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Transistor outpur characteristic using Lab VIEW

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Acknowledgements:

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We are indebted to the educational institution for providing access to the necessary resources, including software, hardware.Their commitment to fostering a conducive learning environment has been a driving force behind our achievements.

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Lastly, we express our appreciation to the broader academic community, whose research and publications paved the way for our understanding of three-phase systems and LabVIEW simulations.Each of these individuals and entities has played a significant role in making this project a reality. Their contributions have undoubtedly enriched our knowledge and skills, and for that, we are deeply grateful.

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Introduction:

Electronic circuits require transistors as essential parts because they allow electrical signals to be regulated and amplified. The NPN epitaxial silicon transistors in the BC546/547/548/549/550 family are very reliable and versatile, making them suitable for a wide range of electrical applications. To maximize circuit design and performance, one must comprehend their output transfer characteristics.

Our measuring system, designed to monitor the output transfer properties of the BC546/547/548/549/550 series of transistors, is presented in this report. A printed circuit board made especially for measuring transistor current and voltage is integrated into the system together with the NI USB-6001 data collecting device. National Instruments' LabVIEW software provides the interface for data acquisition and analysis, offering a comprehensive platform for accurate characterization.

This report's main goal is to provide information on how the BC546/547/548/549/550 transistors behave under different conditions of operation. We seek to clarify important factors and the relationships between collector current and collector-emitter voltage (IC-VCE) by methodically monitoring and analyzing the output transfer characteristics.

We want to show details in transistor behavior that are crucial for effective circuit design and optimization by employing cutting-edge testing methods and equipment. The technique and measuring system configuration are described in depth in this report, together with a thorough analysis and interpretation of the collected data.

The goal of the information provided in this paper is to advance knowledge of transistor properties and how they affect the design and operation of electronic circuits. In order to support engineers and researchers in their quest of innovation and excellence in the field of electrical engineering, we want to clarify the behavior of the transistors in the BC546/547/548/549/550 family.

Goal of the Experiment:

Firstly, the aim is to familiarize participants with LabVIEW, serving both as a programming language and a measurement tool.

Secondly, the experiment focuses on analyzing the output characteristics of the BC547 transistor through the utilization of LabVIEW software.

Thirdly, the objective entails developing a LabVIEW Virtual Instrument (VI) capable of measuring Collector-Emitter Voltage (UCE) and Collector Current (IC) while maintaining a constant Base Current (IB). This VI will allow for the variation of Collector Voltage (UC) and Base Voltage (UB) while plotting graphs to visualize the forward characteristics based on acquired Data Acquisition (DAQ) data.

In achieving these objectives, participants will not only enhance their proficiency in LabVIEW programming and measurement techniques but also gain valuable insights into the behavior of the BC547 transistor across different operating conditions, thus facilitating future engineering endeavors.

Transistor:

Electrical components known as bipolar transistors are essential to electronics. They differ from diodes in that they have three terminals instead of only one. A Bipolar Junction Transistor (BJT), which has two PN-junctions and is the building block of a transistor, is produced when two signal diodes are combined back-to-back. Different semiconductor materials are used to create transistors, which are active devices that may switch or amplify signals in response to slight voltage changes.

Three zones govern the operation of transistors: cutoff, active, and saturation. The fact that their name, "transistor," combines the words "transfer" and "resistor," suggests that their initial use in electronics. Bipolar transistors are classified as PNP or NPN depending on how they are constructed and biased.

The Emitter (E), Base (B), and Collector (C) terminals make up a bipolar transistor. By responding to a biassing voltage given to the Base, these terminals control the flow of current from the Emitter to the Collector, so functioning as a current-controlled switch.

PNP and NPN transistors function according to the same principle; the only differences are in the polarity of the power source and biassing. Like diode symbols, their circuit diagrams include an arrow that represents the usual current flow path from the positive P-type to the negative N-type region, from the Base to the Emitter.

The fundamental mechanism of bipolar transistors in electronic circuits is the facilitation of current regulation and control, whereby a modest Base current influences a much greater Collector current.

