ADP5065 Evaluation Board Manual

FEATURES
Input voltage of 4.0 V to 5.5 V
High current terminals for ADP5065 power connection (VINx), system voltage (ISO_Sx), and battery voltage (ISO_Bx) pins
ADP5065 operation is configurable via I2C interface
Evaluation software included

GENERAL DESCRIPTION
The ADP5065 charger evaluation system is composed of an evaluation board and an USB-to-IIC converter dongle. All evaluation board functions and circuits are controlled via one I2C bus connector. The I2C bus interfaces to the ADP5065 directly, and the digital input/output signals are controlled through an on-board input/output expander circuit for the I2C bus. The evaluation board also features a 3.4 V regulator for VDDIO generation. The board contains jumpers and numerous test points for easy evaluation.

Full performance details are provided in the ADP5065 data sheet, which is available at www.analog.com. The ADP5065 data sheet should be consulted in conjunction with this user guide.

ADP5065 EVALUATION BOARD

Figure 1.
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### REVISION HISTORY

8/12—Revision 0: Initial Version
SOFTWARE INSTALLATIONS
INSTALLING THE EVALUATION SOFTWARE

1. Insert the ADP5065-EVALZ setup CD into the CD-ROM and run the file Setup.exe.
2. When the dialog box shown in Figure 2 appears, click Next>> to install the files to the default destination folder or click Browse… to choose a different location.
3. Select I accept the License Agreement(s), and then click Next>> to continue.
4. A summary of the installation appears. Click Next>> to continue.
5. Wait while the software is installed.
6. Click **Finish** to complete the installation.

7. After the installation is completed, a dialog box opens prompting you to restart your computer if LabVIEW® Run-Time Engine 8.6 was not previously installed on the PC. Click **Restart** to complete the operation.

**INSTALLING THE USB DRIVER**

1. Plug the Analog Devices, Inc., USB-to-IIC converter dongle into the USB port of the computer. After the system recognizes the dongle, the dialog box **Found New Hardware Wizard** appears.

2. If there is more than one compatible driver found, select `windows\inf\usb-iic converter`, and then click **Next >** to install the driver.

3. Click **Continue Anyway**, and then click **Finish** to complete the driver installation.
USING THE SOFTWARE GUI
OPERATING THE BOARD WITH THE GUI

Before running the software,

1. Ensure that the Analog Devices USB-to-IIC converter is plugged into the USB port of the computer.
2. Connect a 5 V power supply between the VIN_F and GND screw terminals (see Figure 15).
3. Click START > All Programs > ADP5065 GUI > ADP5065 GUI 2vX.

The software is then ready to use. The input voltage (V_{Vin}) should be greater than 2.5 V for ADP5065 I^2C communication to start working. The input voltage level is monitored, and indicators relay status information in the charger status area of the box (see Section 4 in Figure 12). The GUI automatically reads the content of registers every 0.3 sec after the last action and updates the status of registers on-screen.

If there is a problem with I^2C communication, the status indicators on the bottom of the screen show an error message. When I^2C communication is fully operational, the status indicators show I2C_STATUS_OK.

Figure 12. ADP5065 Evaluation Software GUI, Opr Control & Status Tab

NOTES
1. OPERATION PARAMETER CONTROLS.
2. FUNCTIONAL ENABLES.
3. INTERRUPT REGISTER INDICATOR (REG 0x0A).
4. CHARGER STATUS.
5. BATTERY STATUS.
6. FAULT INDICATORS.
7. WATCHDOG CONTROL.
8. DIGITAL I/O CONTROLS.
9. I^2C COMMUNICATION STATUS INDICATORS.
BASIC CHARGING PARAMETER SETTINGS

After the input power supply is connected and is between 4.0 V and 5.4 V, the ADP5065 starts the charging startup. If resistance in the THR input corresponds to the battery temperature being between 0°C and 60°C when the battery detection indicates that the battery is connected at the ISO_B and BAT_SNS inputs, the ADP5065 goes into charging mode.

Charging starts with the default operational parameter settings. It is possible to change settings using controls on the left side of the Opr Control & Status tab.

SETTING INTERRUPTS

The ADP5065 includes several interrupt flags to inform the system microcontroller of a status change in the corresponding charger function. All interrupts are disabled by default, and each interrupt can be separately enabled by issuing an I²C write to Register 0x09.

