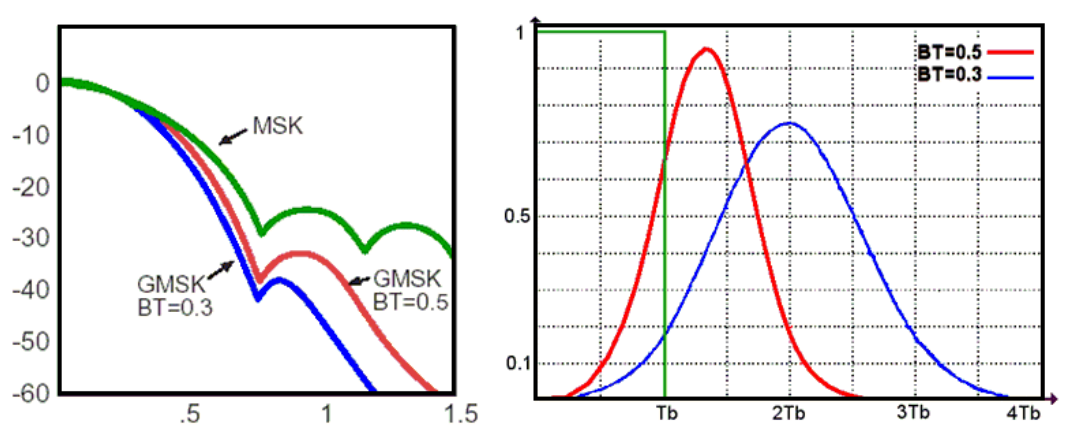


Gaussian Minimum Shift Keying (GMSK)

FAISAL MASOOD

UMER AZIZ WAQAS

outlines

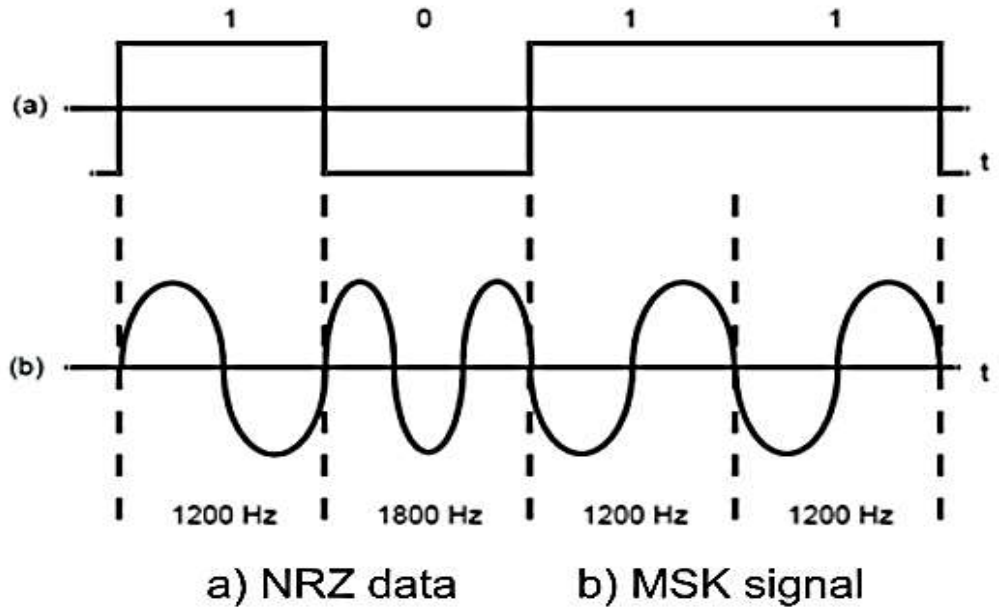
- What is GMSK?
- An Overview to MSK
- Performance & reliability
- Bit Error Rate
- Time domain and frequency response
- Modulation & Demodulation of GMSK
- Generation of GMSK
- Transmitter & Receiver
- Advantages and disadvantages
- Applications & Conclusion

What is GMSK?

- Gaussian Minimum Shift Keying (GMSK) is a form of continuous-phase FSK in which the phase is changed between symbols to provide a constant envelope
- Consequently it is a popular alternative to QPSK
- A Gaussian filter is used before frequency modulation
- GMSK is advanced version of MSK

An overview to MSK

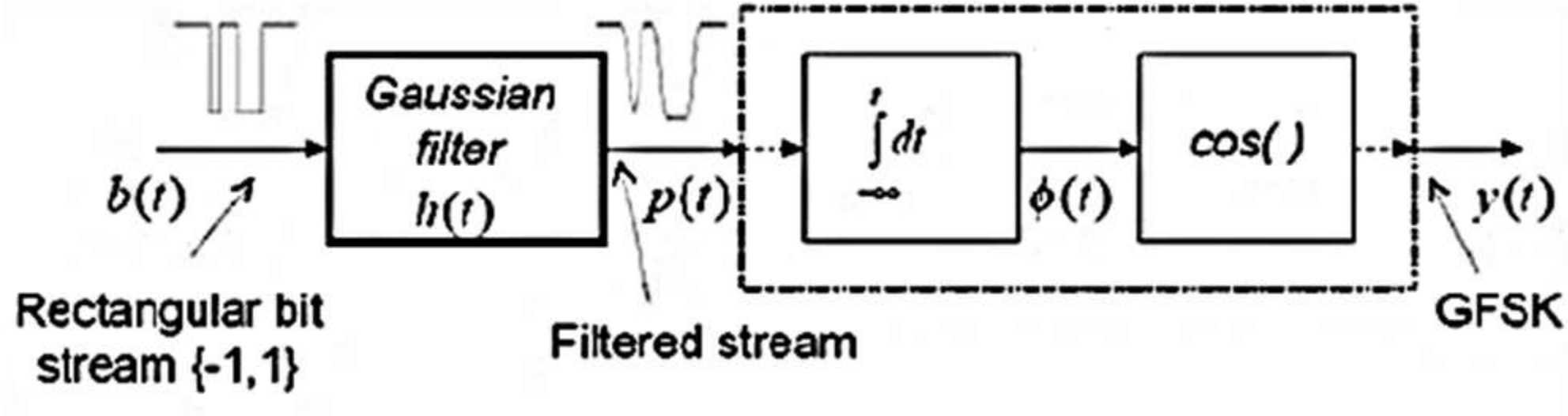
- Minimum shift keying (minimum frequency separation)
  - Phase continuous (CPFSK)
  - Frequency changes
- Baseband modulation starts with a bitstream of 0's,1's and a bit clock
- This baseband signal is generated by first using NRZ filter
- Then FM is applied to produce MSK
- ISI is also introduced



