Faculty 4

M.Sc. in Electronics Engineering

Measurement and Instrumentation

Technical Report

Output Characteristics of Bipolar Junction Transistor(BC547) using LabView

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1. Introduction

LabVIEW (Laboratory Virtual Instrumentation Engineering Workbench) is a graphical development environment widely used in the field of system design, test, measurement, and control. LabVIEW, which is short for Laboratory Virtual Instrument Engineering Workbench, is a systems engineering software for applications that require test, measurement and control with an easy, intuitive graphical programming approach developed by National Instruments (NI). The first version of LabVIEW was released in 1986 for the Apple Macintosh, but the application has since grown to become a cross-platform solution supporting Windows, Linux, and macOS [1], [2].

LabVIEW uses a unique programming paradigm called dataflow, and is often referred to as G language. In contrast to traditional text-based coding languages such as C or Python, LabVIEW executes programs based on the availability of data, ensuring that different parts of the system operate in parallel when possible. However, it is extremely useful for real-time applications, such as for industrial automation, signal processing, and hardware interfacing [1], [2].

LabVIEW has built-in capabilities to control and communicate with different hardware components, enabling application development for things like instrument control, data logging, and analysis. Its main capability is to create front panel designs that serve as user interface, providing real time visualization for measurements and system behaviour. Using the graphical approach makes programming quick and easy and is more suitable for beginners, while experienced users can access more sophisticated functions [1], [2].

Thus, this report discusses output characteristics of Bipolar Junction Transistor (BC547) by using Lab VIEW. The experiment consists designing a measurement system to capture V, I relationships with a transistor under different operating conditions. Using LabVIEW, we also have the option of automate data collection, improve accuracy, and gain valuable insights into transistor performance.

2. Schematic Diagram

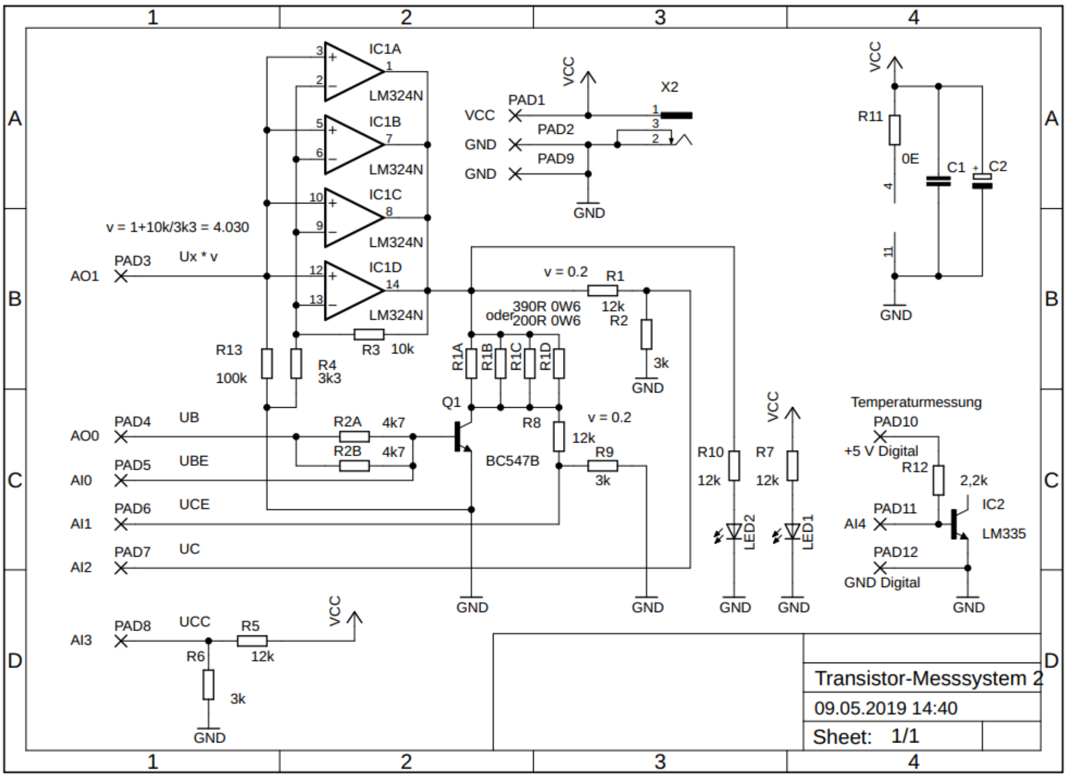

Figure 1: Transistor Measuring System [3].

