AN-1571
APPLICATION NOTE

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*m*Sure® Autocalibration with the ADE9153A

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INTRODUCTION

The *m*Sure® autocalibration feature of the ADE9153A can be widely applied to nonutility applications that include energy measurements applications, such as intelligent lighting, data centers, electric vehicle charging, and machine health monitoring systems.

This application note provides an overview of the use of the *m*Sure autocalibration feature of the ADE9153A to calibrate the system.

Figure 1 shows an overview of the flow that calibrates the energy measurement systems using the ADE9153A *m*Sure autocalibration feature.

The calibration process has two phases: the architecting phase, which helps select component values for the design and register settings for the ADE9153A, and the production flow phase, which is performed on every device manufactured using ADE9153A.

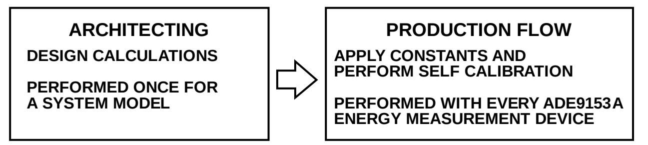

Figure 1. mSure Calibration Overview

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REVISION HISTORY

2/2019—Revision 0: Initial Version

ARCHITECTING THE MONITORING DEVICE

This section describes the selection of the component values for the design and register settings of the ADE9153A.

HARDWARE DESIGN CHOICES

Shunt Channel Sensor Selection

Shunt current sensors are connected to Current Channel A of the ADE9153A. It is recommended to use a gain of 16× on Current Channel A to obtain optimal performance. However, this gain value is not valid in all cases, and the maximum expected measured current and shunt size must taken into account when selecting the gain value.

Headroom is required between the maximum current to be measured, I_{MAX}, and the full-scale analog input range of the analog-to-digital converter (ADC) to allow room for overcurrent.

Convert the input rms current value to peak when selecting the shunt value with the following equation:

$$R_{SHUNT} = \frac{\dfrac{\pm 1\text{ V}}{AI\_PGAGAIN}}{AI_{HEADROOM} \times I_{MAX} \times \sqrt{2}} \quad (1)$$

where:
R_{SHUNT} is the calculated shunt resistance in ohms.
AI_PGAGAIN is the value of the programmable gain amplifier (PGA) of Current Channel A.
$AI_{HEADROOM}$ is the headroom of Current Channel A from maximum full scale.

For example, if the application requires an I_{MAX} measurement of 10 A rms, then

$$R_{SHUNT} = \frac{\dfrac{\pm 1\text{ V}}{16}}{4 \times 10\text{ A} \times \sqrt{2}}$$

Therefore,

R_{SHUNT} = 1.10485 MΩ

Round the calculated R_{SHUNT} value to meet the nearest standard shunt resistance value, for example, 1 MΩ.

Figure 2 shows an example of the shunt channel configuration.

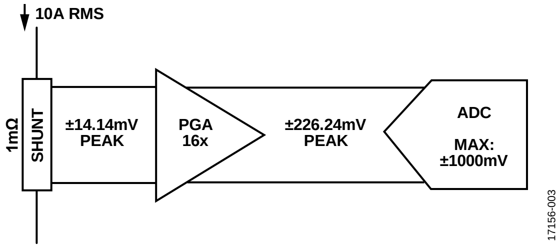

Figure 2. Shunt Channel Configuration Example

There is a tradeoff for the AI_PGAGAIN and R_{SHUNT} values: a smaller gain and/or larger shunt increases *m*Sure performance and larger gain and/or smaller shunt decreases power dissipation. The value of the R_{SHUNT} is calculated to the nearest standard value, which means that the exact $AI_{HEADROOM}$ can be calculated using Equation 1 and the following equations (use the calculated $AI_{HEADROOM}$ value for all future calculations):

$$AI_{HEADROOM} = \frac{\dfrac{\pm 1\text{ V}}{16}}{0.001 \times 10\text{ A} \times \sqrt{2}}$$

Therefore,

$AI_{HEADROOM}$ = 4.41942

CT Channel Sensor Configuration

The ADE9153A includes a second current measurement channel meant for use with a current transformer (CT). This channel only yields an rms measurement and *m*Sure autocalibration performance is reduced for this CT rms only channel. See the ADE9153A data sheet for details. If the second current channel is not needed, skip this step in the setup process.

