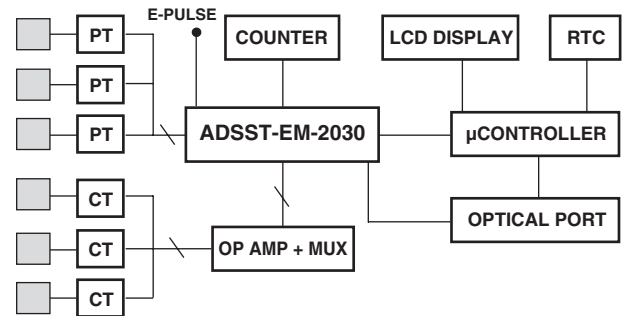


FEATURES

- 3-Phase, 4-Wire Metering IC**
- High Accuracy Support for 50 Hz/60 Hz, IEC1036**
- Design Accuracy:**
 - 0.5% over 5% of Ib to 6% of Ib
 - 0.65% over 2% of Ib to 5% of Ib
- Measures:**
 - kWh
 - kW
 - rms Voltage of Each Phase
 - rms Current of Each Phase
- Phase and Nonlinearity Compensation for CTs**
- Potentiometer-Free Design**
- SPI Communication for:**
 - Data to Microcontroller
 - Calibration
- Programmable E-Pulse**
- Drive for:**
 - Electromechanical Counter
 - 2-Phase Stepper Motor Counter
- Low Power (50 mW Typ)**

FUNCTIONAL BLOCK DIAGRAM



POLY PHASE ENERGY METER USING THE ADSST-EM-2030

GENERAL DESCRIPTION

ADSST-EM-2030 is a highly accurate and low cost phase energy measurement IC intended to be used in 3-phase, 4-wire systems. When used with an op amp and a multiplexer, the ADSST-EM-2030 surpasses the accuracy requirement of the IEC1036 standard.

ADSST-EM-2030 is a MicroConverter[®] consisting of a microcontroller, 6-channel, 12-bit ADC, SPI port, program memory and Flash for storage of constants. The only analog circuitry used in ADSST-EM-2030 is the ADC. All other signal processing is carried out in digital domain. This provides superior accuracy over extreme environmental conditions and time.

ADSST-EM-2030 can drive an electromechanical counter or a 2-phase stepper motor counter, or can be interfaced to a microcontroller to build a feature-rich meter with LCD, maximum demand, time of use, and communication.

Ratio, phase, and nonlinearity errors of the CTs are compensated for by using software. This reduces the cost of CTs and reduces calibration time caused by unreliable potentiometers.

Because the ADSST-EM-2030 is a low power device, it can be powered by a simple R-C power supply, reducing the cost of operation.

ADSST-EM-2030 supplies average real power information on the low frequency outputs F1 and F2. These logic outputs can be used to drive an electromechanical counter. The CF logic pin gives the instantaneous real power information. This output is intended to be used for calibration.

ADSST-EM-2030 is available in a 28-lead SSOP package.

*Protected by U.S. Patent No. 5,969,657; other patents pending.
MicroConverter is a registered trademark of Analog Devices.

REV. 0

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ADSST-EM-2030

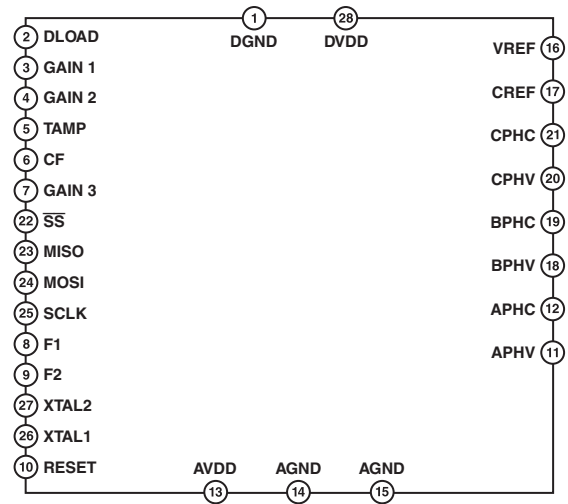
ORDERING GUIDE

| Model | Temperature Range | Package Description | Package Option |
|---------------|-------------------|-----------------------------------|----------------|
| ADSST-EM-2030 | -40°C to +85°C | Tiny Shrink Small Outline Package | RU-28 |

PIN FUNCTION DESCRIPTION

| Pin No. | Mnemonic | Description |
|---------|----------|--|
| 1 | DGND | Digital Ground |
| 2 | DLOAD | Used to Enable Serial Download of Program Memory |
| 3 | GAIN 1 | Logic Channels Output for Multiplexer to Switch Gain for A-Phase Current |
| 4 | GAIN 2 | Logic Channels Output for Multiplexer to Switch Gain for B-Phase Current |
| 5 | TAMP | Logic Output Indicating that One More Current Is Reversed |
| 6 | CF | Calibration Frequency Logic Output. This gives instantaneous real power information and can be used for calibration. |
| 7 | GAIN 3 | Logic Channels Output for Multiplexer to Switch Gain for C-Phase Current |
| 8, 9 | F1, F2 | Low Frequency Logic Outputs. F1 and F2 provide average real power information. The logic outputs can be used to drive electromechanical counters and 2-phase stepper motors. |
| 10 | RESET | System Reset |
| 11 | APHV | A-Phase Voltage Input |
| 12 | APHC | A-Phase Current Input |
| 13 | AVDD | Analog Positive Supply |
| 14 | AGND | Analog Ground |
| 15 | AGND | Analog Ground |
| 16 | VREF | Input for External Voltage Reference |

PIN CONFIGURATION



PIN FUNCTION DESCRIPTION (continued)

| Pin No. | Mnemonic | Description |
|---------|----------|--|
| 17 | CREF | Filter Capacitor for Reference |
| 18 | BPHV | B-Phase Voltage Input |
| 19 | BPHC | B-Phase Current Input |
| 20 | CPHV | C-Phase Voltage Input |
| 21 | CPHC | C-Phase Current Input |
| 22 | SS | This Logic Signal conveys to ADSST-EM-2030 that data transfer on SPI is requested. |
| 23 | MISO | Data Output on SPI from ADSST-EM-2030 |
| 24 | MOSI | |
| 25 | SCLK | Clock for SPI. This clock is generated by an external microcontroller when the data transfer to or from ADSST-EM-2030 takes place. |
| 26 | XTAL1 | Crystal Oscillator |
| 27 | XTAL2 | Crystal Oscillator |
| 28 | DVDD | Digital Positive Supply |

CAUTION

ESD (electrostatic discharge) sensitive device. Electrostatic charges as high as 4000 V readily accumulate on the human body and test equipment and can discharge without detection. Although the ADSST-EM-2030 features proprietary ESD protection circuitry, permanent damage may occur on devices subjected to high energy electrostatic discharges. Therefore, proper ESD precautions are recommended to avoid performance degradation or loss of functionality.



SERIAL PERIPHERAL INTERFACE (SPI)

The SPI bus available on the ADSST-EM-2030 is useful to communicate to an external microcontroller as shown in Figure 1.

