Bode 100 – Application Note

Measuring Optocouplers using Bode 100, and Picotest M3522A with J2200A

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Note: Basic procedures such as setting up and calibrating the Bode 100 are described in the Bode 100 user manual available at: https://www.omicron-lab.com/downloads

Note: All measurements in this application note have been performed using the Bode Analyzer Suite V3.50 Use this version or a newer version to perform the measurements shown in this document. You can download the latest version at: https://www.omicron-lab.com/downloads

1 Executive Summary

Optocouplers are widely used semiconductor components that facilitate the transmission of electrical signals between two separate circuits while ensuring isolation. They serve a crucial role in protecting and enhancing the reliability of electronic systems when dealing with scenarios where one circuit is in a safe environment and the other in a potentially hazardous or electrically noisy setting. The performance of optocouplers is quantified by a crucial factor known as the Current transfer Ratio (CTR), which signifies their gain. When integrated within a control loop of a system the frequency response of the CTR plays a critical role in influencing various dynamic aspects like stability, power supply rejection ratio (PSRR), response to step load changes and the system's output impedance.

Optocouplers typically come with a minimum specified CTR, while a maximum CTR is often left unspecified. Moreover, CTR curves in relation to the LED forward current may not always be readily available. Hence, there arises a need to perform measurements to determine the expected range of performance.

This application note offers insights into measuring CTR characteristics and establishing the connection between forward current and bandwidth using the Bode 100 Vector Network Analyzer [1] , alongside the Picotest M3522A 6 1/2 Digit Multimeter [2] and the Picotest J2200A CTR [3] module. The DUT (Device under test) used in this experiment is the optocoupler family 817-045: Bin A [4], Bin B [5], Bin C [6] and Bin D [7].

2 Device Setup & Calibration of Bode 100

2.1 Setting up the Bode 100

The Gain/Phase measurement mode must be selected within the Bode Analyzer Suite as shown in Figure 1. First, ensure that you have entered Vector Network Analysis and then navigate to the “Gain / Phase” option. Click on “Select Measurement” to proceed.

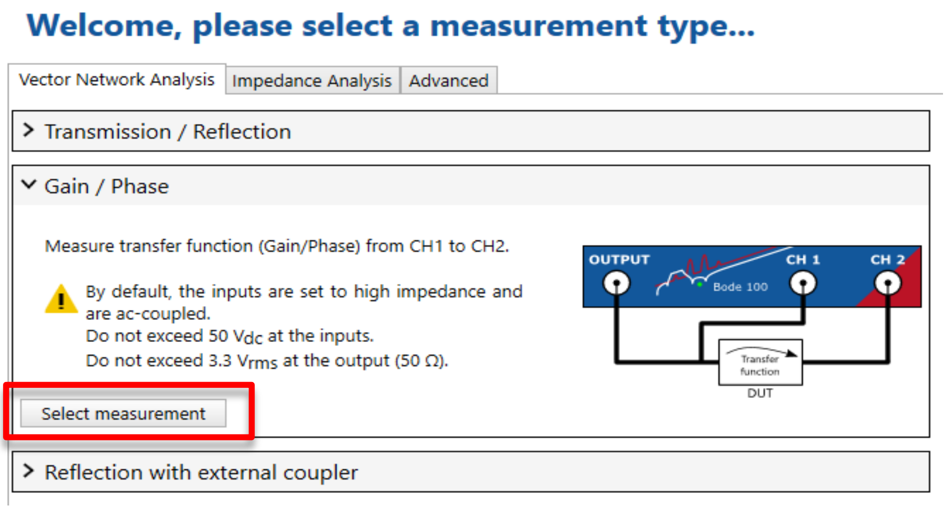

Figure 1: Bode 100 measurement type.

The settings presented in Figure 2 are applied to the Bode 100.

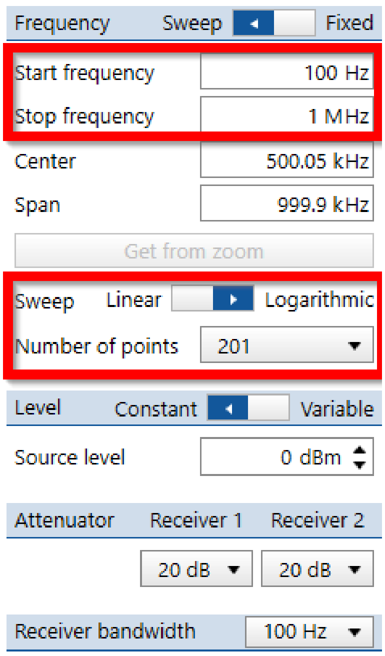

Figure 2: Frequency settings.