GMSK & Msk

- GMSK is similar to MSK except it incorporate a pre-modulation Gaussian LPF

p(t)=h(t)*b(t)

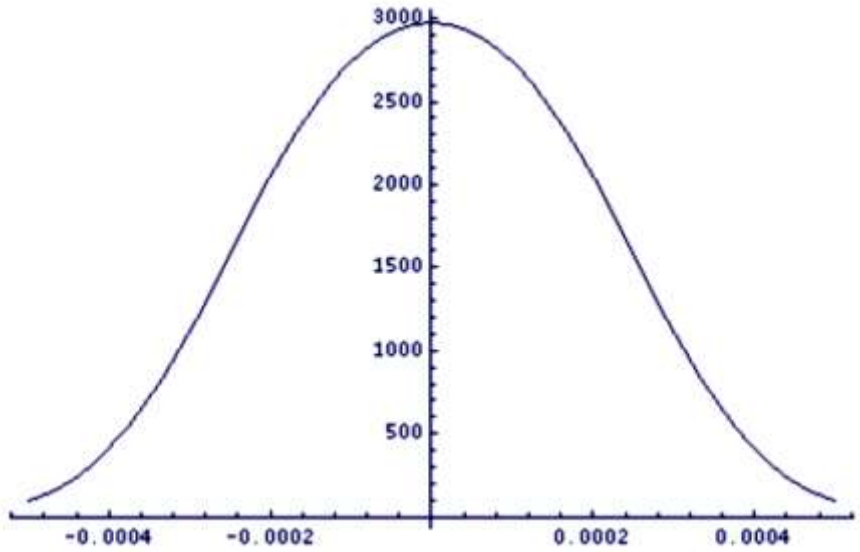


Gaussian filter

The requirements for the filter are:

- should have a sharp cut-off
- narrow bandwidth
- impulse response should show no overshoot
- Gaussian shaped response to an impulse and no ringing

In this way the basic MSK signal is converted to GMSK modulation



- response of the filter to a single 1 is a phase change of Π /2, is equivalent to choosing the constant K to satisfy the following equation

$$\int_{-T}^{T} Kg(t)dt = \pi/2$$

Reliability of gmsk data message

The reliability of a data message produced by a GMSK system is highly dependent on the following:

- **Receiver thermal noise**: this is produced partly by the receive antenna and mostly by the radio receiver.
- **Channel fading:** this is caused by the multipath propagation nature of the radio channel
- **Band limiting:** This is mostly associated with the receiver
- **DC drifts:** may be caused by a number of factors such as temperature variations, asymmetry of the frequency response of the receiver, frequency drifts of the receiver local oscillator

Performance criteria

- The performance of a GMSK modem is generally quantified by measurement of the signal-to-noise ratio (SNR) versus BER. SNR is related to Eb/N0 by

$$\frac{E_b}{N_o} = \frac{S}{R.N_o} = \frac{S}{N}\left(\frac{B_n}{R}\right)$$

Where ;

E_b → Energy/bit
S → Signal Power
R → Data rate in b/sec
No → Noise
B_n → Noise bandwidth of IF filter
Bn x No→ N noise power

Bit error rate

- GMSK bit rate offers better performance within one decibel of optimum MSK when the 3dB bandwidth bit duration product BT is equal to 0.25

- Bit error probability for GMSK is

$$P_e = Q\left\{\sqrt{\frac{2\gamma E_b}{N_o}}\right\}$$

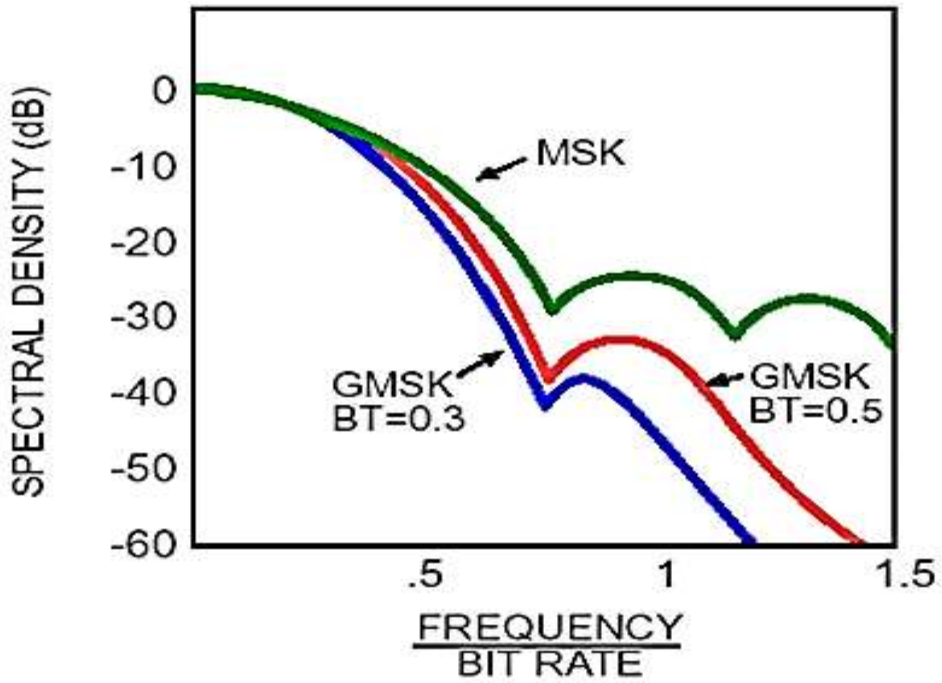
Where γ is constant related to BT.

$$\gamma = \begin{Bmatrix} 0.85\ for\ MSK\ (BT = \infty) \\ 0.68\ for\ GMSK\ (BT = 0.25) \end{Bmatrix}$$

- **Bandwidth-time product BT**.
  - Describes the amount of the symbols overlap
  - BT = 0.3 for GSM networks
  - Good spectral efficiency

