



## DS2756EVKIT+ High Accuracy Battery Fuel Gauge With Programmable Suspend Mode Evaluation Kit

[www.maxim-ic.com](http://www.maxim-ic.com)

### FEATURES

- Demonstrates the capabilities of the DS2756 High Accuracy Battery Fuel Gauge, including:
  - Programmable Suspend Mode
  - Temperature measurement
  - Voltage measurement
  - Current measurement
  - Current and Voltage Snapshot Mode
  - Current accumulation
  - Temperature and Accumulated Current Alarms
  - Information storage
  - Identification
- Interfaces to the USB port of a PC running Windows XP® or older

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- Fuel Gauging

### EVALUATION KIT CONTENTS

1 pc. TSSOP Evaluation Board  
1 pc. DS9123O USB Adapter  
1 pc. RJ-11 Phone Cable

### EQUIPMENT NEEDED

1. A PC running Windows XP or older operating system and an available USB port.
2. Cables with mini-grabber style clips or the ability to solder directly to connection pads.
3. A Lithium-Ion battery and a power supply and/or load circuit.

*Windows XP is a registered trademark of Microsoft Corp.*

### INTRODUCTION

The DS2756 evaluation kit (EV kit) makes performance evaluation, software development, and prototyping with the DS2756 High Accuracy Battery Fuel Gauge easy. The evaluation board interfaces to a PC through a DS9123O USB Adapter and RJ-11 cable connection.

The DS2756 EV kit evaluation software gives the user complete control of all functions of the DS2756. Separate control tabs allow the user access to all EEPROM and RAM memory locations, all control

registers, and real-time updates of all monitored parameters. The software also incorporates a data logging feature to monitor a cell over time and fuel gauging algorithms to improve remaining capacity calculations based on specific cell characteristics.

The evaluation board circuit is designed to provide the DS2756 with accurate parameter measurements and protect the DS2756 from ESD damage. Kit demonstration boards will vary as they are improved upon over time. For information on the demonstration board circuits refer to our website at [www.maxim-ic.com](http://www.maxim-ic.com).

## SETUP AND INSTALLATION

### BOARD CONNECTIONS

Connections to the demonstration board are best made either by soldering directly to the pads or by using cables with mini-grabber clips. Communication to the board can be accomplished by connecting the RJ-11 Jack to the DS91230 USB Adapter with the provided 6 conductor cable. Then the DQ and PAC- terminals on the RJ-11 Jack can be wired directly to the DQ and PAC- pads on the demonstration board.

Figure 1 shows the recommended circuit for the DS2756EVKIT+ demonstration board. The Lithium-Ion cell or NiMH cell stack is connected between the BAT+ and BAT- pads. If a Lithium-Ion cell is used, a protection circuit must be included between the battery and the demo board. The user system load circuit/charger is connected from BAT+ to PAC-. The evaluation software can be run with or without a load or charger as long as a cell is connected between the BAT+ and BAT- terminals providing a minimum of 2.7 volts to power the DS2756.

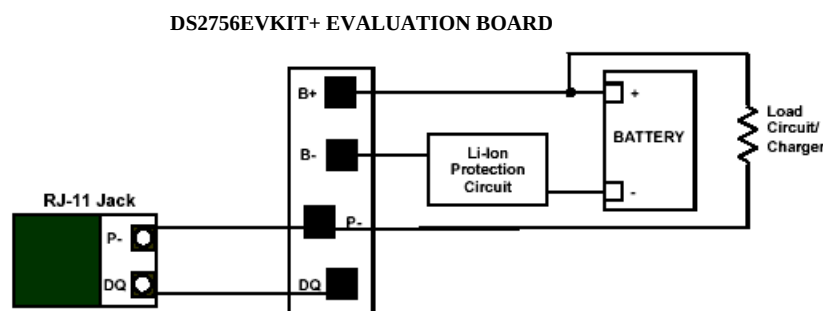


Figure 1: PD010203 Cell, Load, and Charger Connections

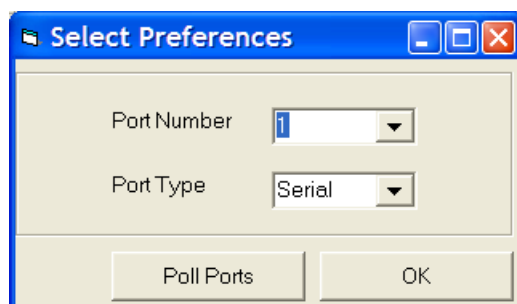
### SOFTWARE INSTALLATION

To install the DS2756 EV kit software, exit all programs currently running and download the latest version at [www.maxim-ic.com](http://www.maxim-ic.com). Unzip the compressed file and double click SETUP.EXE to begin the installation process. Follow the prompts to complete the installation. The DS2756 EV kit software can be uninstalled in the Add/Remove Programs tool in the Control Panel. After the installation is complete, open the DS2756K folder and run DS2756K.EXE or select DS2756K from the program menu. A splash screen containing information about the evaluation kit appears as the program is being loaded.

### SELECTING THE COM PORT

The first time the software runs, the Select Preferences window appears. In this window, select either serial port or USB communication and the port number; then hit OK. The DS2756 EV kit software saves this port selection and automatically uses the selection each time the program starts. To change the port

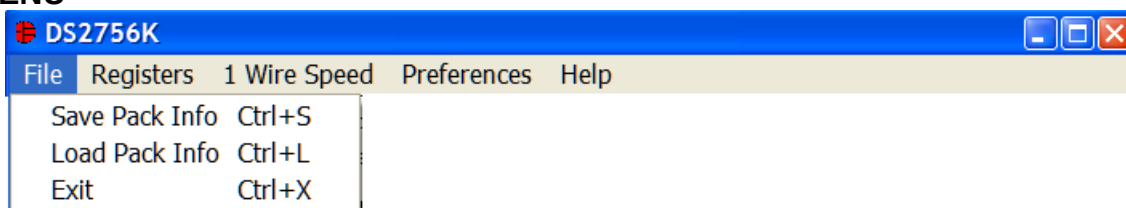
later, click the Preferences option on the menu bar, select Edit Preferences, and then select the appropriate port. To attempt to automatically locate the DS9123O, click the Poll Serial Ports button. Warning - automatically polling for the DS9123O can disrupt other devices connected to your computer's COM ports.



