

## Abstract

This application note discusses the monitoring of crucial motor control parameters with a Z16FMC MCU using Zilog's MultiMotor Series Development Kit. Depending on the application, motor control parameters must be monitored to assure motor operation within safety margins. The application discussed in this document monitors certain motor control parameters to meet these safety requirements. These motor parameters are intended to provide potential data to a data logger program so that other parameters not discussed herein can be added by the user. Such a data logger records data in a Standalone or Terminal mode; this data can be requested at any time during motor operation.

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- **Note:** The source code files associated with this application note, [AN0353-SC01.zip](#), [AN0354-SC01.zip](#), [AN0355-SC01.zip](#), and [AN0356-SC01.zip](#), are available for download on Zilog.com. All source code has been tested with version 5.0.1 of ZDSII for ZNEO-powered MCUs. Subsequent releases of ZDSII may require you to modify the code supplied with this application note.
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## Features

This Z16FMC MultiMotor Series application offers the following features:

- Temperature monitoring
- Over/under voltage monitoring
- Total motor run time reporting
- Speed reporting
- Forward/reverse reporting

## Discussion

BLDC motors find increasing use in the automotive, white goods, telecommunications, and in industrial applications industries. Due to their reliability, efficiency, and safety concerns, each of these industries requires a high degree of control over a brushless motor, plus a requirement for more or better motor parameter monitoring to assure safe operation. This document describes the motor monitoring process. Parameters can be monitored in Hardware (Standalone) Mode and in UART Terminal Mode, and are reported upon request in a GUI. Refer to the Application Note titled [Implementing a Data Logger with Spansion SPI Flash \(AN0360\)](#) for additional details on the storage and retrieval of the data.

To provide an example, ball bearings and electrolytic capacitors are typically the limiting components over the lifetime of a motor and its driver electronics. Knowing the actual run time of a BLDC motor helps to determine the remaining lifetime of the motor and its driver electronics.

In an overcurrent event, the Z16FMC MCU's on-chip comparator causes a hard shutdown of the PWM to protect the motor and its electronics from damages that can occur.

All other parameters are monitored and recorded in an external Flash memory device for faster write and read cycles, and are reported to the user. Upon entering a `D` command followed by the Enter key, the user can cause the external Flash data to be dumped and displayed in the GUI. If the user wishes to stop the data listing, press `Ctrl+C`.

The application allows users to switch from UART motor control to hardware motor control and back. The sensorless firmware operates the motor in a closed-loop routine only, whereas the PWM sine driver, Hall sensor, and space vector modulation firmware<sup>1</sup> can operate the motor in open- or closed-loop routines. The reporting of all motor parameters can be requested at any time while the motor is running or is stopped.

## Theory of Operation

Appliance controllers almost invariably monitor motor speed by sensing the current through the windings, and using sensor and sensorless techniques in conjunction with the ADC. Ordinarily, sampling instances by the ADC are synchronized by the MCU. With this process, an external operational amplifier is often used to convert the current signal to a voltage signal; the ADC next samples the voltage signal and outputs the result to the processor. The processor then synthesizes the PWM outputs to control motor speed. In the case of Zilog's Z16FMC Family of Microcontrollers, an on-chip integrated operational amplifier eliminates the requirement for an external component, thereby reducing overall system cost.

In conjunction with the ADC peripheral, the Z16FMC MCU features a flexible PWM module with three complementary pairs – or six independent PWM outputs – supporting deadband operation and fault protection trip input. These features provide multiphase control capability for a variety of motor types, and ensure safe operation of the motor by providing an immediate cycle-by-cycle hard shutdown of the PWM pins during a fault condition, with a programmable selection for hardware or software recovery. In this application, a user interface informs the user of the critical motor parameters upon request via the GUI.

The firmware records the motor parameters in five-second intervals in the external on-board Flash using SPI serial communication. Upon entering the `D` command followed by the Enter key, the user can dump any stored data and display it in the GUI.

The data being monitored are briefly described below.

**Over and Under Voltage Monitoring.** Operating voltages can fluctuate; the firmware monitors the supply voltage of the BLDC motor and reports the possible over- and under-voltage conditions.