The Interrupts & Timers tab (see Figure 13) in the GUI controls the register settings. Interrupt Register 0x0A is automatically read every 0.3 sec after the last user action involving the GUI. When a certain interrupt is enabled and there is a status change in the corresponding function during charging, the interrupt message is shown in the Opr Control & Status tab (see Section 3 of Figure 12).

SETTING TIMERS

The default settings of the timers are shown in Figure 13. Changing the timer settings can be done by clicking items in the Timer Settings (Write to Register 0x06) box.

NOTES
1. REGISTER 0x09 CONTROLS: INTERRUPT ENABLES.
2. REGISTER 0x06 CONTROLS: TIMER SETTINGS.

Figure 13. ADP5065 Evaluation Software GUI, Interrupts & Timers Tab
DIRECT REGISTER READ AND WRITE

It is possible to read and write the content of each register using the Register R/W tab as indicated in the GUI. Clicking READ ALL updates the content of each register to the GUI. A single register read or write can be initiated by using the controls on the right side of the Register R/W tab of the GUI. Type the I²C subaddress in the Sub Address for READ or WRITE (0x00) box, and then press the ENTER key. Click READ to read the binary data, or click WRITE to write the binary data. Type the binary data for an I²C write, and then press the ENTER key. Note that some registers, such as Register 0x00 and Register 0x01, are read only registers and cannot be overwritten.

Figure 14. ADP5065 Evaluation Software GUI, Register R/W Tab
GUI TROUBLESHOOTING

If the GUI is not responding to an I2C read or write command, the reason might be related to the USB-to-IIC converter communication failing due to one of the reasons discussed in this section.

Issue

The LDO ADP1720 (U1 in the schematic shown in Figure 18) is needed to generate the VDDIO voltage for the SCL/SDA pull-up resistors. If U1 does not have the proper supply voltage, the USB-to-IIC converter communication may fail.

Solution

Connect a voltage supply of greater than 3.4 V to TP5 to power up the VDDIO, or use Jumper J3 to connect the VIN_F or ISO_S_F voltage to U1 after ensuring that there is greater than 3.4 V voltage at either of these nodes.

Issue

The ADP5065 GUI is running, and the Analog Devices USB-to-IIC converter dongle is connected. You have disconnected the LDO U1 power and then reconnected it again. For example, if U1 is powered from VIN_F and the VVIN supply is switched off and then back on, the USB-to-IIC converter communication may fail.

Solution

To regain communication, stop the GUI by clicking STOP. Disconnect the USB-to-IIC converter dongle from your PC and then reconnect it. Start the ADP5065 GUI by clicking the Run button (represented by a right arrow icon).
EVALUATION BOARD OVERVIEW

TYPICAL OPERATION
A typical test setup for the ADP5065 charger consists of a dc power supply unit (PSU) for VVIN, a source meter unit (SMU) or a battery simulator for the ISO_Bx pin, and a variable power resistor or an electronic load for the ISO_Sx pin (see Figure 15). The SMU at the ISO_Bx node should have a 100 mΩ to 250 mΩ resistor (R_s) in series with its positive lead. The resistor emulates the equivalent series resistance of a real battery. Some SMU models that have been successfully used for the ISO_Bx node are

- Keithley 2306—battery simulator
- Keithley 2602A—SMU
- Agilent N6784A/N6762A—SMU

![Figure 15. ADP5065 WLCSP Demo Board Typical Operation Setup](image-url)
**INPUT CURRENT**

**Measuring Total Input Current (I\text{vin})**

When measuring the total input current (I\text{vin}), take into account that the evaluation board includes an LDO (U1) and an \textsuperscript{I}C input/output expander (U2A). The LDO generates a 3.4 V V\text{DDIO} voltage for the \textsuperscript{I}C bus and the SYS\_ON\_OK open-drain output, and the input/output expander controls the I\text{IN}_\text{EXT} and TRK\_EXT digital inputs.

In the default setup of the ADP5065 evaluation board, U1 and U2A are powered from the V\text{VIN} voltage through a 0 Ω resistor (R6). Typically, the additional current consumption due to U1 and U2A is in the range of 1 mA to 2 mA. For accurate measurements of the total input current (I\text{vin}), remove R6 and connect a second dc power supply (in the range of 3.4 V to 5.0 V) to Screw Terminal J6 (see Figure 16).