## MENUS

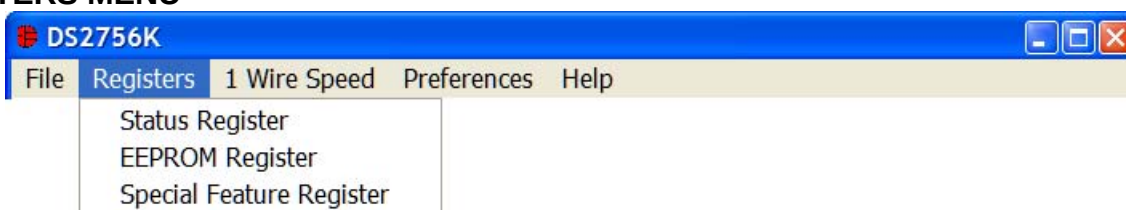
Several pull down menu options have been provided to simplify use of the DS2756 EV kit software for the user. Their functions are individually detailed below.

### FILE MENU



The File Menu allows the user to store information from a file directly into the Device Setup, Battery Data, and Fuel Gauging Data sections under the Pack Info Tab or take the same Pack Information and store to a file. These functions do not directly write or read the DS2756. It is still necessary for the user to store or recall this information to or from the device by issuing a WRITE or READ command under the Pack Info Tab.

### REGISTERS MENU



The Registers Menu gives immediate access to all three status and function registers of the DS2756. Selecting any of the registers will open an individual control window giving the user a description of each register bit and the ability to read or write it. See the status register window example.

## STATUS REGISTER

| Bit     | Register | Setting                                     |
|---------|----------|---------------------------------------------|
| Bit 6-7 | PIE      | Programmable Interrupt Enable is : Disabled |
| Bit 5   | PMOD     | Sleep Mode is : Disabled                    |
| Bit 4   | RNAOP    | Read Net Address Opcode Set to : 33h        |
| Bit 3   | UVEN     | Under Voltage Enable is : Disabled          |
| Bit 2   | IOS      | Interrupt Output Selected is : PIO method   |
| Bit 1   | OBEN     | Offset Blanking is : Enabled                |
| Bit 0   | OVD      | 1 Wire Timing is : Regular Speed            |

Buttons: Recall & Read Address 31h, Write & Copy Address 31h, Read Address 01h, Done

The present state of all register bits are displayed immediately upon opening the register window. R/W locations contain a selection field to allow the user to determine their state. Pressing the WRITE or WRITE & COPY buttons will automatically update the corresponding register inside the DS2756. The Status register has default values stored in user EEPROM location 0x31h. That window contains extra options to write or read the EEPROM location independently of the register in address 0x01h.

## 1 WIRE SPEED MENU

DS2756K

File Registers **1 Wire Speed** Preferences Help

- ✓ Regular Speed
- Overdrive Speed

The 1 Wire Speed Menu allows the user to select the appropriate 1 Wire timing. The speed the device uses is determined by the state of the OVD bit in the Status Register.

## PREFERENCES MENU

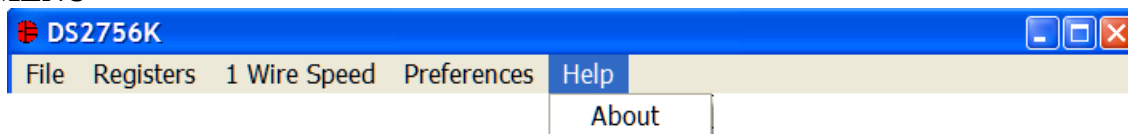
DS2756K

File Registers 1 Wire Speed **Preferences** Help

Edit Preferences

The Preferences Menu allows the user to change COM port settings at any time. Edit Preferences opens the Select Preferences window. See Selecting the COM Port above.

