CALIBRATING CT455 AND CT456 IN LABVIEW

By Ehsan Aerabi and Cédric Simard
Allegro MicroSystems

INTRODUCTION

The LabVIEW-based calibration software is a software unit that is used to program the CT45x product family of contactless current sensors to obtain the best total error performance in a current sensor module. It enables the user to program the gain and offset of the CT45x current sensor to optimize the full-scale (FS) output range and offset for the application. The accompanying software helps the user program the offset to zero and calibrate the gain of the device based on the maximum magnetic field to which the CT45x is to be during operation.

The connection diagram of the LabVIEW-based calibration software used to calibrate a CT45x device is shown in Figure 1. The LabVIEW-based calibration software is connected to the CT45x using jumper wires. The LabVIEW-based calibration software can be operated and controlled using a LabVIEW project running on a Windows PC connected to an appropriate National Instruments (NI) device. The LabVIEW-based calibration software uses a built-in analog-to-digital convertor (ADC) and does not rely on external digital multimeters (DMMs) or other similar instruments. The LabVIEW-based calibration software does not come with a current supply. Therefore, during the calibration process, the LabVIEW-based calibration software requests specific current quantities to be passed through the busbar or printed circuit board (PCB) trace. A current supply must provide the required current on the busbar copper, upon request from the LabVIEW-based calibration software. This function can be automatically controlled by the calibration software, as described later in this document.

It is important to know that the trimming process only works on parts that have never been trimmed before: Parts cannot be trimmed twice. When a fuse is blown, it is permanent, and the code cannot be changed during the trimming process. Performing work using the LabVIEW-based calibration software requires use of untrimmed parts (which are identifiable by a "00" in the part number).

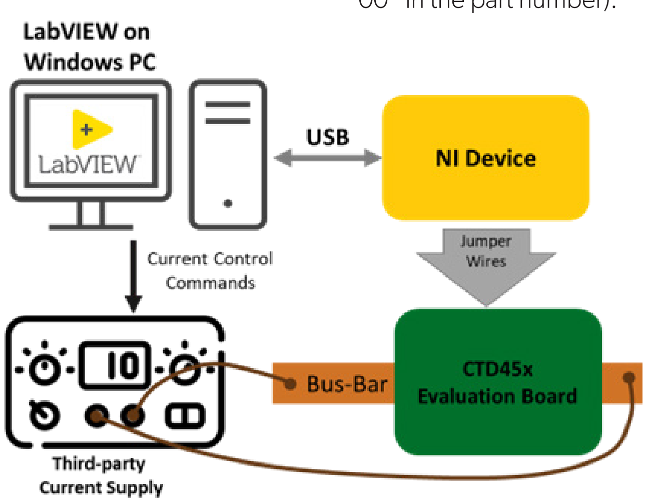


Figure 1: Connection Diagram of LabVIEW-Based Calibration Software Calibration Unit with Windows PC and CT45x Evaluation Board (CTD45x)

PREPARING THE HARDWARE

Purchasing NI Device

Use of the LabVIEW-based calibration software requires a National Instruments device with the following capabilities:

- 1x analog input (AI)
- 2x hardware-timed (HW-timed) analog outputs (AO)
- 3x HW-timed digital input/outputs (DIOs)
- 1x counter
- 1x programmable function interface (PFI) pin for use of the counter output as the clock source.

The software has been tested on NI USB-6259 and NI USB-6351; however, any similar parts with the minimal above-mentioned features can be run by the software.

Model	Bus	Analog Inputs	Input Resolution (Bits)	Max Sampling Rate (MS/s)	Input Range (V)	Analog Outputs	Max Output Rate (MS/s)	Output Range (V)	DIO	Time DIO Lines	HW-Timed DIO (MHz)
NI 6351	PCIe	16	16	1.25	±10	2	2.86	±10	24	8	10

Preparing Relay Circuit for the Relay Board

Calibration requires a simple external relay circuit for the relay board per the schematic shown in Figure 2. On the right side, a 10-pin header is connected to the NI product; on the left side, a 4-pin header is connected to the Allegro device that is to be trimmed. The bill of materials (BOM) is included in the Appendix at the end of this document.