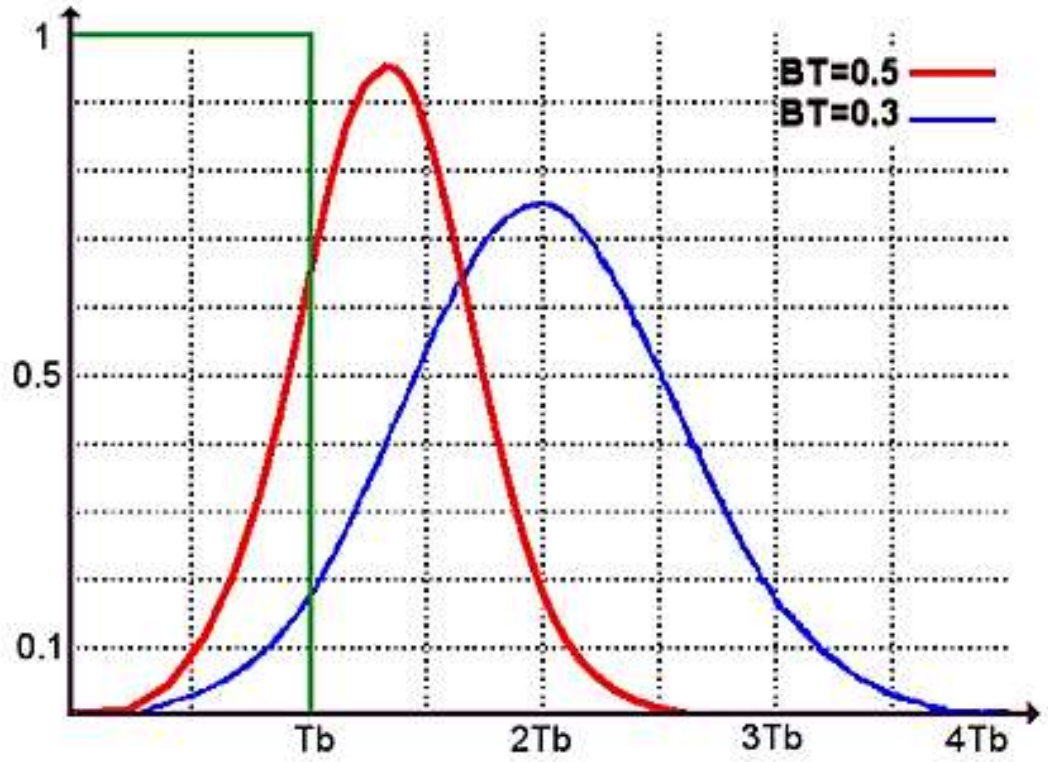
Frequency Response

- GMSKs power spectrum drops much quicker than MSK's. Furthermore, as BT is decreased, the roll-off is much quicker



Time-domain response

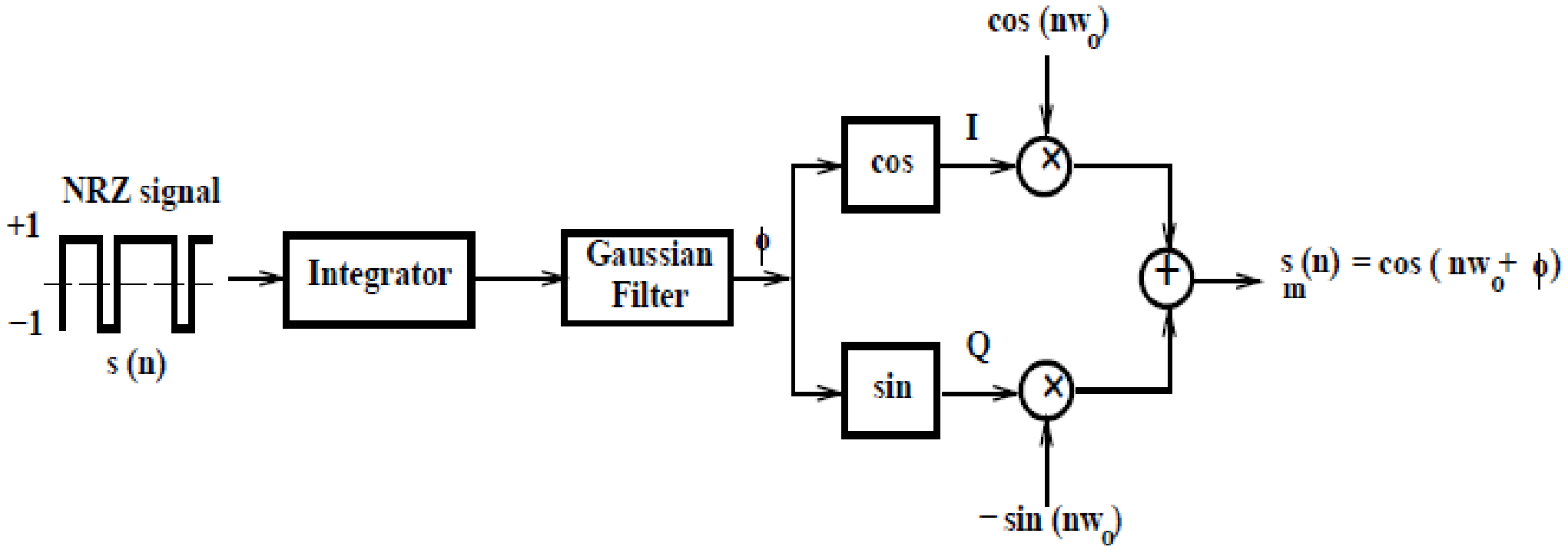
With lower time-bandwidth products the pulse is spread over a longer time, which can cause intersymbol interference.



