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CQPSK presentation for 802.16.1 PHY

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Purpose:

Proposal to serve as a the baseline upstream modulation scheme for the 802.16 PHY standard.

Notice:

Release:

IEEE Patent Policy:

Constant Envelope Quadrature Phase Shift Keying (CQPSK)

Lars Lindh

CQPSK

- Also called Tamed Frequency Modulation (TFM)
- CQPSK is a constant envelope modulation scheme that can be efficiently and economically realized with a non-linear power amplifier working in saturation
- Unlike QPSK it has a constant envelope also between the symbols
- CQPSK combines constant envelope modulation with spectrum efficiency having a higher spectral efficiency than other constant envelope schemes
- Spectrum efficiency is achieved by smoothing the phase transitions of the signal

The CQPSK signal

- The CQPSK signal can be written as

  s(t)=Re{exp(w_ct + ϕ(t))}

  where ϕ(t) is given as

$$f\left(t\right)=K\int_{-\infty}^{t}\left[\sum_{n=-\infty}^{\infty}a_n\cdot g\left(t-nT\right)\right]dt$$

  a_n is the data sequence (+1, -1) and g(t) is the shaping filter.

  g(t) is given as

$$g(t)=\frac{1}{8}g_0(t-T)+\frac{1}{4}g_0(t)+\frac{1}{8}g_0(t+T)$$

$$g_0(t)\approx\sin\left(\frac{pt}{T}\right)\left[\frac{1}{pt}-\frac{2-\frac{2pt}{T}\cot\left(\frac{pt}{T}\right)-\frac{p^2t^2}{T^2}}{\frac{24pt^3}{T^2}}\right]$$