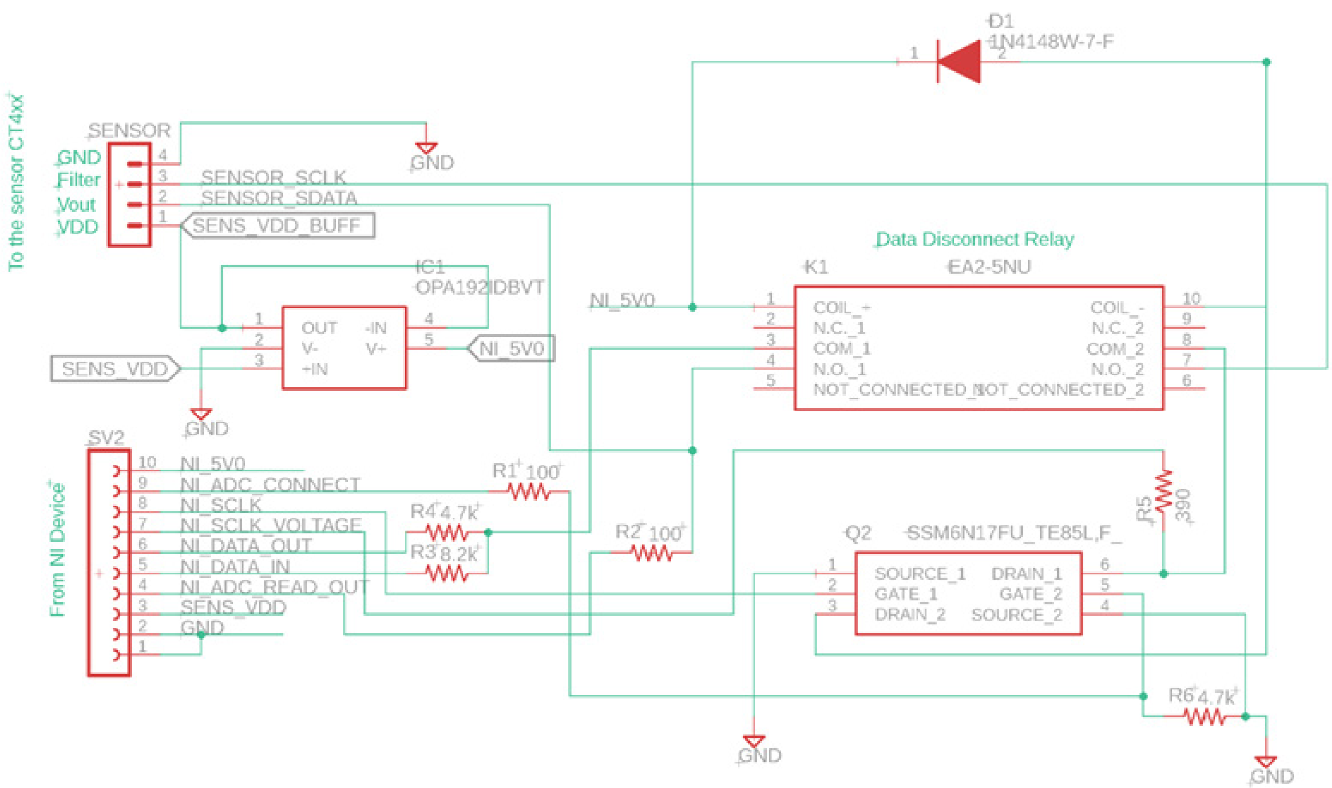


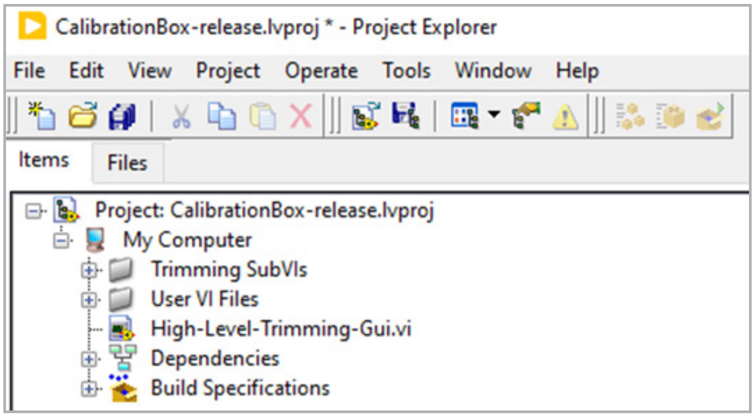
Figure 2: Schematic of Relay Circuit for the Relay Board

LABVIEW-BASED CALIBRATION SOFTWARE

After LabVIEW has been installed, open the following LabVIEW-based calibration software project file:

- CalibrationBox-release.lvproj

The main file—High-Level-Trimming-Gui.vi—loads the graphical user interface of the calibration software.