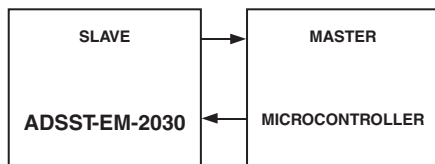


Figure 1. SPI Communication between ADSST-EM-2030 and Microcontroller

Here, the microcontroller functions as master and the ADSST-EM-2030 is a slave for this protocol. Using this communication port, the microcontroller will be able to read and write to the ADSST-EM-2030 to perform the following functions:

- Calibrate the meter
- Configure the ADSST-EM-2030 chipset
- Read measured parameters from the ADSST-EM-2030 chipset

Four pins are used on the ADSST-EM-2030 chipset for the communication, and are shown Table I.

Table I. Pin Description for SPI Communication Port

| Pin No. | Mnemonic | Description |
|---------|-----------------|-------------|
| 22 | \overline{SS} | Select |
| 23 | MISO | Output |
| 24 | MOSI | Input |
| 25 | SCLK | SPI Clock |

TIMING SPECIFICATIONS

This section contains timing information for the ADSST-EM-2030 chipset.

General Notes

Use the exact timing information given. Do not attempt to derive parameters from the addition or subtraction of others. While addition or subtraction would yield meaningful results for an individual device, the values given in this data sheet reflect statistical variations and worst cases. Consequently, parameters cannot be added up meaningfully to derive longer times.

Timing Notes

Switching characteristics specify how the processor changes its signals. Designers have no control on this timing—circuitry external to the processor must be designed for compatibility with these signal characteristics. These characteristics can be used to ensure that any timing requirement of a microcontroller connected to the chipset is satisfied.

Timing requirements apply to signals that are controlled by circuitry external to the chipset, such as the data input for a read operation. Timing requirements guarantee that the chipset operates correctly with the external microcontroller.

Data Access

Data can be written or read to the ADSST-EM-2030 chipset only when the \overline{SS} pin is low. Since the chipset is a slave, the external controller must bring the \overline{SS} pin low, the SCLK clock should be sent to clock in or clock out the data. For sending the data to the chipset, data should be sent on MOSI pin; for receiving the data from the chipset, data should be collected on MISO pin.

With the external microcontroller as the master for the SPI communication, the microcontroller should send eight successive clocks to the ADSST-EM-2030 every 5 ms. At this instant, the microcontroller may either send a command or data or may receive an acknowledgment followed by data from the chipset. The ADSST-EM-2030 maintains a time gap of 5 ms between transmission of two successive bytes to or from the microcontroller. This helps in avoiding clashing of interrupts while the chipset and the microcontroller are executing their respective tasks.

Table II. SPI Pin Timings

| Timing | Parameter | Min | Typ | Max | Unit |
|-----------|---|-----|-----|-----|------|
| t_{SS} | \overline{SS} to SCLOCK Edge | 0 | | | ns |
| t_{SC} | SCLOCK Low Pulsewidth | | 300 | | ns |
| t_{SH} | SCLOCK High Pulsewidth | | 300 | | ns |
| t_{DAV} | Data Output Valid after SCLOCK Edge | | | 50 | ns |
| t_{DSU} | Data Input Setup Time before SCLOCK Edge | 100 | | | ns |
| t_{DHD} | Data Input Hold Time before SCLOCK Edge | 100 | | | ns |
| t_{DF} | Data Output Fall Time | | 10 | 25 | ns |
| t_{DR} | Data Output Rise Time | | 10 | 25 | ns |
| t_{SR} | SCLOCK Rise Time | | 10 | 25 | ns |
| t_{SF} | SCLOCK Fall Time | | 10 | 25 | ns |
| t_{SFS} | \overline{SS} High after SCLOCK Edge | 0 | | | ns |

ADSST-EM-2030

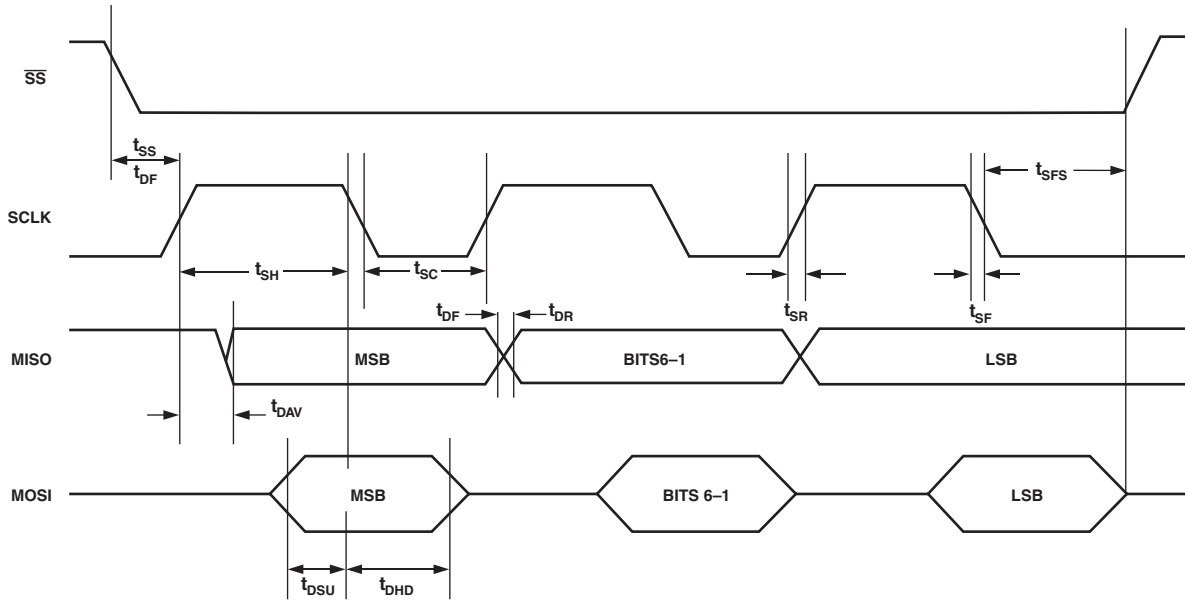


Figure 2. SPI Communication Port Timing

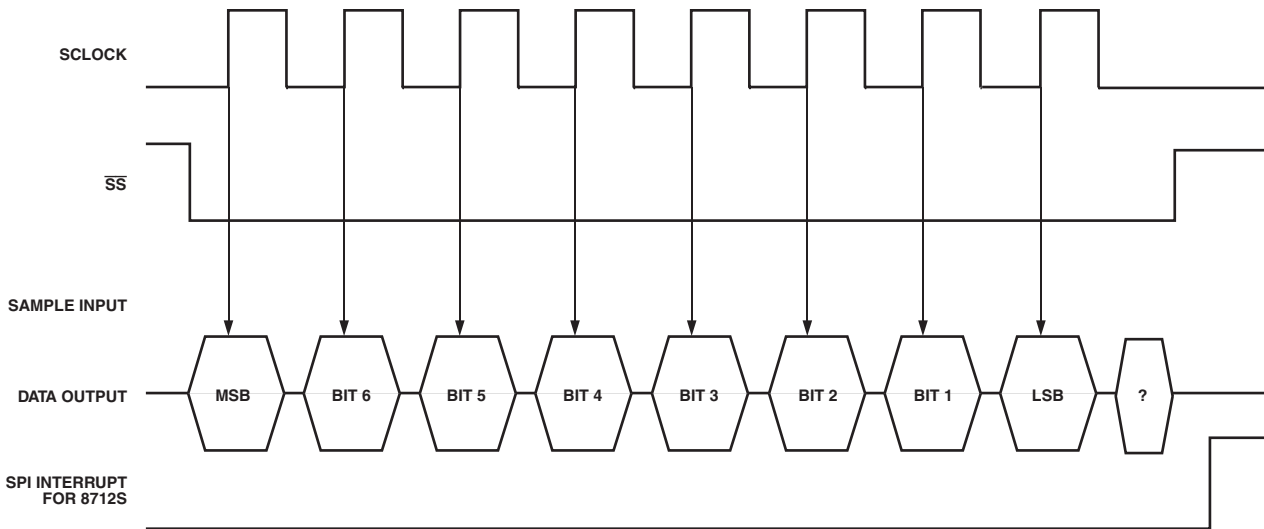


Figure 3. SPI Timing for Data Transmission Byte

SPI FUNCTIONS

Three specific functions can be performed on the SPI communication port on the ADSST-EM-2030 chipset:

Data Read—The external microcontroller can read the data from the ADSST-EM-2030 by sending specific commands; this includes metering data, constants, and so on.