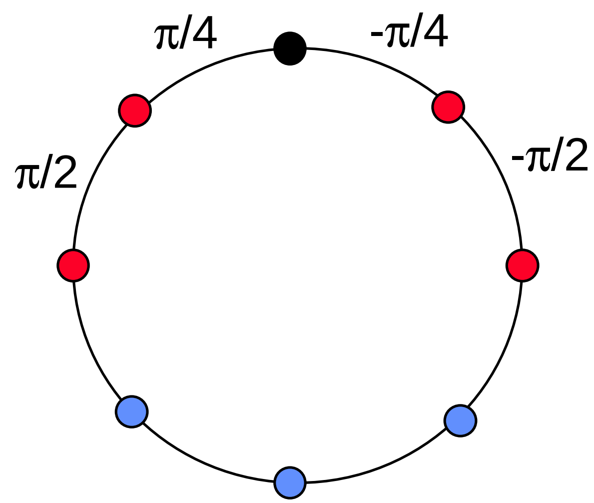
The CQPSK signal

- At symbol times the phase difference is given by

  $\phi(mT+T) - \phi(mT) = (\pi/2)(a_{n-1}/4 + a_n/2 + a_{n+1}/4)$

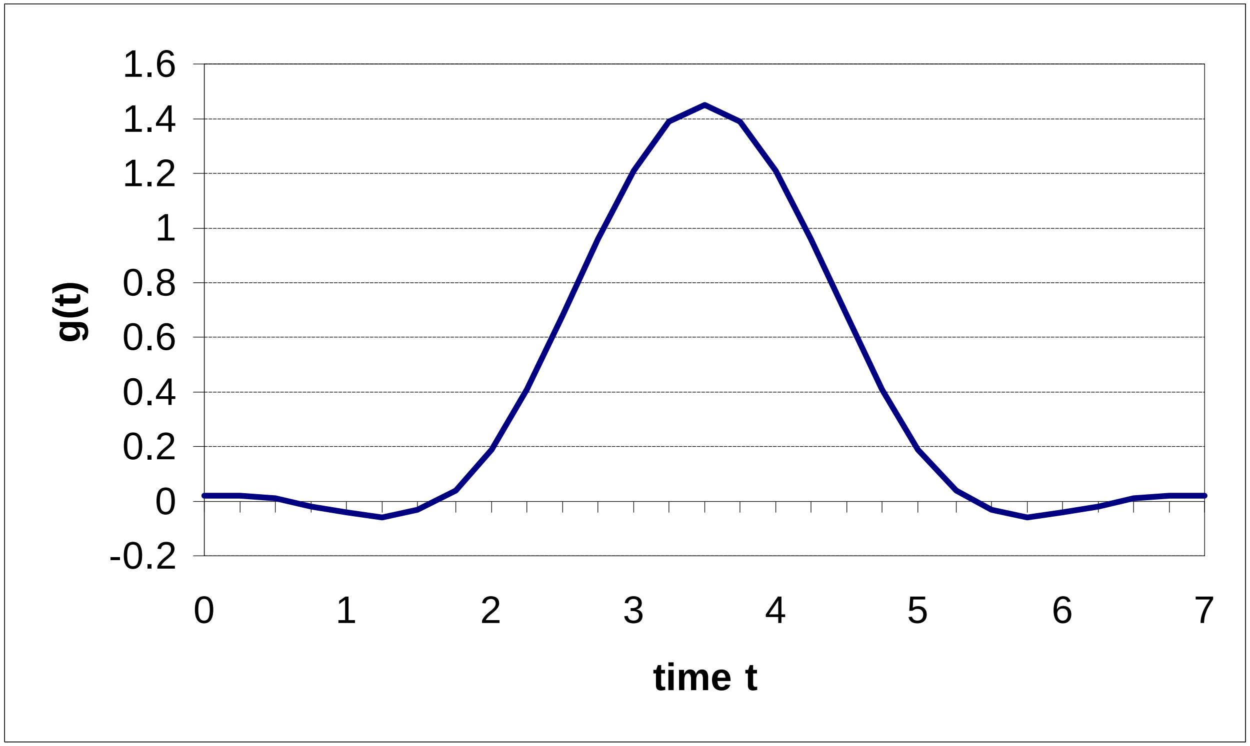
  $a_i = \pm 1$

a_{n-1}	a_n	a_{n-2}	$\Delta\phi$
+1	+1	+1	$\pi/2$
+1	+1	-1	$\pi/4$
+1	-1	+1	0
+1	-1	-1	$-\pi/4$
-1	+1	+1	$\pi/4$
-1	+1	-1	0
-1	-1	+1	$-\pi/4$
-1	-1	-1	$-\pi/2$