The PCB schematics are displayed in Figure 1. The two signals that the NI USB-6001 produces through the AO0 and AI2 interfaces are U_B and U_C. Two signals are sent to the transistor: one is sent to the base, and the other is amplified before being sent to the transistor's collector [3].

A range of voltages are applied at these two working locations. When combined with computed current values, these voltages aid in the graphing of the transistor's transfer output characteristics [3].

3. Programming Specifications

Implemented a LabVIEW program to automate the NPN Bipolar Junction Transistor (BC547) characteristics output and current measurement with voltage application. The program consists of multiple stages, each responsible for a specific task, which also safeguards the operation of the circuit. Below outlines the key functional stages of the program:

Setup for Data Acquisition and Control (DAQ)

- Two DAQ Assistants are set up for the smooth transfer of data; one writes voltages to the transistor, while the other will read in the output signals. This time delay between these operations ensures stable measurements and reduces measurement errors.
- Base Voltage Application (First Loop Stage)
  The voltages chosen (U_B) are preset to values from 0.8V to 1.3V, ensuring that the transistor operates above the threshold (~0.7V). Here, each voltage value is a separate element in an array and is subsequently introduced, one after another, across multiple iterations.
- Collector-Emitter Voltage Variation (Second Loop Stage)
  In the second loop, the collector-emitter voltage (U_{CE}) is varied in 20 discrete steps from 0 V to 2 V to capture different operating regions of the transistor. The applied voltage is divided by a constant to ensure the safety of the circuit when being used.

- Calculation of Base Current (I_B) and Collector Current (I_C)

  The program determines the base current (I_B) using the relation:

$$\boxed{I_B = \frac{(U_B - U_{BE})}{2.35}}$$

  where UBE is the measured base-emitter voltage, and 2.35Ω is the known resistance value in the base circuit.

  Similarly, the collector current (IC) is derived using:

$$\boxed{I_C = \frac{(U_C - 4.03) - U_{CE}}{0.05}}$$

  where U_C is the collector voltage, and 4.03 is the amplifier gain.

- Amplification and Data Processing
  The voltage are subsequently amplified with a gain factor of 4.03 to improve the measurement resolution. This results with improved transistors characteristics resolution. The program also uses a shift register to retain values from previous iterations, allowing for continuous data tracking.

- Temperature Monitoring and Safety Controls
  Since the transistors' performance is temperature dependent, a temperature sensor is found as part of the program. The measured temperature is continuously plotted.

- Data Display and Graph Plotting
  Multiple indicators are used to show the measured values of U_B, U_{BE}, I_B, U_C, U_{CE}, I_C Also plotted with U_{CE} vs I_C characteristics, allowing for real-time visualization of transistor behaviour.

4. Hardware description

This setup utilises a DAQ module, resistors, an amplifier LabVIEW and a temperature monitoring system – all based on LabVIEW – to ensure control and safety over the data collection process, as well as the circuit itself for the BC547 transistor's output characteristics analysis. A USB-to-serial interface transmits base voltage (U_B) via AOut0 (U_B), while U_{CE} and U_{BE} are measured using AIn1 (U_{CE}) and AIn0 (U_{BE}). The base current (I_B) is calculated using 2.35Ω resistors, while collector current (I_C) is derived with an amplifier gain of 4.03 for improved accuracy. A temperature sensor, with a scaling factor of 2.73 and 100 calibration is used to monitor the heat levels on a real-time basis. With real-time visualization of U_B, U_{BE}, U_{CE}, I_B, and I_C, the user can analyse the behaviour of the transistor dynamically where measured values can be guaranteed, confirming that the transistor is working reliably.