Preparing the Configuration File

1. Ensure the proper version of LabVIEW is installed. Device software configuration requires NI LabVIEW version 2022 Q3 (or higher): This version of LabVIEW is required to open and edit the configuration VI files.
2. To run the software, configure the software to use the appropriate resources from the NI device. To do so, allocate the set of pins shown on the 10-pin header in Figure 2—the analog output (AO), analog input (AI), programmable function interface (PFI) and digital inputs and outputs (DIOs)—to the proper resources in the NI device. Every pin must be allocated as follows:
   A. Open the UserConfigFile.vi file and advance to its block diagram by pressing Ctrl+E .
   B. Referring to Figure 3, from the top, the first item to be set is a counter that must be chosen and allocated to the CLK source, and a PFI to the CLK OUT terminal.
   C. Allocate an AO for the CLK voltage, two DIOs for SDATA, one AO for VDD, and one DIO for the data direction. The DIs must be HW-timed.
3. To finish, save the configuration file.

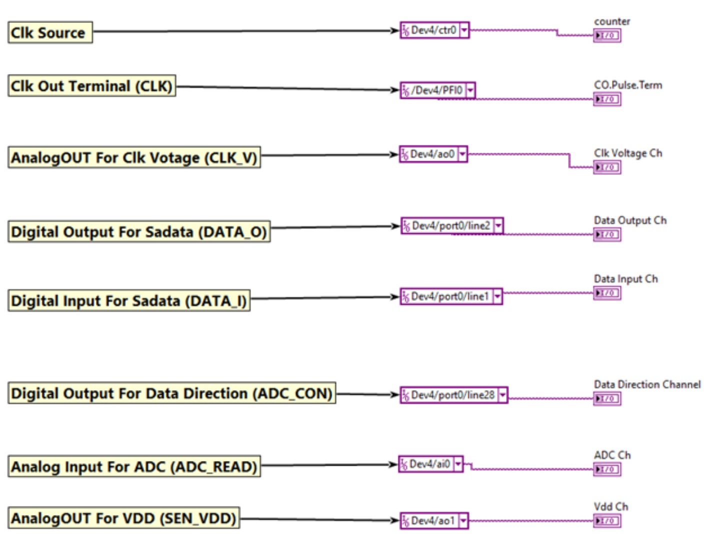


Figure 3: Block-Diagram of UserConfigFile.vi

A link between the configuration file and the pin header on the relay PCB is shown in Figure 4. This link is helpful when wiring each chosen NI device pin to its corresponding header pin. It also provides the minimum requirement for that function.

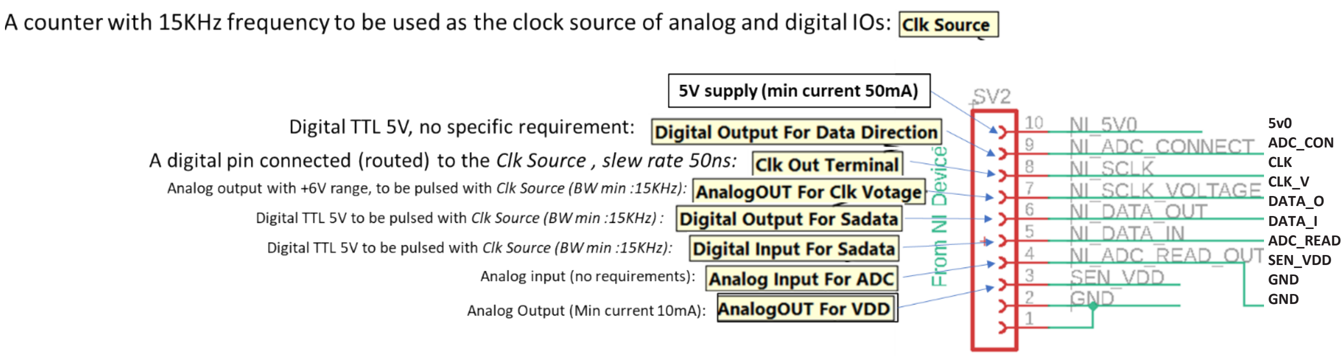


Figure 4: How to Link Configuration File to Relay Board Header Pin and Minimum Requirements of Each Function