Common Emitter:

The emitter of a transistor is placed between its base and collector when it is in the common emitter configuration. In this case, the emitter and base are connected to the input circuit, and the emitter and collector terminals are drawn upon by the output circuit. The common emitter layout gets its name from the fact that this arrangement makes the emitter common to the input and output circuits. The behavior of the transistor can be efficiently regulated and managed in this configuration to achieve desired switching or amplification functionalities. The common emitter configuration is a fundamental feature of all transistors, whether they are NPN or PNP, and it offers a wide range of applications in electrical circuits.[1]

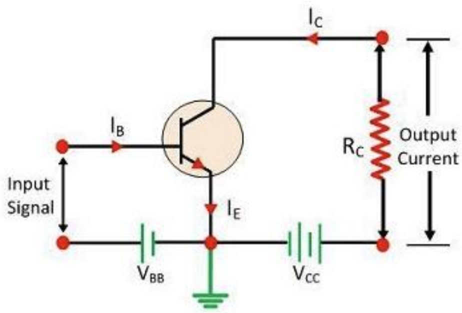


Figure 1: Common Emitter [1]

Output Characteristic:

In the common emitter (CE) configuration, the output characteristic curve illustrates the relationship between collector current (IC) and collector-emitter voltage (VCE) at a constant base current (IB). This curve, depicting the behavior of a typical NPN transistor, showcases the active region where a slight increase in collector current accompanies a rise in collector-emitter voltage. Notably, the slope of the curve is more pronounced compared to the output characteristic of the common base (CB) configuration, indicating higher sensitivity to variations in VCE.

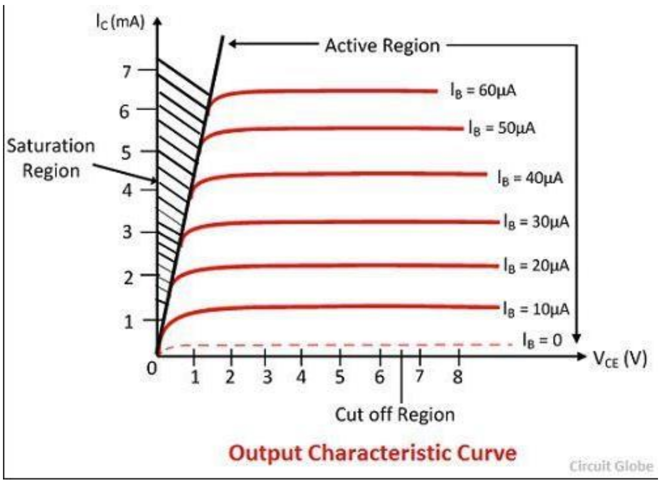


Figure 2: Output Characteristic

In this configuration, the output resistance is lower than that of the common base setup, enhancing the transistor's versatility in electronic applications. The value of the collector current (IC) rises with increasing VCE at a constant IB, leading to a simultaneous increase in the transistor's current gain factor (β). Conversely, as VCE decreases, IC experiences a rapid decline. The collector-base junction remains in forward bias during operation, ensuring the transistor operates in the saturation region.

Within the saturation region, the collector current becomes independent and is unaffected by the input current IB. This region is characterized by a stable IC, contributing to the transistor's reliability in specific circuit applications. In the active region, IC is expressed as βIB, where IC, albeit small, is not zero and is equivalent to the reverse leakage current ICEO. Understanding these characteristics is crucial for designing and optimizing circuits employing NPN transistors in the common emitter configuration.

We calculate Ic and Ib using this formula.

$$Ic = \frac{Vc - Vce}{Rc} \qquad (1)$$

$$Ib = \frac{Vb - Vbe}{Rb} \qquad (2)$$

Components:

The following components are used:

1. NI LabVIEW© 2020. (National Instruments software)
2. NI USB-6001
3. Printed Circuit Board.

Specifications NI USB-6001:

The NI USB-6001, part of the USB-6000 Series manufactured by National Instruments (NI), serves as a versatile data acquisition device tailored for measurement and automation tasks. Understanding its specifications aids in optimizing its usage within various applications. Here's an overview:

Analog Input Channels:
Offers typically 8 single-ended or 4 differential analog input channels.

Analog Output Channels:
Typically equipped with 2 analog output channels.

Digital I/O:
Provides a specified number of digital I/O channels, configurable for various purposes.

Analog Input Characteristics:
Defines input range and resolution for precise voltage measurements.