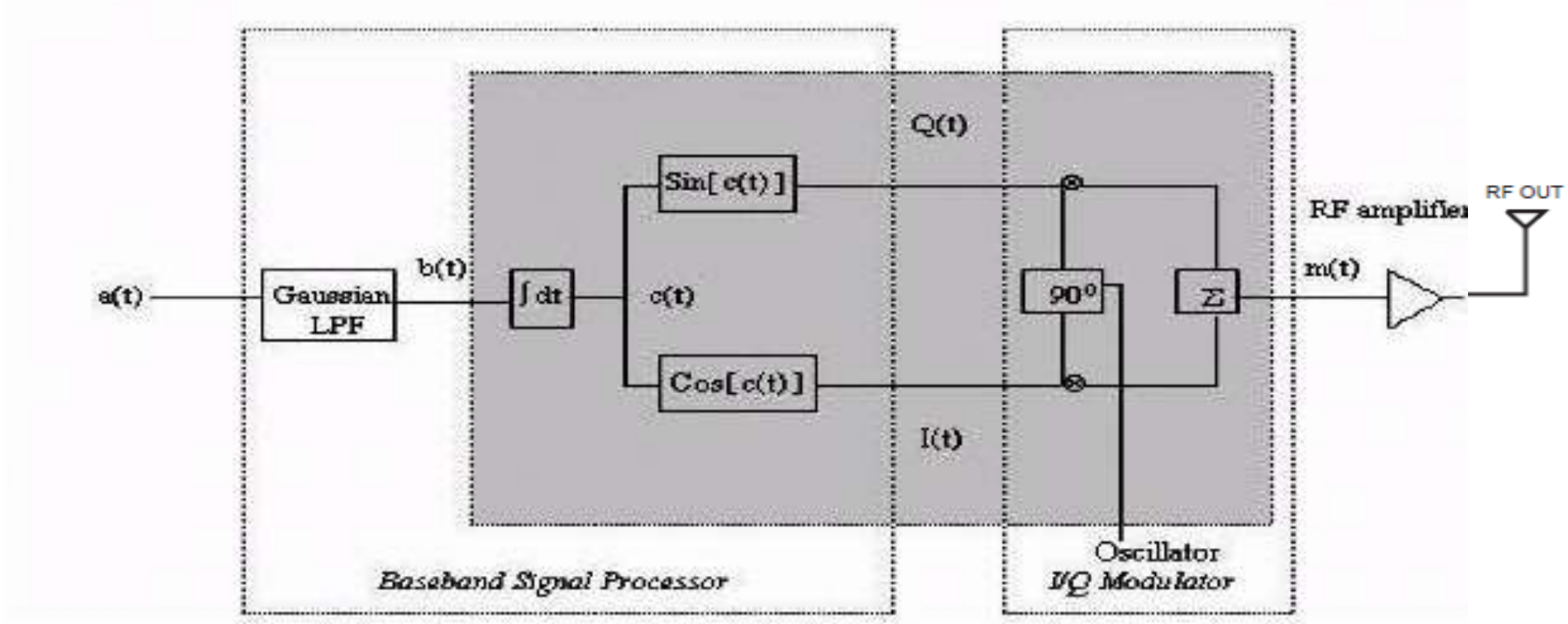
Therefore as a compromise between spectral efficiency and time-domain performance, an intermediate time-bandwidth product must be chosen.

modulation

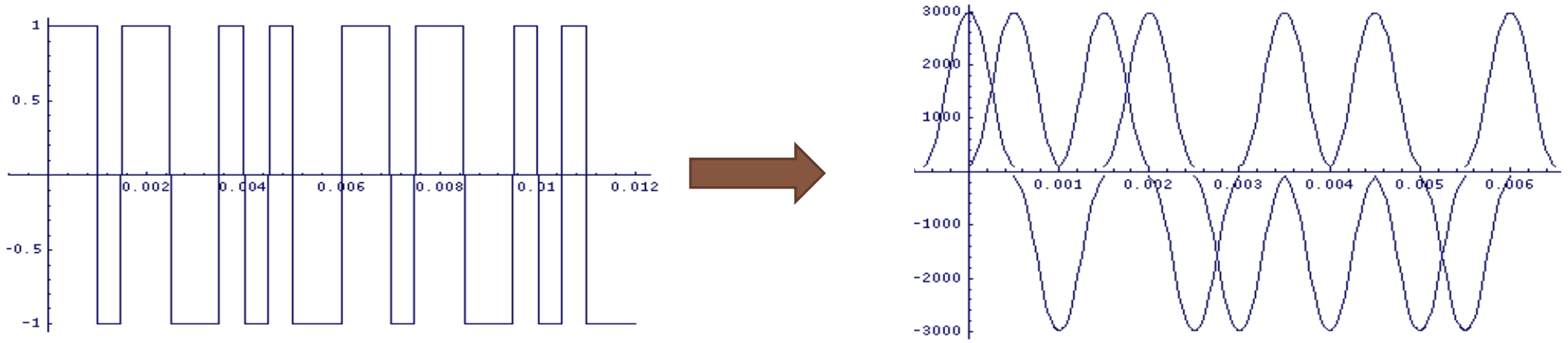
- Modulation index = 0.5
- Implementation is cheaper



Generation of GMSK waveform



Pulse shape



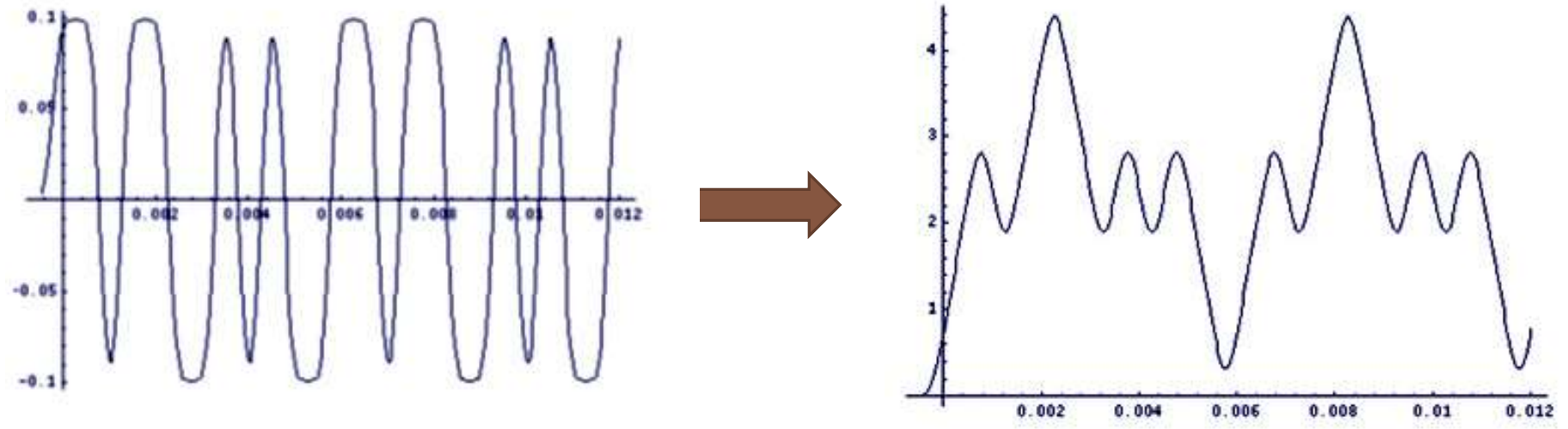
- Input: Binary pulse train (+1/-1)
- Each binary pulse goes through a LPF with a Gaussian impulse response
  - The filter smoothens the binary pulses
  - The filter output is truncated and scaled