## HELP MENU

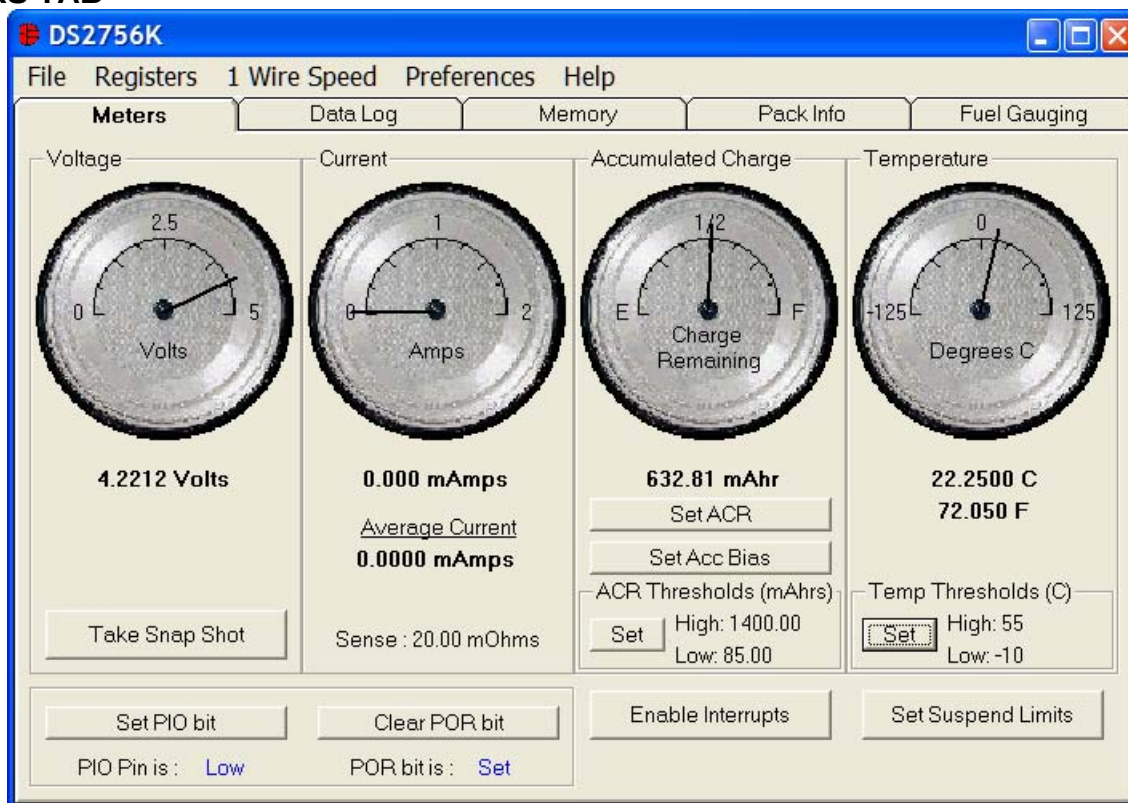


Selecting the About topic from the Help Menu will open a window containing information about this program and Dallas Semiconductor.

## PROGRAM TABS

All functions of the program are divided under five tabs in the main program window. Left click on the appropriate tab to move to the desired function page. Located under the Meters tab is all information on real-time updates measured by the DS2756: voltage, current, accumulated charge, temperature, and the status of the PIO and POR bits of the Special Feature Register. The Data Log tab allows the user to store all real time information to a file. The Memory tab displays the contents of every register and memory location inside the DS2756 and allows the user to alter the data. The Pack Information tab gives the user the ability to assign a default device configuration and store that information to the DS2756 and/or a file. The Fuel Gauging tab uses the cell characterization information stored under Pack Info to maintain a high accuracy remaining capacity indicator.

## METERS TAB



The Meters Screen displays the latest real-time measurements of cell voltage, temperature, current and accumulated charge with both analog meter readouts and digital values. The sense resistor value used to calculate the current reading is shown in the current section. Left click on it or go to the sense resistor sub-tab under Pack Info to change this value.

The user can use the Snapshot Mode of the DS2756 by left clicking on the TAKE SNAP SHOT button. This will send the Sync Function Command to the device that will take a Snap Shot of the Voltage and Current registers and hold those values. When the device is in Snapshot Mode, this button will then read RESUME. Left clicking on the RESUME button will clear the SNAP bit in the Special Feature register and allow the device to return to normal operation

The present states of the PIO bit and the POR bit of the Special Feature Register are shown at the bottom of the window. The user can toggle the value of the PIO bit by left clicking on the associated button. If the POR bit is set, the user can clear the bit by left clicking on the associated button. If the POR bit is cleared, the button will not be visible.

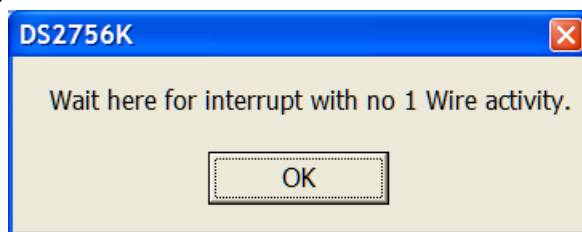
## SETTING SUSPEND THRESHOLDS

The Suspend Thresholds set the current level that the device uses to determine if it should enter and exit Suspend Mode. Left clicking on the Set Suspend Limits button will open a new window to allow the high and low Suspend limits to be entered in terms of mA. Left clicking on the Write button will write the appropriate EEPROM locations.

## SETTING INTERRUPT THRESHOLDS

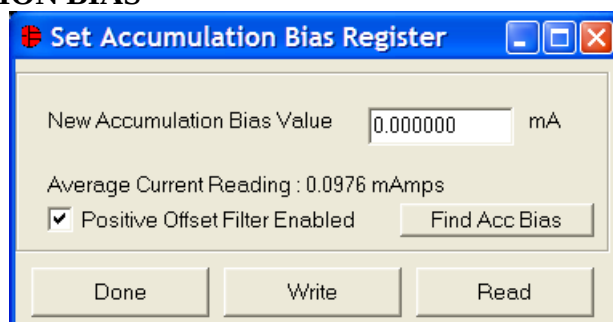
The bottom right side of the Meters Tab shows the alarm settings. Left clicking on the SET button will open a new window to allow the high and low Temperature and ACR Alarm limits to be entered in terms of degree C or mAhrs. Left clicking on the OK button will write the appropriate SRAM locations.

## ENABLING INTERRUPTS



The DS2756 can be configured in the Status Register to provide an interrupt on PIO or DQ. The Interrupts are enabled by setting the Interrupt Enable (IE) bit in the Special Feature Register. Once the Interrupts are enabled, all 1 Wire activity must stop because a 1 Wire Reset will clear the IE bit. So when the user left clicks the ENABLE INTERRUPTS button, the above message box will be displayed. As long as that message box is displayed, no 1 Wire activity is generated by the DS2756. The user must monitor the PIO or DQ pins externally to observe the interrupt when one of the alarm limits is crossed.