Due to the common mode ADC requirements of ADE9153A, it is not recommended to use a center tap CT. The CT sensors are connected to the Current Channel B.

The input of Current Channel B has a full-scale range of ±1 V peak. Because the ADC is measuring the peak current value, convert the rms value to peak when selecting the shunt value.

Calculate the size of the burden resistor (R_{BURDEN}) with the following equation:

$$R_{BURDEN} = \frac{\dfrac{\pm 1\text{ V}}{BI\_PGAGAIN}}{BI_{HEADROOM} \times \dfrac{I_{MAX}}{CT_{RATIO}} \times \sqrt{2}}$$

where:
BI_PGAGAIN is the value of the PGA of Current Channel B. It is recommended to set this value to 1 to optimize signal-to-noise ratio (SNR).
$BI_{HEADROOM}$ is the Current Channel B headroom from maximum full scale. The value of the $IB_{HEADROOM}$ for Current Channel B is recommended to be the same as the value in Current Channel A.
CT_{RATIO} is the transformation ratio of the current transformer.

See the ADE9153A data sheet for the CT_{RATIO}, typically 1500:1 to 3000:1.

$$R_{BURDEN} = \frac{\dfrac{\pm 1\text{ V}}{1}}{4 \times \dfrac{10\text{ A}}{2500} \times \sqrt{2}}$$

Therefore,

R_{BURDEN} = 44.19417 Ω

Round the calculated R_{BURDEN} value to meet the nearest standard resistance value, for example, 43 Ω. See the ADE9153A data sheet to ensure that the calculated value of the R_{BURDEN} resistor is within the recommended range.

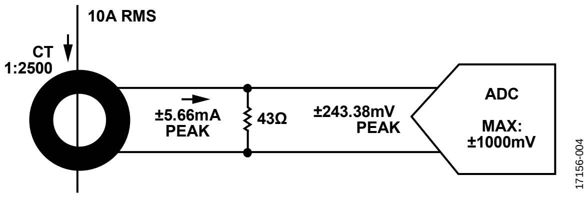

Figure 3. Example CT Channel Configuration

The value of the burden resistor is estimated to a standard the value. The exact $BI_{HEADROOM}$ value can be calculated using the following equation:

$$BI_{HEADROOM} = \frac{\frac{\pm 1\ V}{BI\_PGAGAIN}}{R_{BURDEN} \times \frac{I_{MAX}}{CT_{RATIO}} \times \sqrt{2}}$$

$$BI_{HEADROOM} = \frac{\frac{\pm 1\ V}{1}}{43\ \Omega \times \frac{10}{2500} \times \sqrt{2}}$$

Therefore,

$BI_{HEADROOM} = 4.11109$

Voltage Channel Configuration

On the voltage channel, the potential divider resistors must be selected to control the voltage across the VAP and VAN pins.

The restrictions for potential divider selection are as follows:

- The total potential divider impedance cannot be <1 MΩ for a system operating at a nominal voltage of 240 V and maximum voltage of 500 V.
- The recommended small resistor value for optimal performance is 1 kΩ.

If a line voltage >240 V is being measured, proportionally increase the size of the large resistor (R_{BIG}) to 1 MΩ. It is recommended to scale the nominal input voltage (V_{NOM}) to half of the analog full-scale voltage, such that the voltage channel headroom ($V_{HEADROOM}$) = 2.

It is recommended to modify the value of the large resistor and keep the small resistor (R_{SMALL}) value at 1 kΩ.

