Measuring the Switching Time of a Bipolar Junction Transistor - $T_{(ON)}$ and $T_{(OFF)}$

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Overview

Bipolar junction transistors (BJTs) are current controlled devices with a collector, emitter and base terminals. They can be fabricated as NPN or PNP types and require different biasing conditions depending on their built structure. To turn "ON" an NPN transistor, there needs to be enough current flowing through the base terminal, triggering a current flowing from the collector to the emitter.

Figure 1 shows how a BJT behaves when used as a switch. The following are important characteristics to keep in mind:

- (T_{ON}) - the time from 50% of the input pulse (leading edge) to 90% of the output pulse is called the turn-on time.
- (T_{OFF}) - the time from 50% of the input pulse (trailing edge) to 10% of the output pulse is called the turn-off time.

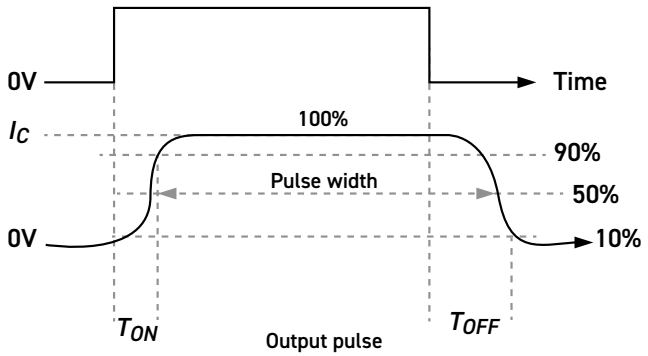
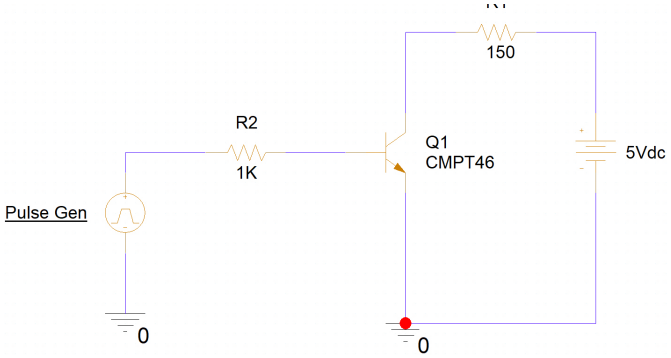


Figure 1:
BJT input and output characteristics

In **Figure 2**, a common emitter configuration is used to measure $T_{(ON)}$ and $T_{(OFF)}$ using a Central Semiconductor BJT - the CMPTA46, which features an N-channel configuration with 450V 500mA 350mW max ratings. This device is packaged in a SOT-23 and is designed for high voltage applications.



Biasing Conditions:
*VCC = +5V
*Vpulsed = +5V <-> -1V
*Duty Cycle = 10%
*Frequency = 1KHz

Figure 2:
Common emitter configuration

In **Figure 3** below, the yellow signal is the input pulse (Base), and the blue signal is the output pulse (Collector). As the collector current increases, the collector voltage drops, indicating the transistor is in the "on" region.

