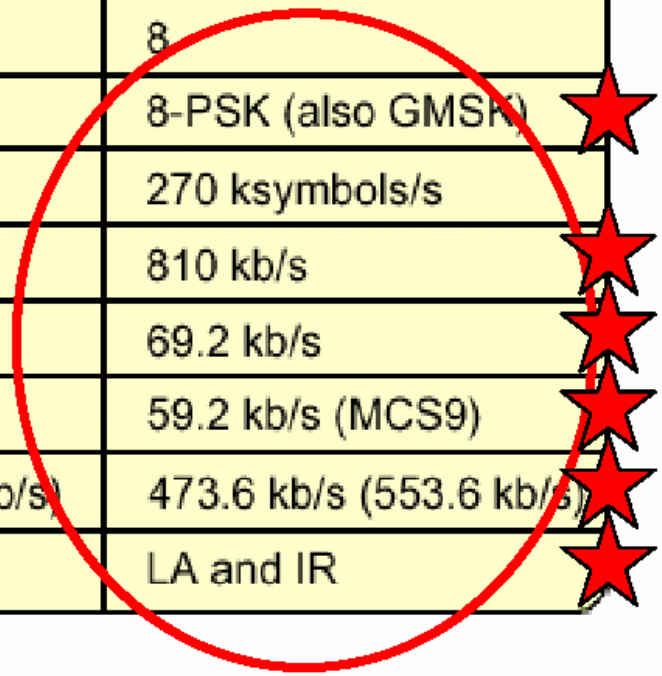
Changes!! Air Interface

- GMSK modulation is maintained for certain data rates
- 8-PSK modulation with $3\pi/8$ rotation per symbol is used for higher data rates
- TS format is maintained for backward compatibility and easier design
- Symbol rate is the same as in GSM (270.833 ksps)
- For 8-PSK modulation, the raw bit rate is tripled

  (3x270.833 = 812.499 kbps)

Physical Layer: GPRS / EDGE Comparsion

Parameter	GSM/GPRS	EDGE
Carrier spacing	200 kHz	200 kHz
Frame length	4.6 ms frames	4.6 ms frames
Timeslots per carrier	8	8
Modulation	GMSK	8-PSK (also GMSK)
Symbol rate	270 ksymbols/s	270 ksymbols/s
Modulation bit rate	270 kb/s	810 kb/s
Radio data rate per time slot	22.8 kb/s	69.2 kb/s
Max. user data rate per time slot	20 kb/s (CS4)	59.2 kb/s (MCS9)
Max user data rate - 8 time slots	160 kb/s (182.4 kb/s)	473.6 kb/s (553.6 kb/s)
Link Quality Control (LQC)	None	LA and IR



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Link Quality Control:

LA (Link Adaptation)

– select the MCS that gives a maximum throughput for certain C/I

IR (Incremental Redundancy)

– Packet is sent with a certain puncture scheme

– If a packet is received in error, the transmitter will retransmit the packet with another puncture scheme

– at the end all the packets will be combined (better performance)