To calculate for the larger resistor divider, use the following equation:

$$R_{BIG} = \left(\frac{V_{NOM} \times V_{HEADROOM} \times \sqrt{2}}{\pm 0.5\ V} - 1 \right) \times R_{SMALL}$$

For a V_{NOM} voltage of 240 V, the value of the R_{BIG} resistor can be calculated with the following equation:

$$R_{BIG} = \left(\frac{240\ V \times 2 \times \sqrt{2}}{\pm 0.5\ V} - 1 \right) \times 1000$$

Therefore,

$R_{BIG} = 1.36\ M\Omega$

It is recommended for the value of the R_{BIG} resistor to be 1 MΩ because the system operates at 240 V. Figure 4 shows an example of this voltage channel configuration.

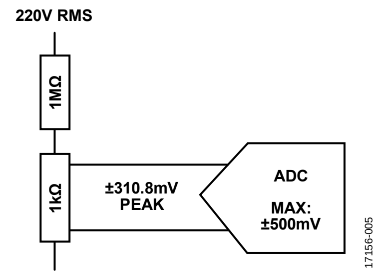

Figure 4. Voltage Channel Configuration Example

To calculate the exact $V_{HEADROOM}$ value, use the following equation:

$$V_{HEADROOM} = \left(\frac{R_{BIG}}{R_{SMALL}} + 1 \right) \times \frac{\pm 0.5\ V}{V_{NOM} \times \sqrt{2}}$$

$$V_{HEADROOM} = \left(\frac{1\ M\Omega}{1\ k\Omega} + 1 \right) \times \frac{\pm 0.5\ V}{240\ V \times \sqrt{2}}$$

Therefore,

$V_{HEADROOM} = 1.47461$

ADE9153A REGISTER CONFIGURATION

ADC Programmable Gain Amplifier Registers

Configure the AI_PGAGAIN and BI_PGAGAIN registers to match the gain of each channel selected in the Hardware Design Choices section. The gain of the voltage channel is always equal to 1.

VDIV_RSMALL Register

Configure the VDIV_RSMALL register to indicate the resistance value of the R_{SMALL} resistor of the voltage channel, expressed in ohms (see the Voltage Channel Configuration). For example, write 0d1000 to VDIV_RSMALL register for the recommended 1 kΩ resistor.

Line Frequency Selection

Set the SELFREQ bit (Bit 4) in the ACCMODE register (Address 0x492) per the line frequency that the device is connected to. Set the SELFREQ bit field to 0 for a 50 Hz system and 1 for a 60 Hz system.

Setting Up Reactive Power Measurement

The setup of the VLEVEL register (Address 0x40F) is based on the nominal value of the voltage channel, which can be calculated with the following equation:

$VLEVEL = V_{HR\_ROUNDOFF} \times 1{,}144{,}084$

where:
VLEVEL is the value of the VLEVEL register.
$V_{HR\_ROUNDOFF}$ is the margin of the dynamic range of the nominal input signal, $V_{HEADROOM}$, with respect to full scale, rounded up to the nearest whole number.

For this example, as described in the Voltage Channel Configuration section, the value of $V_{HEADROOM}$ is 1.47. Round this value up to the nearest whole number. In this example the $V_{HR\_ROUNDOFF}$ value is 2. Therefore, set the VLEVEL register to 2,288,168 decimal by writing 0x22EA28.

Configuring the Energy Pulse Output

The ADE9153A IC is targeted at nonutility applications, such as intelligent lighting, data centers, electric vehicle charging, and machine health monitoring systems. These applications do not typically require a pulse output that is proportional to the energy used. In utility applications, this pulse output is referred to as the calibration frequency output. If this pulse output is required, refer to EngineerZone for more information.

CONVERSION CONSTANTS

The ADE9153A energy measurement device has a set of conversion constant values unique to the individual system that translate register values to real values of current, voltage, power, and energy, such as volts, amperes, and watts. For example, the AIRMS register has an associated current conversion constant value expressed in nA/Code, which is translated to a real current value.

Two types of conversion constants are used in this application note: the target conversion constant, which is identical for all devices for a particular design, and the *m*Sure conversion constant, which varies from device to device.

