$$u(t) = K_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{de(t)}{dt} \tag{1a}$$

$$u(t) = K_p \left(br(t) - y(t)\right) + K_i \int_0^t e(\tau)d\tau + K_d \frac{d}{dt}\Big(cr(t) - y(t)\Big) \tag{1b}$$

$$D(s) = \frac{K_d s}{1 + \frac{1}{N}s}(cR(s) - Y(s)) \tag{2a}$$

$$(N + s)\, D(s) = K_d N s(cR(s) - Y(s)) \tag{2b}$$

$$ND(t) + \frac{dD(t)}{dt} = K_d N \frac{d}{dt}\Big(cr(t) - y(t)\Big) \tag{2c}$$

$$P[k] = K_p(br[k] - y[k]) \tag{3a}$$

$$I[k] = I[k-1] + K_i T_s(r[k] - y[k]) \tag{3b}$$

$$ND[k] + \frac{D[k] - D[k-1]}{T_s} = K_d N \frac{cr[k] - y[k] + cr[k-1] - y[k-1]}{T_s} \tag{4a}$$

$$(1 + NT_s)D[k] = D[k-1] + K_d N\Big((cr - y)[k] - (cr - y)[k-1]\Big) \tag{4b}$$

$$D[k] = \frac{1}{1 + NT_s}\Big(D[k-1] + K_d N\big((cr - y)[k] - (cr - y)[k-1]\big)\Big) \tag{4c}$$

$$P[k] = K_p e[k] \tag{5a}$$

$$I[k] = I[k-1] + K_i T_s e[k] \tag{5b}$$

$$D[k] = K_d f_s(e[k] - e[k-1]) \tag{5c}$$