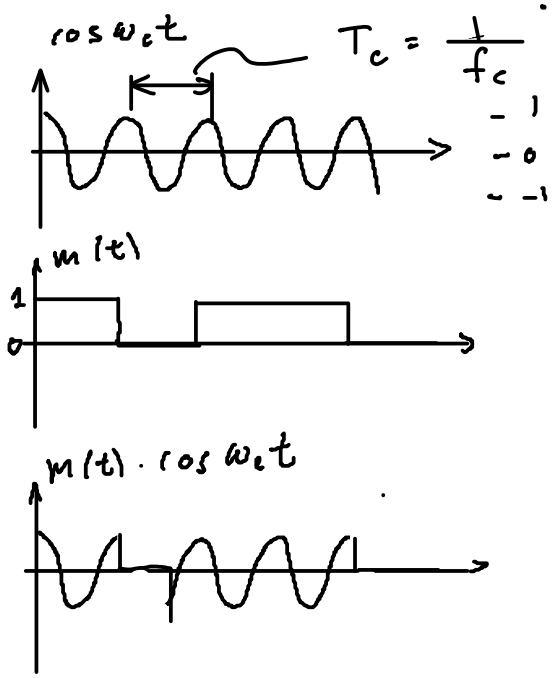
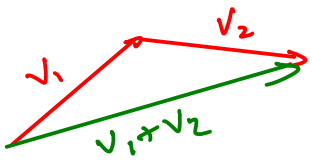
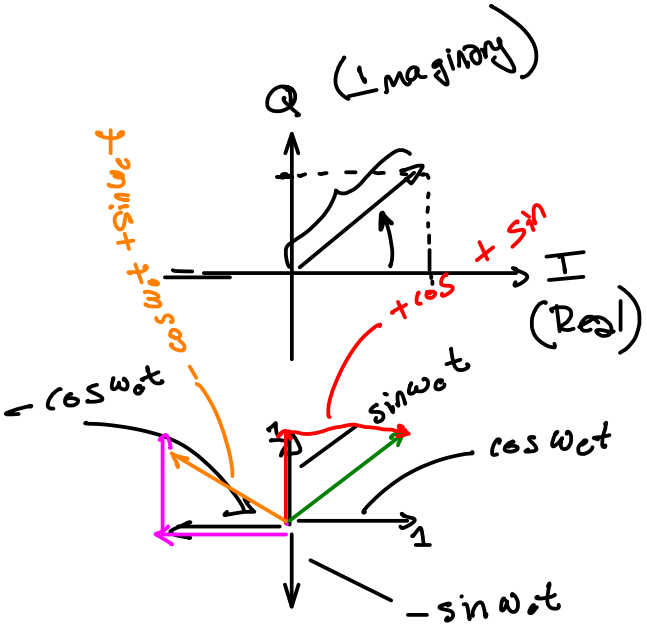
Exercise 1: Draw the waveform of an OOK (ASK) signal. Show the periods of the carrier and the modulating signal.

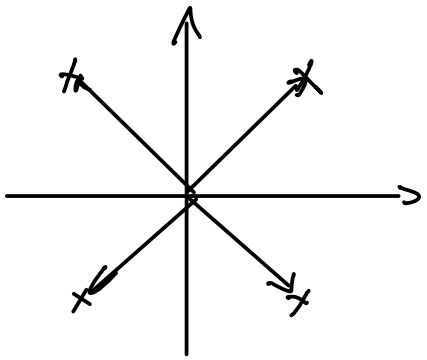


BPSK

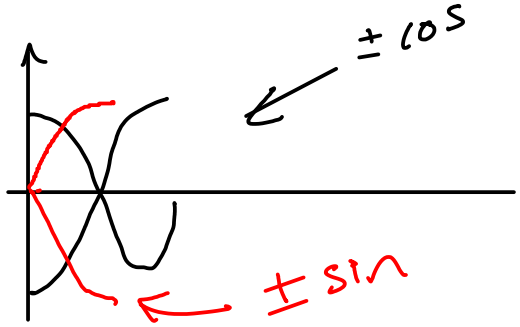
bit value →	0	1
m(t) →	+1	−1
m(t) cos(ωct)	cos ωct	− cos ωct
cos(ωct + θ)	cos(ωct + 0)	cos(ωct + π)
θ	0	π