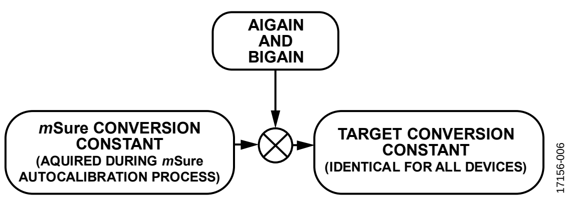

Figure 5. Relationship Between Target Conversion Constant and m*Sure Conversion Constants*

m*Sure Conversion Constant*

The *m*Sure conversion constants are obtained during the *m*Sure autocalibration process. The *m*Sure conversion constants include MS_ACAL_AICC, MS_ACAL_BICC, and MS_ACAL_AVCC, which are unique to each ADE9153A energy measurement device.

AIGAIN and BIGAIN Registers

The AIGAIN and BIGAIN register values for each channel are calculated based on the *m*Sure conversion constant and target value for each channel to calibrate each device so that all devices arrive at the target conversion constant. Therefore, the xIGAIN register setting is also unique for each ADE9153A device.

Target Conversion Constants

Current Channel A (Shunt Channel)

The target conversion constant for Current Channel A is TARGET_AICC. To calculate the value for TARGET_AICC, use the following equation:

$$TARGET\_AICC = \frac{I_{MAX} \times AI_{HEADROOM}}{52{,}725{,}703} \quad (2)$$

Therefore,

$$TARGET\_AICC = \frac{10\text{ A} \times 4.41942}{52{,}725{,}703} = 838.19082\text{ nA/Code}$$

Current Channel B (CT Channel, Optional)

The conversion constant for Current Channel B is TARGET_BICC. To calculate the value for the TARGET_BICC conversion constant, use the following equation:

$$TARGET\_BICC = \frac{I_{MAX} \times BI_{HEADROOM}}{52{,}725{,}703}$$

Voltage Channel

The target conversion constant for the voltage channel is TARGET_AVCC. To calculate the value for TARGET_AVCC conversion constant, use the following equation:

$$TARGET\_AVCC = \frac{V_{NOM} \times V_{HEADROOM}}{26{,}362{,}852} \quad (3)$$

Therefore,

$$TARGET\_AVCC = \frac{240\text{ V} \times 1.47461}{26{,}362{,}852} = 13{,}424.43526\text{ nV/code}$$

The calculated values for the TARGET_AICC, TARGET_BICC, and TARGET_AVCC conversion constants can be rounded up to the nearest whole number or modified slightly to meet the requirements of the energy measurement design.

For example, the calculated value for the TARGET_AICC conversion constant (838.19082 nA/Code) can be rounded to 838 nA/Code. The value in the AIGAIN register is calculated based on the value of the MS_ACAL_AICC register and TARGET_AICC.

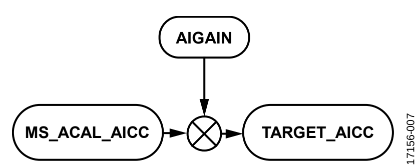

Figure 6. m*Sure Conversion Constant and Target Conversion Constant in Current Channel A*

Power Conversion Constants

When the TARGET_AICC and TARGET_AVCC values are found, these values can be used to find the target conversion constants for active power (TARGET_WCC), reactive power (TARGET_VARCC), and apparent power (TARGET_VACC) with the equation below, where the APGAIN register is used to modify the value of TARGET_WCC.

$$TARGET\_WCC = TARGET\_AICC \times TARGET\_AVCC \times \left(1 + \frac{APGAIN}{2^{27}}\right) \quad (4)$$

The values of the TARGET_AICC and TARGET_AVCC are taken from Equation 2 and Equation 3, respectively. The value of the APGAIN register can be used to modify the target conversion constant of the powers (active, reactive, and apparent).

In Equation 4, the APGAIN is 0, with no gain applied.