Data Write—The external microcontroller can send data to the ADSST-EM-2030 to be stored in its internal nonvolatile memory; this includes calibration and configuration constants, and so on.

Special Commands—The external microcontroller can send special commands to the ADSST-EM-2030 for performing specific functions. These commands do not have any data.

Data Read

The microcontroller being the master for the SPI communication, has to send the desired commands for getting data from ADSST-EM-2030. For the data transfer to take place, the following sequence of operations must take place:

1. The microcontroller should send the specific command to the ADSST-EM-2030 chipset to read the desired data.
2. The ADSST-EM-2030 will first respond with an acknowledgment to the microcontroller within 5 ms that it has received the command. To send the acknowledgment, the ADSST-EM-2030 adds 0x30 to the received command, and which is then sent back to the microcontroller.

3. If the microcontroller does not get this acknowledgment from the ADSST-EM-2030 within 5 ms then the microcontroller may transmit this command to read the same data again.
4. After being sensed by the microcontroller, the ADSST-EM-2030 sends an acknowledgment to the microcontroller, the chipset then prepares a packet of 10 bytes of requested data and starts transmitting the bytes one by one at intervals of 5 ms. This packet of 10 bytes also includes a header as the first byte of the packet and checksum as the last byte.
5. The microcontroller can strip the data from this packet, compute the checksum, and compare it with the last byte in the packet. If the checksum does not match, the microcontroller should then send the command again to ADSST-EM-2030 chipset.

The complete process of reading a packet of data should take 60 ms. The next command from the microcontroller to the ADSST-EM-2030 can be sent immediately after receipt of data or wait for the desired amount of time. The amount of time the microcontroller should wait for the next command to be sent to the ADSST-EM-2030 is purely dependent on the execution of other functions on the microcontroller. It may be sufficient for the microcontroller to collect data from the chipset after

every second. The remaining time may be used by the microcontroller to perform other housekeeping functions.

For example, if the command sent by the microcontroller is 0x01, the ADSST-EM-2030 adds 0x30 to it, making it 0x31, and sends this to the microcontroller as an acknowledgment.

The data packet structure created by the ADSST-EM-2030 has 10 bytes. The first byte is a packet start byte (0xEE) and the last byte is a checksum byte.

< START of Packet (0xEE) >< 8 Bytes of Data>
< CHECKSUM >

The checksum is calculated by adding the first nine bytes, including the packet start byte.

$$\text{CHECKSUM} = 1^{\text{st}} + 2^{\text{nd}} + \dots + 9^{\text{th}} \text{ Byte}$$

Table III shows various commands that can be sent to the ADSST-EM-2030 chipset by the microcontroller on the SPI communication port. The chipset returns a specific number of bytes for each data parameter specified, in the data column of the table. The data that can be read from the chipset could be calibration constants or instantaneous data.

Table III. Read Commands to ADSST-EM-2030 on SPI

| Function | Command to ADSST-EM-2030 from μC | Number of Data Bytes from ADSST-EM-2030 |
|--|--|--|
| CONSTANTS | | |
| GAIN CALIBRATION CONSTANTS | | |
| Read Voltage Gain Constants | 0x01 | 6 |
| Read Low Gain Current Constants | 0x02 | 6 |
| Read High Gain Current Constants | 0x03 | 6 |
| POWER CALIBRATION CONSTANTS AT HIGH CURRENT RANGE | | |
| A-Phase Power Constant at High Current (Including E-Pulse and Counter Pulse Constant) | 0x07 | 4 |
| B-Phase Power Constant at High Current | 0x09 | 2 |
| C-Phase Power Constant at High Current | 0x0B | 2 |
| POWER CALIBRATION CONSTANTS AT LOW CURRENT RANGE | | |
| A-Phase Power Constant at Low Current | 0x06 | 2 |
| B-Phase Power Constant at Low Current | 0x08 | 2 |
| C-Phase Power Constant at Low Current | 0x0A | 2 |
| PHASE COMPENSATION COEFFICIENTS | | |
| Read A-, B-, and C-Phase Coefficients | 0x15 | 6 |
| DC OFFSET CONSTANTS | | |
| Read DC Offset Constants | 0x0E | 6 |
| INSTANTANEOUS PARAMETERS | | |
| Read Voltages for Phase A, B, and C | 0x0F | 6 |
| Read Currents for Phase A, B, and C | 0x10 | 6 |
| Read Energy and Power for Phase A, B, and C | 0x11 | 8 |

ADSST-EM-2030

Data Structure in the Packet

The ADSST-EM-2030 sends out eight bytes of data for every command. The last bytes of a parameter with a 6-byte structure are kept at zero and should be neglected.

Table IV. Byte Wise Packet Data Structure for Voltage Gain Constants

Command to ADSST-EM-2030: 0x01

Acknowledgment from ADSST-EM-2030: 0x31

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|------------------------------------|------|------|------|------|-----|-----|------|
| SPB | AVMS | AVLS | BVMS | BVLS | CVMS | CVLS | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | AVMS | Voltage Constant for A-Phase – MSB | | | | | | | |
| 3 | AVLS | Voltage Constant for A-Phase – LSB | | | | | | | |
| 4 | BVMS | Voltage Constant for B-Phase – MSB | | | | | | | |
| 5 | BVLS | Voltage Constant for B-Phase – LSB | | | | | | | |
| 6 | CVMS | Voltage Constant for C-Phase – MSB | | | | | | | |
| 7 | CVLS | Voltage Constant for C-Phase – LSB | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table V. Byte Wise Packet Data Structure for Low Gain Current Constants

Command to ADSST-EM-2030: 0x02

Acknowledgment from ADSST-EM-2030: 0x32

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|---|------|------|------|------|-----|-----|------|
| SPB | AILM | AILL | BILM | BILL | CILM | CILL | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | AILM | Current Constant for A-Phase – Low Gain – MSB | | | | | | | |
| 3 | AILL | Current Constant for A-Phase – Low Gain – LSB | | | | | | | |
| 4 | BILM | Current Constant for B-Phase – Low Gain – MSB | | | | | | | |
| 5 | BILL | Current Constant for B-Phase – Low Gain – LSB | | | | | | | |
| 6 | CILM | Current Constant for C-Phase – Low Gain – MSB | | | | | | | |
| 7 | CILL | Current Constant for C-Phase – Low Gain – LSB | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table VI. Byte Wise Packet Data Structure for High Gain Current Constants