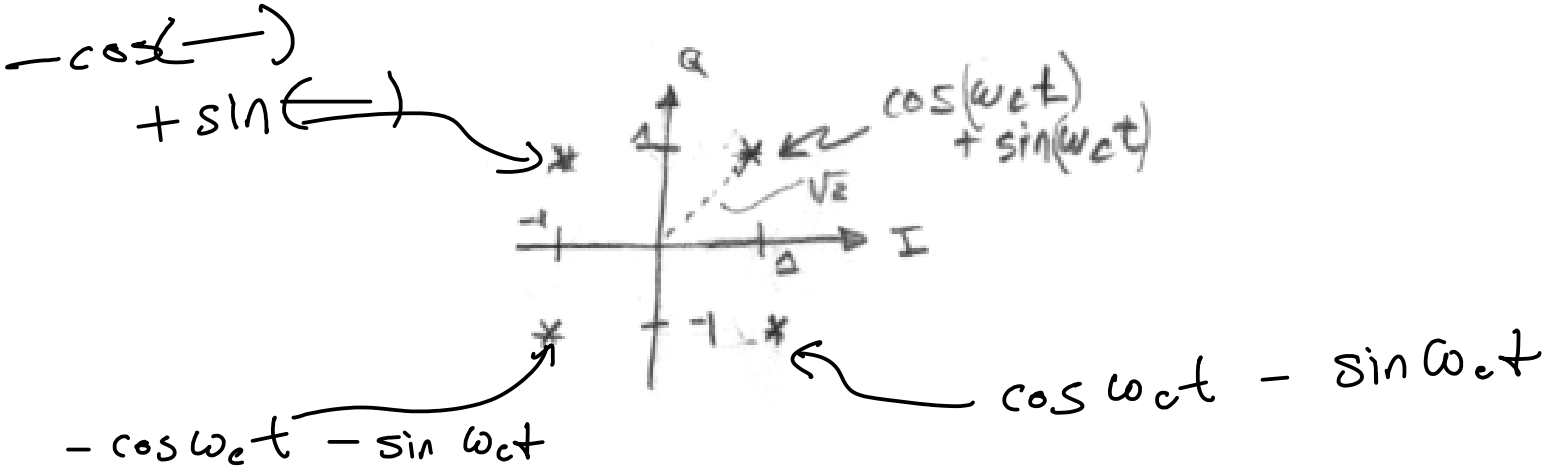




Phasor Representation



Exercise 2: Label the other three points in the constellation diagram with the equation of the signal that corresponds to that point.

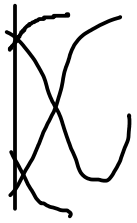


equation for 16-QAM

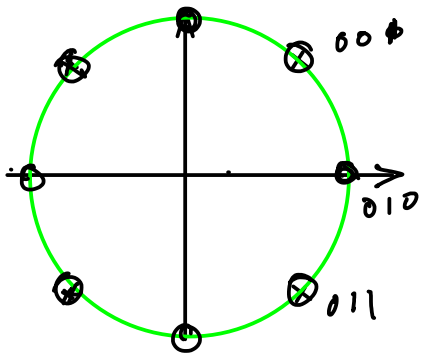
$$\left(\pm 1 \text{ or } \pm 3\right)\cos\omega_c t + \left(\pm 1 \text{ or } \pm 3\right)\sin\omega_c t$$

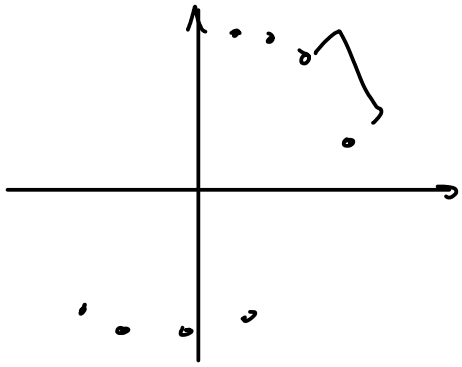
$$I(t)\cos\omega_c t + Q(t)\sin\omega_c t$$

$$I(t) \quad Q(t) = \begin{cases} \pm 1 \\ \pm 3 \end{cases}$$

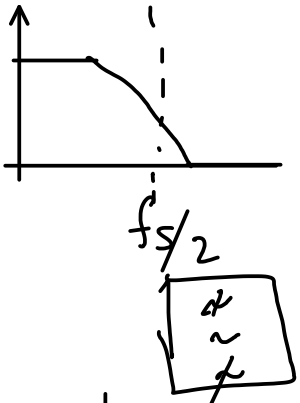


Exercise 3: Draw the constellation for 8-PSK.