Analog Output Characteristics:
Specifies output range and resolution for accurate voltage output.

Digital I/O Characteristics:
Defines voltage levels for logic states and configurable directionality.

Timing and Synchronization:
Determines maximum sample rate and available clocking options for synchronization.

Software Support:
Compatible with NI software like LabVIEW and Measurement & Automation Explorer (MAX).

Form Factor:
Features USB interface for seamless computer connectivity.

Compatibility:
Supports specified operating systems for seamless integration.

Dimensions and Weight:
Provides physical dimensions and weight for practical considerations.

Power Requirements:
Typically, USB-powered for convenience.

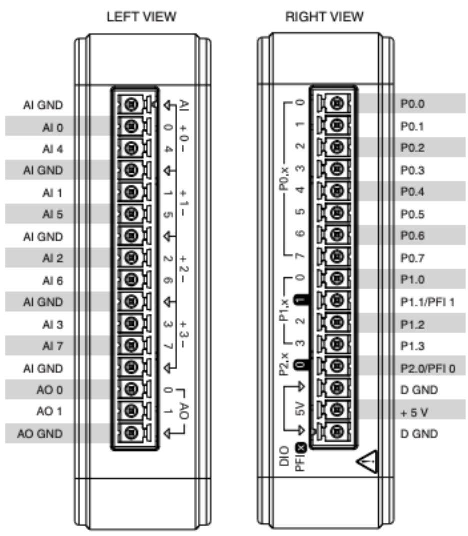


Figure 3: Device Pinout [4]

PCB Schematic:

The integration of the NI USB-6001, which produces two crucial signals—UB and UC—via AO0 and AI2 ports, is shown in the PCB schematic in Figure 2. In this arrangement, one signal is sent to the base of the transistor, and the other is amplified and sent to the collector of the transistor. Two operational points are established by this configuration, each of which is connected to a certain voltage level. Simultaneously, different computed current values aid in the display of the transfer output properties of the transistor

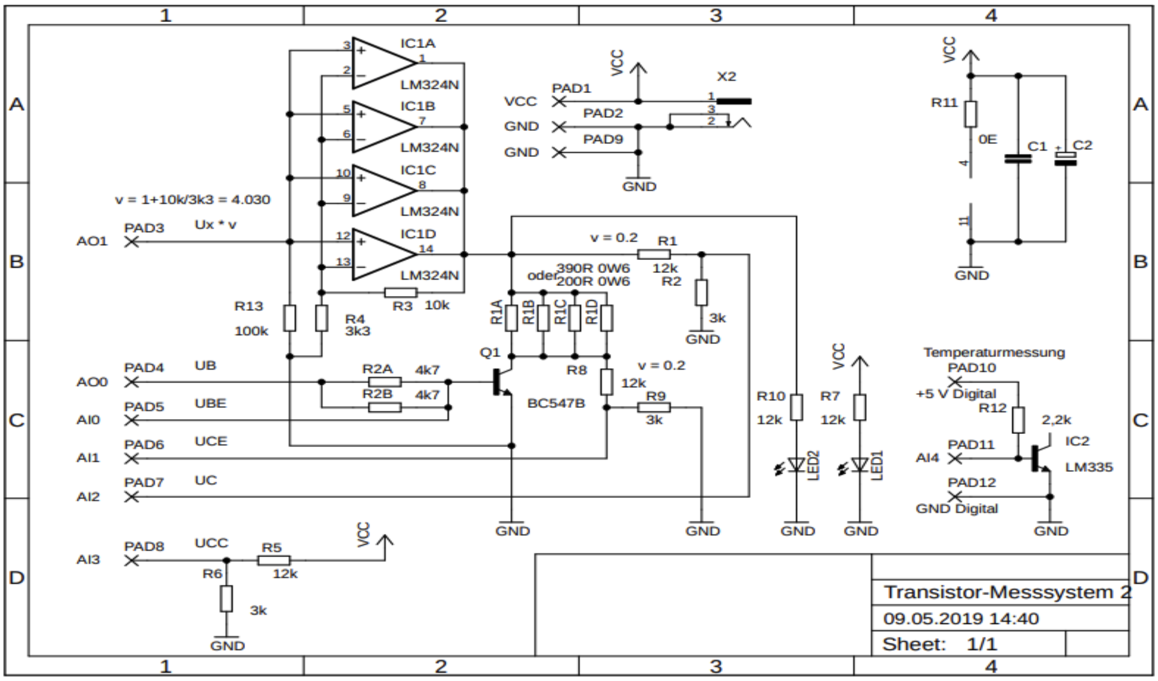


Figure 4: PCB Schematic NI USB-6001[4]