Command to ADSST-EM-2030: 0x03

Acknowledgment from ADSST-EM-2030: 0x33

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|--|------|------|------|------|-----|-----|------|
| SPB | AIHM | AIHL | BIHM | BIHL | CIHM | CIHL | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | AIHM | Current Constant for A-Phase – High Gain – MSB | | | | | | | |
| 3 | AIHL | Current Constant for A-Phase – High Gain – LSB | | | | | | | |
| 4 | BIHM | Current Constant for B-Phase – High Gain – MSB | | | | | | | |
| 5 | BIHL | Current Constant for B-Phase – High Gain – LSB | | | | | | | |
| 6 | CIHM | Current Constant for C-Phase – High Gain – MSB | | | | | | | |
| 7 | CIHL | Current Constant for C-Phase – High Gain – LSB | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table VII. Byte Wise Packet Data Structure for Power Constants at High Current for Phase A

Command to ADSST-EM-2030: 0x07

Acknowledgment from ADSST-EM-2030: 0x37

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|---|-----|-----|-----|-----|-----|-----|------|
| SPB | PAHM | PAHL | EPC | CPC | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PAHM | Power Constant for A-Phase, High Current – MSB | | | | | | | |
| 3 | PAHL | Power Constant for A-Phase, High Current – LSB | | | | | | | |
| 4 | EPC | E-Pulse Constant in Pulses per kWh (1 = 1600, 2 = 800, 3 = 400, and 4 = 200), Default Value = 1 | | | | | | | |
| 5 | CPC | Counter Pulse Constant in Pulses per kWh (1 = 200 and 2 = 400), Default Value = 1 | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table VIII. Byte Wise Packet Data Structure for Power Constants at High Current for Phase B

Command to ADSST-EM-2030: 0x09

Acknowledgment from ADSST-EM-2030: 0x39

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|--|-----|-----|-----|-----|-----|-----|------|
| SPB | PBHM | PBHL | NLV | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PBHM | Power Constant for B-Phase, High Current – MSB | | | | | | | |
| 3 | PBHL | Power Constant for B-Phase, High Current – LSB | | | | | | | |
| 4 | NLV | No Legal Value (0x00) | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table IX. Byte Wise Packet Data Structure for Power Constants at High Current for Phase C

Command to ADSST-EM-2030: 0x0B

Acknowledgment from ADSST-EM-2030: 0x3B

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|--|-----|-----|-----|-----|-----|-----|------|
| SPB | PCHM | PCHL | NLV | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PCHM | Power Constant for C-Phase, High Current – MSB | | | | | | | |
| 3 | PCHL | Power Constant for C-Phase, High Current – LSB | | | | | | | |
| 4 | NLV | No Legal Value (0x00) | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

ADSST-EM-2030

Table X. Byte Wise Packet Data Structure for Power Constants at Low Current for Phase A

Command to ADSST-EM-2030: 0x06

Acknowledgment from ADSST-EM-2030: 0x36

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|---|-----|-----|-----|-----|-----|-----|------|
| SPB | PALM | PALL | NLV | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PALM | Power Constant for A-Phase, Low Current – MSB | | | | | | | |
| 3 | PALL | Power Constant for A-Phase, Low Current – LSB | | | | | | | |
| 4 | NLV | No Legal Value (0x00) | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XI. Byte Wise Packet Data Structure for Power Constants at Low Current for Phase B

Command to ADSST-EM-2030: 0x08

Acknowledgment from ADSST-EM-2030: 0x38

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|---|-----|-----|-----|-----|-----|-----|------|
| SPB | PBLM | PBLL | NLV | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PBLM | Power Constant for B-Phase, Low Current – MSB | | | | | | | |
| 3 | PBLL | Power Constant for B-Phase, Low Current – LSB | | | | | | | |
| 4 | NLV | No Legal Value (0x00) | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XII. Byte Wise Packet Data Structure for Power Constants at Low Current for Phase C

Command to ADSST-EM-2030: 0x0A

Acknowledgment from ADSST-EM-2030: 0x3A

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|---|-----|-----|-----|-----|-----|-----|------|
| SPB | PCLM | PCLL | NLV | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PCLM | Power Constant for C-Phase, Low Current – MSB | | | | | | | |
| 3 | PCLL | Power Constant for C-Phase, Low Current – LSB | | | | | | | |
| 4 | NLV | No Legal Value (0x00) | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XIII. Byte Wise Packet Data Structure for Phase Compensation Coefficients

Command to ADSST-EM-2030: 0x15
 Acknowledgment from ADSST-EM-2030: 0x45

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|---|-----|-----|-----|-----|-----|-----|------|
| SPB | PGA | PSA | PGB | PSB | PGC | PSC | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PGA | Phase Constant for Low Current – Phase A | | | | | | | |
| 3 | PSA | Phase Constant for High Current – Phase A | | | | | | | |
| 4 | PGB | Phase Constant for Low Current – Phase B | | | | | | | |
| 5 | PSB | Phase Constant for High Current – Phase B | | | | | | | |
| 6 | PGC | Phase Constant for Low Current – Phase C | | | | | | | |
| 7 | PSC | Phase Constant for High Current – Phase C | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XIV. Byte Wise Packet Data Structure for DC Offset Constants

Command to ADSST-EM-2030: 0x0E
 Acknowledgment from ADSST-EM-2030: 0x3E

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|-----------------------------|-----|-----|-----|-----|-----|-----|------|
| SPB | DAM | DAL | DBM | DBL | DCM | DCL | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | DAM | DC Offset for Phase A - MSB | | | | | | | |
| 3 | DAL | DC Offset for Phase A - LSB | | | | | | | |
| 4 | DBM | DC Offset for Phase B – MSB | | | | | | | |
| 5 | DBL | DC Offset for Phase B – LSB | | | | | | | |
| 6 | DCM | DC Offset for Phase C – MSB | | | | | | | |
| 7 | DCL | DC Offset for Phase C – LSB | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XV. Byte Wise Packet Data Structure while Reading Instantaneous Voltages in Volts

Command to ADSST-EM-2030: 0x0F
 Acknowledgment from ADSST-EM-2030: 0x3F
 Voltage Value Resolution: Two Decimal Points

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------------|--|-----|-----|-----|-----|-------------|----------|------|
| SPB | VAM | VAL | VBM | VBL | VCM | VCL | Tamper Info | Not used | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | VAM | Voltage for Phase A – MSB | | | | | | | |
| 3 | VAL | Voltage for Phase A – LSB | | | | | | | |
| 4 | VBM | Voltage for Phase B – MSB | | | | | | | |
| 5 | VBL | Voltage for Phase B – LSB | | | | | | | |
| 6 | VCM | Voltage for Phase C – MSB | | | | | | | |
| 7 | VCL | Voltage for Phase C – LSB | | | | | | | |
| 8 | Tamper Info | 0 bit: A – CT Reversal First Bit: B – CT Reversal Second Bit: C – CT Reversal Third Bit: Phase Sequence Error | | | | | | | |
| 9 | Not used | | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

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Table XVI. Byte Wise Packet Data Structure While Reading Instantaneous Current in Amperes

Command to ADSST-EM-2030: 0x10

Acknowledgment from ADSST-EM-2030: 0x40

Current value resolution: Three Decimal Points

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|---------------------------|-----|-----|-----|-----|------|------|------|
| SPB | IAM | IAL | IBM | IBL | ICM | ICL | ACTR | ACTR | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | IAM | Current for Phase A – MSB | | | | | | | |
| 3 | IAL | Current for Phase A – LSB | | | | | | | |
| 4 | IBM | Current for Phase B – MSB | | | | | | | |
| 5 | IBL | Current for Phase B – LSB | | | | | | | |
| 6 | ICM | Current for Phase C – MSB | | | | | | | |
| 7 | ICL | Current for Phase C – LSB | | | | | | | |
| 8 | ACTR | Freq (MSB) | | | | | | | |
| 9 | ACTR | Freq (LSB) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XVII. Byte Wise Packet Data Structure While Reading Instantaneous Power and Energy