To achieve the best possible results, it is recommended to perform a Thru-calibration to eliminate any disparities between the two cables connecting CH1 and CH2 of the Bode 100. This calibration involves connecting both cables to the Bode 100 source signal as shown in the following figure. The comprehensive instructions for performing this calibration can be found in the Bode 100 user manual.

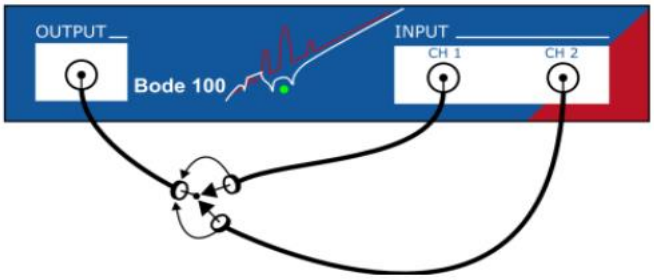

Figure 3: Thru calibration.

2.2 Setting up the Picotest M3522A

To initiate the configuration process for the M3522A [8], which can be seen in Figure 4, start by pressing the MENU button. Using the arrow keys, navigate to the CTR option. Once located, press the Enter button to proceed.

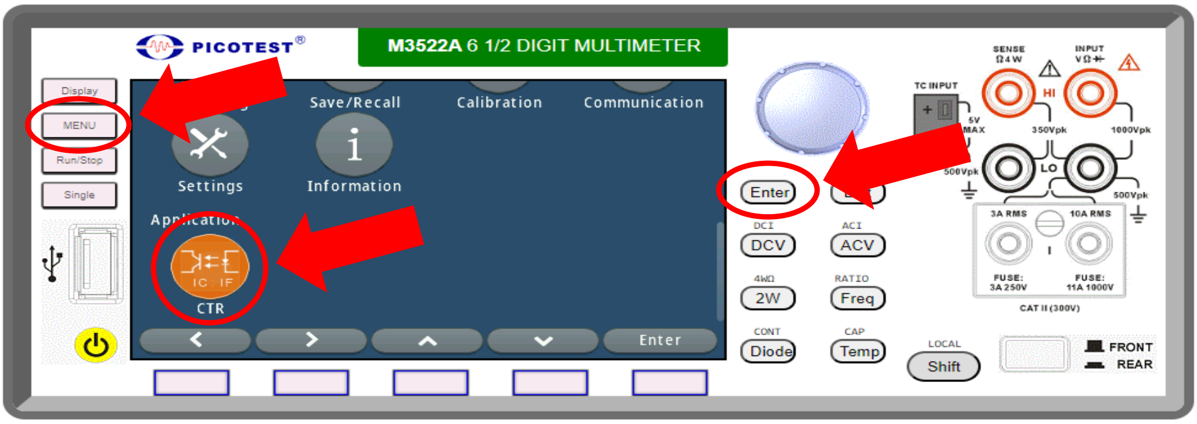

Figure 4: Picotest M3522A setup.

Set the Target Current I_f (forward current) and adjust the Target Voltage V_{CC} to the desired level as it is showed in Figure 5. The accuracy of these settings is important for obtaining reliable results. Then, use the arrow keys to define the values of current and voltage.

Figure 5: Picotest M3522A voltage and current targets.

Press the Display button and the main view including the circuit schematic and variable values will appear as it is presented in Figure 6. Notice that the resistances R1 and R2 are set to 1 kΩ. Note that the resistance R1 and R2 will change to 100 Ω if the forward current is increased above 1.2 mA.

Figure 6: Display main view.

2.3 Connecting the DUT

Using the Picotest J2200A, streamlines the process of switching between various DUTs and their corresponding settings. Depending on the package type of the DUT it must be placed properly on the socket for testing as the Figure 7 demonstrates.