A voltage protection circuit has been included to prevent against potential problems; it will activate if the operational 12 VDC external voltage is exceeded. This safeguard guarantees the system's integrity in a variety of operating scenarios. The schematic also includes a temperature sensor (LM335; by measuring temperature variations, it increases the overall robustness of the circuit). Because of this integration, the system may react to environmental changes in a dynamic way, resulting in optimal performance and dependability under a variety of operating scenarios.

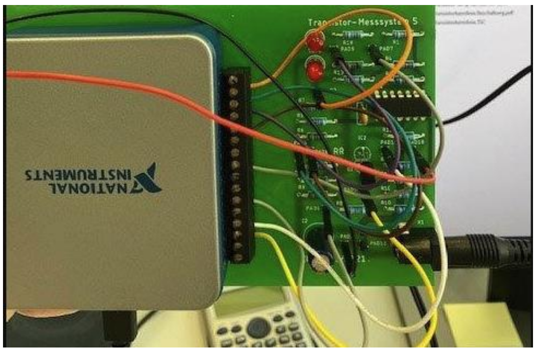
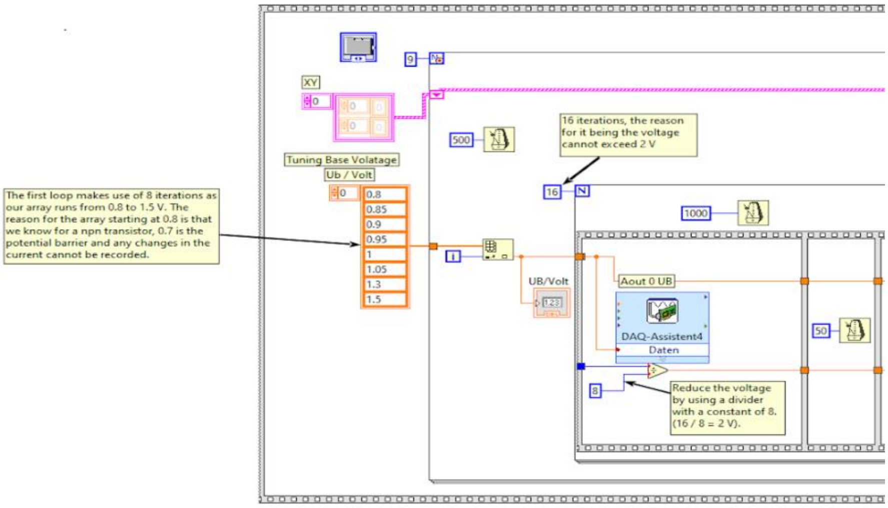


Figure 5: Transistor Circuit box [4]

Labview program:

Here we use for loop. As there is no considerable difference between for and while loops, the reason for replacing it is leaning more towards our understanding of the program. For loop makes use of iterations, which makes it easier for us to navigate in the program. • The first loop makes use of 9 iterations as our array runs from 0.8 to 1.5 V. The reason for the array starting at 0.8 is that we know for a npn transistor, 0.7 is the potential barrier and any changes in the current cannot be recorded. So, it is advised to use values after 0.7 to record the surge in the current which helps us in plotting the transfer characteristics.