Command to ADSST-EM-2030: 0x11

Acknowledgment from ADSST-EM-2030: 0x41

Power Value (in kW) Resolution: Five Decimal Points

Energy Value (in kWh) Resolution: Four Decimal Points

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|--------------------------------|-----|-----|-----|-----|-----|-----|------|
| SPB | PT1 | PT2 | PT3 | PT4 | ET1 | ET2 | ET3 | ET4 | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | PT1 | Total Power First Byte – MSB | | | | | | | |
| 3 | PT2 | Total Power Second Byte | | | | | | | |
| 4 | PT3 | Total Power Third Byte | | | | | | | |
| 5 | PT4 | Total Power Fourth Byte – LSB | | | | | | | |
| 6 | ET1 | Total Energy First Byte – MSB | | | | | | | |
| 7 | ET2 | Total Energy Second Byte | | | | | | | |
| 8 | ET3 | Total Energy Third Byte | | | | | | | |
| 9 | ET4 | Total Energy Fourth Byte – LSB | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Data Interpretation

The data sent by ADSST-EM-2030 is in Hex, and the microcontroller has to convert this and place the decimal point at the correct place for display.

Table XVIII. Interpretation of the Voltage Data

The data sent for Voltage has a resolution up to two decimal places.

| Each Phase Voltage Data | | |
|-------------------------|---------------|----------|
| Hex Value (2 Byte) | Decimal Value | Voltage |
| 5A10h | 23056 | 230.56 V |

Table XIX. Interpretation of the Current Data

The data sent for Current has a resolution up to three decimal places.

| Each Phase Current Data | | |
|-------------------------|---------------|----------|
| Hex Value (2 Byte) | Decimal Value | Current |
| 278Bh | 10123 | 10.123 A |

Table XX. Interpretation of the Power Data

The data sent for Power has a resolution up to five decimal places.

| Each Phase Power Data | | |
|-----------------------|---------------|------------|
| Hex Value (4 Byte) | Decimal Value | Power |
| 0D1C4Ah | 859210 | 8.59210 kW |

Table XXI. Interpretation of the Energy Data

The data sent for Energy has a resolution up to four decimal places.

| Each Phase Energy Data | | |
|------------------------|---------------|-------------|
| Hex Value (4 Byte) | Decimal Value | Energy |
| 0D1C4Ah | 859210 | 85.9210 kWh |

Data Write

Because microcontroller is the master for the SPI communication, it has to send the desired commands for sending the data to the ADSST-EM-2030. For the data transfer to take place, the following sequence of operation has to occur:

1. The microcontroller should send the packet of 10 bytes including the specific command to the ADSST-EM-2030 chipset to write the desired data. Thus, the packet of 10 bytes includes a header as the first byte of the packet, a specific command for write data, and checksum as the last byte.
2. The ADSST-EM-2030 will receive the bytes one by one in intervals of 5 ms.
3. The ADSST-EM-2030 strips the data from this packet, computes the checksum and compares it with the last byte in the packet. If the checksum does not match, the microcontroller should send the command to the ADSST-EM-2030 chipset again, else the ADSST-EM-2030 sends the acknowledgment of receipt of all the bytes to be written.
4. To send the acknowledgment, the ADSST-EM-2030 adds 0x30 to the received command, which is then sent back to the microcontroller.
5. If the microcontroller does not get this acknowledgment from the ADSST-EM-2030 by 5 ms, then the microcontroller may transmit this command to write the same data again.

The complete process of writing a packet of data should take 60 ms. The next command from the microcontroller to the ADSST-EM-2030 can be sent immediately after receipt of data or wait for the desired amount of time. The amount of time the microcontroller waits for the next command to be sent to ADSST-EM-2030 is purely dependent on the execution of other functions on the microcontroller. It may be sufficient for the microcontroller to collect data from the chipset after every one second. The remaining time may be used by the microcontroller to perform other housekeeping functions.

For example, if the command sent by the microcontroller is 0x01; the ADSST-EM-2030 adds 0x30 to it, making it 0x31, and sends this to the microcontroller as an acknowledgment.

The data packet structure created by the ADSST-EM-2030 has 10 bytes. The first byte is a packet start byte (0xEE), and the last byte is a checksum byte.

< START of Packet (0xEE) ><Command of 1 Byte>
< 7 Bytes of Data><CHECKSUM >

The checksum is calculated by adding the first nine bytes including the Packet start byte.

$$\text{CHECKSUM} = 1^{\text{st}} + 2^{\text{nd}} + \dots + 9^{\text{th}} \text{ Byte}$$

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Table XXII shows various commands that can be sent to the ADSST-EM-2030 chipset by the microcontroller on the SPI communication port. The chipset writes the specific number of bytes for each data parameter specified in the data column of the table. The data that can be written to the chipset could be calibration constants.

Table XXII. Interpretation of the Energy Data

| Data | Command to ADSST-EM-2030 | Data Bytes |
|---|--------------------------|------------|
| GAIN CALIBRATION | | |
| Voltage Coefficient | 0x81 | 6 |
| Current Low Gain Coefficient | 0x82 | 6 |
| Current High Gain Coefficient | 0x83 | 6 |
| POWER CALIBRATION CONSTANTS AT HIGH CURRENT RANGE | | |
| A-Phase Power Constant at High Current (with E-Pulse and Counter Pulse) | 0x87 | 4 |
| B-Phase Power Constant at High Current | 0x89 | 2 |
| C-Phase Power Constant at High Current | 0x8B | 2 |
| POWER CALIBRATION CONSTANTS AT LOW CURRENT RANGE | | |
| A-Phase Power Constant at Low Current | 0x86 | 2 |
| B-Phase Power Constant at Low Current | 0x88 | 2 |
| C-Phase Power Constant at Low Current | 0x8A | 2 |
| PHASE COMPENSATION COEFFICIENTS | | |
| A-, B-, C-Phase Coefficient | 0x95 | 6 |

Data Structure in the Packet

The ADSST-EM-2030 sends out seven bytes of data for every command. The last bytes of a 6-byte structure are kept at zero and should be neglected.

