Conventional PLL
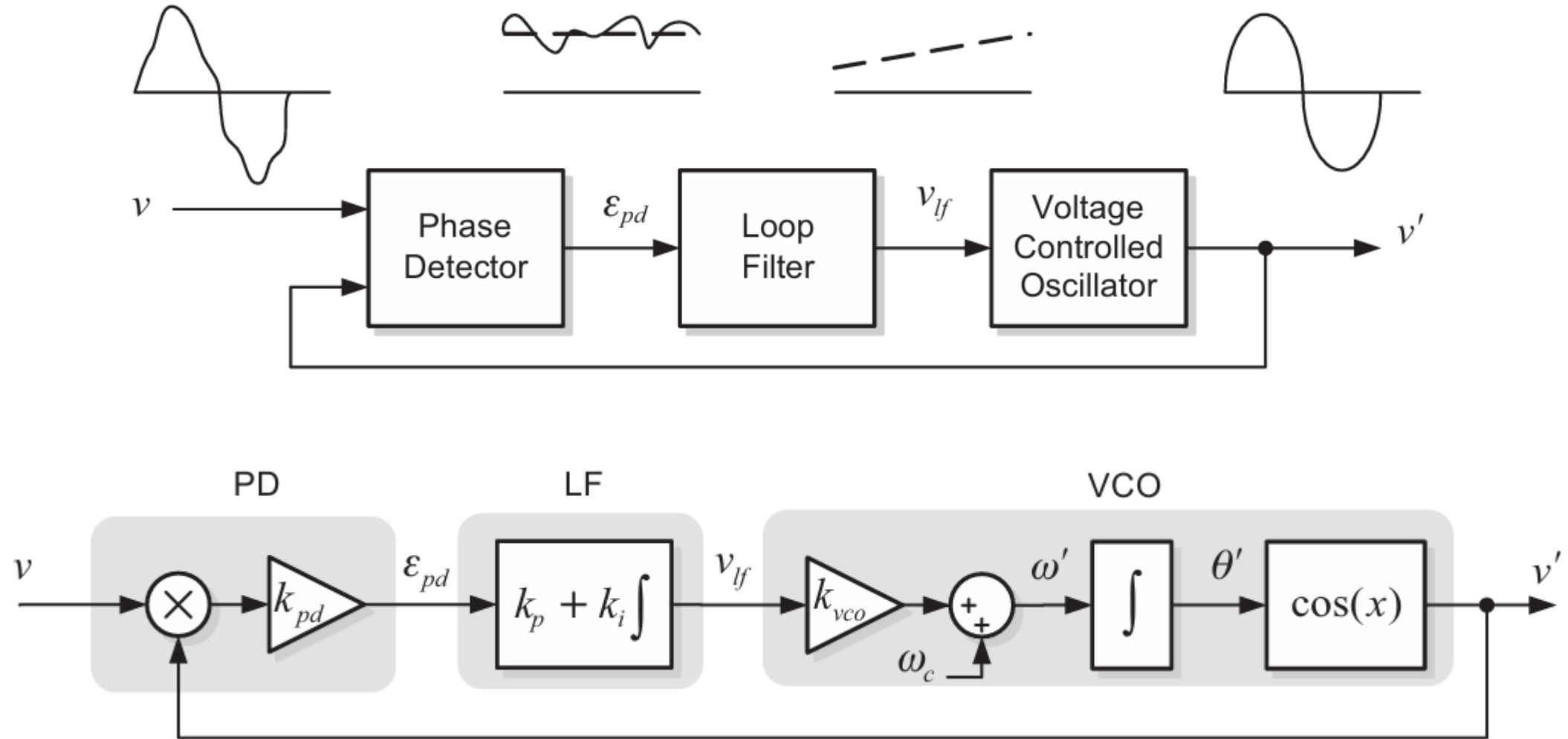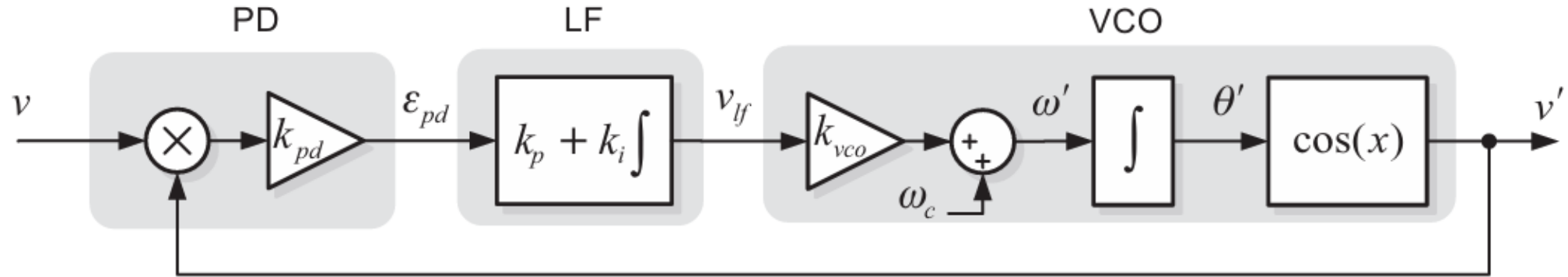
Conventional PLL