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1. Provided in the AN0353-SC01, AN0354-SC01, AN0355-SC01, and AN0356-SC01 source code files, respectively.

**Temperature Monitoring.** The firmware monitors the temperature during the motor operation and can report the value.

**Total Motor Run Time.** Total motor run time can be useful toward determining the remaining lifetime of ball bearings and electrolytic capacitors or to identify other potential maintenance tasks.

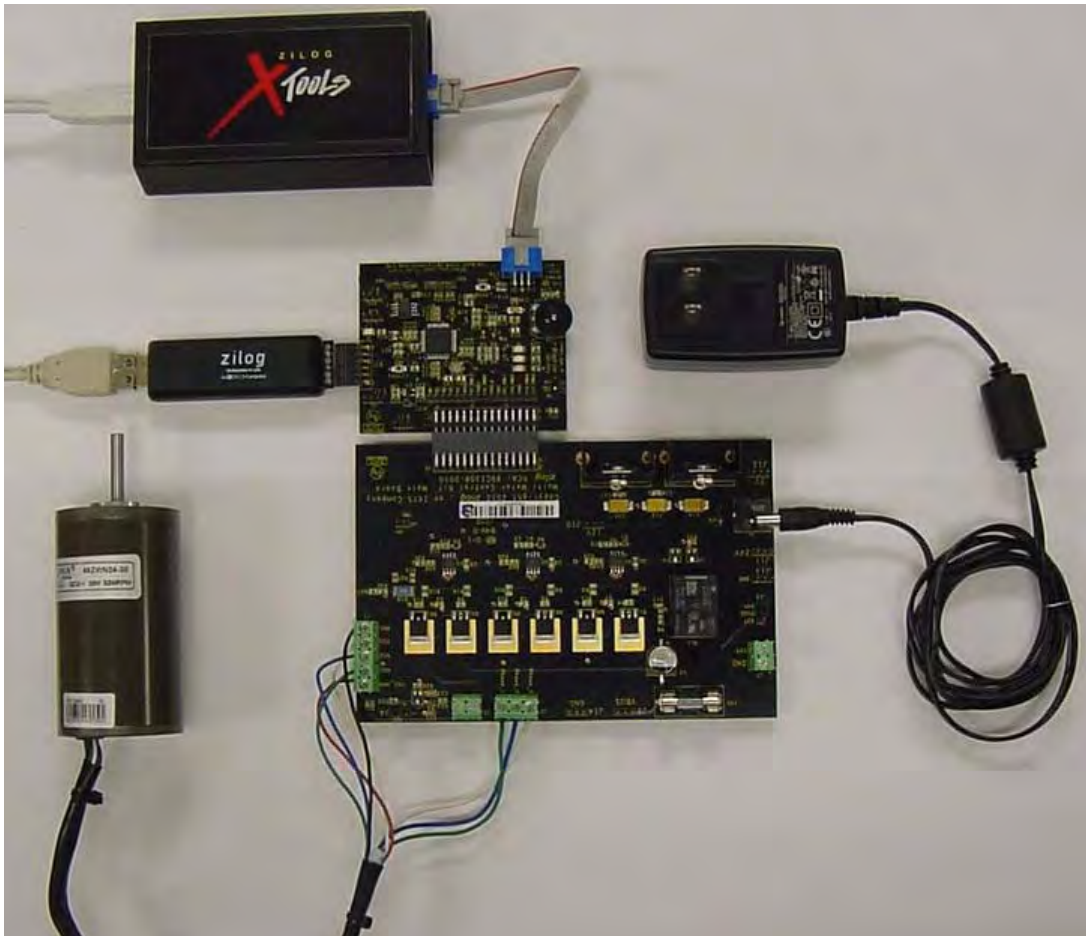
**Speed Reporting.** Depending on the application in which the motor is used, obtaining the motor speed can be set at any time.

**Motor Spin Direction Reporting.** Motor spin direction is always displayed in the GUI, in either Standalone or Terminal modes.

## Testing

The code supporting this MultiMotor Series application was developed and tested with Zilog's MultiMotor Series Development Kit, which features the Z16FMC2810 MCU.

Figure 1 shows a fully-assembled MultiMotor Series Development Kit.