Therefore,

TARGET_WCC = 1510.24987 µW/Code

TARGET_VARCC = 1510.24987 µW/Code

TARGET_VACC = 1510.24987 µW/Code

From there the constants for the AWATTHR_HI, AFVARHR_HI, and AVAHR_HI registers can be calculated based on the value of the TARGET_WCC to get the target conversion constant of the active power value (TARGET_WHCC).

$$TARGET\_WHCC = \frac{TARGET\_WCC \times 2^{13}}{3600 \times 4000}$$

$$TARGET\_WHCC = \frac{1510.24987\ \mu W/Code \times 2^{13}}{14,400,000}$$

Therefore,

TARGET_WHCC = 859.16437 nWh/Code
TARGET_VARHCC = 859.16437 nVARh /Code
TARGET_VAHCC = 859.16437 nVAh/Code

PRODUCTION FLOW

When the prototype is validated, the *m*Sure autocalibration can be performed.

The calibration technique used in this application note calibrates all devices to the same conversion constant, TARGET_xxCC, which means that all the devices read the same xIRMS, xVRMS, and power values when presented with the same load.

To achieve the same conversion constant for each device, each device has a unique value for the AIGAIN, AVGAIN, and BIGAIN registers. The Step 1—Configure the ADE9153A Registers section uses normal power mode for autocalibration. Please consult the ADE9153A data sheet for details on turbo mode configuration.

STEP 1—CONFIGURE THE ADE9153A REGISTERS

All registers described in Table 1 are common to each ADE9153A device. These register values can be configured in a header file or loaded from EEPROM. For more information and for details on the values to be written to the registers described in Table 1, see the ADE9153A data sheet and the ADE9153A Technical Reference Manual.

The following values are common to all ADE9153A devices and must be stored in the EEPROM or Header file. See the Target Conversion Constants section for the values of these conversion constants:

- TARGET_AICC
- TARGET_AVCC
- TARGET_BICC
- TARGET_WCC, TARGET_VARCC, and TARGET_VACC
- TARGET_WHCC, TARGET_VARHCC, and TARGET_VAHCC

Table 1. ADE9153A Registers to Configure

Register Name	Register Address
WTHR	0x420
VARTHR	0x421
VATHR	0x422
CFMODE	0x490
CF1DEN	0x494
CF2DEN	0x495
ACCMODE	0x492
VLEVEL	0x40F
COMPMODE	0x491
AI_PGAGAIN	0x4B9
BI_PGAGAIN	0x023
Run	0x480
EP_CFG	0x4B0
VDIV_RSMALL	0x04C
CT_PHASE_DELAY	0x049
CT_CORNER	0x04A
APHASECAL	0x001

STEP 2—RUNNING *m*Sure AUTOCALIBRATION ON CURRENT CHANNEL A

To initiate *m*Sure autocalibration on Current Channel A, write 0x0000013 to the MS_ACAL_CFG register, Address 0x030.

Note that the metrology outputs are disabled when running the *m*Sure autocalibration.

Two registers indicate the results of the *m*Sure autocalibration, as described in Table 2.

Table 2. *m*Sure Calibration Results for Current Channel A

Register Name	Register Address	Format	Unit
MS_ACAL_AICC	0x220	21.11	nA/Code
MS_ACAL_AICERT	0x221	INT	ppm

MS_ACAL_AICC is the conversion constant of the Current Channel A as measured by the *m*Sure calibration. The MS_ACAL_AICERT register indicates the certainty of the estimation of the conversion constant value provided by the MS_ACAL_AICC register. This result is given in PPM. For example, if the MS_ACAL_AICERT register reads 3000 Codes, the *m*Sure engine is certain of the estimate to better than 0.3%.

The user controls the length of the *m*Sure autocalibration period. The user can either run the *m*Sure autocalibration for a fixed period, or run the *m*Sure autocalibration and check the value of the MS_ACAL_AICERT register every second until the certainty of the conversion constant value is within an acceptable range, and then stop the *m*Sure autocalibration.