$$h_g(t) = \left[\frac{\sqrt{\pi}}{\alpha}\, exp\frac{-\pi^2}{\alpha^2}t^2\right]$$

→ α= roll of factor of the filter
t=time period, t=K*Tb
Tb=bit period
K= integer

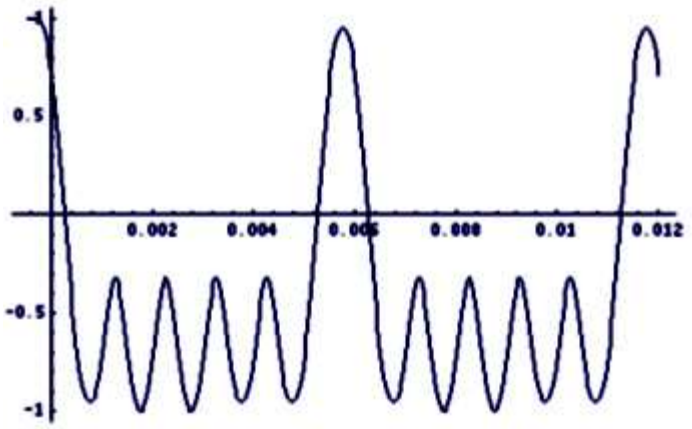
- This process results in a train of Gaussian shaped pulses **b(t)**

SUMMING AND INTEGRATION

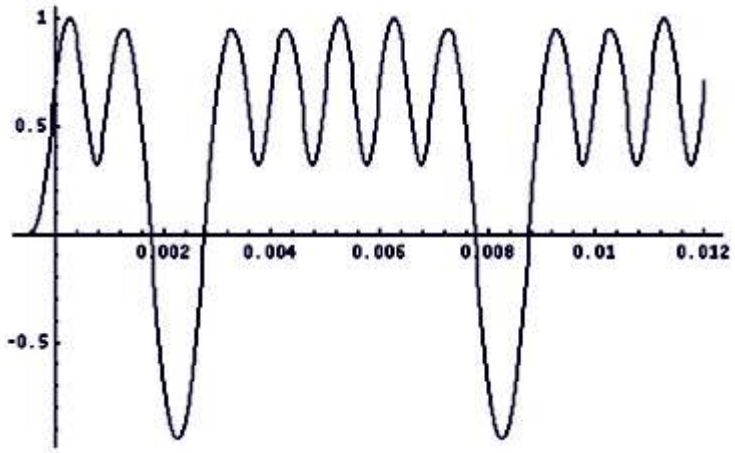


- The pulses are summed together (left)
- The signal is integrated over time to obtain a continuous waveform **c(t)** which captures the bit transition information (right)

I&Q Signals



I(t) = cos[c(t)]



Q(t) = sin[c(t)]

- The resulting waveform is divided into In-Phase and Quadrature components
  - In-phase: (Left)
  - Quadrature: (Right)
- The two signal components are then up-converted to the carrier frequency

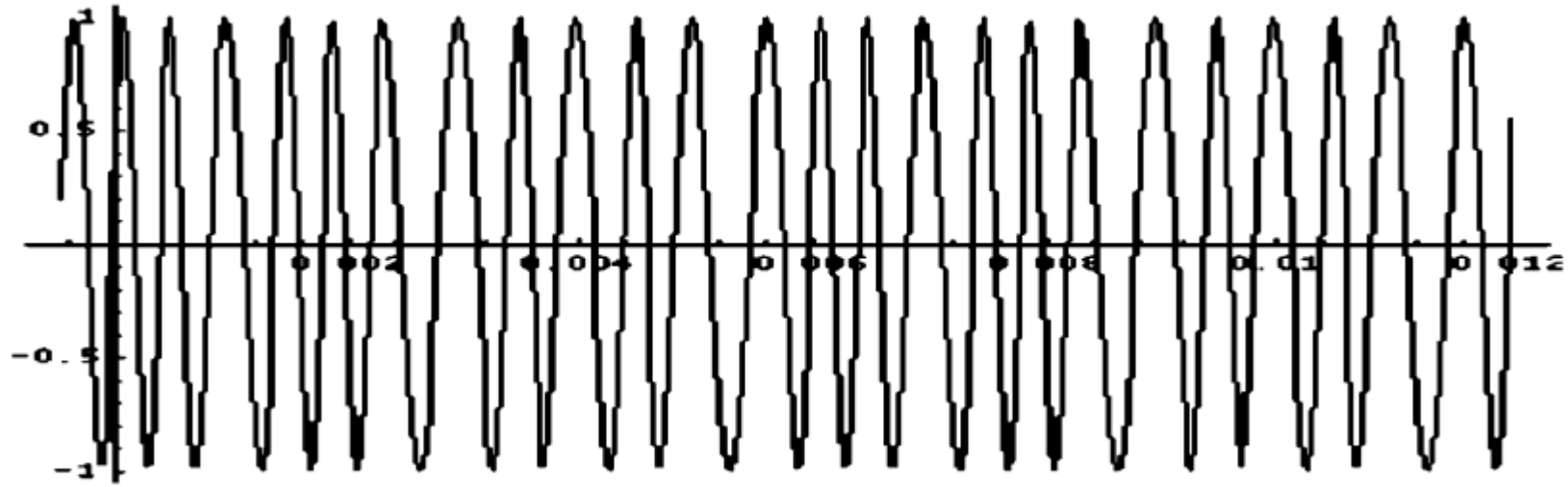
GMSK Waveform

- upconverting the I(t) produces

  = cos[c(t)] cos((2Πfct)