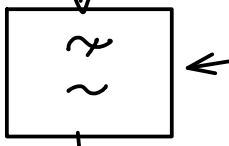




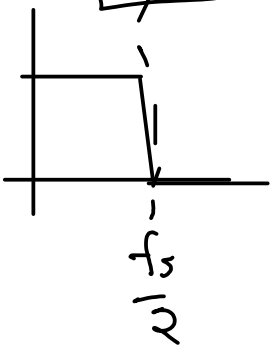
Exercise 4: If the I and Q modulating signals have symbol rates of 2 MHz, what is the minimum bandwidth of the I and Q channels so that there is no ISI? What would be the bandwidth of the modulated (RF) signal? What are the spectral efficiencies (symbols/second/Hz) of the baseband and of the modulated signals?



$I(t)$ ← 2 MHz symbol rate



← bandwidth = 1 MHz min ($\alpha=0$)

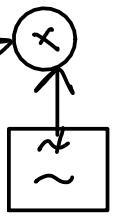


$\cos\omega_c t$ →

1 MHz baseband BW

$\Rightarrow$ 2 MHz RF BW

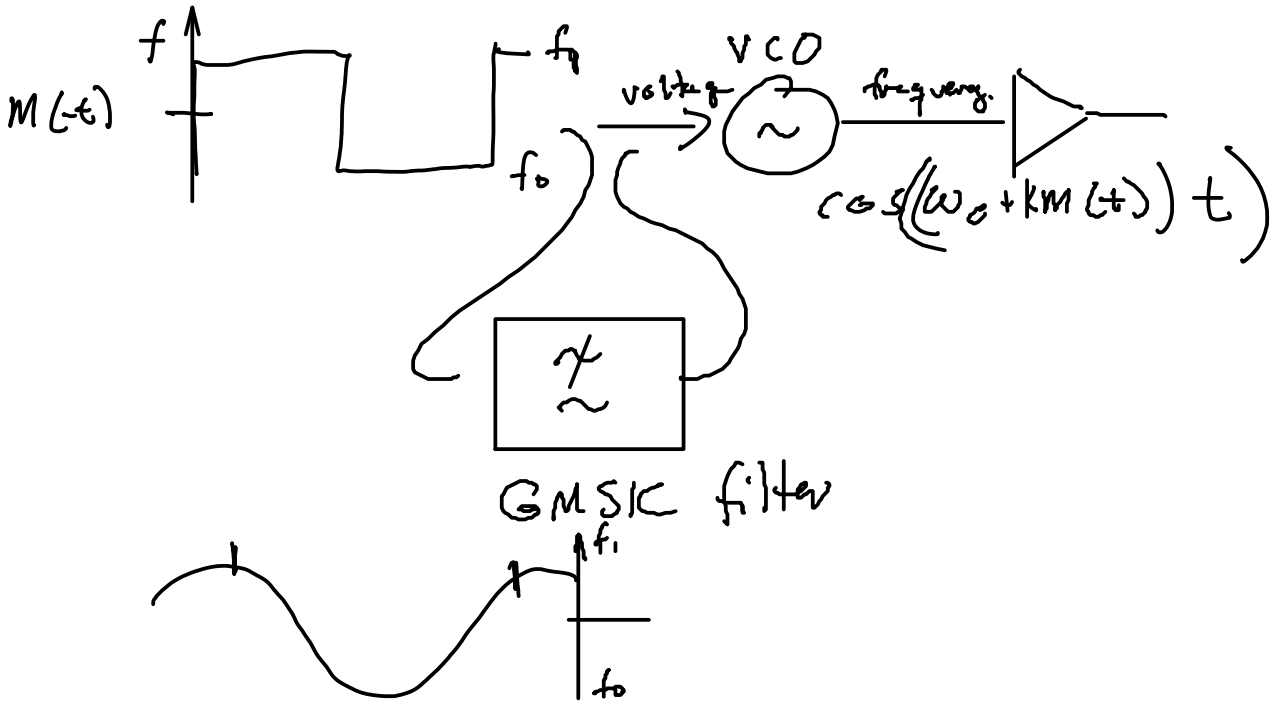
$\sin\omega_c t$ →



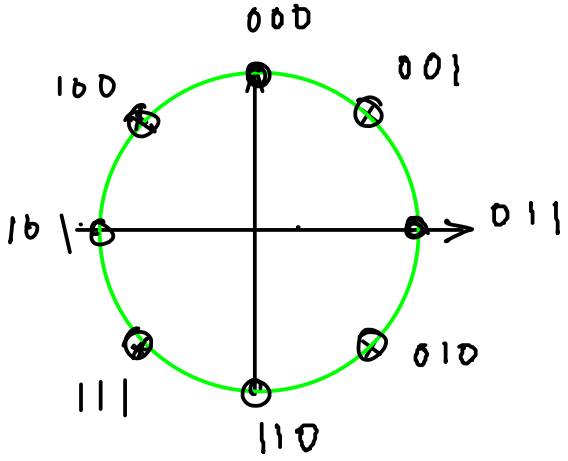
$Q(t)$ ← also 2 MHz.