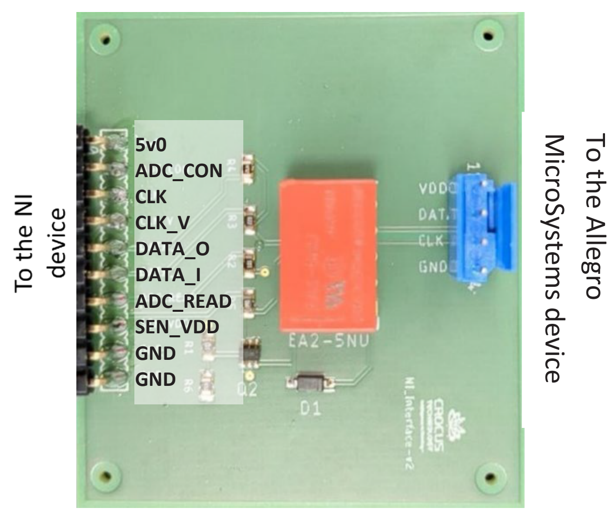


Figure 5: View of Relay PCB

Setup the Current Supply

To create the current required for device gain calibration, the LabVIEW-based calibration software needs a current source. An integrated GIPB/VISA-based current supply controller is included. Keysight N8731a has been used to test the controller.

The following files must be changed to function with their current supply in order to replace the integrated current supply:

- UserSetCurr(SubVI).vi
- UserCurrON(SubVI).vi
- UserCurrOFF(SubVI).vi

UserSetCurr.vi, by default, has a VISA constructor object. It has "VISA-Refnum in", "VISA-Refnum out", "error" inputs/outputs, and a "Current Limit"; see Figure 6.

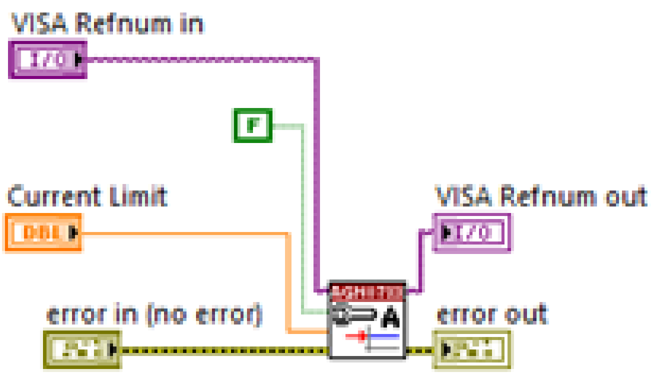


Figure 6: Block Diagram of UserSetCurr(SubVI).vi

Alternatively, any other controller may be used; however, at least one input must remain—the "Current Limit"input, which controls the amount of current that is to be driven after calling UserCurrON(SubVI).vi.

To turn the current on and off, UserCurrON(SubVI).vi and UserCurrOFF(SubVI).vi must be replaced. The specific input or output to be used is at the user's discretion. The default settling time of the current supply is a delay of 300 ns, but this can be adjusted; see Figure 7.

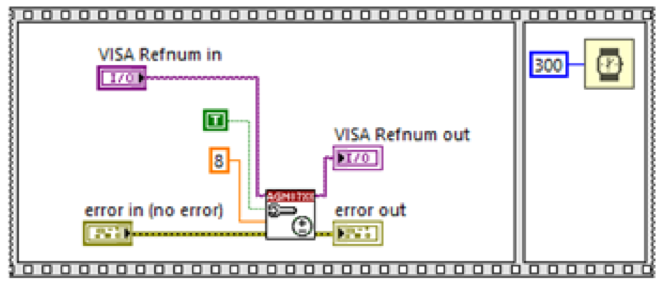


Figure 7: Block Diagram Of UserCurrON(SubVI).vi

IMPORTANT: The software calls the user files dynamically and, therefore, their input/output terminal structure must not be modified from the default. For instance, the software expects to observe input/output terminals for UserConfig-File.vi as shown in Figure 8.