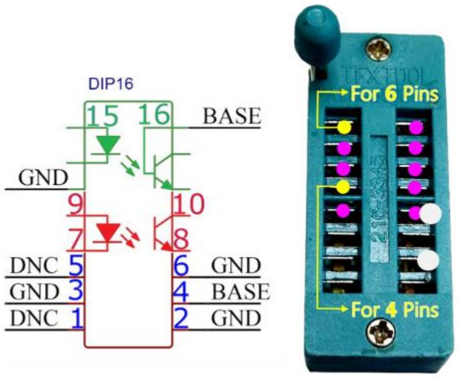

Figure 7: DUT socket configuration on Picotest J2200A Measurement Setup [9]

2.4 Connection Setup Bode 100, Picotest J2200A & Picotest M3522A

Figure 8 shows the measurement setup. The Bode 100 Output is connected to the Picotest J2200A input (OSC). Bode 100 Inputs CH 1 and CH 2 are connected to ports CH 1 and CH 2 of the Picotest J2200A. The J2200A module features a USB-C port that is connected to the Picotest M3522A.

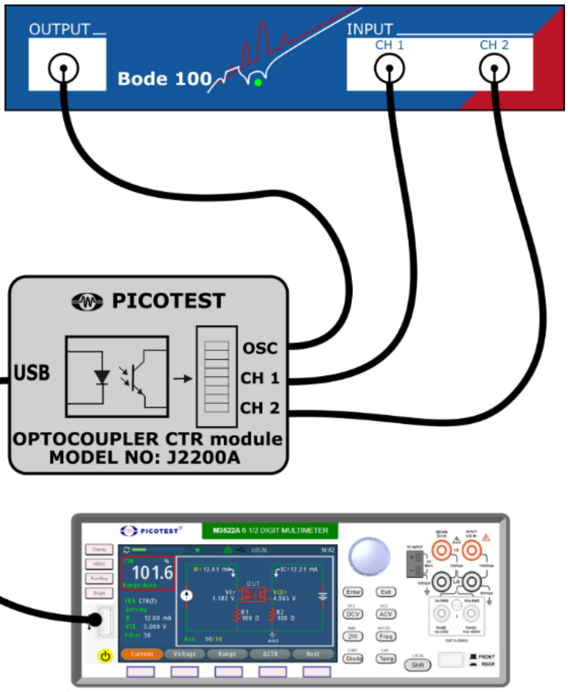

Figure 8: Measurement setup.

3 Measurement Results

The following section presents the outcomes obtained in the real-life measurements.

3.1 Gain and Bandwidth

Figure 9 shows the gain and the bandwidth of the different optocouplers used in this application note. A forward current of 5 mA and a voltage (V_{CC}) of 11 V is applied. The behavior of each optocoupler begins to deviate around 50 kHz. The gain of the 817A is the lowest of the set of DUTs, but it's cut-off frequency is close to the 817B. The 817C and 817D, exhibit close values of gain (only 0.711 dB difference) and a similar cut-off frequency. The results summary is shown in Table 1.

Table 1: Gain values at 100 Hz and 50 kHz, and cut-off frequency (at -3 dB of the nominal value)

Type	Number	Voltage CE (V)	Gain at 100 Hz (dB)	Gain at 50 kHz (dB)	Cut-off frequency (kHz)
817A 045	140817140110	9.04	2.3	2.1	301.2
817B 045	140817140210	9.04	8.8	8.7	315.5
817C 045	140817140310	9.04	12.6	12.3	228.8
817D 045	140817140410	9.04	13.3	13.0	197.6