Note that the MS_ACAL_AICC and MS_ACAL_AICERT registers do not update for the first 8 sec after an *m*Sure autocalibration begins, and prior to the 8 sec, these registers retain the value of the previous *m*Sure autocalibration. If the system, including the ADE9153A, is configured to run an *m*Sure autocalibration until the MS_ACAL_AICERT register is better than a specific certainty (CERT) level, it is important to only start the comparison of the values in each register after 8 sec have elapsed or risk checking the CERT value from the previous autocalibration and prematurely stopping the current the *m*Sure autocalibration process.

To stop the *m*Sure autocalibration, write 0x0000001to the MS_ACAL_CFG register, Address 0x030.

At this point in the calibration process, the value of the MS_ACAL_AICC is the estimate of the channel conversion constant or transfer function for Current Channel A.

STEP 3—CALCULATE THE AIGAIN REGISTER AND COMPLETE AUTOCALIBRATION OF CURRENT CHANNEL A

To calibrate the Current Channel A readings to match the TARGET_AICC conversion constant, the user must calculate the value to be written to the AIGAIN register.

To calculate the value to write to the AIGAIN register (AIGAIN_REGISTER_VALUE), use the following equation:

$$AIGAIN\_REGISTER\_VALUE = \left(\frac{MS\_ACAL\_AICC}{TARGET\_AICC} - 1\right) \times 2^{27}$$

To complete the autocalibration of Current Channel A, write this value to the AIGAIN register, Address 0x000, and store the value in the EEPROM (or another nonvolatile memory) as the unique calibration value for this particular device for Current Channel A.

STEP 4—RUNNING *m*Sure AUTOCALIBRATION ON CURRENT CHANNEL B (OPTIONAL)

Skip this step and the step described in the Step 5—Calculate the BIGAIN Register and Complete Autocalibration of Current Channel B (Optional) section if Current Channel B is not used.

To run the *m*Sure autocalibration on Current Channel B, follow the steps described in the Step 2—Running *mSure* Autocalibration on Current Channel A and Step 3—Calculate the AIGAIN Register and Complete Autocalibration of Current Channel A sections. For Current Channel B, substitute the MS_ACAL_BICC and MS_ACAL_BICERT registers for the MS_ACAL_AICC and MS_ACAL_AICERT registers.

To initiate *m*Sure autocalibration on Current Channel B, write 0x0000023 to the MS_ACAL_CFG register, Address 0x030.

The MS_ACAL_BICC and MS_ACAL_BICERT registers indicate the results of the *m*Sure autocalibration, as described in Table 3.

Table 3. *m*Sure Calibration Results for Current Channel B

Register Name	Register Address	Format	Unit
MS_ACAL_BICC	0x222	21.11	nA/Code
MS_ACAL_BICERT	0x227	INT32	ppm

To stop the *m*Sure autocalibration on Current Channel B, write 0x0000001 to the MS_ACAL_CFG register, Address 0x030.

STEP 5—CALCULATE THE BIGAIN REGISTER AND COMPLETE AUTOCALIBRATION OF CURRENT CHANNEL B (OPTIONAL)

Read the MS_ACAL_BICC register result for Current Channel B.

Calculate the BIGAIN register value (BIGAIN_REGISTER_VALUE) as shown in the following equation:

$$BIGAIN\_REGISTER\_VALUE = \left(\frac{MS\_ACAL\_BICC}{TARGET\_BICC} - 1\right) \times 2^{27}$$

To complete the autocalibration of Current Channel B, write this value to the BIGAIN register, Address 0x010.

STEP 6—RUNNING *m*Sure AUTOCALIBRATION ON THE VOLTAGE CHANNEL

To run the *m*Sure autocalibration on the voltage channel, write 0x0000043 to the MS_ACAL_CFG register, Address 0x030.

The result associated with the voltage channel can be found in the registers described in Table 4.

Table 4. *m*Sure Calibration Results for the Voltage Channel

Register Name	Register Address	Format	Unit
MS_ACAL_AVCC	0x224	21.11	nV/Code
MS_ACAL_AVCERT	0x225	INT	ppm

To stop the mSure autocalibration on the voltage channel, write 0x0000001 to the MS_ACAL_CFG register, Address 0x030.