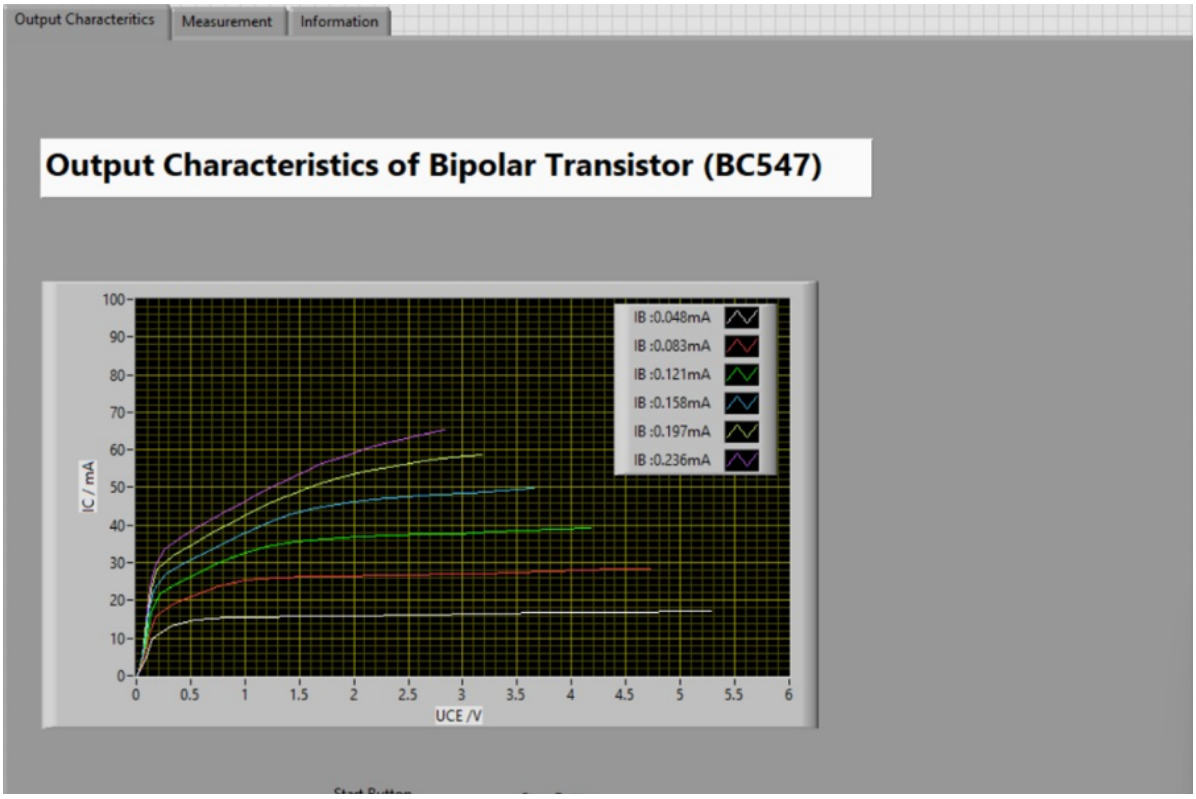

Figure 2: Transistor Output Characteristics (a).