**Figure 1. The MultiMotor Series Development Kit**

The AN0353-SC01, AN0355-SC01, and AN0356-SC01 firmware files discussed earlier have been tested with Linux BLDC motor included in the MultiMotor Series Development Kit. The Field Oriented Control firmware, AN0354-SC01, has been tested with an ACIM machine, which is not included in the MultiMotor Series Development Kit.

## Testing Procedure

The code supporting this MultiMotor Series application was developed and tested with Zilog's MultiMotor Series Development Kit featuring the Z16FMC MCU Module. Observe the following procedure to test the driving schemes of the motor. Refer to the [MultiMotor Series Development Kit Quick Start Guide \(QS0091\)](#) for additional details.

1. Connect the Linux BLDC motor to the MultiMotor Series Development Board.

Halls:

- BLK to GND
- WHT to HSA
- BLU to HSB
- GRN to HSC
- RED to  $V_{CC}$

Phases:

- WHT to Phase A
- BLU to Phase B
- GRN to Phase C

2. Connect the Z16FMC MCU Module to the MultiMotor Series Development Board.
3. Connect the optoisolated UART-to-USB adapter and cable between Jumper J19 on the Z16FMC MCU Module and the host PC.
4. Connect the optoisolated USB SmartCable between Jumper J14 on the Z16FMC MCU Module and the host PC.
5. Connect the 24V DC power supply to the MultiMotor Series Development Board at connector P1, then plug the power supply into an electrical outlet.
6. Launch the ZDSII – ZNEO v5.0.1 application and select your choice of motor driver firmware by navigating via the **File** menu in ZDSII to select **Open Project**. Next, navigate to the directory into which you copied the source code files you downloaded from the Zilog website, and double-click the appropriate `.zdsproj` project file to open it. See the example in Figure 2.

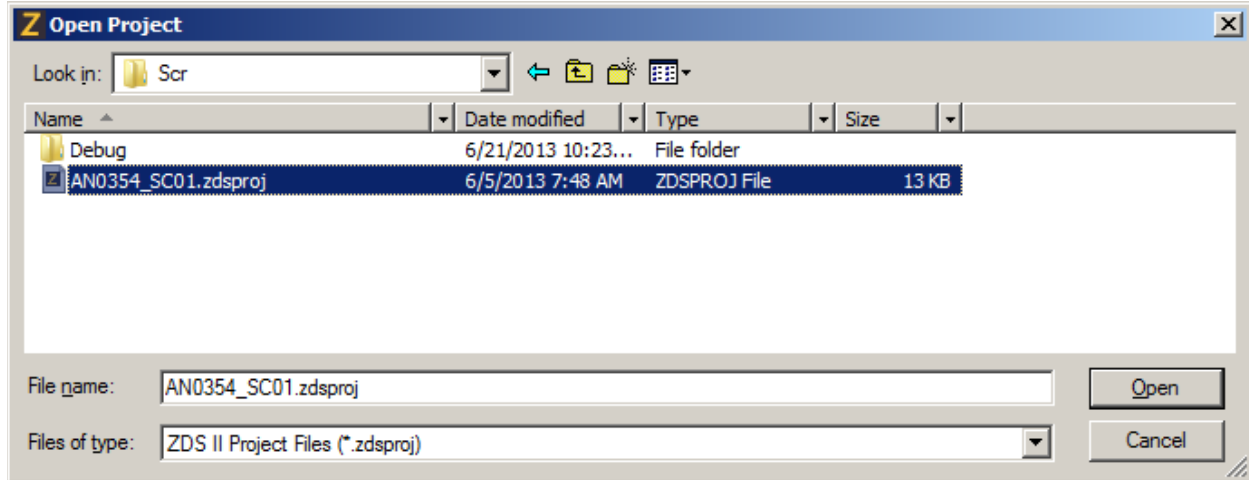


Figure 2. Example: Selecting a Project File in ZDSII

7. Compile the motor driver firmware by selecting **Compile** from the **Build** menu in ZDSII.
8. From the **Debug** menu in ZDSII, select **Reset**, then click **Go**.
9. Using a serial terminal emulation program such as HyperTerminal, TeraTerm, or RealTerm, configure the serial port to 57600-8-N-1-N. A typical example of multimotor operation under UART control using RealTerm is shown in Figure 3; this example is discussed more fully in the [Space Vector Modulation of a 3-Phase AC Induction Motor with the Z16FMC MCU Application Note \(AN0354\)](#).