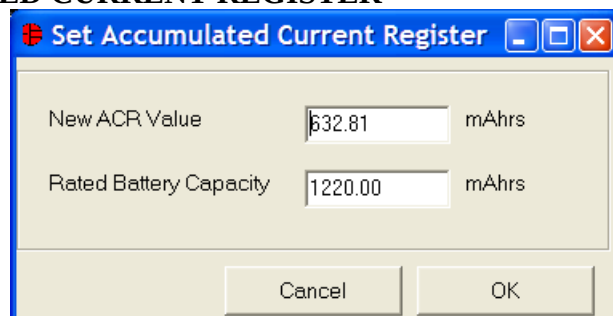
## SETTING ACCUMULATION BIAS



The user can update the Accumulation Bias Register by left clicking on the SET ACC BIAS button on the Meters Tab. That will open up the Set Accumulation Bias Register window. When the user left clicks the WRITE button the value that is entered into the New Accumulation Bias Value text box will be written to the Accumulation Bias Register (location 0x33h). This new value will be added to the current register on each conversion cycle. Clicking the WRITE button will also update the Offset Blanking Enable (OBEN) bit of the Status Register with the value of the associated checkbox.

The FIND ACC BIAS button allows the software to auto-detect the appropriate Accumulation Bias Register value based on the Average Current Reading. The auto-detection should be performed while the pack is disconnected and there is no current flow. The process takes approximately 10 seconds.

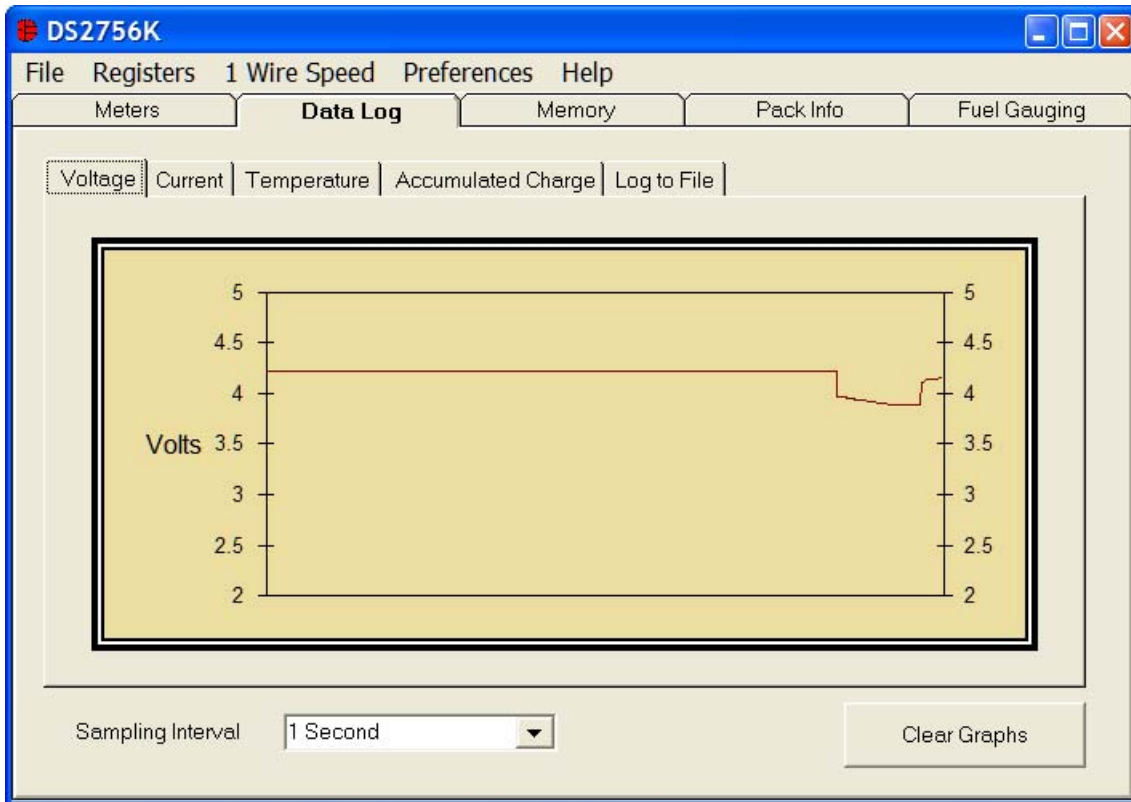
## SETTING ACCUMULATED CURRENT REGISTER



The user can bring up the Set Accumulated Current Register window by left clicking the Set ACR button of the Meters Tab. This window allows the user to enter values for the Accumulated Current Register and

Rated Battery Capacity in mAH. Rated Battery Capacity is used to determine full-scale range on the Accumulated Charge Meter. This value is stored in software only and does not affect the Fuel Gauging data.