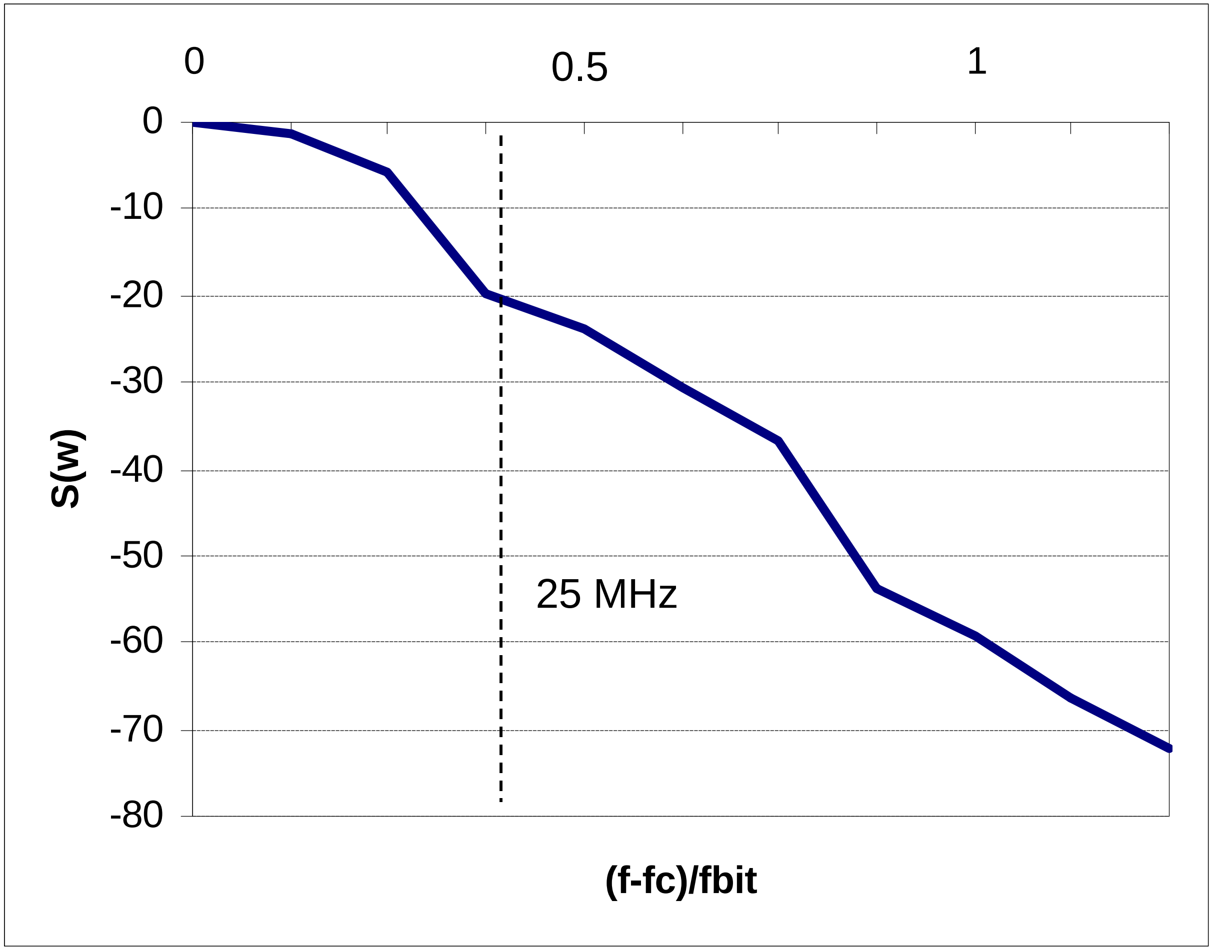
- 5 different phase changes possible in a 8-PSK constellation
- The shaping filter keeps the signal on the unit circle also between the symbols

The shaping filter g(t)



- Interpolating factor 4
- truncation length 7T

CQPSK spectrum

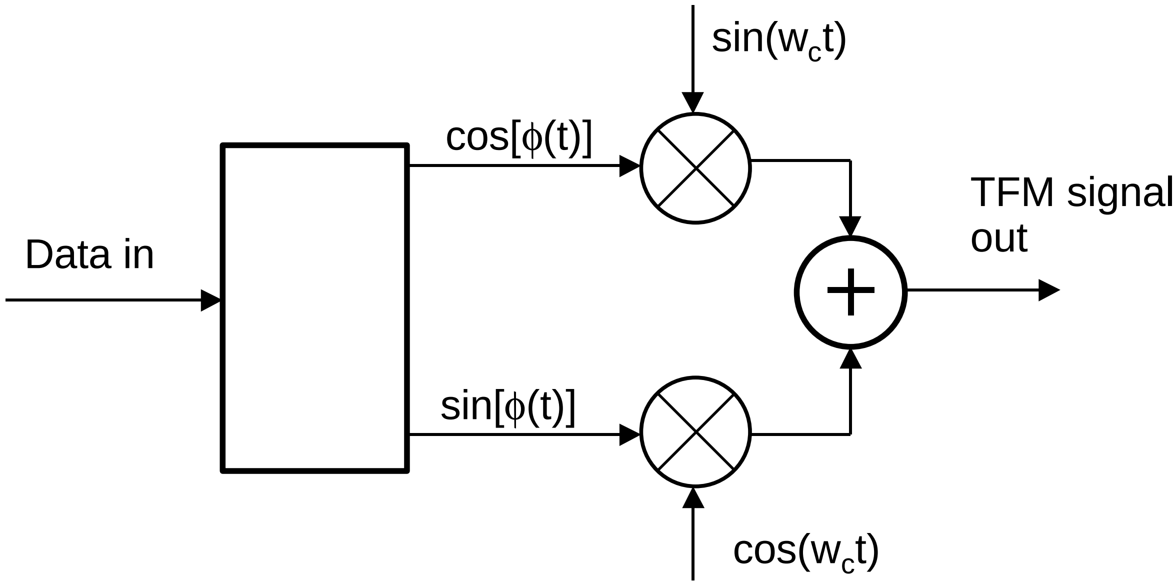


- Typical spectral efficiency 1.33
- Corresponds to QPSK with alpha 0.5
- with a 25 MHz channel bitrate is 33 1/3 Mb/s