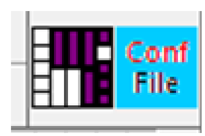


Figure 8: Input/Output Terminals for UserConfigFile.vi

Any modification to this terminal arrangement leads to an error. Do NOT remove any inputs or outputs, even if they are not to be used (e.g., error-in, error-out palettes). Rather, bypass them by connecting the corresponding inputs and outputs, and leave them without use (e.g., connecting error-in to error-out).

Running the LabVIEW-based Calibration Software

The main file in this project is the High-Level-Trimming.vi file, the graphical user interface (GUI) for which is shown in Figure 8.

A window for the trimming inputs is located on the left side of the GUI panel. All of these values must be set before the software may be used—Polarity, DeviceFamily, MaxCurrent, Supply (5 V or 3.3 V) are all included.

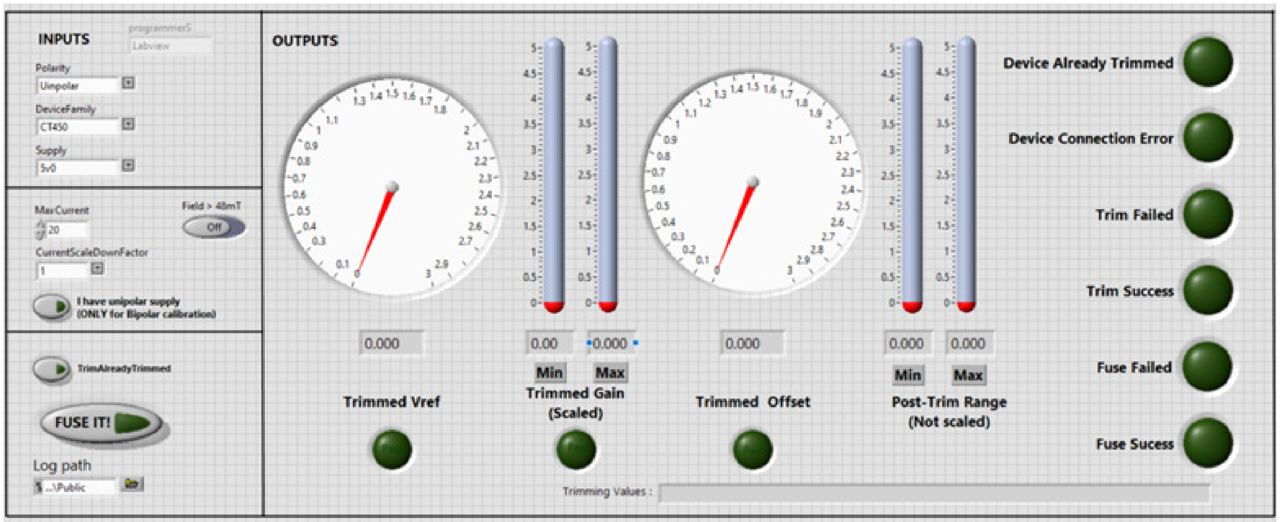


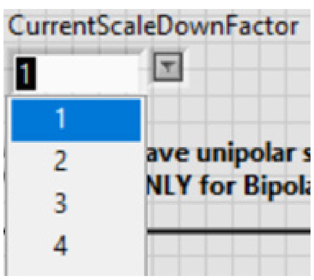
Figure 9: GUI Panel of High-Level-Trimming.vi

SCALING DOWN THE MAX CURRENT

CURRENT_SCALE_DOWN is a parameter to avoid using the maximum current for calibration. In some cases, a high-current supply is not available or the maximum current generates considerable heat. Therefore, the current can be scaled down during calibration by selecting among the values 2, 5, and 10, to apply less current accordingly. For instance, to use 400 A in a calibration carried out for the maximum current of 2000 A, 2000 A can be written on the MAX_CURRENT text box and CURRENT_SCALE_DOWN = 5 can be selected.

IMPORTANT: If calibration with a high scale-down factor (e.g., 10) does not terminate with success, a lower scale-down value must be chosen.

IMPORTANT: When current is scaled-down, a percentage of the full range is measured and the full range is approximated. The estimation error due to noise and nonlinearity participate in the outcome in a way that the full-scale voltage on the maximum current may exceed the maximum sensitivity drift in the datasheet. This full-range drift depends on the current scale and the scale-down factor, and it must be examined by the customer.



