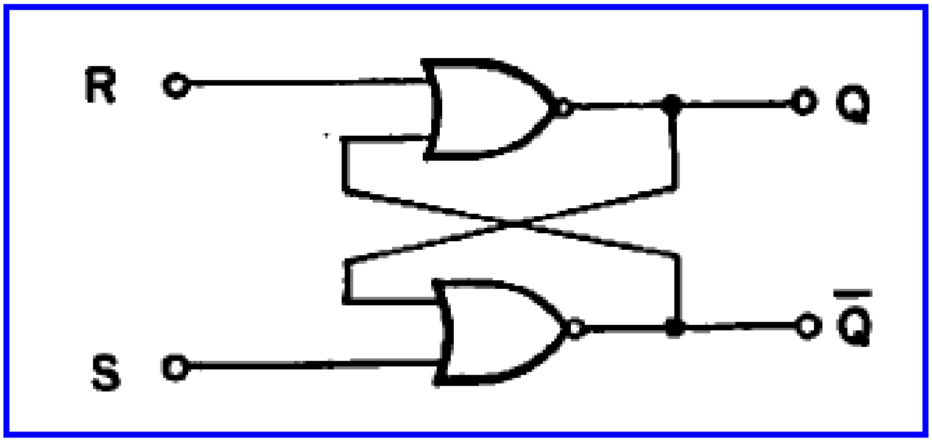
The S-R Phase Detector

Consider now the **Set/Reset Flip-Flop**:



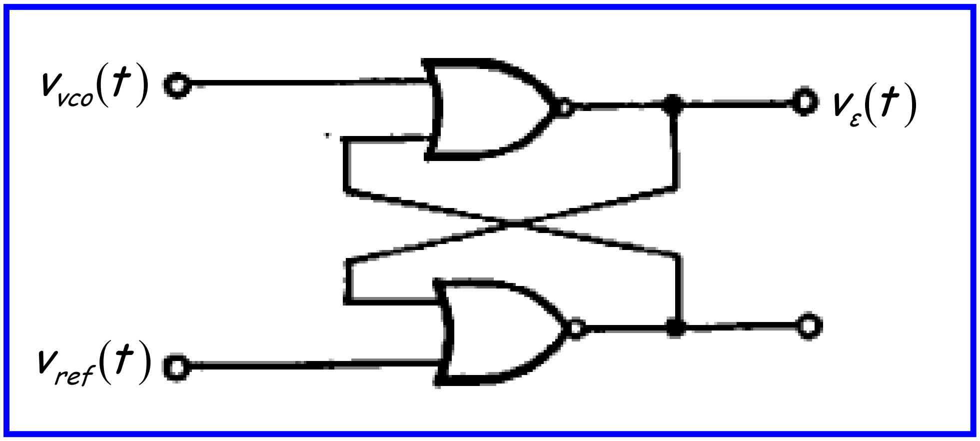
Recall the **truth table** for this device is:

R	S	Q_{n+1}
0	0	Q_n
0	1	1
1	0	0
1	1	Not used

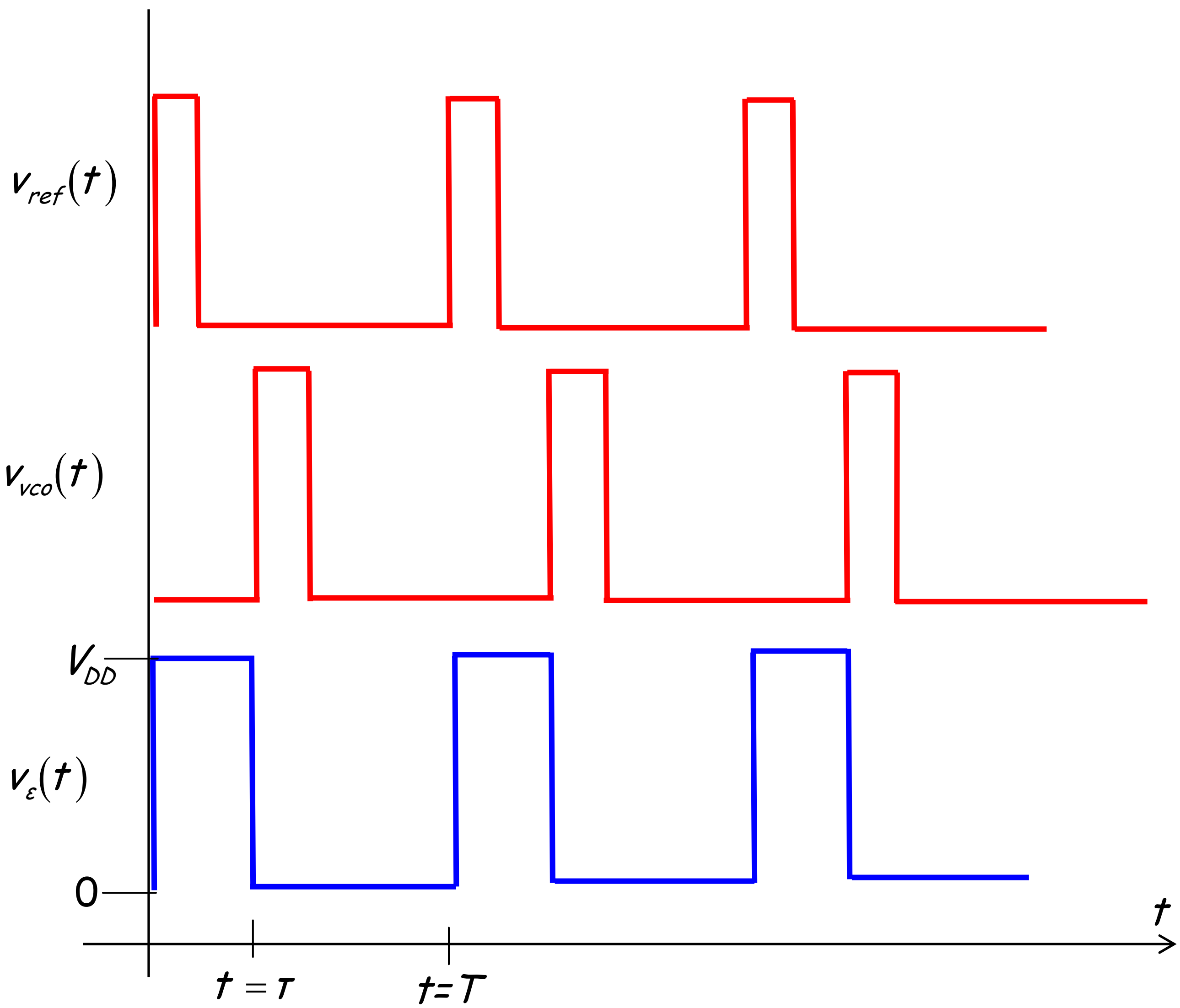
It turns out that this device makes a great **phase detector** for **digital** signals of the form:

$$v(t) = pulse\left[\theta(t)\right]$$

I.E.:



A plot of these signals **could** be:



Q: *Hey wait a minute! I thought you said that the **error** voltage was supposed to be **proportional** to the phase difference. This does not appear to be at all true.*

A: It **is** true! It's just that the error voltage proportional to the phase difference is again a little bit **hidden**.

Say we find the **time-averaged** value of error voltage $v_\varepsilon(t)$ by integrating the error signal shown above over one period:

$$\frac{1}{T}\int_0^T v_\varepsilon(t)\,dt = V_{DD}\left(\frac{\tau}{T}\right)$$

This is of course the **DC component** of the error voltage (V_ε).

And **look** what it tells us!

The DC component of the error voltage provides us with the **delay** value τ/T —**this** is what we need to determine the phase difference!

Combining with the results above, we get:

$$V_\varepsilon = V_{DD}\left(\frac{\tau}{T}\right) = \left(\frac{V_{DD}}{2\pi}\right)\Delta\theta$$

Thus, the **proportionality constant** for the **Set-Reset phase detector** is:

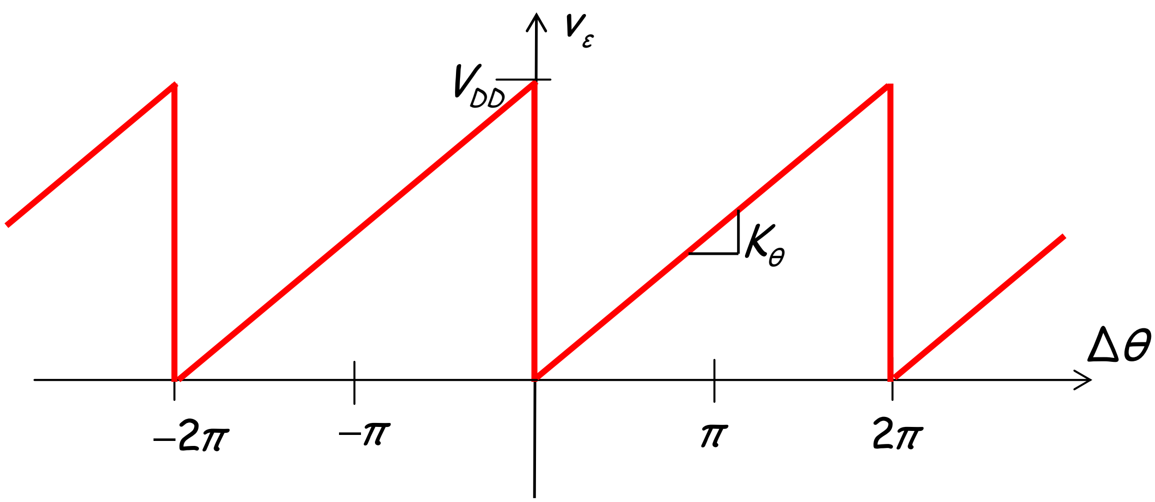
$$K_\theta = \left(\frac{V_{DD}}{2\pi}\right)$$

So that:

$$V_\varepsilon = K_\theta \, \Delta\theta$$

Note that the gain value K_θ of the Set-Reset phase detector is **half** that of the Ex-OR phase detector.

However, the Set-Reset phase detector is a 2π -phase detector—**twice** that of the Ex-OR. Its transfer function is:



One **last point** about the S-R phase detector; **if** the flip-flop is **"edge triggered",** then it can likewise be used for digital signals of the form:

$$v(t) = rect\left[\theta(t)\right]$$

In fact, for edge-triggered S-R phase detectors, the **duty cycle** of the input signals matters **not at all**—only the **period** (frequency) of the digital signal matters in the detector output.