![Figure 16. Board Setup for Total Input Current (I\text{vin}) Measurement](image)

**VINx Pin Input Current Limit**

The VINx pin input current limit of the ADP5065 can be evaluated in charging mode. The maximum value that can be programmed for the charge current into the battery (ISO\_Bx) is 1250 mA. For measuring the VINx pin input current limit across the full programming range of 100 mA to 1500 mA, additional system load must be connected to the ISO\_Sx pin.

1. Set the V\text{VIN} supply voltage to 5.0 V.
2. Set the V\text{ISO}_\text{Bx} voltage to 3.2 V using an SMU or a battery simulator.
   a. The Battery Status box in the Opr Control & Status tab of the GUI (see Section 5 in Figure 12) should show BAT\_SNS > V\text{weak}.
   b. The ADP5065 should start charging about 110 mA of current into the battery.
3. Measure the VINx pin input current.
4. Use the GUI to change the programmed value of the input current limit and repeat the measurement.

A 1250 mA charge current into the battery might not be large enough to drive the input current up to the limit when the current limit is programmed to a value of 1000 mA or higher. Connect additional load to the ISO\_Sx node to evaluate values at the higher end of the programming range.
TRICKLE CHARGE CURRENT

Trickle charge is activated only during the battery charging startup sequence if the voltage level at the ISO_Bx pin is lower than the $V_{TRK\_DEAD}$ threshold (typically 2.5 V). The startup sequence is initiated automatically by connecting $V_{VIN}$. When $V_{VIN}$ is already at 5.0 V, you can initiate the startup sequence by issuing an I2C write to the EN_CHG bit (Bit D0, Register 0x07) to bring the EN_CHG bit low, disabling the dc-to-dc converter, and then issuing another write to bring the EN_CHG bit back to high. To measure the trickle charge current level,

1. Set the $V_{ISO\_B}$ voltage (SMU or battery simulator) to 2 V.
2. Set the $V_{VIN}$ supply voltage to 5.0 V.
3. Check that the GUI Charger Status box (see Section 4 in Figure 12) shows Trickle Charge.
4. Check that the GUI Battery Status box (see Section 5 in Figure 12) shows BAT_SNS < $V_{trk}$.
5. Step $V_{ISO\_B}$ up to 52.5 mA. You can change the setting in the GUI Trickle Charge Current box from 5 mA to 20 mA.
6. Measure the trickle charge current into the battery. The default value for $I_{TRK\_DEAD}$ is 20 mA. You can change the setting in the GUI Trickle Charge Current box from 5 mA to 20 mA.
7. Check whether a battery short was detected by waiting for the 30 sec timeout to expire and then checking that the $I_{Bat\_shr}$ indicator is illuminated in the GUI Fault Register 0x0D box (see Section 6 in Figure 12). You can change the setting in the Battery Short Time-Out drop-down box (see Section 1 in Figure 12) to a value between 1 sec and 180 sec.
8. Measure the trickle charge current into the battery. The default value for $I_{TRK\_DEAD}$ is 20 mA. You can change the setting in the GUI Trickle Charge Current box from 5 mA to 20 mA.
9. Set the $I_{Bat\_shr}$ voltage to 5.0 V.
10. Set the $V_{ISO\_B}$ voltage to 3.6 V.
11. Check that the GUI Battery Status box (see Section 5 in Figure 12) shows BAT_SNS > $V_{weak}$.
12. Set the VINx pin input current limit to its maximum value, 1500 mA.
13. Measure the charge current into the battery. The default value for the fast charge current is 1250 mA. You can change the setting in the GUI Fast Charge Current box to a value between 550 mA to 1250 mA.
14. Note that the fast charge current might be reduced due to one of the following conditions:
   a. The $V_{BAT\_SNS}$ level is close to the termination voltage, $V_{TRM}$ (default 4.20 V).
   b. The die temperature, $T_{D}$, exceeds the isothermal charging temperature, $T_{ISOM}$ (typically 115°C).
   c. The available current from the dc-to-dc converter output of the ADP5065 is limited by the maximum duty cycle (for example, when the $I_{CHG}$ setting is 1250 mA and $V_{ISO\_B} > 3.7$ V).