$$\int_0^t C dt = Ct$$

$$\theta = \int_0^t 2\pi f dt = 2\pi f t$$
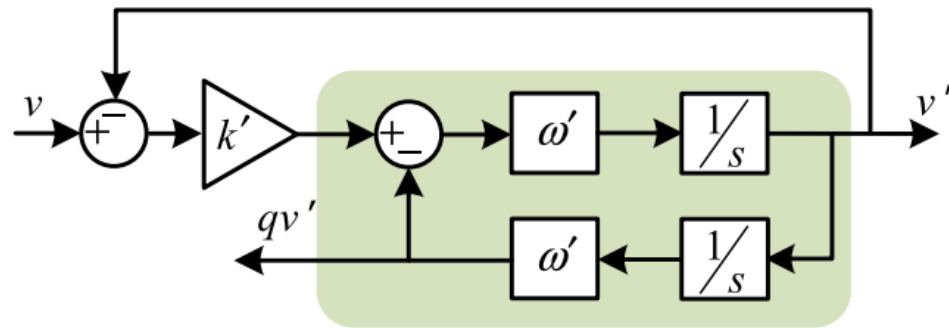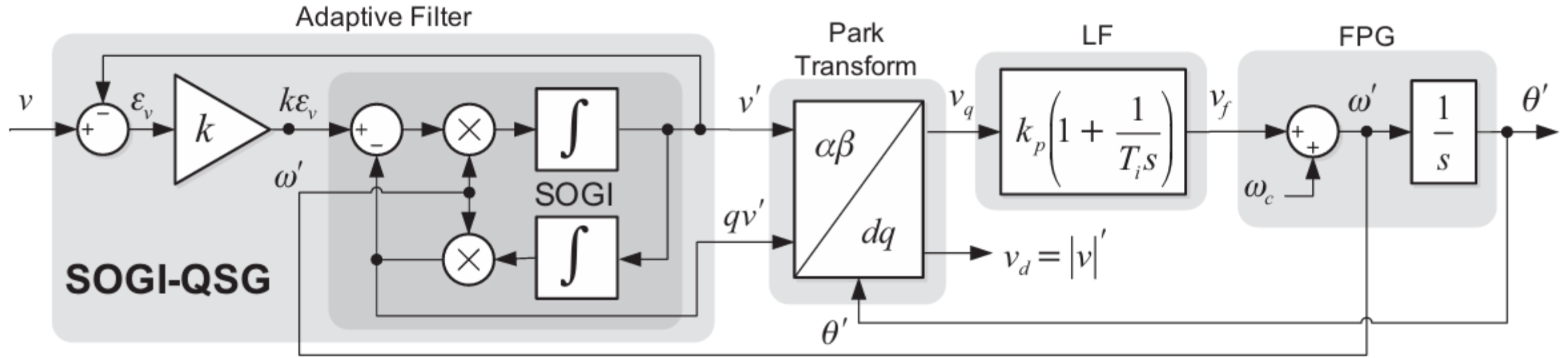
$$\sin(\alpha)\cos(\beta) = -\frac{1}{2}\left(\sin(\alpha+\beta) - \sin(\alpha-\beta)\right)$$

$$\sin(\alpha)\sin(\beta) = -\frac{1}{2}\left(\cos(\alpha+\beta) - \cos(\alpha-\beta)\right)$$

$$\sin(0) = 0$$

$$\cos\left(\frac{\pi}{2}\right) = 0$$

SOGI-PLL

$$D(s) = \frac{v'(s)}{v(s)} = \frac{k'\omega' s}{s^2 + k'\omega' s + \omega'^2},$$

$$Q(s) = \frac{qv'(s)}{v(s)} = \frac{k'\omega'^2}{s^2 + k'\omega' s + \omega'^2}.$$

Discrete

$$G_{LF}(s) = K_P + \frac{K_I}{s} \qquad (2.16)$$

$$I(s) = \frac{1}{s} \qquad (2.17)$$

$$s = \frac{2}{T}\frac{z-1}{z+1} \qquad (2.18)$$

$$G_{LF}(s) = \frac{K_P s + K_I}{s}$$

$$\Rightarrow G_{LF}(z) = \frac{y(z)}{x(z)} = \frac{K_P\left(\frac{2}{T}\frac{z-1}{z+1}\right) + K_I}{\frac{2}{T}\frac{z-1}{z+1}}$$

$$= \frac{\left(K_P + \frac{K_I T}{2}\right) + \left(\frac{K_I T}{2} - K_P\right)z^{-1}}{1 - z^{-1}}$$