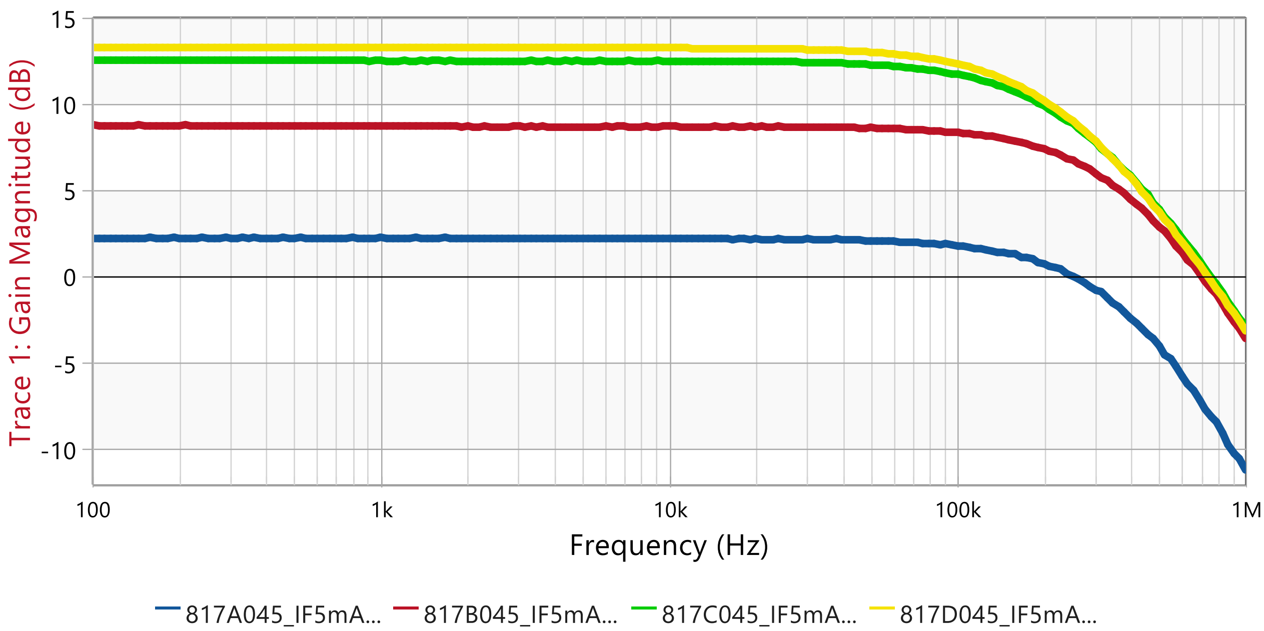

Figure 9: DUTs gain response obtained with Bode 100.

The behavior of the 817B [5] optocoupler was examined under different forward currents which can be seen in Figure 10. Below. The gain response and the bandwidth increase as the applied forward current increases. The summary of the results is presented in Table 2.

Table 2: **B17B045** gain and cut-off frequency at different forward currents.

Forward current (mA)	Collector current (mA)	Voltage CE (V)	Gain at 100 Hz (dB)	Gain at 50 kHz (dB)	Cut-off Frequency (kHz)
1	1.1	10.9	4.4	2.9	78.6
2	3.2	10.7	6.1	5.8	208.8
5	10.5	10	8.6	8.4	313.8
8	19.6	9.1	9.5	9.3	327.4

