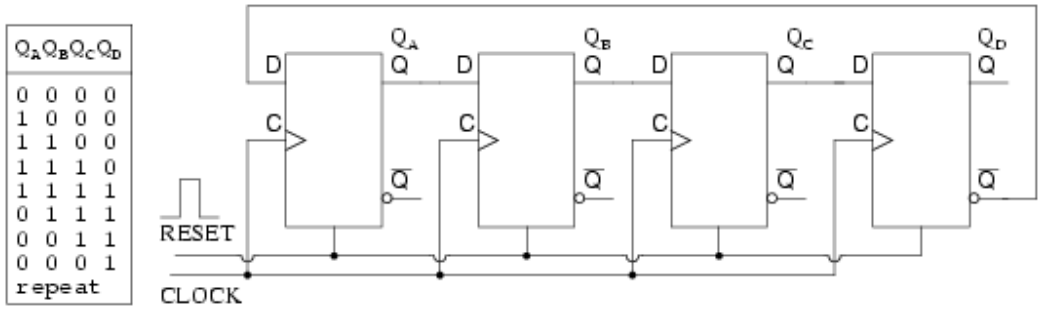
JOHNSON COUNTERS

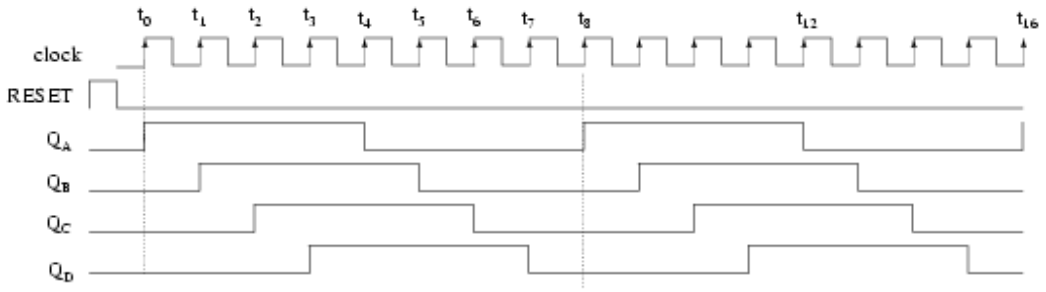
The switch-tail ring counter, also know as the Johnson counter, overcomes some of the limitations of the ring counter. Like a ring counter a Johnson counter is a shift register fed back on its' self. It requires half the stages of a comparable ring counter for a given division ratio. If the complement output of a ring counter is fed back to the input instead of the true output, a Johnson counter results. The difference between a ring counter and a Johnson counter is which output of the last stage is fed back (Q or Q'). Carefully compare the feedback connection below to the previous ring counter.



Johnson counter (note the $\overline{Q}_D$ to D_A feedback connection)

This "reversed" feedback connection has a profound effect upon the behavior of the otherwise similar circuits. Recirculating a single **1** around a ring counter divides the input clock by a factor equal to the number of stages. Whereas, a Johnson counter divides by a factor equal to twice the number of stages. For example, a 4-stage ring counter divides by **4**. A 4-stage Johnson counter divides by **8**.

Start a Johnson counter by clearing all stages to **0**s before the first clock. This is often done at power-up time. Referring to the figure below, the first clock shifts three **0**s from ($\mathbf{Q_A}$ $\mathbf{Q_B}$ $\mathbf{Q_C}$) to the right into ($\mathbf{Q_B}$ $\mathbf{Q_C}$ $\mathbf{Q_D}$). The **1** at $\mathbf{Q_D}$' (the complement of Q) is shifted back into $\mathbf{Q_A}$. Thus, we start shifting **1**s to the right, replacing the **0**s. Where a ring counter recirculated a single **1**, the 4-stage Johnson counter recirculates four **0**s then four **1**s for an 8-bit pattern, then repeats.



Four stage Johnson counter waveforms

The above waveforms illustrates that multi-phase square waves are generated by a Johnson counter. The 4-stage unit above generates four overlapping phases of 50% duty cycle. How many stages would be required to generate a set of three phase waveforms? For example, a three stage Johnson counter, driven by a 360 Hertz clock would generate three 120^{o} phased square waves at 60 Hertz.