Protection Circuits 1 (Short-Circuit Protection)

■ General Description

Voltage detectors (VDs) are used for short-circuit protection, but are deficient for dead shorts. This is because the output (V_{OUT}) of a VD becomes unstable when the detection voltage at the VD's input voltage (V_{IN}) pin decreases to below the VD's lowest operating voltage of 0.9 V.
The short circuit protection circuits shown below halt IC operation in the event of a dead short at the output. These latch-type circuits are realized by adding few components as peripheral circuits to an IC.

■ Features

- Effective for dead short protection
- Makes possible strengthening of protection circuits by combining with the XC9201 series (with current-limiting capability).

■ Functional Description 1

● During Start-Up (Delayed Protection Circuits)

The capacitance of capacitor 1 (C1) is suitably selected to delay the time taken by V_{BE} of transistor 1 (Q1) to reach approximately 0.6 V. This is aimed at preventing transistor 1 (Q1) from turning on and from setting CE = 0 V when CE_in becomes active. The output voltage reaches 2 V or more and transistor 2 (Q2) turns on during this delay. This operation establishes a short circuit across the base and emitter (B-E) of transistor 1 (Q1), thus allowing transistor 1 (Q1) to remain OFF.
The time taken by the C1 voltage to reach 0.6 V must be set to be longer than the IC's soft start time.

<<Formula for Time Delay>>

$$T = -R2 \times C1 \times \ln\left(\frac{CE\_in - V_{BE1}}{CE\_in}\right)$$

where,
T : time delay of transistor Q1 (sec)
R2 : resistance of resistor 2 (Ω)
C1 : capacitance of capacitor C1 (F)
V_{BE1} : V_{BE} of transistor Q1 (V)
CE_in : signal voltage (V)

■ Functional Description 2

● During Output Detection (Output Short-Circuited)

The voltage between resistor 4 and ground (R4-GND) decreases to below VBE of transistor 2 (Q2), which is approximately 0.6 V, when the output voltage (V_{OUT}) is short-circuited. Transistor 2 (Q2) will then be turned off. A current flows into capacitor 1 (C1), which has been short-circuited by transistor 2 (Q2). The voltage between capacitor 1 and ground (C1-GND) increases gradually. When this voltage becomes equal to VBE of transistor 1 (Q1), which is approximately 0.6 V, transistor 1 (Q1) turns on, then CE, being short-circuited, decreases to 0 V, and the IC stops.

<<Calculation of Constants for Voltage Detection>>

Assume that I_{C2} = 0.1 m (A) and CE_in = 5 (V) as conditions in determining constants.
First,

$$R2 = \frac{CE\_in}{I_{C2}} = \frac{5}{0.1m} = 50k \rightarrow$$ Hence, select 51 k (Ω) for R2.

The next step is to determine the current I_{B2}.
Assuming that h_{fe}= 100 for Q2,

$$I_{B2}\ \frac{I_{C2}}{h_{fe}} = \frac{0.1m}{100} = 1\mu\ (A)$$

Assume that a bias current (I_{BIAS}) 10 times or more higher than the current flowing to the base is applied to R3 and R4.

$$R4 = \frac{V_{BE2}}{I_{BIAS}} = \frac{0.6}{12\mu} = 50k \rightarrow$$ Hence, select 51 k (Ω) for R4.

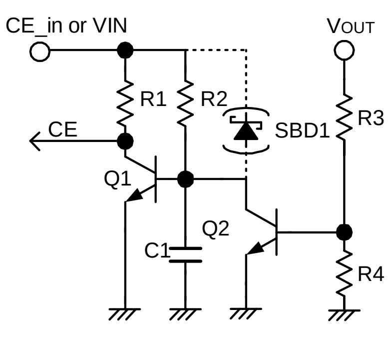
Set the detection voltage V_{DF} to 2 (V), then,

$$V_{R4}(V_{BE2}) : V_{R3} = R4 : R3$$

$$R3 = \frac{V_{R3} \times R4}{V_{R4}(V_{BE2})} = \frac{1.4 \times 51k}{0.6} = 119k$$

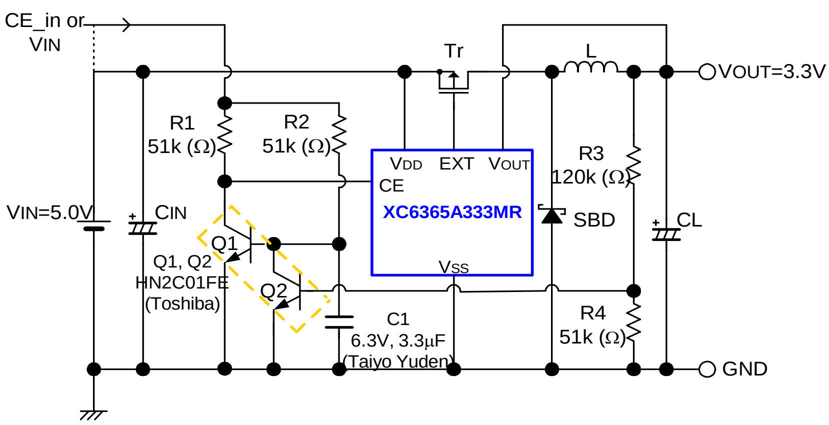
→ Hence, 120 k (Ω) is selected for R3.

■ Basic Circuit



* Add SBD1 to the circuit to discharge C1 instantaneously, if necessary.

■ Application Example (Step-Down Circuit)



Note
Bipolar transistors are current-driven devices. A certain amount of current must be passed through them to ensure proper operation.