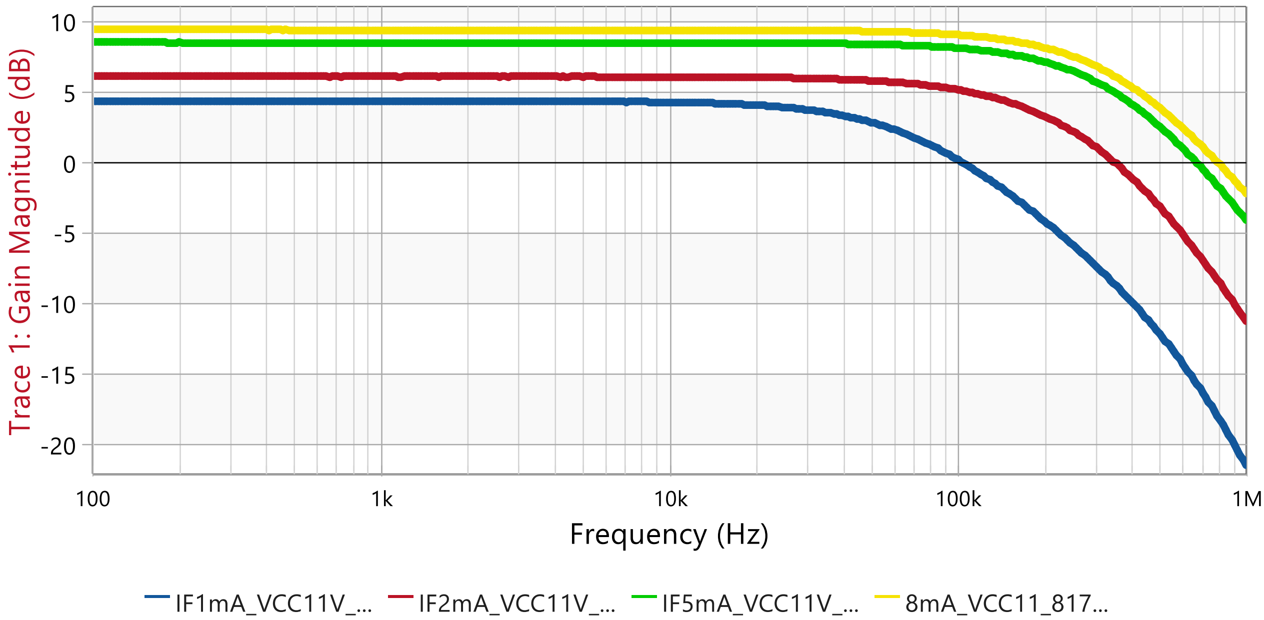

Figure 10: B17B045 gain response at different forward currents.

3.2 Absolute CTR vs Forward Current

The Picotest M3522A not only makes it easy to measure the frequency response of optocouplers but it can also be used to measure parameters like the relationship between the Absolute CTR (%) and the forward current characteristic. For this test we analyzed all DUTs (Bin A, Bin B, Bin C and Bin D). The response in terms of Absolute CTR % is given by the Picotest M3522A using a pulse forward current. The collector-emitter voltage is set to 5 V.

The solid line curves are taken from the datasheets [4], [5], [6], [7], while the dashed line curves represent the measured DUTs. It is observed that while the measurement and the datasheet curves do not match precisely, the measured results fall comfortably within the range specifications provided for each optocoupler.

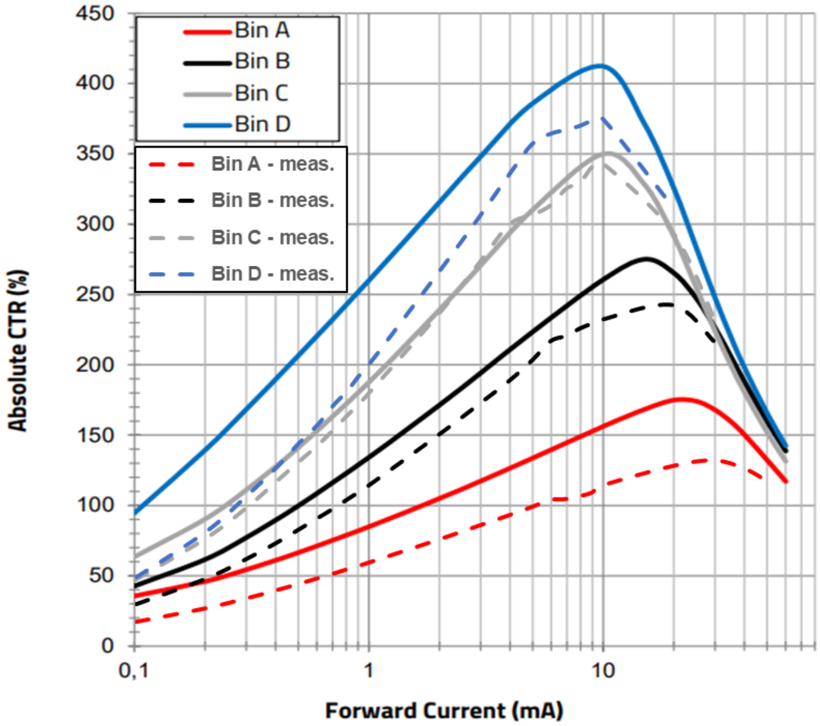

Figure 11: Absolute CTR vs Forward current at $V_{CE} = 5V$

4 Summary

In Summary, the OMICRON Lab Bode 100 Vector Network Analyzer, when utilized alongside the Picotest J2200A Optocoupler CTR Module and Picotest M3522A 6 1/2 Digit Multimeter, presents a simple to use and comprehensive solution for evaluating and analyzing optocoupler performance. Its combination of speed and efficiency, user-friendliness, and statistical analysis capabilities, positions it as an exceptional tool for engineers navigating the realm of optocouplers.

Whether the application is in the domains of research, development, or quality assurance, the Bode 100 stands as a guiding light of advanced features and precision, elevating optocoupler characterization and facilitating the fine-tuning of the circuit designs.

5 References

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