## DATALOG TAB



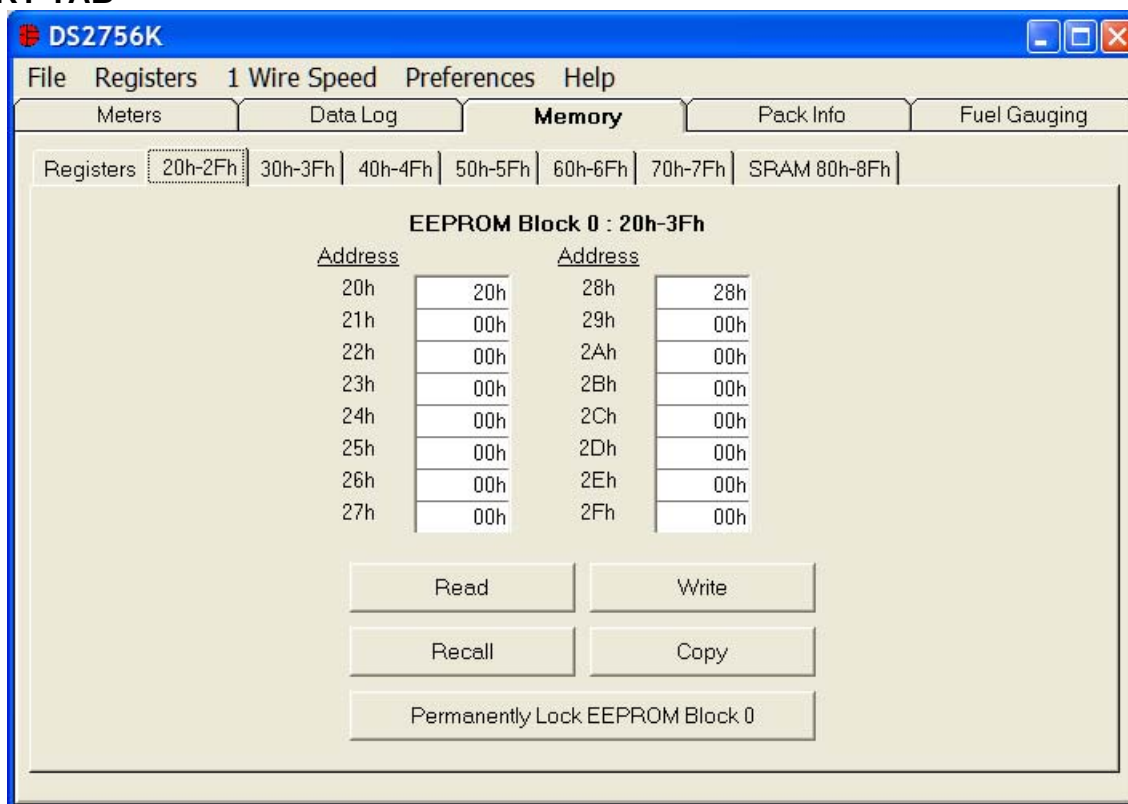
The Data log tab allows the user to see the DS2756's parameter measurements graphed over time. There are separate sub-tabs for voltage, current, temperature, and accumulated charge. Each graph displays the last 500 data points collected by the DS2756 EV kit software. The sampling interval can be adjusted from 1 second to 15 minutes and can be adjusted from the Sampling Interval Menu at the bottom of the window. The Clear Graphs button will clear all data from all four graphs, but does not reset the log to file function.

The Log to File sub-tab contains information for storing all log data to an ASCII file. The default filename is c:\DS2756K\_datalog.txt, but can be modified in the filename text field. The Log Data button toggles data logging off and on. Data will be stored at the same interval selected for updating the graphs in the tab-delimited format of

“Time<tab>Voltage<tab>Current<tab>Temperature<tab>ACR”

for easy import into a spreadsheet. The most recent 50 samples are displayed in the window for observation. Warning - The Log Data function overwrites previous file information. Data previously stored in the file will be lost.

## MEMORY TAB



The Memory Tab gives the user access to all 13 register, 96 EEPROM, and 32 SRAM bytes inside the DS2756. They are separated into eight sub-tabs for convenience. Any value can be modified by clicking in that address' text box and typing a new value in hexadecimal format. The WRITE button will copy the 16 bytes of data on the tab to the corresponding location inside the DS2756 (Scratchpad RAM on the EEPROM blocks). The READ button will update the entire tab's text boxes with data from the DS2756 (Scratchpad RAM on the EEPROM blocks). Sub-tabs displaying any EEPROM data will also have COPY and RECALL buttons to allow the user to transfer the data between Scratchpad and EEPROM memory internal to the DS2756. Each EEPROM block on the DS2756 is 32 bytes, so that Block 0 is from location 0x20 to 0x3F, Block 1 is from 0x40 to 0x5F and Block 2 is from 0x60 to 0x7F. The PERMANENTLY LOCK EEPROM BLOCK 0/1/2 buttons will permanently store the data currently located in that block's 32 bytes of EEPROM. Verify your data first by issuing a Recall and a Read on both tabs of the EEPROM block.

## PACK INFORMATION TAB

**DS2756K**

File Registers 1 Wire Speed Preferences Help

Meters Data Log Memory **Pack Info** Fuel Gauging

Device Select Register Setup Sense Resistor Battery Data Fuel Gauging Data

|               | 0 C | 10 C | 20 C | 30 C | 40 C |
|---------------|-----|------|------|------|------|
| Full Charge   | 534 | 541  | 546  | 553  | 564  |
| Standby Empty | 45  | 30   | 18   | 4    | 0    |
| Active Empty  | 122 | 90   | 56   | 29   | 15   |

Charging

|                         | 0 C | 20 C | 40 C |
|-------------------------|-----|------|------|
| Empty to Full (minutes) | 107 | 122  | 150  |
| Break to Full (minutes) | 28  | 34   | 40   |
| Break Point (mAh)       | 20  |      |      |