Table XXIII. Byte Wise Packet Data Structure for Voltage Gain Constants

Command to ADSST-EM-2030: 0x81

Acknowledgment from ADSST-EM-2030: 0xB1

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|------------------------------------|------|------|------|------|------|-----|------|
| SPB | CWV | WAVM | WAVL | WBVM | WBVL | WCVM | WCVL | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | CWV | Command to Write Voltage Constant | | | | | | | |
| 3 | WAVM | Voltage Constant for A-Phase – MSB | | | | | | | |
| 4 | WAVL | Voltage Constant for A-Phase – LSB | | | | | | | |
| 5 | WBVM | Voltage Constant for B-Phase – MSB | | | | | | | |
| 6 | WBVL | Voltage Constant for B-Phase – LSB | | | | | | | |
| 7 | WCVM | Voltage Constant for C-Phase – MSB | | | | | | | |
| 8 | WCVL | Voltage Constant for C-Phase – LSB | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XXIV. Byte Wise Packet Data Structure for Low Gain Current Constants

Command to ADSST-EM-2030: 0x82
 Acknowledgment from ADSST-EM-2030: 0xB2

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|------|---|------|------|------|------|-----|------|
| SPB | CWI | WAIM | WAIL | WBIM | WBIL | WCIM | WCIL | NLV | CSUM |
| Byte No. | Name | | Description | | | | | | |
| 1 | SPB | | Start Packet Byte (0xEE) | | | | | | |
| 2 | CWI | | Command to Write Low Gain Current Constant | | | | | | |
| 3 | WAIM | | Current Constant for A-Phase – Low Gain – MSB | | | | | | |
| 4 | WAIL | | Current Constant for A-Phase – Low Gain – LSB | | | | | | |
| 5 | WBIM | | Current Constant for B-Phase – Low Gain – MSB | | | | | | |
| 6 | WBIL | | Current Constant for B-Phase – Low Gain – LSB | | | | | | |
| 7 | WCIM | | Current Constant for C-Phase – Low Gain – MSB | | | | | | |
| 8 | WCIL | | Current Constant for C-Phase – Low Gain – LSB | | | | | | |
| 9 | NLV | | No Legal Value (0x00) | | | | | | |
| 10 | CSUM | | Checksum | | | | | | |

Table XXV. Byte Wise Packet Data Structure for High Gain Current Constants

Command to ADSST-EM-2030: 0x83
 Acknowledgment from ADSST-EM-2030: 0xB3

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------|-------|--|-------|-------|-------|-------|-----|------|
| SPB | CWHI | WAHIM | WAHIL | WBHIM | WBHIL | WCHIM | WCHIL | NLV | CSUM |
| Byte No. | Name | | Description | | | | | | |
| 1 | SPB | | Start Packet Byte (0xEE) | | | | | | |
| 2 | CWHI | | Command to Write High Gain Current Constant | | | | | | |
| 3 | WAHIM | | Current Constant for A-Phase – High Gain – MSB | | | | | | |
| 4 | WAHIL | | Current Constant for A-Phase – High Gain – LSB | | | | | | |
| 5 | WBHIM | | Current Constant for B-Phase – High Gain – MSB | | | | | | |
| 6 | WBHIL | | Current Constant for A-Phase – High Gain – LSB | | | | | | |
| 7 | WCHIM | | Current Constant for A-Phase – High Gain – MSB | | | | | | |
| 8 | WCHIL | | Current Constant for A-Phase – High Gain – LSB | | | | | | |
| 9 | NLV | | No Legal Value (0x00) | | | | | | |
| 10 | CSUM | | Checksum | | | | | | |

Table XXVI. Byte Wise Packet Data Structure for Power Constants at High Current for Phase A

Command to ADSST-EM-2030: 0x87
 Acknowledgment from ADSST-EM-2030: 0xB7

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------|-------|---|-----|-----|-----|-----|-----|------|
| SPB | CWAPH | WPAHN | WPAHL | EPC | CPC | NLV | NLV | NLV | CSUM |
| Byte No. | Name | | Description | | | | | | |
| 1 | SPB | | Start Packet Byte (0xEE) | | | | | | |
| 2 | CWAPH | | Command to Write Power Constant for A-Phase at High Current | | | | | | |
| 3 | WPAHM | | Power Constant for A-Phase, High Current – MSB | | | | | | |
| 4 | WPAHL | | Power Constant for A-Phase, High Current – LSB | | | | | | |
| 5 | EPC | | E-Pulse Constant in Pulses per kWh (1 = 1600, 2 = 800, 3 = 400, and 4 = 200), Default Value = 1 | | | | | | |
| 6 | CPC | | Counter Pulse Constant in Pulses per kWh (1 = 200 and 2 = 400), Default Value = 1 | | | | | | |
| 7 | NLV | | No Legal Value (0x00) | | | | | | |
| 8 | NLV | | No Legal Value (0x00) | | | | | | |
| 9 | NLV | | No Legal Value (0x00) | | | | | | |
| 10 | CSUM | | Checksum | | | | | | |

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Table XXVII. Byte Wise Packet Data Structure for Power Constants at High Current for Phase B

Command to ADSST-EM-2030: 0x89

Acknowledgment from ADSST-EM-2030: 0xB9

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------|---|-------|-----|-----|-----|-----|-----|------|
| SPB | CWBPH | WPBHM | WPBHL | EPC | CPC | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | CWBPH | Command to Write Power Constant for B-Phase at High Current | | | | | | | |
| 3 | WPBHM | Power Constant for B-Phase, High Current – MSB | | | | | | | |
| 4 | WPBHL | Power Constant for B-Phase, High Current – LSB | | | | | | | |
| 5 | EPC | No Legal Value (0x00) | | | | | | | |
| 6 | CPC | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XXVIII. Byte Wise Packet Data Structure for Power Constants at High Current Phase C

Command to ADSST-EM-2030: 0x8B

Acknowledgment from ADSST-EM-2030: 0xBB

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------|---|-------|-----|-----|-----|-----|-----|------|
| SPB | CWCPH | WPCHM | WPCHL | EPC | CPC | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | CWCPH | Command to Write Power Constant for C Phase at High Current | | | | | | | |
| 3 | WPCHM | Power Constant for C-Phase, High Current – MSB | | | | | | | |
| 4 | WPCHL | Power Constant for C-Phase, High Current – LSB | | | | | | | |
| 5 | EPC | No Legal Value (0x00) | | | | | | | |
| 6 | CPC | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XXIX. Byte Wise Packet Data Structure for Power Constants at Low Current for Phase A

Command to ADSST-EM-2030: 0x86

Acknowledgment from ADSST-EM-2030: 0xB6

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------|--|-------|-----|-----|-----|-----|-----|------|
| SPB | CWAPL | WPALM | WPALL | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | CWAPL | Command to Write Power Constant for A-Phase at Low Current | | | | | | | |
| 3 | WPALM | Power Constant for A-Phase, Low Current – MSB | | | | | | | |
| 4 | WPALL | Power Constant for A-Phase, Low Current – LSB | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XXX. Byte Wise Packet Data Structure for Power Constants at Low Current for Phase B

Command to ADSST-EM-2030: 0x88

Acknowledgment from ADSST-EM-2030: 0xB8

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------|--|-------|-----|-----|-----|-----|-----|------|
| SPB | CWBPL | WPBLM | WPBLL | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | CWBPL | Command to Write Power Constant for B-Phase at Low Current | | | | | | | |
| 3 | WPBLM | Power Constant for B-Phase, Low Current – MSB | | | | | | | |
| 4 | WPBLL | Power Constant for B-Phase, Low Current – LSB | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XXXI. Byte Wise Packet Data Structure for Power Constants at Low Current for Phase C

Command to ADSST-EM-2030: 0x8A

Acknowledgment from ADSST-EM-2030: 0xBA

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|-------|--|-------|-----|-----|-----|-----|-----|------|
| SPB | CWCPL | WPCLM | WPCLL | NLV | NLV | NLV | NLV | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | CWCPL | Command to Write Power Constant for C-Phase at Low Current | | | | | | | |
| 3 | WPCLM | Power Constant for C-Phase, Low Current – MSB | | | | | | | |
| 4 | WPCLL | Power Constant for C-Phase, Low Current – LSB | | | | | | | |
| 5 | NLV | No Legal Value (0x00) | | | | | | | |
| 6 | NLV | No Legal Value (0x00) | | | | | | | |
| 7 | NLV | No Legal Value (0x00) | | | | | | | |
| 8 | NLV | No Legal Value (0x00) | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