CQPSK transmitters

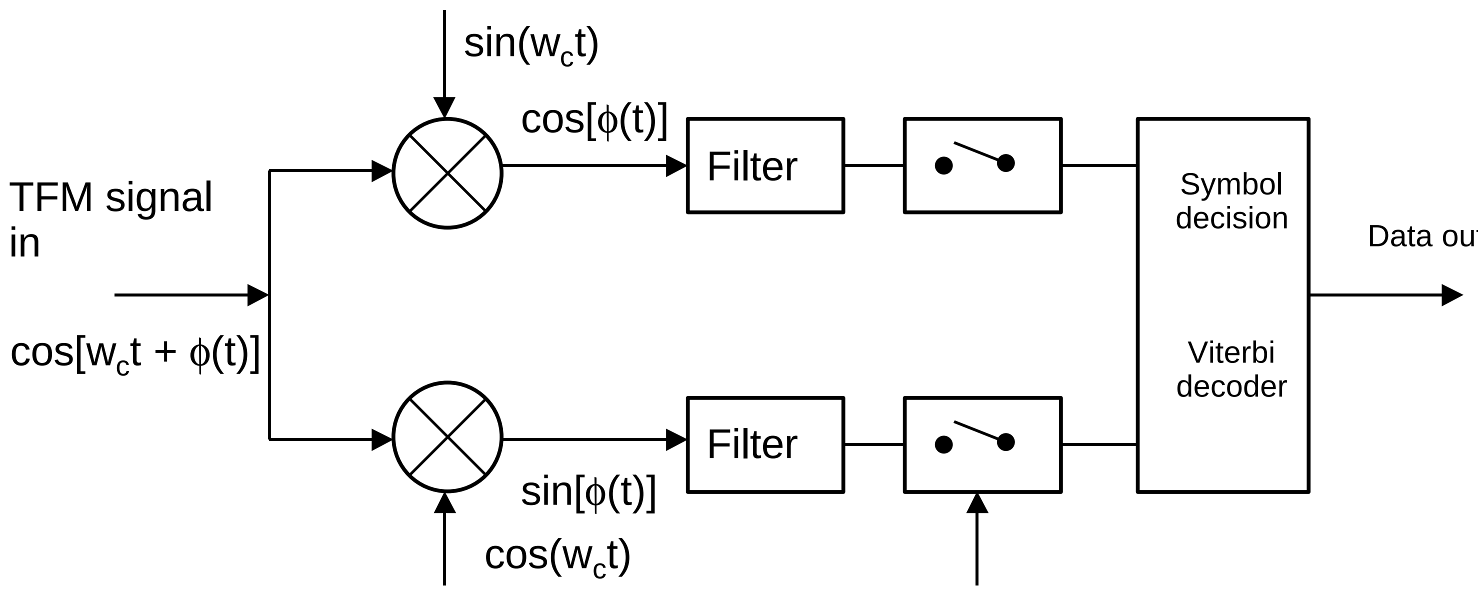
- Direct frequency modulation of a Voltage Controlled Oscillator (VCO)
- Generates -90, -45, 0, +45 or +90 degrees phase shift during one bit time
- Advantageous scheme for low cost terminals

CQPSK transmitters



- Quadrature based CQPSK transmitter
- Good choice for business terminal which also implement QAM

CQPSK receiver



- Quadrature based receiver
- Receiver can optionally use a Viterbi decoder to decode the most likely bits corresponding to the phase differences in the signal

Conclusions

- CQPSK with low amplifier back off gives high system gain
- Lower power consumption and heating
- Lower transmitter complexity
- Only CQPSK together with H-FDD can make possible low cost terminals which are able to compete with existing technologies and address both the business and residential broadband access markets