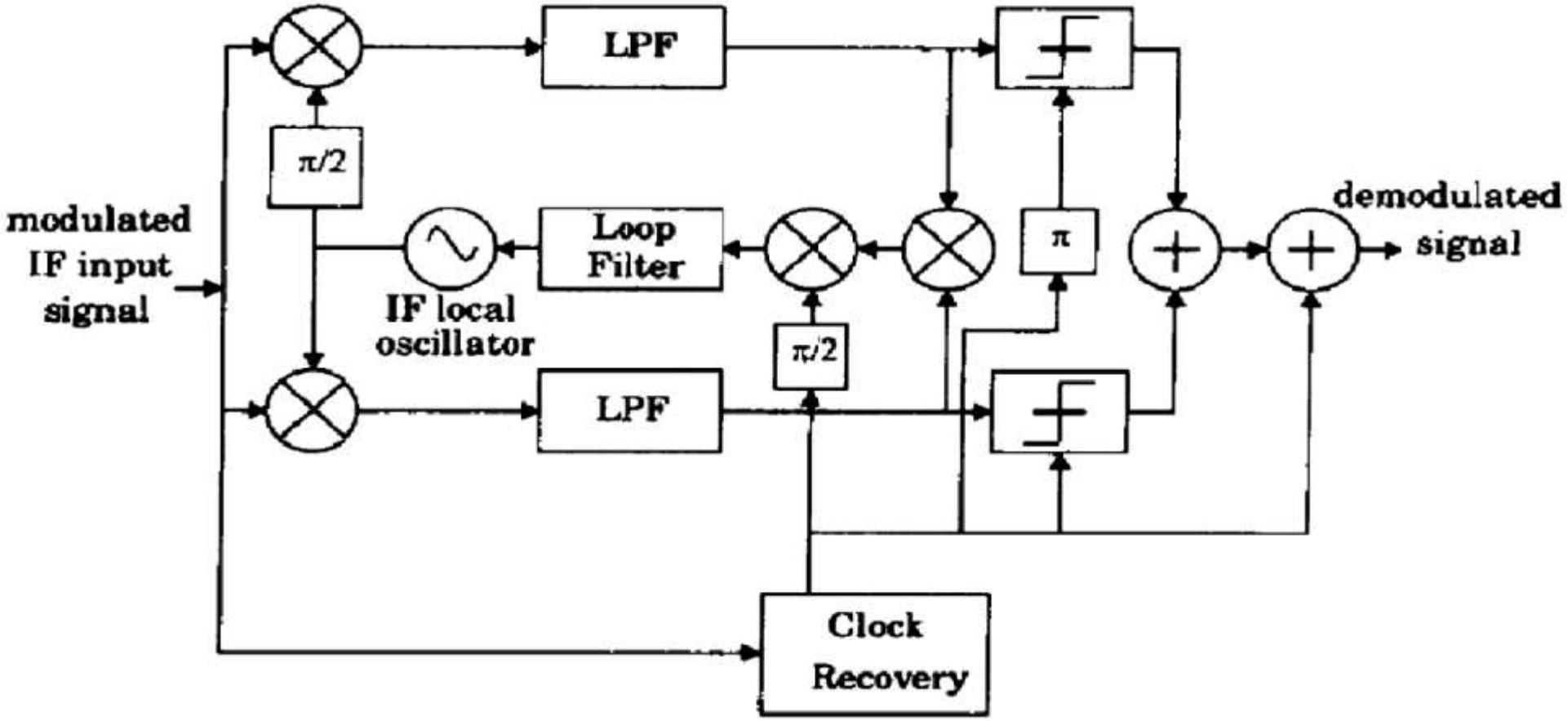
- Upconverting the Q(t) produces

  = -sin[c(t)] sin(2Πfct)

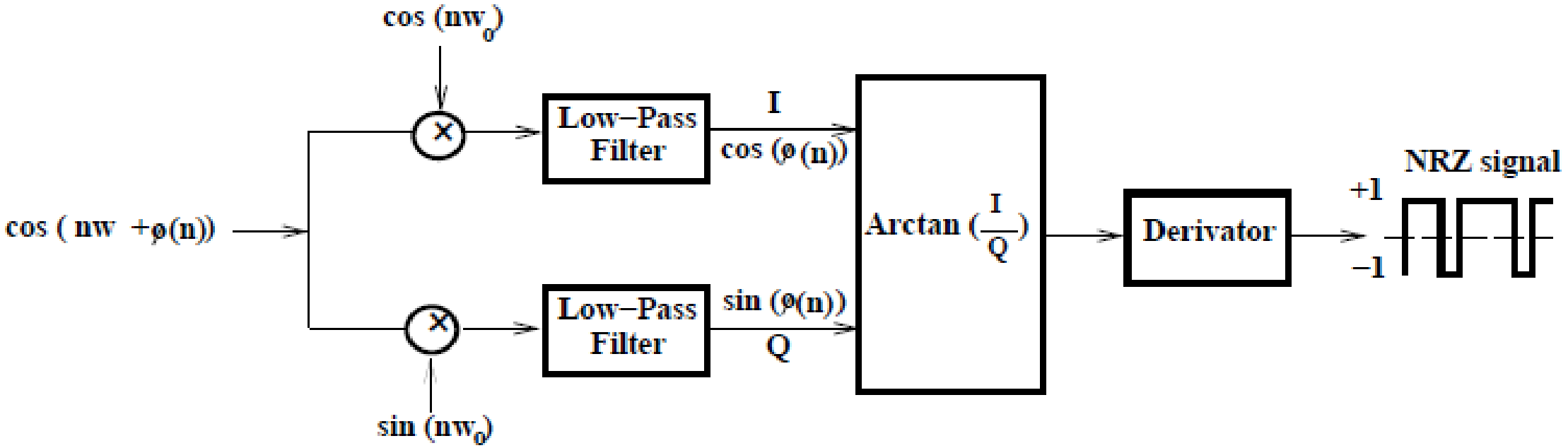


m(t)= cos (2Πfct) I(t) + (-sin(2Πfct) Q(t))