STEP 7—CALCULATE THE AVGAIN REGISTER AND COMPLETE AUTOCALIBRATION OF THE VOLTAGE CHANNEL

Read the *m*Sure result from the MS_ACAL_AVCC register. To calculate the value to write to the AVGAIN register (AVGAIN_REGISTER_VALUE), use the following equation:

$$AVGAIN\_REGISTER\_VALUE = \left(\frac{MS\_ACAL\_AVCC}{TARGET\_AVCC} - 1\right) \times 2^{27}$$

Write this value to the AVGAIN register, Address 0x002.

NORMAL OPERATION IN THE FIELD

This section describes the normal configurations during a power-up of the system and translating the real values out of the register values in codes.

DEFAULT CONFIGURATION AT POWER-UP

During power-up, important registers must be configured or initialized first before the system with ADE9153A operates. The register configurations are common to each ADE9153A energy measurement device, including the thresholds, modes, and architecture requirements discussed in this application note. There are also some register configuration that must be unique to a single ADE9153A energy measurement device, such as the xxGAIN registers and the MS_xxCC_USER registers. Table 5 provides a summary of these registers including their addresses. Refer to the ADE9153A datasheet for more information

TRANSLATING ADE9153A REGISTER READINGS TO PHYSICAL VALUES

The target conversion constants (TARGET_xxCC) values stored in the ADE9153A energy measurement device can be used to translate the rms or power register values in codes to physical values such as volts, amperes, or kilowatts.

For example,

$$AIRMS \times TARGET\_AICC = Real\ Current$$

where:
AIRMS is the stored value in the AIRMS register.
Real Current is the physical current value, expressed in amps.

Table 5. ADE9153A Default Configuration During Power-Up

Register Name	Register Address	Type of Information
WTHR	0x420	Common to all ADE9153A energy measurement device.
VARTHR	0x421	Common to all ADE9153A energy measurement device.
VATHR	0x422	Common to all ADE9153A energy measurement device.
CFMODE	0x490	Common to all ADE9153A energy measurement device.
CF1DEN	0x494	Common to all ADE9153A energy measurement device.
CD2DEN	0x495	Common to all ADE9153A energy measurement device.
ACCMODE	0x492	Common to all ADE9153A energy measurement device.
VLEVEL	0x40F	Common to all ADE9153A energy measurement device.
COMPMODE	0x491	Common to all ADE9153A energy measurement device.
AI_PGAGAIN	0x4B9	Common to all ADE9153A energy measurement device.
BI_PGAGAIN	0x023	Common to all ADE9153A energy measurement device.
DSP_RUN	0x480	Common to all ADE9153A energy measurement device.
EP_CFG	0x4B0	Common to all ADE9153A energy measurement device.
VDIV_RSMALL	0x04C	Common to all ADE9153A energy measurement device.
CT_PHASE_DELAY	0x049	Common to all ADE9153A energy measurement device.
CT_CORNER	0x04A	Common to all ADE9153A energy measurement device.
APHASECAL	0x001	Common to all ADE9153A energy measurement device.
AIGAIN	0x000	Unique to each ADE9153A energy measurement device and determined. See the Production Flow section.
BIGAIN	0x010	Unique to each ADE9153A energy measurement device and determined. See the Production Flow section.
AVGAIN	0x002	Unique to each ADE9153A energy measurement device and determined. See the Production Flow section.
MS_AICC_USER	0x045	Unique to each ADE9153A energy measurement device and determined. See the Production Flow section.
MS_BICC_USER	0x046	Unique to each ADE9153A energy measurement device and determined. See the Production Flow section.
MS_AVCC_USER	0x047	Unique to each ADE9153A energy measurement device and determined. See the Production Flow section.

CONCLUSION

When the process described in this application note is followed, the result is a complete ADE9153A energy measurement device in a system is initialized, calibrated, and is ready for the field. The *m*Sure autocalibration technology of the ADE9153A allows simplified calibration with no need for calibration equipment.

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