Table XXXII. Byte Wise Packet Data Structure for Phase Compensation Coefficients

Command to ADSST-EM-2030: 0x95

Acknowledgment from ADSST-EM-2030: 0xC5

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|----------|------|--|------|------|------|------|------|-----|------|
| SPB | CWPC | WPGA | WPSA | WPGB | WPSB | WPGC | WPSC | NLV | CSUM |
| Byte No. | Name | Description | | | | | | | |
| 1 | SPB | Start Packet Byte (0xEE) | | | | | | | |
| 2 | CWPC | Command to Write Phase Compensation Coefficients | | | | | | | |
| 3 | WPGA | Phase Constant for Low Current – Phase A | | | | | | | |
| 4 | WPSA | Phase Constant for High Current – Phase A | | | | | | | |
| 5 | WPGB | Phase Constant for Low Current – Phase B | | | | | | | |
| 6 | WPSB | Phase Constant for High Current – Phase B | | | | | | | |
| 7 | WPGC | Phase Constant for Low Current – Phase C | | | | | | | |
| 8 | WPSC | Phase Constant for High Current – Phase C | | | | | | | |
| 9 | NLV | No Legal Value (0x00) | | | | | | | |
| 10 | CSUM | Checksum | | | | | | | |

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Special Data

The microcontroller sends some special commands to ADSST-EM-2030 for the special functions like dc offset calculation, initializing the energies, and resetting the calibration constants. The packet sent by the microcontroller to the ADSST-EM-2030 contains only the command byte and no data bytes. On receiving the packet of command, the ADSST-EM-2030 sends back the acknowledgment to the microcontroller by adding 0x30 to the command value. If the microcontroller does not get this acknowledgment from the ADSST-EM-2030 by 5 ms, then the microcontroller may transmit this command to write the same data again.

Table XXXIII shows special commands that can be sent to the ADSST-EM-2030 chipset by the microcontroller on the SPI communication port. The chipset sends back the acknowledgment for each command to the microcontroller. The functions that are done by the chipset are dc offset calibration, initialization of energies, and resetting the calibration constants.

Table XXXIII. Special Commands to the ADSST-EM-2030 on SPI

| Function | Command to ADSST-EM-2030 | Acknowledgment to the Microcontroller | Comment |
|---------------------|--------------------------|---------------------------------------|---|
| DC OFFSET | | | |
| Calculate DC Offset | 0x0D | 0x3D | Calculates DC Offset Constants |
| INITIALIZATION | | | |
| Energy Initialize | 0x16 | 0x46 | Initializes the Energy Values to Zero |
| RESET | | | |
| Reset Calibration | 0x18 | 0x48 | Reset the Calibration Constants to the Default Values |

Reset Calibration

To calibrate the meter using the ADSST-EM-2030, first reset the calibration. By sending a command 0x18 on the SPI to the ADSST-EM-2030, the chipset automatically resets the calibration.

Procedure

1. Power up the meter with standard voltage without any current on the current channels.
2. Send 0x18 on the SPI.

DC Offset Calibration for Voltage and Current

The dc offset calibration takes care of the dc offset that may be there in the signal path introduced by any of the front-end elements. By sending 0x0D command on the SPI communication port to the ADSST-EM-2030, the chipset performs calculation of dc offsets on the voltage and current channels and stores the coefficients in its flash memory. While the calibration is in progress, communication on SPI will not be accepted by the chipset.

Procedure

1. Power up the meter with standard voltage of all phases without any current on the current channels.
2. Send 0x0D on the SPI to perform DC offset calibration.
3. Read back the coefficients on SPI by sending 0x0E to the chipset.

Voltage Gain Calibration

The ADSST-EM-2030 enables software calibration of the voltage channels to take care of tolerances for the passive components used in the signal path.

Procedure

1. Power up the meter by setting the voltage source at 230 V on all the three phases (say V_R).

2. Send 0x01 command on the SPI to the chipset for reading the voltage constants as C_{VA} , C_{VB} , and C_{VC} .
3. The ADSST-EM-2030 will return back six bytes of voltage values for the three phases (V_A , V_B , and V_C).
4. Compute the new constants on a PC or a calculator in Hex as:

$$C'_{VA} = \frac{V_R}{V_A} \times C_{VA}$$

$$C'_{VB} = \frac{V_R}{V_B} \times C_{VB}$$

$$C'_{VC} = \frac{V_R}{V_C} \times C_{VC}$$

5. These coefficients can then be written by sending the 0x81 command to the chipset on the SPI. Refer to Table XXIII for the Write Data sequence. The coefficients are sent in the same sequence as in the Table XXIII. This automatically stores the voltage constants in the chipset's internal nonvolatile memory.
6. To verify the coefficients, send 0x01 to the chipset to receive the six bytes of data as voltage coefficients.
7. The default constants in the chipset for all the voltage channels is 0x709C.

Current Calibration

The ADSST-EM-2030 enables software calibration of the current channels to take care of tolerances for the passive components used in the signal path.

Low Gain Current Calibration

1. Power up the meter by setting the current source at 60 amps on all three phases (I_R).
2. Send 0x02 command on the SPI to the chipset for reading the current constants as: C_{IA} , C_{IB} , and C_{IC} .

- The ADSST-EM-2030 will return back six bytes of current values for the three phases: I_A , I_B , and I_C .
- Compute the new constants on a PC or a calculator in Hex as:

$$C'_{IA} = \frac{I_R}{I_A} \times C_{IA}$$

$$C'_{IB} = \frac{I_R}{I_B} \times C_{IB}$$

$$C'_{IC} = \frac{I_R}{I_C} \times C_{IC}$$

- These coefficients can then be written by sending the 0x82 command to the chipset on the SPI. Refer to Table XXIV for the Write Data sequence. The coefficients are sent in the same sequence as in the Table XXIV. This automatically stores the current constants in the chipsets' internal nonvolatile memory.
- To verify the coefficients, send 0x02 to the chipset to receive the six bytes of data as current coefficients.
- The default constants in the chipset for all the low gain current channels is 0x7000.

High Gain Current Calibration

- Power up the meter by setting the current source at 5 amps on all three phases (i_R).
- Send 0x03 command on the SPI to the chipset for reading the current constants as: C_{iA} , C_{iB} , and C_{iC} .
- The ADSST-EM-2030 will return back six bytes of current values for the three phases (i_A , i_B , i_C).
- Compute the new constants on a PC or a calculator in Hex as:

$$C'_{iA} = \frac{i_R}{i_A} \times C_{iA}$$

$$C'_{iB} = \frac{i_R}{i_B} \times C_{iB}$$

$$C'_{iC} = \frac{i_R}{i_C} \times C_{iC}$$

- These coefficients can then be written by sending the 0x83 command to the chipset on the SPI. Refer to Table XXV for the Write Data sequence. The coefficients are sent in the same sequence as in Table XXV. This automatically stores the current constants in the chipset's internal nonvolatile memory.
- To verify the coefficients, send 0x03 to the chipset to receive the six bytes of data as current coefficients.
- The default constants in the chipset for all the high gain current channels is 0x2300.