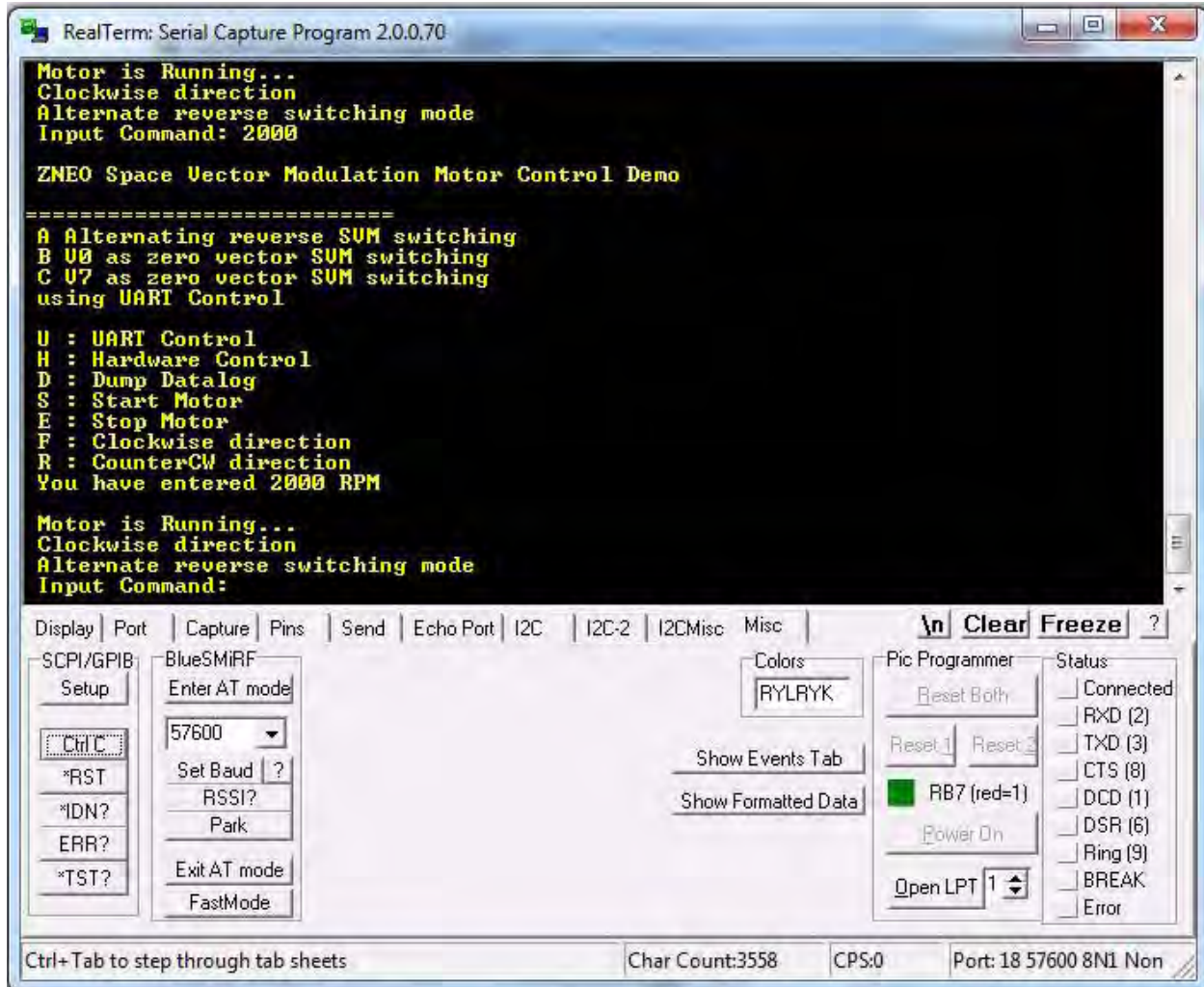


Figure 3. An Example Data Display



10. In the **Scrollback** drop-down menu in the **Display** tab, select 1000 lines, as indicated in Figure 4.

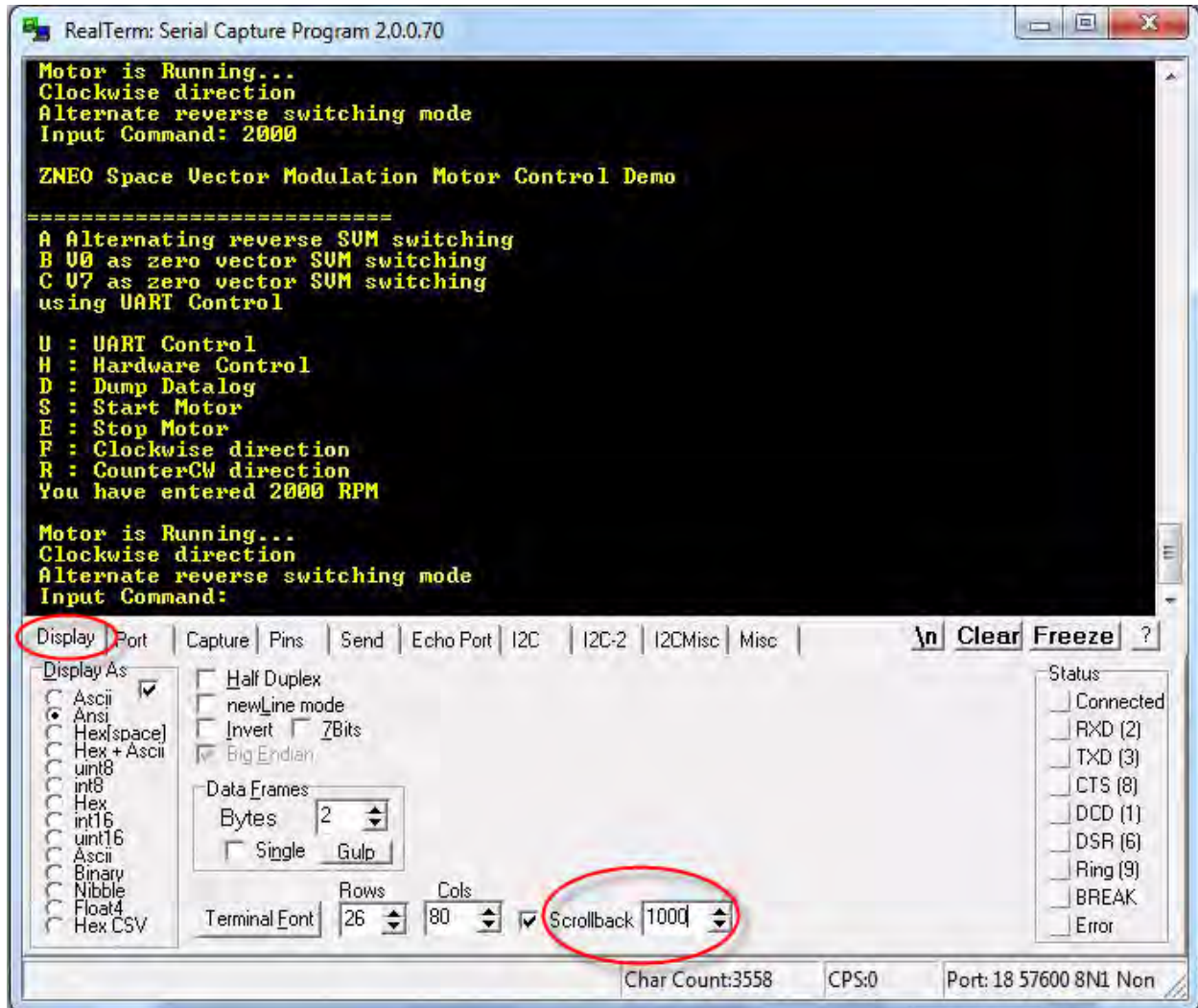