Read DS2756

Write DS2756

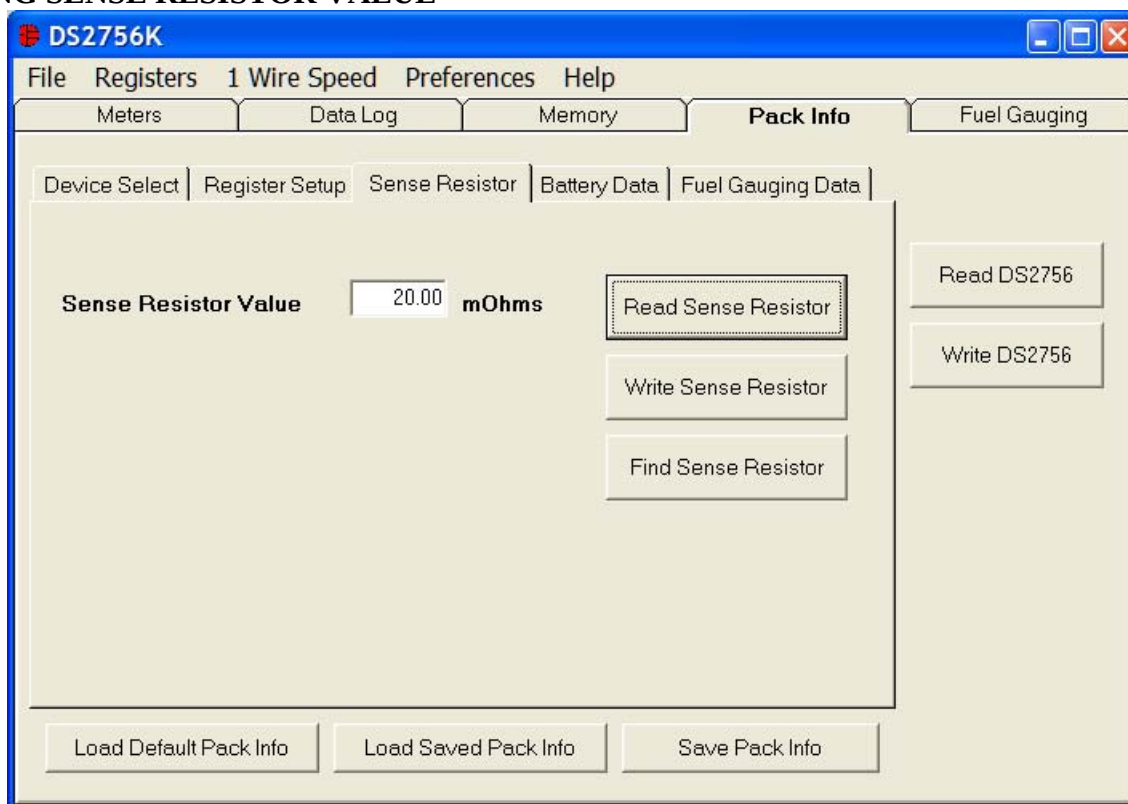
Load Default Pack Info Load Saved Pack Info Save Pack Info

The Pack Information tab gives the pack manufacturer the ability to assign default register settings, device and sense resistor selection, and recommended manufacturer data and fuel gauging information.

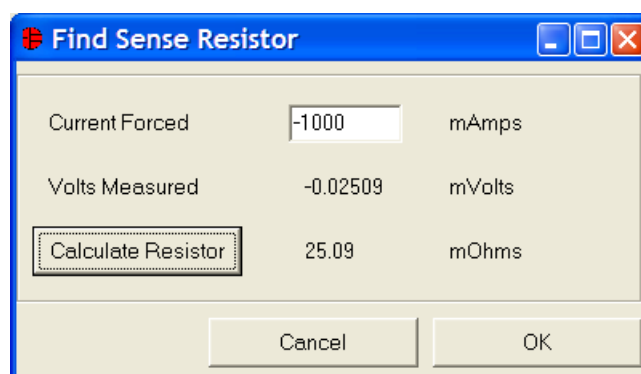
The Device Select sub-tab allows the user to choose which device on the 1-wire bus to communicate with. Clicking on the Find DS2756 Net Addresses button will begin a SEARCH NET ADDRESS operation on the 1-wire bus. All DS2756s found on the bus will be listed in the Net Addresses field. To communicate to any device on the bus, click on its address inside the Net Addresses field to select it. The program will now use this device for all operations until a different DS2756 is chosen.

The Device Setup sub-tab shows the current state of all major features of the DS2756. All status indicators shown here directly mirror their corresponding bits in the Status and Special Feature registers. Clicking on any of the status indicators will open the corresponding register window to allow editing. See Registers Menu above. The selection fields on the right hand side of the sub-tab set how the EEPROM backup bits (location 0x31h) will be programmed when the DS2756 is programmed with the pack information.

## SETTING SENSE RESISTOR VALUE



The Sense Resistor Select sub-tab allows the user to correct the current measurements if a different value of sense resistor is used. All DS2756s with an integrated sense resistor use 20mΩs. If the sense resistor is located externally, the user should select the external resistor radio button on this tab, then enter the value of the resistor in mΩs in the Sense Resistor Value field and then click the WRITE SENSE RESISTOR button.



The FIND SENSE RESISTOR button opens the Find Sense Resistor window. The user can then determine the resistance by forcing a known current and measuring the voltage drop with the DS2756. The resistance value is stored with ¼ mΩ resolution into the user EEPROM of the device. The program uses this value to convert the voltage difference from the VSENS+ and VSENS- pins into milliamps. If this value does not match the value of the external resistor, current measurements will be inaccurate.

## MEMORY MAP

The Battery Data and Fuel Gauging Data sub-tabs demonstrate how the pack manufacturer can use the DS2756s EEPROM fields to store relevant pack information such as manufacturer, chemistry, etc... The fuel gauging characterization data is used by the fuel gauging algorithms in the software. See the Fuel Gauging Tab description below. Clicking on the LOAD DEFAULT PACK INFO button will enter example data into the information fields of the Device Setup, Battery Data, and Fuel Gauging Data sub-tabs. To change any of this information, simply click on the desired text field and enter the new value. Once all data is in the desired format, click on the Write DS2756 button to copy it to the EEPROM of the DS2756. This information can also be stored to a file and recalled later using the LOAD/SAVE PACK INFO buttons.