Power Calibration

The meter can now be calibrated for power for each phase. The calculation requires the default constants that are stored in the internal nonvolatile memory. Due to the chipset's in-built feature of performing automatic gain switching for the current channels, the power needs to be calibrated at low gain (i.e., high currents) and high gain (i.e., low currents). It is recommended that low gain calibration is performed at I_{MAX} and high gain calibration is performed at $I_{NOMINAL}/2$. In the present example, the meter is specified for 230 V operation with I_{MAX} at 60 amps.

Low Gain Power Calibration

The default power constant for all three phases at low gain is 0x3EE4. By sending commands such as 0x07, 0x09, and 0x0B on the SPI, the chipset will send six bytes each, corresponding to Phases A, B, and C.

Procedure

- Power up the meter after setting the voltage at 230 V, current at 60 amps and power factor at unity.
- Read the default power constants for Phase A by sending 0x07 command on the SPI. The chipset will return six bytes, giving the default constants P_{CA} for power constants for Phase A.
- Read the default constants for Phase B by sending 0x09 command on the SPI. The chipset will return six bytes, giving the default constants P_{CB} for power constants for Phase B.
- Read the default power constants for Phase C by sending 0x0B command on the SPI. The chipset will return six bytes, giving the default constants P_{CC} for power constants for Phase C.
- Read the value of power as shown by the reference meter for the three phases, say P_A , P_B , and P_C .
- If the voltage and current on the source have been set at 230 V and high current (60 amps), then the reference meter should display for each phase a value of P_{REF} . Using this, calculate new constants as:

$$P'_{CA} = P_{CA} \times \frac{P_{REF}}{P_A}$$

$$P'_{CB} = P_{CB} \times \frac{P_{REF}}{P_B}$$

$$P'_{CC} = P_{CC} \times \frac{P_{REF}}{P_C}$$

- Send command 0x87 followed by P'_{CA} value on the SPI. The chipset will accept the values and store these as power constants for Phase A. Send command 0x89 followed by P'_{CB} value and then command 0xB9 followed by P'_{CC} value. The chipset will store these power constants for Phase B and Phase C respectively.

High Gain Power Calibration

The default power constants for all three phases at high gain is 0xAA0. By sending commands such as 0x06, 0x08 and 0x0A on SPI, the chipset will send six bytes each, corresponding to Phase A, B, and C.

Procedure

- Power up the meter after setting the voltage at 230 V, current at 5 amps and power factor at unity.
- Read the default power constants for Phase A by sending 0x06 command on the SPI. The chipset will return six bytes, giving the default constants P_{CA} for Power constants for Phase A.
- Read the default constants for Phase B by sending 0x08 command on the SPI. The chipset will return six bytes, giving the default constants P_{CB} for Power constants for Phase B.
- Read the default power constants for Phase C by sending 0x0A command on the SPI. The chipset will return six bytes, giving the default constants P_{CC} for Power constants for Phase C.
- Read the value of power as shown by the reference meter for the three phases, say P_A , P_B , and P_C .

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6. If the voltage and current on the source have been set at 230 V and low current (5 amps), then the reference meter should display for each phase a value, say P_{REF} . Calculate new constants as:

$$P'_{CA} = P_{CA} \times \frac{P_{REF}}{P_A}$$

$$P'_{CB} = P_{CB} \times \frac{P_{REF}}{P_B}$$

$$P'_{CC} = P_{CC} \times \frac{P_{REF}}{P_C}$$

7. Send command 0x86 followed by P'_{CA} value on the SPI. Send command 0x88 followed by P'_{CB} value and then command 0x8A followed by P'_{CC} to save the power constants for high gain.

Phase Compensation

The ADSST-EM-2030 uses a phase compensation technique* to take care of the nonlinearities in current transformers. These are two constants, Start value (S) and Guard value (G). The start value corresponds to the phase shift that is exhibited at high current, and the guard value corresponds to the phase shift at lower currents. The default value for S is 0x08 and for G is 0x20. These constants can be read by sending command 0x15 to the chipset on the SPI. The six bytes of data from the chipset will correspond to G_A , S_A , G_B , S_B , G_C , and S_C , in the same sequence as shown in the Table XIII.

Set the current source at I_{MAX} , voltage source at $V_{NOMINAL}$, and the Phase Lag for the current ($\cos\Delta$) at 0.5. Energize the meter using the ADSST-EM-2030 chipset (MUT) and measure the error from the reference meter. Round off the error from the reference meter to the first decimal place and multiply by 10. The value thus attained may be added to start value read from the ADSST-EM-2030 chipset. So if the error is negative, then the start value will get subtracted, and if it is positive, then the start value will get added. For example:

1. Let the measured start value for Phase A be S_A
2. Percentage Error noted in the S Value be 0.22%
3. Error rounded off to the first decimal place = 0.2
4. Correction Value: $E_P = 0.2 \times 10 = 2$

Hence the correction start value will be: $S'_A = S_A + E_P$

Or set the current source at $I_{NOMINAL}/2$, voltage source at $V_{NOMINAL}$, and the Phase Lag for the current ($\cos\Delta$) at 0.5. Energize the meter using the ADSST-EM-2030 chipset (MUT) and measure the error from the reference meter. Round off the error from the reference meter to the first decimal place and multiply by 10. The value thus attained may be added to guard value read from the ADSST-EM-2030 chipset. So if the error is negative, then the guard value will get subtracted and if it is positive, then the guard value will get added. For example:

1. Let the measured start value for Phase A be G_A
2. Percentage Error noted in the G Value be -0.27%
3. Error rounded off to the first decimal place = -0.3
4. Correction Value: $E_P = -0.3 \times 10 = -3$

Hence the correction start value will be: $G'_A = G_A + E_P$

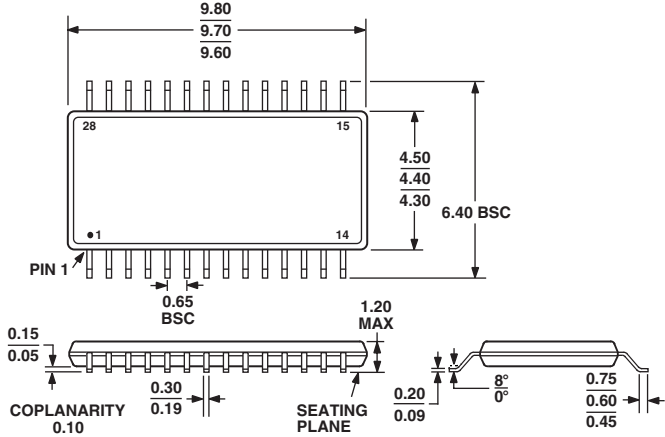
Procedure

1. Power up the meter after setting the source at 230 V and 60 amps, and power factor at 0.5.
2. Read the error shown by the reference meter. Round off the error value to the first decimal place and multiply by 10. If the error is negative, then decrease the S value (S_A , S_B , and S_C for Phase A, B, and C respectively). If the error is positive, then increase the S value.
3. Set the power source at 230 V and 5 amp. Read the error shown by the reference meter. Round off the error value to the first decimal place and multiply by 10. If the error is negative then decrease the G value (G_A , G_B , and G_C for phase A, B, and C respectively). If the error is positive, then increase the G value.
4. Send command 0x95 to the ADSST-EM-2030 chipset followed by the new sequence G'_A , S'_A , G'_B , S'_B , G'_C , and S'_C .

OUTLINE DIMENSIONS

28-Lead Thin Shrink Small Outline Package [TSSOP]
(RU-28)

Dimensions shown in millimeters



COMPLIANT TO JEDEC STANDARDS MO-153AE