GMSK RECEIVER



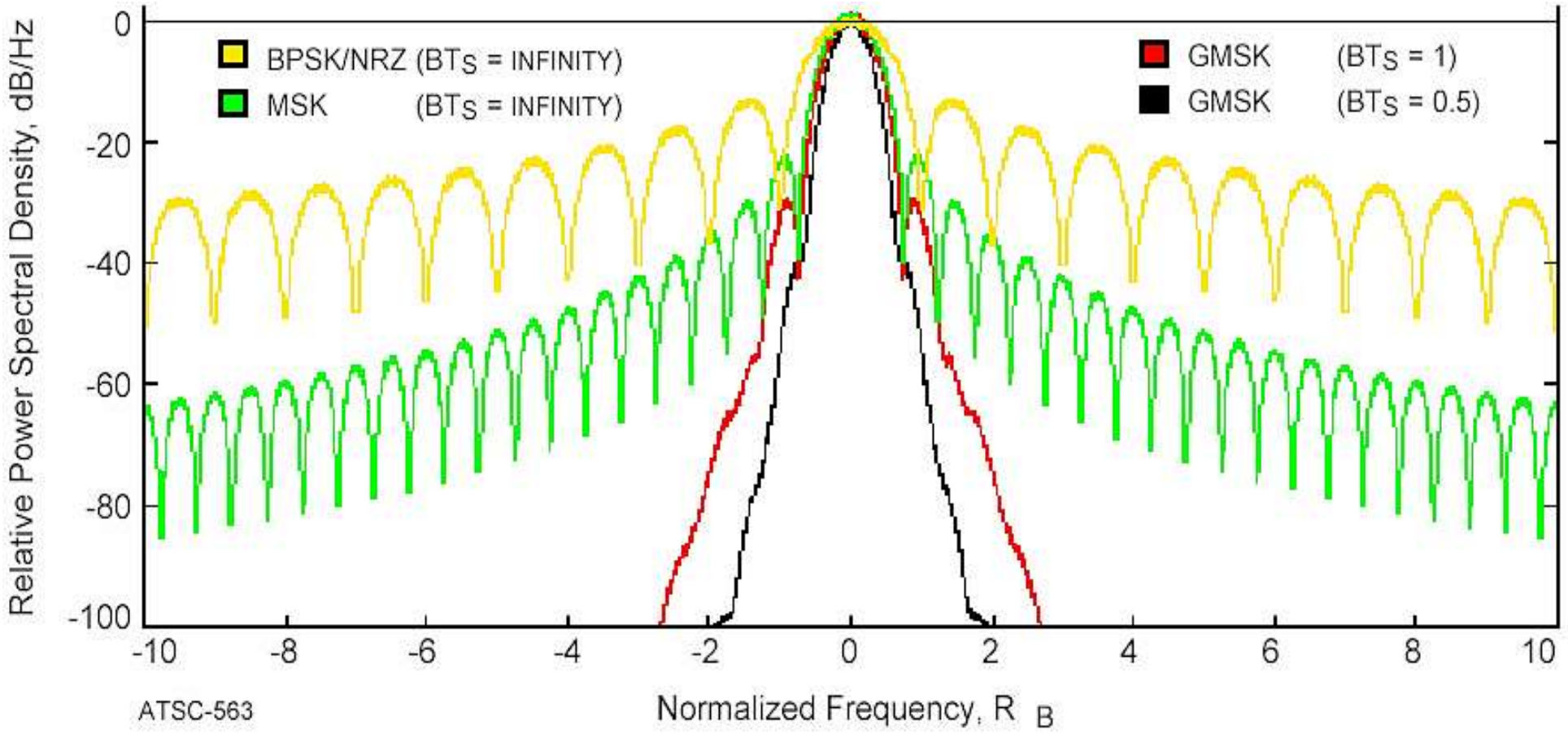
DEMODULATION



- Acrtan derives back Φ, which is applied to derivator to get NRZ signal.

Gmsk spectral shaping

- Generally achieves a bandwidth efficiency less than 0.7 b/s/Hz , QPSK can be as high as 1.6 b/s/Hz



Advantages

- High spectral efficiency
- Reducing sideband power
- Excellent power efficiency due to constant envelope
- Good choice for voice modulation
- ISI is tolerable
- GMSK is highly useful in wireless communication
- Good BER performance
- Self synchronizing capability

disadvantages

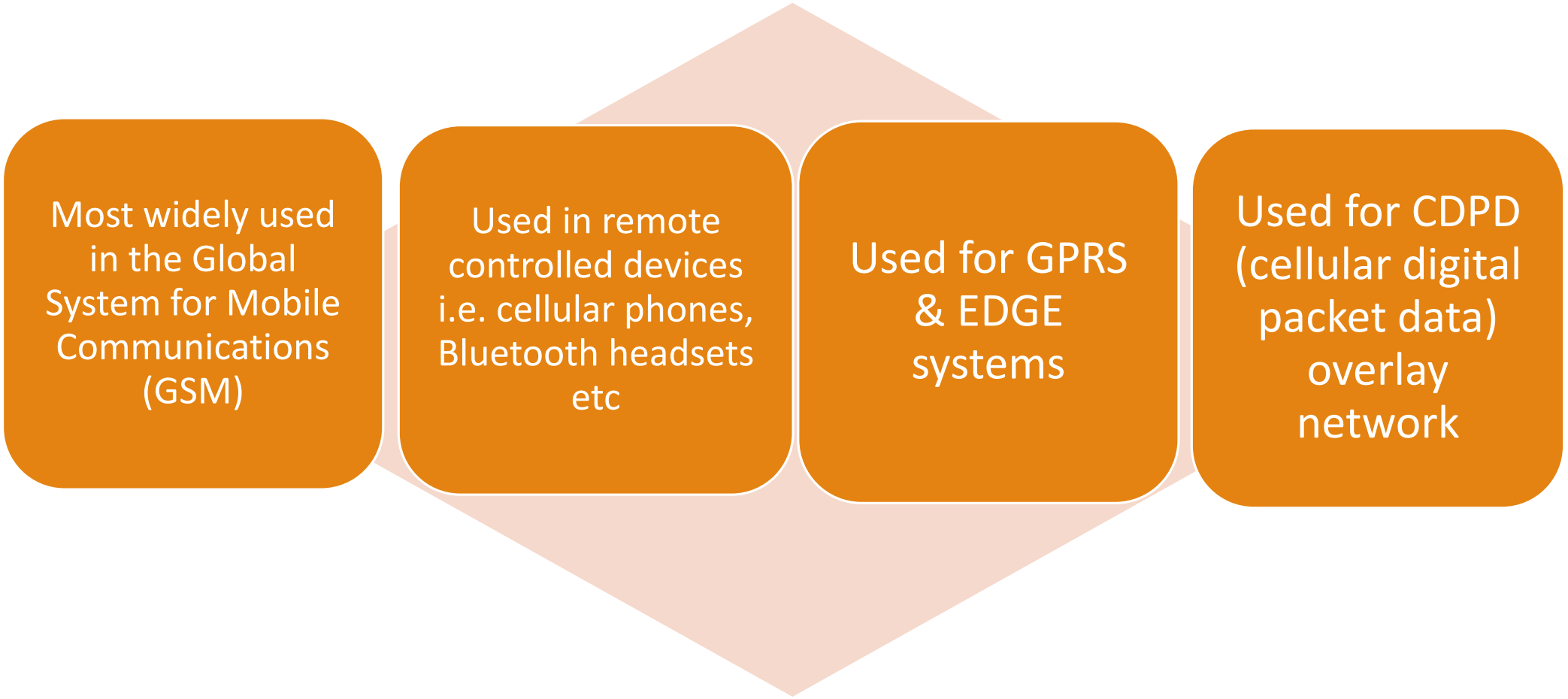
- Higher power level than QPSK
- Requiring more complex channel equalization algorithms such as an adaptive equalizer at the receiver
- Probability of error is higher then MSK.