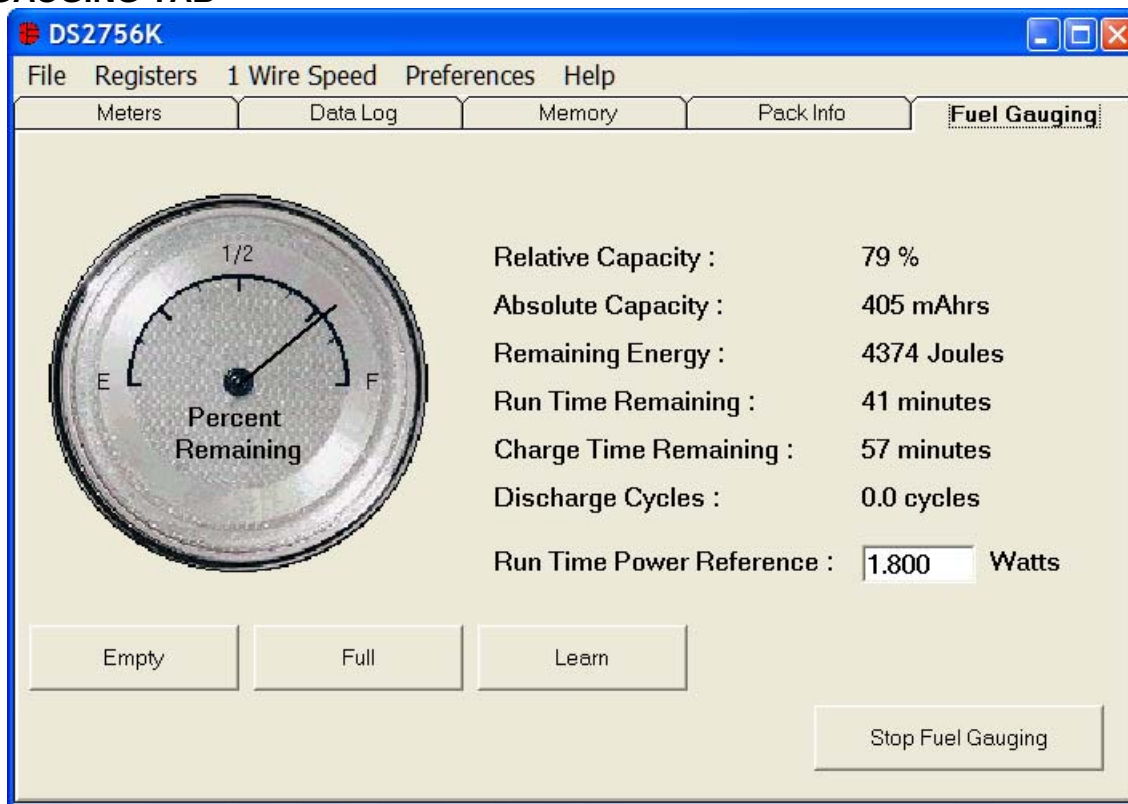
### MEMORY MAP OF PACK INFORMATION DATA

|           |      |                                                                 |       |      |  |
|-----------|------|-----------------------------------------------------------------|-------|------|--|
| Addresses | 0x20 | Fuel Gauging – Full Point at 0°C                                |       |      |  |
|           | 0x21 |                                                                 |       |      |  |
|           | 0x22 | Fuel Gauging – Full Point difference from 10°C to 0°C           |       |      |  |
|           | 0x23 | Fuel Gauging – Full Point difference from 20°C to 10°C          |       |      |  |
|           | 0x24 | Fuel Gauging – Full Point difference from 30°C to 20°C          |       |      |  |
|           | 0x25 | Fuel Gauging – Full Point difference from 40°C to 30°C          |       |      |  |
|           | 0x26 | Total Accumulated Discharge – Divided by 20 to store in 2 bytes |       |      |  |
|           | 0x27 |                                                                 |       |      |  |
|           | 0x28 | Fuel Gauging – Age Scalar                                       |       |      |  |
|           | 0x29 |                                                                 |       |      |  |
|           | 0x2A | Fuel Gauging – Time from Break Point to Full at 40°C            |       |      |  |
|           | 0x2B | Fuel Gauging – Time from Break Point to Full at 20°C            |       |      |  |
|           | 0x2C | Fuel Gauging – Time from Break Point to Full at 0°C             |       |      |  |
|           | 0x2D | Fuel Gauging – Time from Empty to Full at 40°C                  |       |      |  |
|           | 0x2E | Fuel Gauging – Time from Empty to Full at 20°C                  |       |      |  |
|           | 0x2F | Fuel Gauging – Time from Empty to Full at 0°C                   |       |      |  |
|           | 0x30 | Sense Resistor (1/4mΩ resolution)*                              |       |      |  |
|           | 0x31 | PMOD                                                            | RNAOP | SWEN |  |
|           | 0x32 | Fuel Gauging – Charge Estimation Break Point in mAH             |       |      |  |
|           | 0x33 | Current Offset – Do not overwrite                               |       |      |  |
|           | 0x34 | Discharge Suspend Threshold                                     |       |      |  |
|           | 0x35 | Charge Suspend Threshold                                        |       |      |  |
|           | 0x36 | Date Code                                                       |       |      |  |
|           | 0x37 | Fuel Gauging – Standby Empty Point difference from 0°C to 10°C  |       |      |  |
|           | 0x38 | Fuel Gauging – Standby Empty Point difference from 10°C to 20°C |       |      |  |
|           | 0x39 | Fuel Gauging – Standby Empty Point difference from 20°C to 30°C |       |      |  |
|           | 0x3A | Fuel Gauging – Standby Empty Point difference from 30°C to 40°C |       |      |  |
|           | 0x3B | Fuel Gauging – Active Empty Point difference from 0°C to 10°C   |       |      |  |
|           | 0x3C | Fuel Gauging – Active Empty Point difference from 10°C to 20°C  |       |      |  |
|           | 0x3D | Fuel Gauging – Active Empty Point difference from 20°C to 30°C  |       |      |  |
|           | 0x3E | Fuel Gauging – Active Empty Point difference from 30°C to 40°C  |       |      |  |
|           | 0x3F | Fuel Gauging – Active Empty Point at 40°C                       |       |      |  |

The memory map above shows the format in which the data is stored within the device.