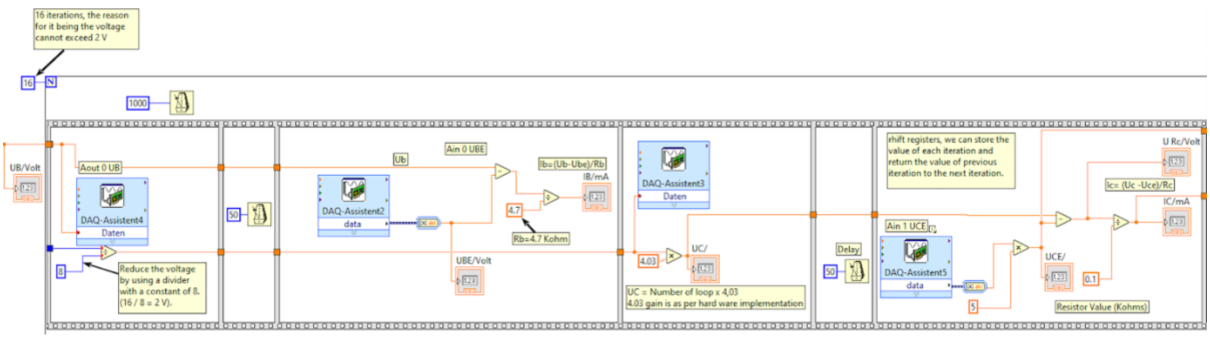


Figurer 6: First part of this program (For loop ,iteration,UB,Base voltage)

UB is given from an array to prevent restarting of the program every time there is a value change. The second loop has 16 iterations, the reason for it being the voltage cannot exceed 2 V as it can inherently damage the circuit. We make sure to reduce the voltage by using a divider with a constant of 8. (16 / 8 = 2 V).

DAQ :

As we can see in the first program, the UB goes to the second terminal and the output from the DAQ2 goes to the first terminal. We exchange this, if left as it is in the first one, we will get a negative value since the DAQ2 output is smaller than UB.We add a delay between DAQ4 and DAQ2 to avoid any discrepancy in the data as reading of the data and writing of the data cannot be done at the same time. The delay could be of any number of seconds, we chose 50s.DAQ5 is removed as it is not necessary and the absence of it does not affect the program in any way. In properties of DAQ, we need to make sure it is RSE configured as we are measuring the parameters with respect to the ground.start and stop button is also used by addition a terminal condition to the for loop. The reason for it being, since sometimes, the temperature can increase to an extent that could damage the circuit, a stop button must always be present to prevent that from happening. In our program, the temperature does not cross the bounds to damage the circuit but it is used as a precautionary button.



Figurer 7: DAQ (calculate UCB,UBE)

Temperature:

We have attached a thermometer block to record the value of the temperature of the transistor after each loop is iterated.using a DAQ to show the tempurature in celsius .

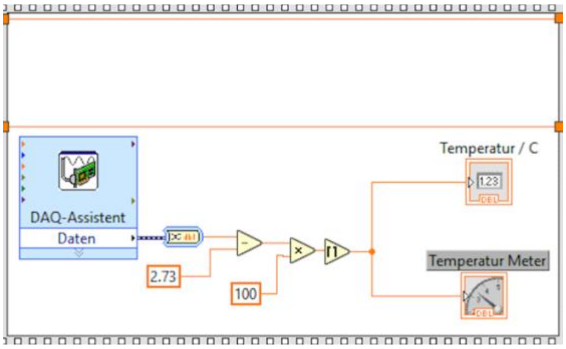


Figure 8: Tempurature calculation

A start and stop button is also used by addition a terminal condition to the for loop. The reason for it being, since sometimes, the temperature can increase to an extent that could damage the circuit, a start and stop button must always be present to prevent that from happening.That shown in figure 8.