$$(2.19)$$

Discrete

$$I(s) = \frac{1}{s}$$

$$\Rightarrow \quad I(z) = \frac{y(z)}{x(z)} = \frac{1}{\dfrac{2}{T}\dfrac{z-1}{z+1}}$$

$$= \frac{\left(\dfrac{T}{2}\right) + \left(\dfrac{T}{2}\right)z^{-1}}{1 - z^{-1}}$$
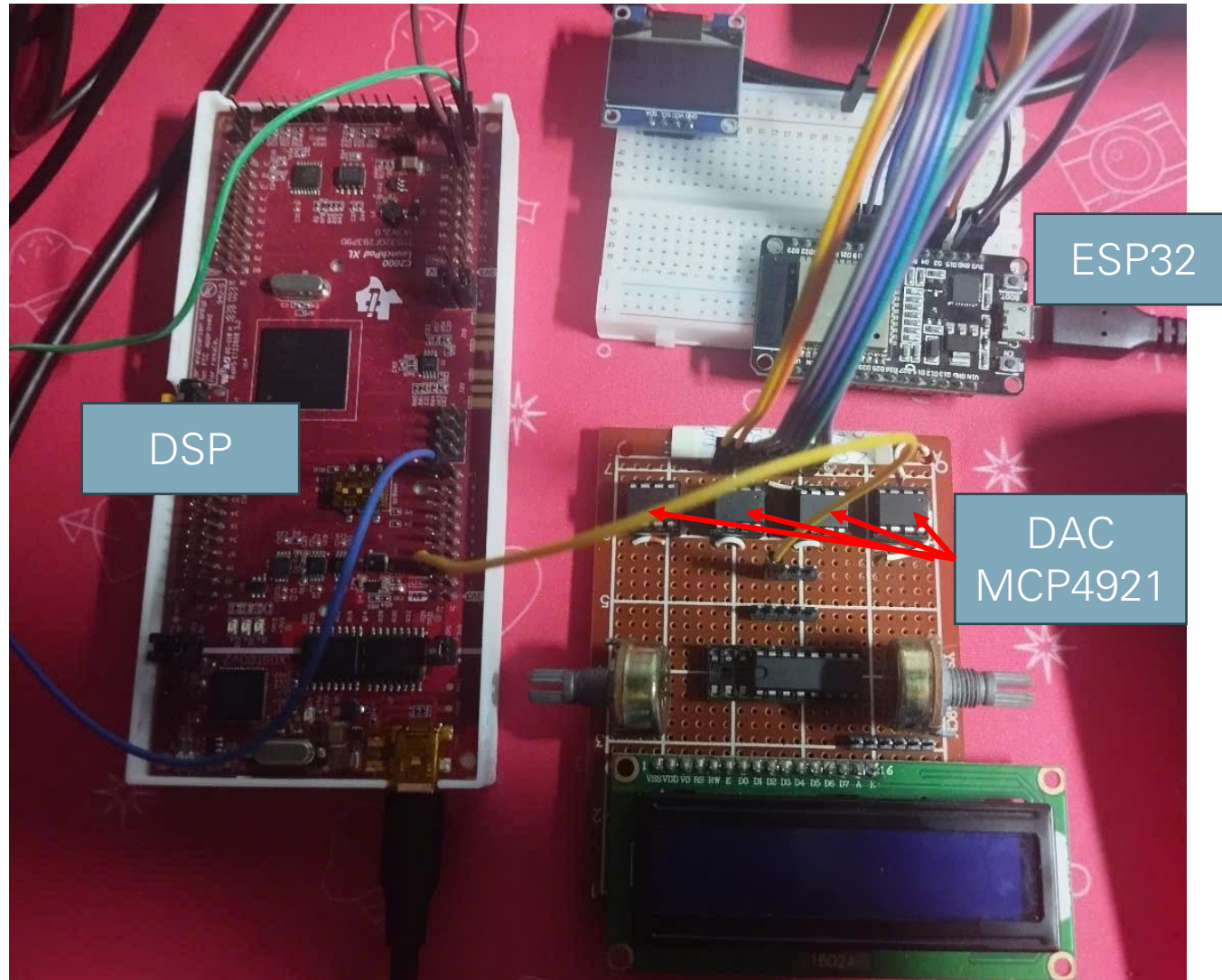
$$(2.20)$$

Implement in C code:

$$A(z) = \frac{y(z)}{x(z)} = \frac{b_0 + b_1 z^{-1}}{1 - a_1 z^{-1}}$$

$$\Rightarrow y(z) = b_0 x(z) + b_1 x(z) z^{-1} + a_1 y(z) z^{-1}$$

$$y(z) = b_0 x(z) + b_1 x(z) z^{-1} + a_1 y(z) z^{-1}$$

$$\Rightarrow y(k) = b_0 x(k) + b_1 x(k-1) + a_1 y(k-1)$$

Hardware

ESP32

DSP

DAC
MCP4921

Event

ePWM1

PWM counter

ADC TRIG

t

Ts = 1e-4s

ADC ISR

Convert ADC value to real value

Run PLL

Return