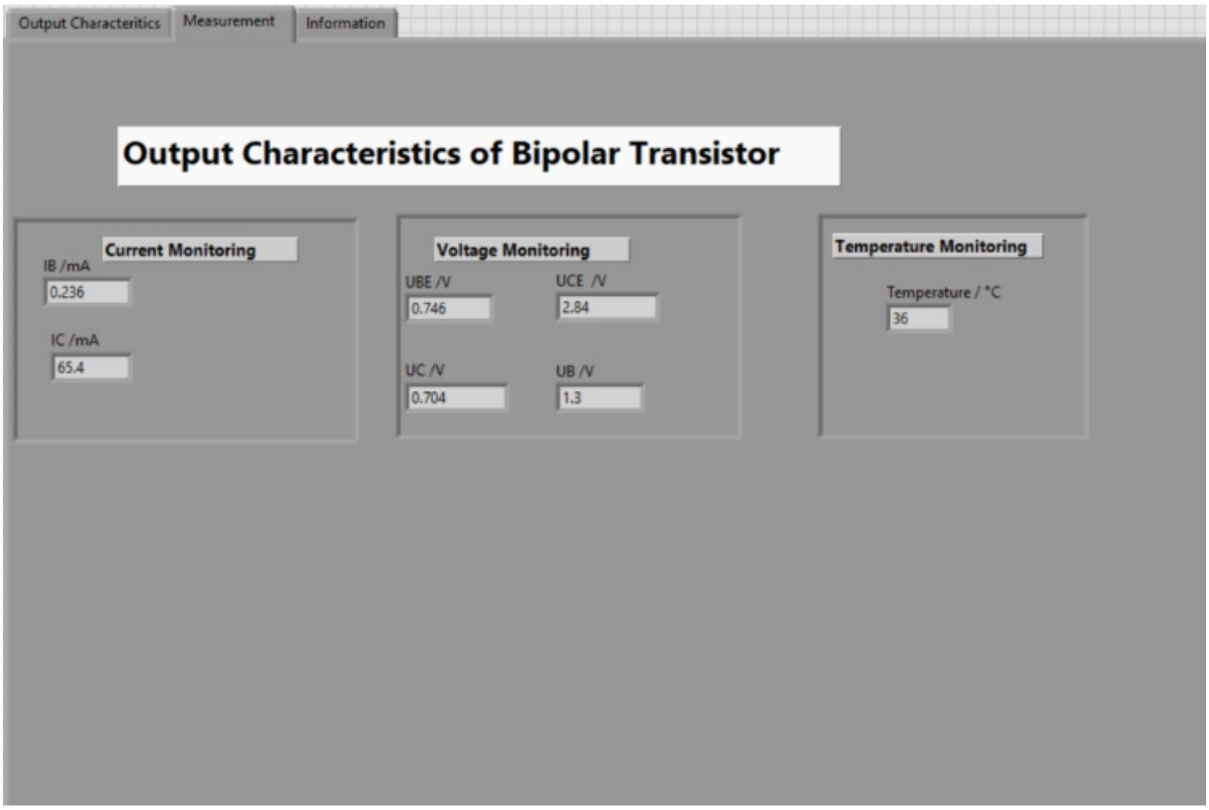

Figure 3: Transistor Output Characteristics (b).

DC output characteristics of the BC547 NPN transistor were obtained by plotting the collector-emitter voltage (U_{CE}) versus collector current (I_C) for various base current (I_B) levels. The LabVIEW program automates the entire process by applying different base voltages (U_B) and measuring the corresponding U_{CE} and I_C and continuously updating the output graph.

The graph shows the non-linear input voltage output current type relationship you expect to see in a transistor. At first, as U_{CE} rises, the I_C increases slowly, then rapidly because it approaches saturation. Outside of this area increasing U_{CE} further does not have much effect on I_C showing the transistor is running in saturation mode. At higher resistance values, the curve steepens, showing a reduction in I_C, as a larger resistance limits the current flow through the transistor.

This output characteristic analysis is crucial in understanding the transistor's operating regions—cutoff, active, and saturation—which are fundamental for designing amplification and switching circuits. The dynamic graph plotted in LabVIEW provides a clear visualization of these behaviours, helping in selecting the optimal operating conditions for various applications.

5. References

[1] National Instruments, “What is NI LabVIEW?,” Emerson, 2025. [Online]. Available: https://www.ni.com/de/shop/labview.html. [Accessed 12 03 2025].

[2] I. Poole, “Electronics Notes (Incorporating Radio-Electronics.com),” Electronics Notes, 2025. [Online]. Available: https://www.electronics-notes.com/articles/test-methods/labview/what-is-labview.php. [Accessed 12 03 2025].

[3] Hochschule Bremen (HSB), “Aulis HSB learning platform,” [Online]. Available: https://aulis.hs-bremen.de/ilias.php?baseClass=ilrepositorygui&cmdNode=yl:no&cmdClass=ilObjFileGUI&cmd=sendfile&ref_id=2133542. [Accessed 12 03 2025].