$$p_e \leq (M-1)Q\left(\sqrt{\frac{E_b \log_2 M}{N_o}}\right)$$

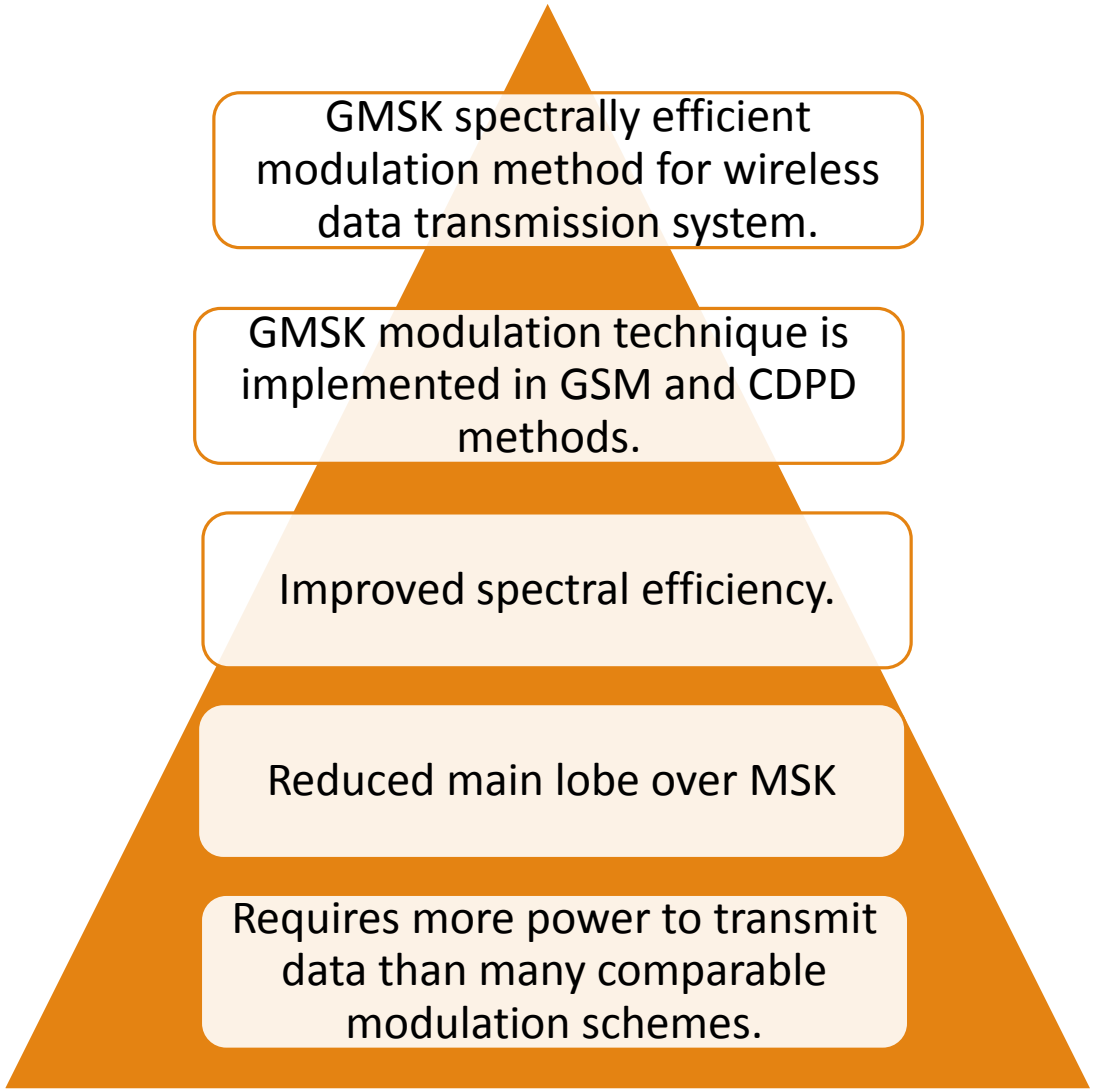
Where;

Q → Q-function
Eb → energy of bit
No → Noise

Applications



conclusion


GMSK spectrally efficient modulation method for wireless data transmission system.
GMSK modulation technique is implemented in GSM and CDPD methods.
Improved spectral efficiency.
Reduced main lobe over MSK
Requires more power to transmit data than many comparable modulation schemes.

references

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Questions & Answers

Knowledge is about “courage to ask”.