\* The FuelPack algorithm expects the sense resistor value will be stored in address 0x34h of the UserData.Memory array that is passed to the algorithm. However, in EEPROM, that location is defined in the DS2756 to be the Discharge Suspend Threshold and the sense resistor is stored in EEPROM Memory location 0x30h as shown in the Memory Map. In order for the FuelPack algorithm to correctly calculate the remaining capacity, the user must copy the value of the sense resistor register (EEPROM Memory Address 0x30h) into the UserData.Memory(0x34h) prior to passing the structure to the FuelPack algorithm. The DS2756 EV kit software automatically performs this operation.

## FUEL GAUGING TAB

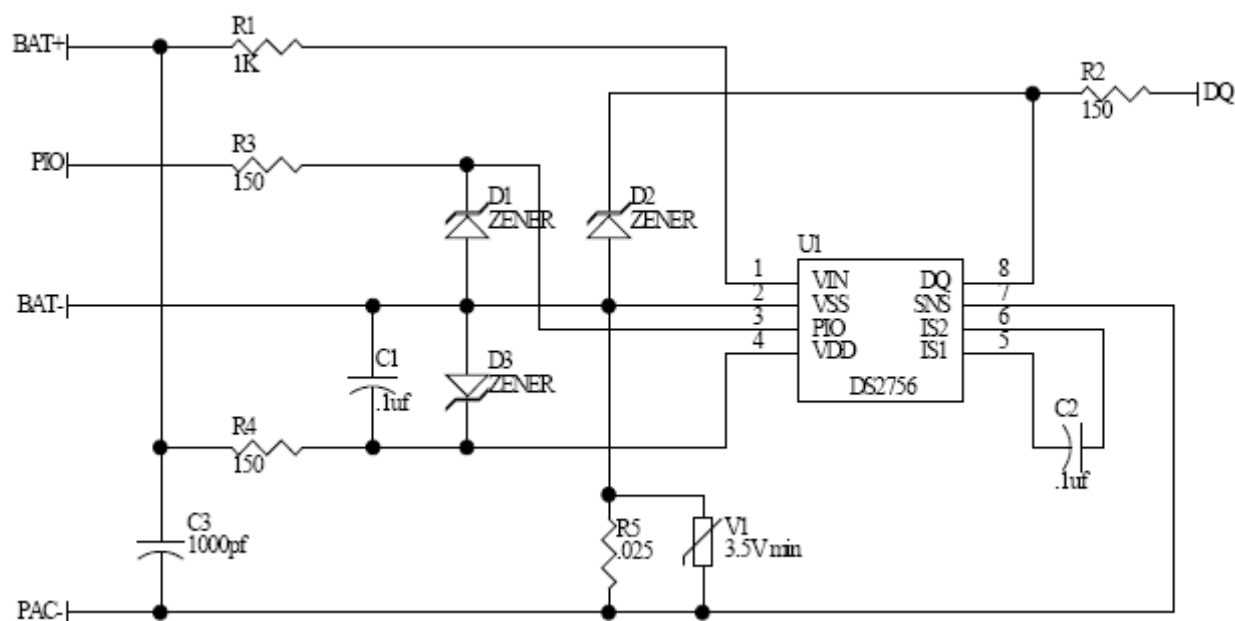


The final program tab performs a high accuracy calculation of remaining cell capacity using Dallas Semiconductor's fuel gauging algorithms. For this feature to function properly, cell characterization data must be stored in the DS2756's user EEPROM. See the Pack Information section above. If characterization data cannot be found, the fuel gauge will not start and an error message will be displayed. The Relative Capacity number represents what percentage of cell capacity is remaining based on present algorithm inputs such as temperature, discharge rate, etc... This value is also reflected in the analog meter. The remaining cell capacity is also displayed in terms of milliamp-hours and Joules under Absolute Capacity and Remaining Energy respectively.

The remaining run time is calculated using the Run Time Power Reference input from the user. Instantaneous current measurements in the user's application can vary greatly. By using a reference scalar instead of actual current and voltage measurements, the program produces a stable estimation of remaining run time. The user should enter the largest expected power draw from the device into the Run Time Power Reference field for the most accurate estimation.

If this example were part of a fully integrated fuel gauging system, the algorithms would need to be updated by the host each time the cell was fully charged or discharged in order to maintain long term accuracy. To simulate this, the user should click the EMPTY or FULL buttons each time the monitored

pack is completely charged or discharged. The EMPTY button will reset the Accumulated Current Register to the expected empty point based on present conditions. The FULL button will set the Accumulated Current Register to the expected full point based on present conditions. The LEARN button will reset the expected full point to the present Accumulated Current Register value and update the fuel gauging information in the DS2756's user EEPROM. In doing this, the algorithms "learn" from previous results and are more accurate in the future. This tab gives an example only of fuel gauging. For more information on the process of high accuracy fuel gauging consult Dallas Semiconductor's fuel gauging application notes.



**REVISION HISTORY**

| <b>REVISION<br/>DATE</b> | <b>DESCRIPTION</b>                                    | <b>PAGES<br/>CHANGED</b> |
|--------------------------|-------------------------------------------------------|--------------------------|
| 9/09                     | Changed the part number from DS2756K to DS2756EVKIT+. | All                      |