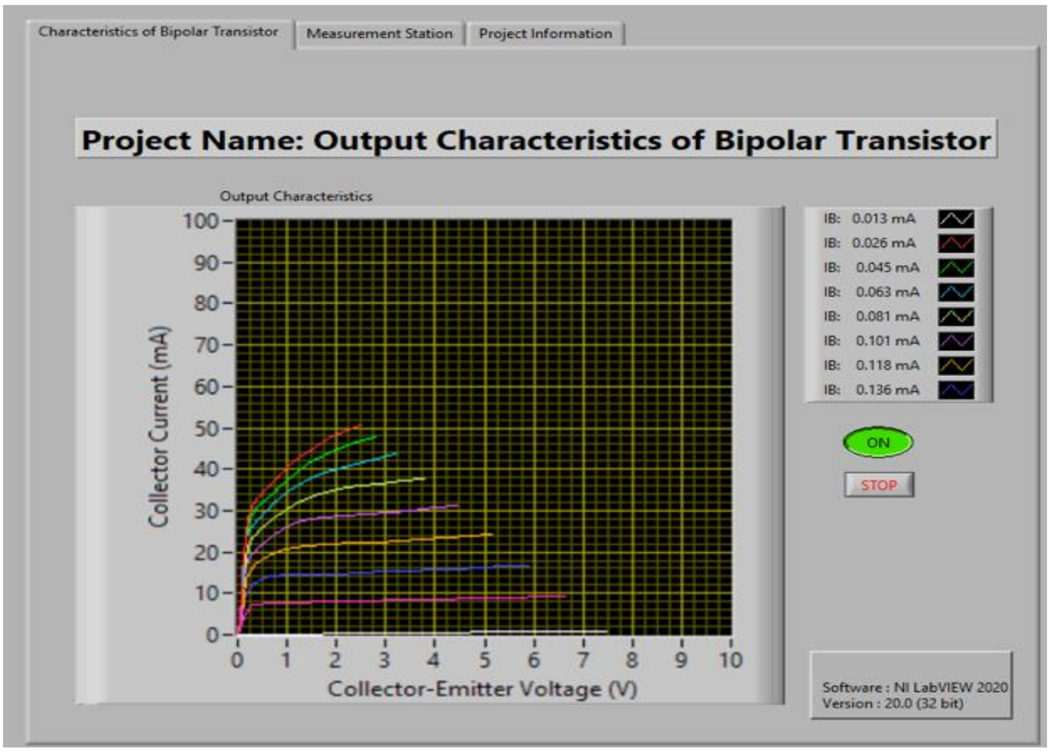


Figure 9: Final Output of the program

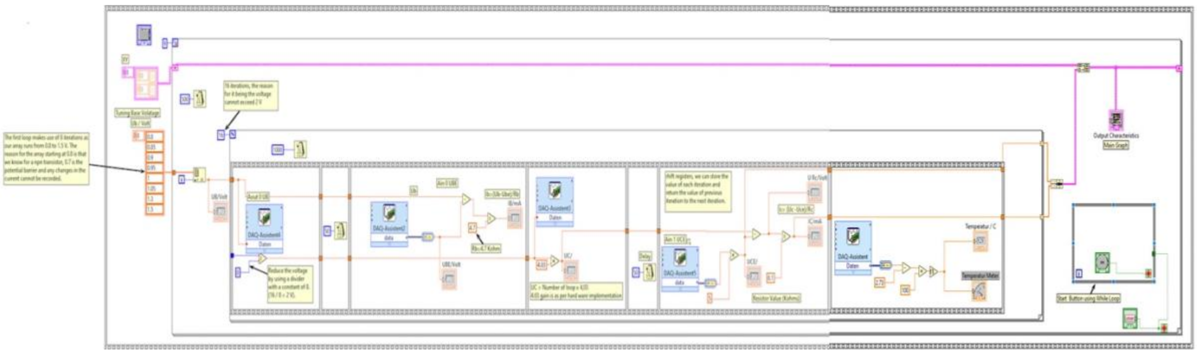


Figure 10 Final Block Diagram

CONCLUSION:

In conclusion, our project provided us with invaluable experience in utilizing NI LabVIEW software and DAQ systems for the analysis of the output characteristics of an NPN bipolar junction transistor, specifically the BC547. By maintaining the Base Current (IB) constant while varying the Collector Voltage (UC) and Base Voltage (UB), we successfully measured the Collector-Emitter Voltage (UCE) and Collector Current (IC) to construct a graph illustrating the transistor's forward characteristics.

Throughout the project, we encountered several challenges, ranging from technical issues with the equipment to complexities in data acquisition and analysis. However, through persistent investigation and problem-solving, we were able to overcome these hurdles and achieve our objectives. These challenges not only provided opportunities for learning but also underscored the importance of adaptability and perseverance in scientific research and experimental work.

Our successful completion of this project not only deepened our understanding of transistor behavior but also enhanced our proficiency in using advanced measurement and analysis tools like NI LabVIEW and DAQ systems. Moving forward, the knowledge and skills gained from this project will serve as a solid foundation for future endeavors in electronics and experimental research, equipping us with the capabilities to tackle even more complex challenges in the field

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