(assume 1b/symbol)

	baseband (BB) (for each of I & Q)	RF
Spectral Efficiency = bits/s / Hz	2 Mbits/s / 1 MHz	4 Mbits/s. / 2 MHz
	2 b/s/Hz	2 b/s/Hz



Exercise 5: Assign gray-coded values to the 8-PSK constellation.



100

101

111

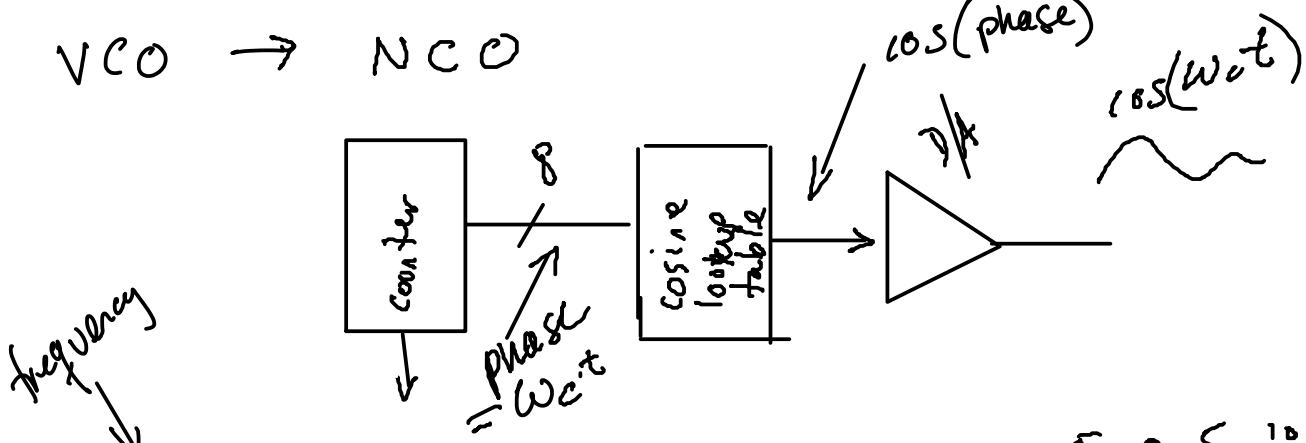
110

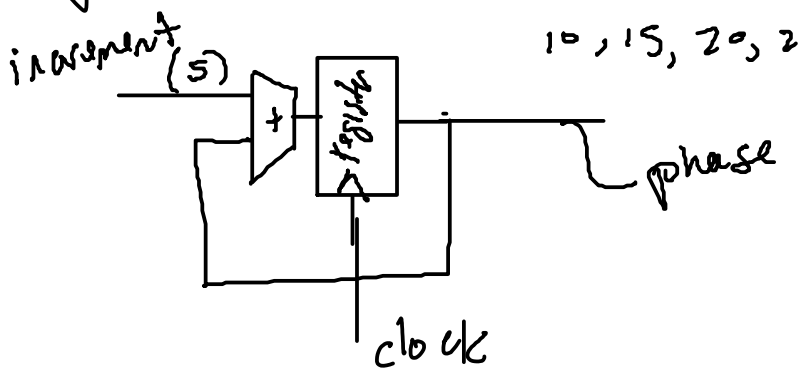
010

011

001

VCO → NCO





10, 15, 20, 25, 30 . . 255, 0, 5, 10

one iteration per sample

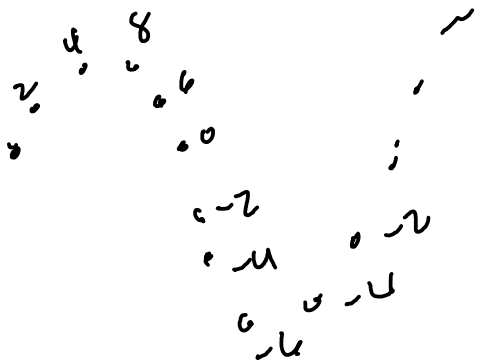
for each bit {

```
for (          ){
phase = phase + (frequency · sample period)
output = cos (phase)
putchar (output)
}
```

}

different for 0 or 1

mark space



0	2	4	8	6	2	-2