FAST CHARGE CURRENT

To measure the fast charge current level,

1. Set the $V_{VIN}$ supply voltage to 5.0 V.
2. Set the $V_{ISO\_B}$ voltage to 3.6 V.
3. Check that the GUI Battery Status box (see Section 5 in Figure 12) shows BAT_SNS > $V_{weak}$.
4. Set the VINx pin input current limit to its maximum value, 1500 mA.
5. Measure the charge current into the battery. The default value for the fast charge current is 1250 mA. You can change the setting in the GUI Fast Charge Current box to a value between 550 mA to 1250 mA.
6. Note that the fast charge current might be reduced due to one of the following conditions:
   a. The $V_{BAT\_SNS}$ level is close to the termination voltage, $V_{TRM}$ (default 4.20 V).
   b. The die temperature, $T_{D}$, exceeds the isothermal charging temperature, $T_{ISOM}$ (typically 115°C).
   c. The available current from the dc-to-dc converter output of the ADP5065 is limited by the maximum duty cycle (for example, when the $I_{CHG}$ setting is 1250 mA and $V_{ISO\_B} > 3.7$ V).

TERMINATION VOLTAGE AND END-OF-CHARGE CURRENT

Measuring Termination Voltage Using an SMU or Battery Simulator

The ADP5065 fast charge constant voltage (CV) regulation has been optimized for batteries that have series resistance in the range of 100 mΩ to 250 mΩ. When using an SMU or a battery simulator connected to ISO_Bx, the series resistance ($R_{S}$ in Figure 15) should be within this range.

Some battery simulators, such as Keithley 2306, have programmable source resistance integrated in the instrument itself. For SMU units, an external resistor should be used to obtain accurate measurement results of the termination voltage.

To measure the termination current,

1. Set the $V_{VIN}$ supply voltage to 5.0 V.
2. Set the termination voltage to 4.2 V using the GUI.
3. Disable the end of charge by setting the EN_EOC bit to low in the Functional Settings1 register (Address 0x07).
4. Measure the charge current into the battery. The default value for $I_{CHG}$ is 1250 mA. You can change the setting in the GUI Charge Complete box (see Section 4 in Figure 12) to a value between 1 sec and 180 sec.
5. Disable the charge complete timer bit (EN_TEND) in Register 0x06 using the GUI (see Figure 13).
6. Sweep $V_{ISO\_B}$ up to 52.5 mA and $V_{ISO\_B} > 3.7$ V.
7. Measure the charge current into the battery. The default value for $I_{CHG}$ is 1250 mA. You can change the setting in the GUI Charge Complete box (see Section 4 in Figure 12) to a value between 1 sec and 180 sec.
8. Set the $V_{ISO\_B}$ voltage to 5.0 V.
9. Set the $V_{VIN}$ supply voltage to 5.0 V.
10. Set the $V_{ISO\_B}$ voltage to 3.6 V.
11. Check that the GUI Battery Status box (see Section 5 in Figure 12) shows BAT_SNS > $V_{weak}$.
12. Set the VINx pin input current limit to its maximum value, 1500 mA.
13. Measure the charge current into the battery. The default value for the fast charge current is 1250 mA. You can change the setting in the GUI Fast Charge Current box to a value between 550 mA to 1250 mA.
14. Note that the fast charge current might be reduced due to one of the following conditions:
   a. The $V_{BAT\_SNS}$ level is close to the termination voltage, $V_{TRM}$ (default 4.20 V).
   b. The die temperature, $T_{D}$, exceeds the isothermal charging temperature, $T_{ISOM}$ (typically 115°C).
   c. The available current from the dc-to-dc converter output of the ADP5065 is limited by the maximum duty cycle (for example, when the $I_{CHG}$ setting is 1250 mA and $V_{ISO\_B} > 3.7$ V).

Measuring the End-of-Charge Current

To measure the end-of-change current,

1. Set the Termination Current (see Section 1 of Figure 12) to 52.5 mA.
2. Step $V_{ISO\_B}$ down to 100 mV.
3. Enable the end of charge by setting the EN_EOC bit to high in the Functional Settings1 register (Address 0x07).
4. Step $V_{ISO\_B}$ up and monitor the charge current for each step until the GUI Charger Status box (see Section 4 in Figure 12) shows Charge Complete. The last charge current value before Charge Complete is displayed is the charge complete current threshold. Charging is stopped, and there is no current flowing into the ISO_Bx node.