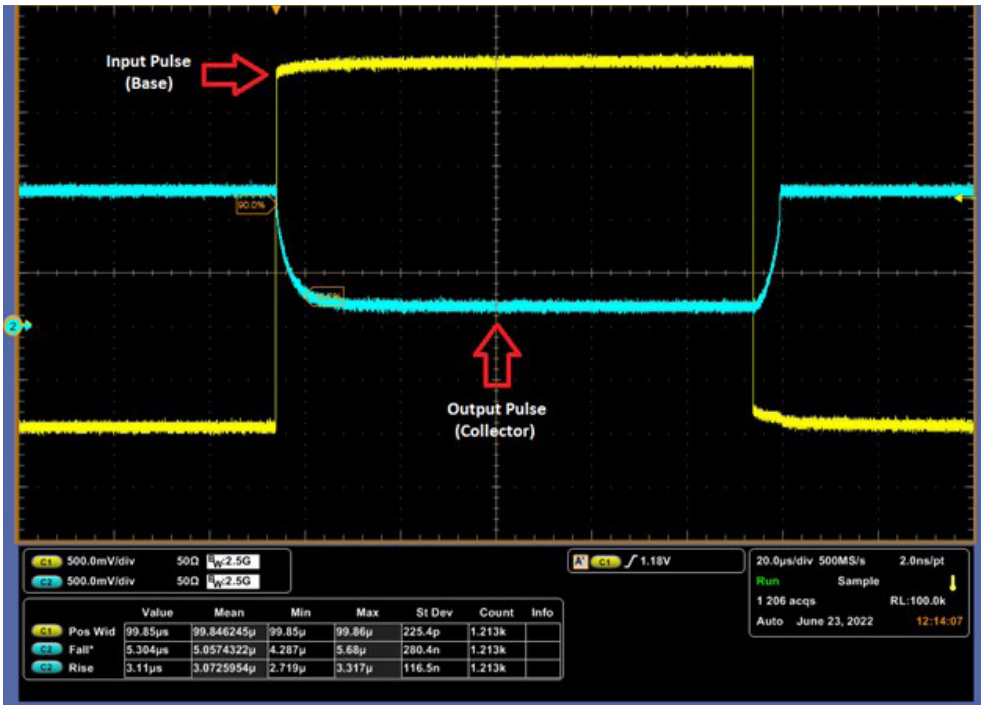
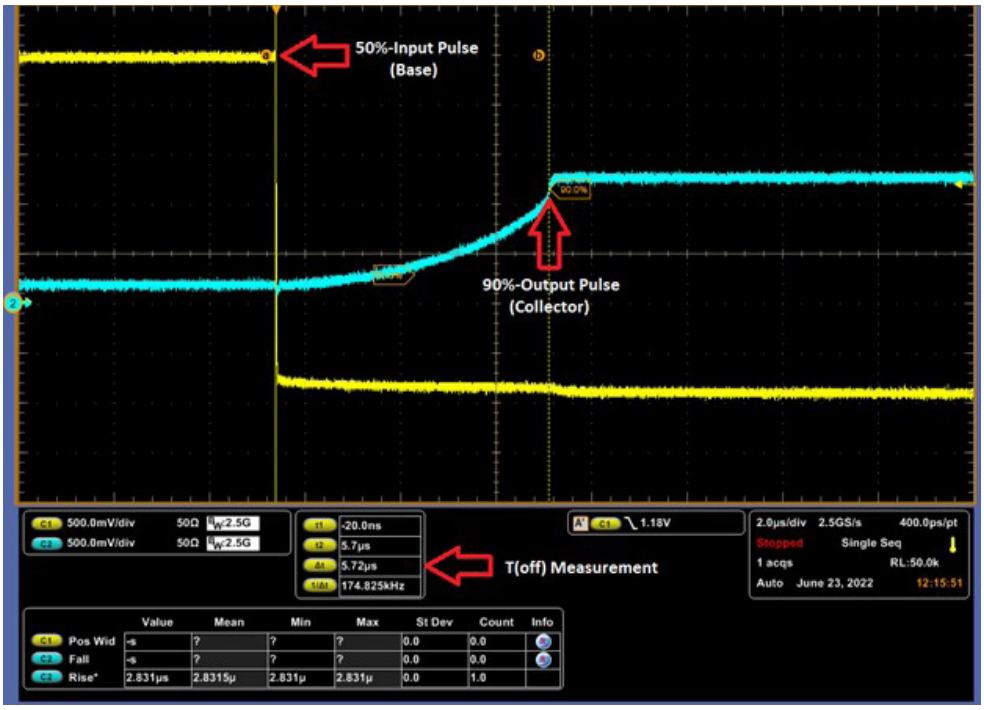


Figure 3:
CMPTA46 input and output characteristics

Jumping to **Figure 4**, where we see cursor "a" is the input pulse (yellow signal). Cursor "b" is at the 90% mark on the output pulse (blue signal). Taking the time delta between the two gives us a $T_{(ON)}$ measurement of 4.3us.

Figure 4:
CMPTA46 – $T_{(on)}$ characteristics

Taking the same approach in **Figure 5** by acquiring the measurements on the trailing edge side of the input pulse, we get a $T_{(OFF)}$ time measurement of 5.72us.



Conclusion

Through test, we have demonstrated how to test the switching time of a bipolar junction transistor, specifically the CMPTA46, which has a $T_{(ON)}$ of 4.3us and $T_{(OFF)}$ of 5.72us. BJTs are most often used as switching devices and are typically used to control DC power for lamps, relays and motors.

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