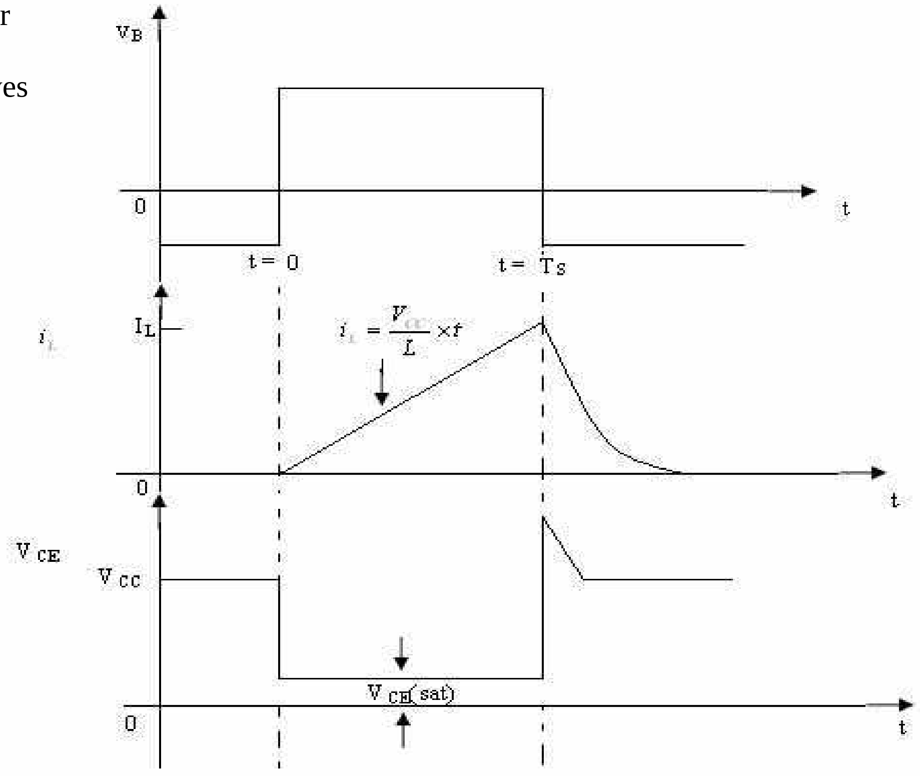
Simple current sweep circuit:

a simple transistor current sweep circuit is shown in figure. Here the transistor is used as a switch and the inductor L In series with the transistor is bridged across the supply voltage. R_d represents the sum of the diode forward resistance And the damping resistance.
The gating waveform(pulse) at the base Operates between two levels.

The lower level keeps the transistor

In cutoff while the upper level drives

the transistor into saturation.



Case(i):

For t<0 , the input to the is at its

Lower level . so the transistor is

Cut-off.

Hence no current flows in the

Transistor and $i_L = 0 and V_{CE} = V_{CC}$

Here Diode D is OFF since initial
current flowing through an inductor is zero.

Case(ii):

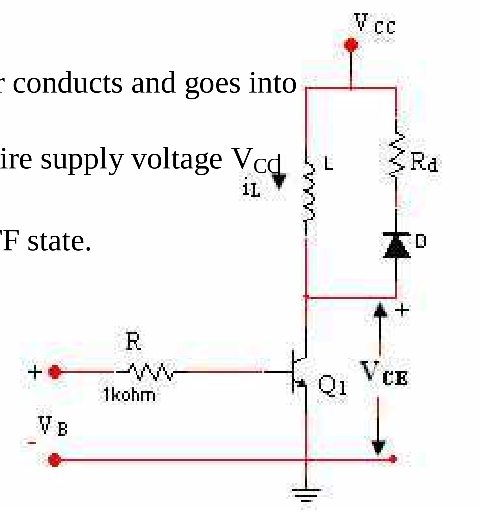
At t = 0+ , the gate signal goes to its upper level . so the transistor conducts and goes into

saturation. Hence the collector voltage falls to $V_{CE(sat)}$ and the entire supply voltage V_{CC}

is applied across the inductor. So that here also diode D is in OFF state.

so the current through the inductor

$$i_L = \frac{1}{L}\int V_{CC}dt = \frac{V_{CC}}{L}t$$



Increases linearly with time. This continues till $t = T_S$.

Case(iii):

At $t = T_S+$, the gating signal comes to its lower level and so the transistor will be cutoff And no current flows through it, since the current through the inductor can not changes Instantaneously it flows through the diode and the diode conducts.

Hence there will be a voltage drop of $I_L R_d$ across the resistance R_d.

So At $t = T_S+$, the potential at the collector terminal rises abruptly to $V_{CC} + I_L R_d$

For $t > T_S$, the inductor current decays exponentially to zero with a time constant $\tau = L / R_d$. So the voltage at the collector also decays exponentially and settles at V_{CC} .

** in the above analysis we are assuming that inductor is an ideal one. But coming to the practical case some resistance must be existed in series with an inductance. So sweep error existed here . to reduce this sweep error there is a need to replace constant voltage source V_{CC} with a trapezoidal voltage source.

At first let us estimate the sweep error in the above circuit later on we will see how can We generate trapezoidal voltage.

Expression for sweep error:

We know from the topic of deviation from linearity , $e_S = \dfrac{T_S}{RC} = \dfrac{T_S}{\tau}$

We know in the above analysis , sweep waveforms begins at t = 0+ ,(Q OFF & D OFF)

So from the resultant circuit ,

$V_{CC} = i_L(t)(R_L + R_O) + L\frac{di_L(t)}{dt}$, where R_O is the output resistance of a transistor when it is on state. (by neglecting $V_{CE(sat)}$)

Laplace transform of the above equation is ,

$$\frac{V_{CC}}{S} = I_L(S)(R_L + R_O) + LSI_L(S)$$

$$I_L(S) = \frac{V_{CC}}{S}\frac{1}{(R_L + R_O)\left[1 + \frac{LS}{R_L + R_O}\right]}$$

By using partial fraction expansion,

$$I_L(S) = \frac{V_{CC}}{R_L + R_O}\left[\frac{1}{S} - \frac{1}{S + \frac{(R_L + R_O)}{L}}\right]$$

by applying inverse laplace transform ,

$$i_L(t) = \frac{V_{CC}}{R_L + R_O}\left[1 - e^{-\frac{t}{\tau}}\right] \quad \text{where } \tau = \frac{L}{R_L + R_O} = \text{time constant of circuit}$$

If $\frac{t}{\tau} << 1$ then $i_L(t) = \frac{V_{CC}}{R_L + R_O}\left[1 - \left(1 - \frac{t}{\tau}\right)\right]$

$$i_L(t) = \frac{V_{CC}}{R_L + R_O}\frac{t}{\tau}$$

At t = Ts , $i_L(t) = I_L$

So $$I_L = \frac{V_{CC}}{R_L + R_O}\frac{T_S}{\tau}$$

$$e_S = \frac{T_S}{\tau} = \frac{(R_L + R_O)I_L}{V_{CC}}$$