Measuring Recharge Voltage

To measure the recharge voltage,

1. Step $V_{ISO\_B}$ down and monitor the voltage until the GUI Charger Status box (see Section 4 in Figure 12) shows Fast Charge (CC-Mode) and charge current flows to the ISO_Bx node. The last value before the Charger Status changes is the recharge voltage level. With the default settings, the recharge voltage threshold is 3.94 V ($V_{ISO\_B}$).
2. It is possible to use the GUI to change the termination current and the recharge voltage. Repeat the steps in the
Measuring the End-of-Charge Current section and the Measuring Recharge Voltage section to evaluate various settings.

**THR INPUT AND JEITA SETTINGS**

The THR input of the ADP5065 evaluation board is equipped with two 10 kΩ resistors (R10 and R13) and Jumper J4. When using the actual Li-Ion battery NTC thermistor terminal, the board should be configured as shown in Figure 17.

1. Remove Resistor R10.
2. Connect the Li-Ion battery NTC thermistor terminal to THR, Test Point TP18.

![Figure 17. THR Input Evaluation Setup](image)

**Evaluating THR Input Using the Typical Board Setup**

To evaluate the THR input using the typical board setup,

1. Set the V_{VIN} supply voltage to 5.0 V.
2. Set the V_{ISO_B} voltage to 3.6 V
3. Set the GUI Fast Charge Current to 550 mA (see Section 1 in Figure 12).
4. Set the VIN Input Current Limit to 1500 mA.
5. Measure the current to ISO_Bx; the value should be 550 mA.
6. Remove Jumper J4 from board.
7. The GUI THR-pin status box (see Section 5 in Figure 12) should show BatCool.
8. Enable JEITA by setting the EN_JEITA bit (Bit 7 of Register 0x07) high.
9. Measure the current to ISO_Bx. The charging current should now be half of the fast charge current setting.
10. Reinstall Jumper J4 on the board.
11. The charge current should return to the full charge current setting value.
12. The GUI THR-pin status box (see Section 5 in Figure 12) should show Thermistor OK.

**Evaluating THR Input Using a Trimmer Resistor**

Evaluating the resistance thresholds according to JEITA Li-Ion battery temperature levels is possible with a trimmer resistor of, for example, 50 kΩ. To evaluate the THR input using a trimmer resistor,

1. Use the setup shown in Figure 17, but connect the trimmer resistor between the THR input and GND instead of connecting it to the battery thermistor.
2. Set the V_{VIN} supply voltage to 5.0 V.
3. Set the V_{ISO_B} voltage to 3.6 V
4. Set the GUI Fast Charge Current to 550 mA (see Section 1 in Figure 12).
5. Set the VIN Input Current Limit to 1500 mA.
6. Enable JEITA by setting the EN_JEITA bit (Bit 7 of Register 0x07) high.
7. Change the trimmer resistor setting to evaluate the JEITA thresholds. The THR input resistance thresholds are specified in the ADP5065 data sheet.
8. The GUI THR-pin status box (see Section 5 in Figure 12) should show BatCold, BatCool, Thermistor OK, BatWarm, or BatHot when adjusting the trimmer resistance to a value between 0 O and 50 kΩ.
PCB LAYOUT

Figure 19. ADP5065 Evaluation Board Top Layer

Figure 20. ADP5065 Evaluation Board Layer 2

Figure 21. ADP5065 Evaluation Board Layer 3

Figure 22. ADP5065 Evaluation Board Bottom Layer (View from the Top)
# BILL OF MATERIALS

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<th>Description</th>
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## RELATED LINKS

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<td>ADP5065</td>
<td>Product Page: Fast Charge Battery Management with Power Path and USB Compatibility</td>
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<tr>
<td>ADP1720</td>
<td>Product Page: 50 mA, High Voltage, Micropower Linear Regulator</td>
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NOTES

ESD Caution
ESD (electrostatic discharge) sensitive device. Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

