PROBLEM

- Derive the effect of the transmit IQ-imbalance for the system with IF demodulation.
- Use the system (filters, transmit signal, parameters etc.) in S9P3, simulate the IF-demodulated system with transmit IQ-imbalance (use QPSK signal).

I. Derivation

$$\begin{aligned}\mathrm{x(t)} &= a_I(t)\cos(\omega_C t) - a_Q(t)gsin(\omega_C t + \varphi) \\ &= \left[a_I(t) - a_Q(t)gsin(\varphi)\right]\cos(\omega_C t) - \left[a_Q(t)gcos(\varphi)\right]\sin(\omega_C t) \\ &= a_I^E(t)\cos(\omega_C t) - a_Q^E(t)\sin(\omega_C t)\end{aligned}$$

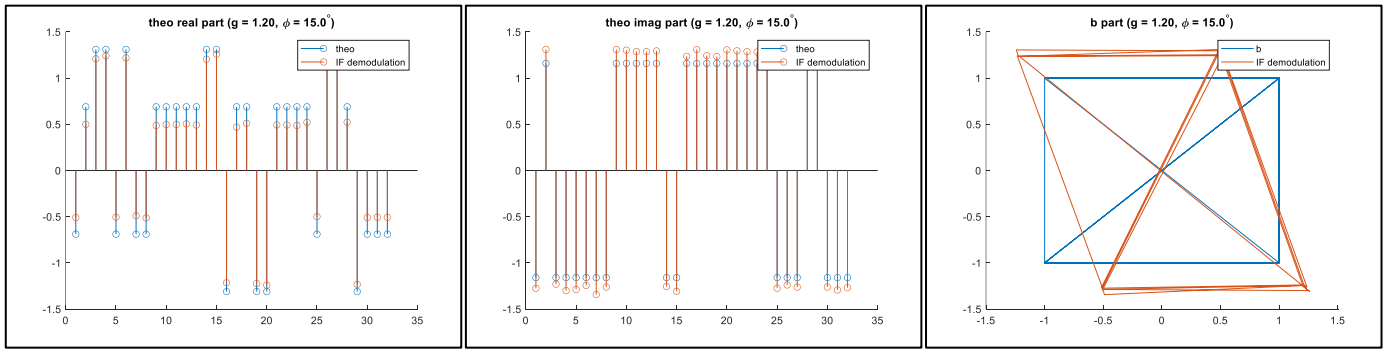
$$\begin{aligned}\mathrm{y(t)} &= \mathrm{LPF}\{2 \times \mathrm{x(t)} \times \cos((\omega_C - \omega_{IF})\mathrm{m})\} \\ &= \mathrm{LPF}\{a_I^E(t)(\cos((2\omega_C - \omega_{IF})\mathrm{m}) + \cos(\omega_{IF}\mathrm{m})) - a_Q^E(t)(\sin((2\omega_C - \omega_{IF})\mathrm{m}) + \sin(\omega_{IF}\mathrm{m}))\} \\ &= a_I^E(t)\cos(\omega_{IF}\mathrm{m}) - a_Q^E(t)\sin(\omega_{IF}\mathrm{m}) \\ &= a_I^E(t)\frac{e^{j\omega_{IF}\mathrm{m}} + e^{-j\omega_{IF}\mathrm{m}}}{2} - a_Q^E(t)\frac{e^{j\omega_{IF}\mathrm{m}} - e^{-j\omega_{IF}\mathrm{m}}}{2j}\end{aligned}$$

$$\begin{aligned}\mathrm{z(t)} &= \mathrm{LPF}\{2 \times \mathrm{y(t)} \times e^{-j\omega_{IF}\mathrm{m}}\} \\ &= LPF\{2 \times [a_I^E(t)\frac{1 + e^{-j2\omega_{IF}\mathrm{m}}}{2} - a_Q^E(t)\frac{1 - e^{-j2\omega_{IF}\mathrm{m}}}{2j}]\} \\ &= a_I^E(t) + ja_Q^E(t)\end{aligned}$$

$$demodulated\ signal = a_I^E(t) + ja_Q^E(t), \begin{cases} real\ part = a_I^E(t) = a_I(t) - a_Q(t)gsin(\varphi) \\ imag\ part = a_Q^E(t) = a_Q(t)gcos(\varphi) \end{cases}$$

II. Simulation

A. Demo



B. Different φ

1. 當 φ 不斷增加，到 90 度時，sin 會變成 cos，導致 Q 和 I 重合，如第三張圖。

2. 當 φ 繼續再增加，sin 的正負號會反過來，導致接收端在做 detection 時，會直接判斷成其他的 symbol，如第四和第五張圖。