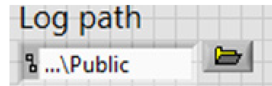
Using Unipolar Supply to Trim a Bipolar Sensor

There is an option to use a unipolar supply for bipolar calibration. This option supports some cases where a bipolar supply is not available to calibrate a sensor for bipolar sensing; to calibrate a bipolar sensor in such a case, a unipolar current supply can be used where the software uses only the positive current range (half scale).

IMPORTANT: Do not activate this option during calibration of a unipolar sensor.

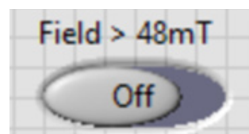
The FUSE_IT switch is used to set burn the internal fuse bits of the device. This procedure cannot be stopped.

The log files are kept in the last field, LOG_PATH.



When the software is executed (Ctrl+R), four stages are started sequentially and, if a step is stopped successfully, the LED atop of the step turns on. If all of the stages pass, TRIM_SUCCESS lightens at the end of the process. If the FUSE_IT option is enabled, the software fuses the device, and the associated LED tuns on.

If a device is already calibrated (trimmed), it is NOT possible to fuse new calibration bits again; to indicate this situation, the DEVICE_ALREADY_TRIMMED LED is turned on. However, it is also possible to ignore this and continue a full calibration round. To do so, the TRIM_ALREADY_TRIMMED button must be checked. This can have unexpected effects on the device trim.



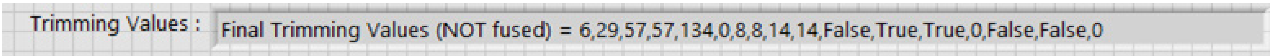
Trimming for values in excess of 48 mT necessitates a special internal programming procedure. If the maximum magnetic flux (measured or simulated) exceeds 48 mT, consider enabling this option.

Trim and Test Without Fusing

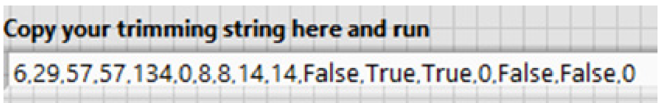
Fusing the CT45x is an irreversible action. The trimming bits become permanently burned into the sensor. However, for evaluation, a part may require calibration and testing several times without permanently fusing the values.

In another scenario, a fused device might be recalibrated to have a different offset and gain. The new offset and gain become temporarily stored in RAM and disappear after power-down. Nevertheless, this provides the capability to trim and test an old fused part several times, without the need to solder a new nonprogrammed part.

To this aim, at the end of calibration, trim values appear at the bottom of the calibration program interface:



Open the ProgramUtility.vi file from the TRIMMING_SUBVI folder. Copy the values from the main window and paste them in the PROGRAM_UTILITY text box and run it. The values become set, and the supply continues. Measurements can be performed after this step.



APPENDIX

BOM of Relay Board Relay Circuit

Part	Value	Device	Package	Description
D1	1N4148W-7-F	1N4148W-7-F	SOD3716X145N	Diode Switching 150 mA 100 V 400 mW SOD123 Diodes Inc 1N4148W-7-F Switching Diode 100 V
K1	EA2-5NU	EA2-5NU	DIPS762W70P254L1420H540Q10N	Kemet
Q2	SSM6N17FU_TE85L			
IC1	OPA192IDBVT	SOT95P280X145-5N	Precision Amplifiers High-Voltage, Rail-to-Rail Input/Output,	
R1	100 Ω	R-US_R0603	R0603	Resistor
R2	100 Ω	R-US_R0603	R0603	Resistor
R3	8.2 kΩ	R-US_R0603	R0603	Resistor
R4	4.7 kΩ	R-US_R0603	R0603	Resistor
R5	390 Ω	R-US_R0603	R0603	Resistor
R6	4.7 kΩ	R-US_R0603	R0603	Resistor
SENSOR		MA04-1	MA04-1	Pin Header
SV2		FE10-1	FE10	Female Header

Revision History

Number	Date	Description	Responsibility
3	September 10, 2024	Rebranded Crocus document including formatting and editorial changes throughout.	Cédric Simard

955 PERIMETER ROAD • MANCHESTER, NH 03103 • USA
+1-603-626-2300 • FAX: +1-603-641-5336 • ALLEGROMICRO.COM