Legal Terms and Conditions
By using the evaluation board discussed herein (together with any tools, components documentation or support materials, the “Evaluation Board”), you are agreeing to be bound by the terms and conditions set forth below (“Agreement”) unless you have purchased the Evaluation Board, in which case the Analog Devices Standard Terms and Conditions of Sale shall govern. Do not use the Evaluation Board until you have read and agreed to the Agreement. Your use of the Evaluation Board shall signify your acceptance of the Agreement. This Agreement is made by and between you (“Customer”) and Analog Devices, Inc. (“ADI”), with its principal place of business at One Technology Way, Norwood, MA 02062, USA. Subject to the terms and conditions of the Agreement, ADI hereby grants to Customer a free, limited, personal, temporary, non-exclusive, non-sublicensable, non-transferable license to use the Evaluation Board FOR EVALUATION PURPOSES ONLY. Customer understands and agrees that the Evaluation Board is provided for the sole and exclusive purpose referenced above, and agrees not to use the Evaluation Board for any other purpose. Furthermore, the license granted is expressly made subject to the following additional limitations: Customer shall not (i) rent, lease, display, sell, transfer, assign, sublicense, or distribute the Evaluation Board; and (ii) permit any Third Party to access the Evaluation Board. As used herein, the term “Third Party” includes any entity other than ADI, Customer, their employees, affiliates and in-house consultants. The Evaluation Board is NOT sold to Customer; all rights not expressly granted herein, including ownership of the Evaluation Board, are reserved by ADI. CONFIDENTIALITY. This Agreement and the Evaluation Board shall all be considered the confidential and proprietary information of ADI. Customer may not disclose or transfer any portion of the Evaluation Board to any other party for any reason. Upon discontinuation of use of the Evaluation Board or termination of this Agreement, Customer agrees to promptly return the Evaluation Board to ADI. ADDITIONAL RESTRICTIONS. Customer shall inform ADI of any occurred damages or any modifications or alterations it makes to the Evaluation Board, including but not limited to soldering or any other activity that affects the material content of the Evaluation Board. Modifications to the Evaluation Board must comply with applicable law, including but not limited to the RoHS Directive. TERMINATION. ADI may terminate this Agreement at any time upon giving written notice to Customer. Customer agrees to return to ADI the Evaluation Board at that time. LIMITATION OF LIABILITY. THE EVALUATION BOARD PROVIDED HEREUNDER IS PROVIDED "AS IS" AND ADI MAKES NO WARRANTIES OR REPRESENTATIONS OF ANY KIND WITH RESPECT TO IT. ADI SPECIFICALLY DISCLAIMS ANY REPRESENTATIONS, ENDORSEMENTS, WARRANTIES, OR WARRANTIES, EXPRESS OR IMPLIED, RELATED TO THE EVALUATION BOARD INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTY OF MERCHANTABILITY, TITLE, FITNESS FOR A PARTICULAR PURPOSE OR NONINFRINGEMENT OF INTELLECTUAL PROPERTY RIGHTS. IN NO EVENT WILL ADI AND ITS LICENSORS BE LIABLE FOR ANY INCIDENTAL, SPECIAL, INDIRECT, OR CONSEQUENTIAL DAMAGES RESULTING FROM CUSTOMER’S POSSESSION OR USE OF THE EVALUATION BOARD, INCLUDING BUT NOT LIMITED TO LOST PROFITS, DELAY COSTS, LABOR COSTS OR LOSS OF GOODWILL. ADI’S TOTAL LIABILITY FROM ANY AND ALL CAUSES SHALL BE LIMITED TO THE AMOUNT OF ONE HUNDRED US DOLLARS ($100.00). EXPORT. Customer agrees that it will not directly or indirectly export the Evaluation Board to another country, and that it will comply with all applicable United States federal laws and regulations relating to exports. GOVERNING LAW. This Agreement shall be governed by and construed in accordance with the substantive laws of the Commonwealth of Massachusetts (excluding conflict of law rules). Any legal action regarding this Agreement will be heard in the state or federal courts having jurisdiction in Suffolk County, Massachusetts, and Customer hereby submits to the personal jurisdiction and venue of such courts. The United Nations Convention on Contracts for the International Sale of Goods shall not apply to this Agreement and is expressly disclaimed.

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