Figure 4. Select 1000 in the Scrollback Window Under Display Tab

11. In the RealTerm window, select the **Miscellaneous** tab, as indicated in Figure 5.

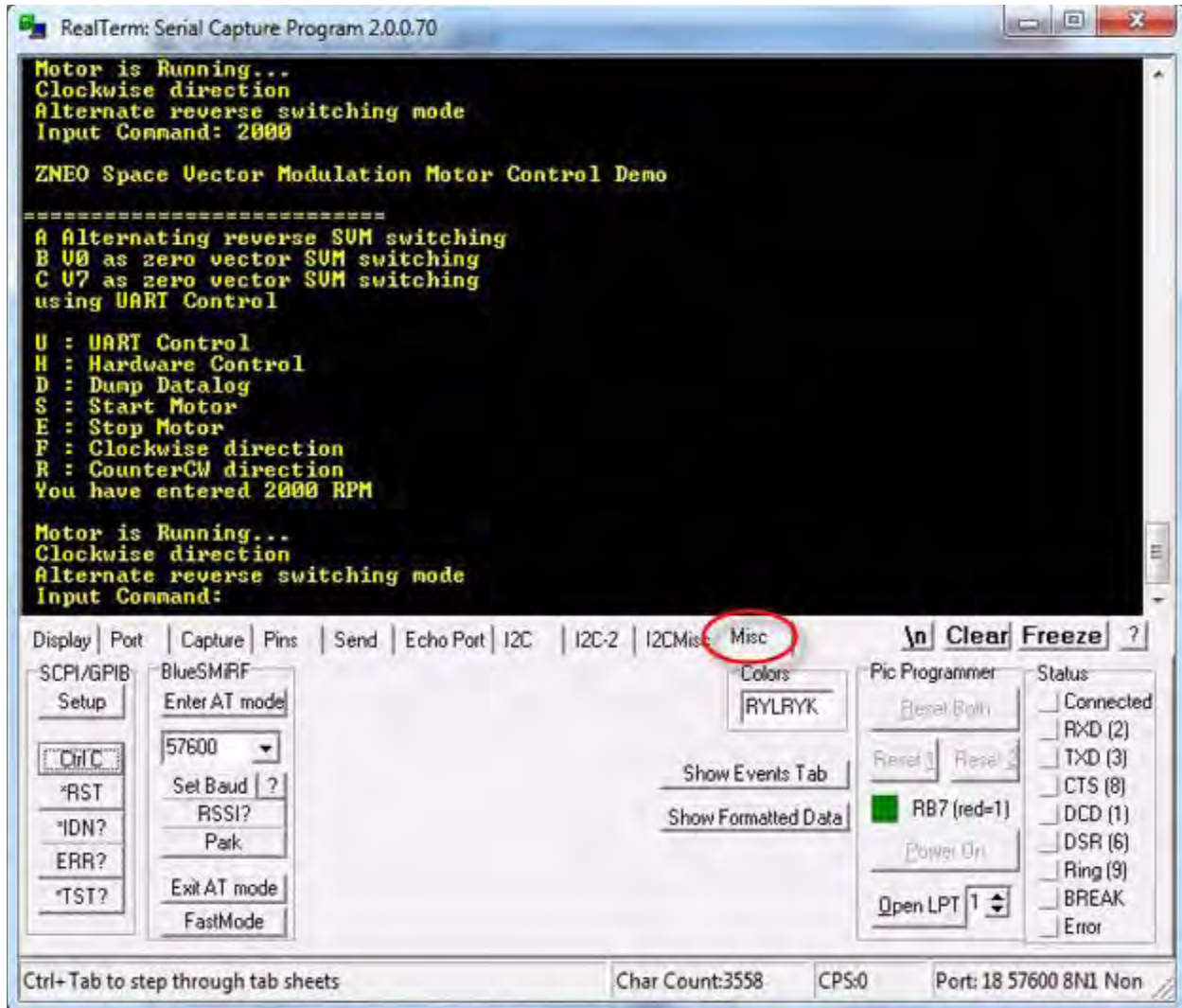


Figure 5. Select the Miscellaneous Tab

12. If you have selected Hardware (Standalone) Mode, set the Start/Stop switch to **Run** on the MultiMotor Series Development Board.



- At the Input Command: prompt in the RealTerm window, enter the character d and press Enter to dump the data from the data logger, as indicated in Figure 6.

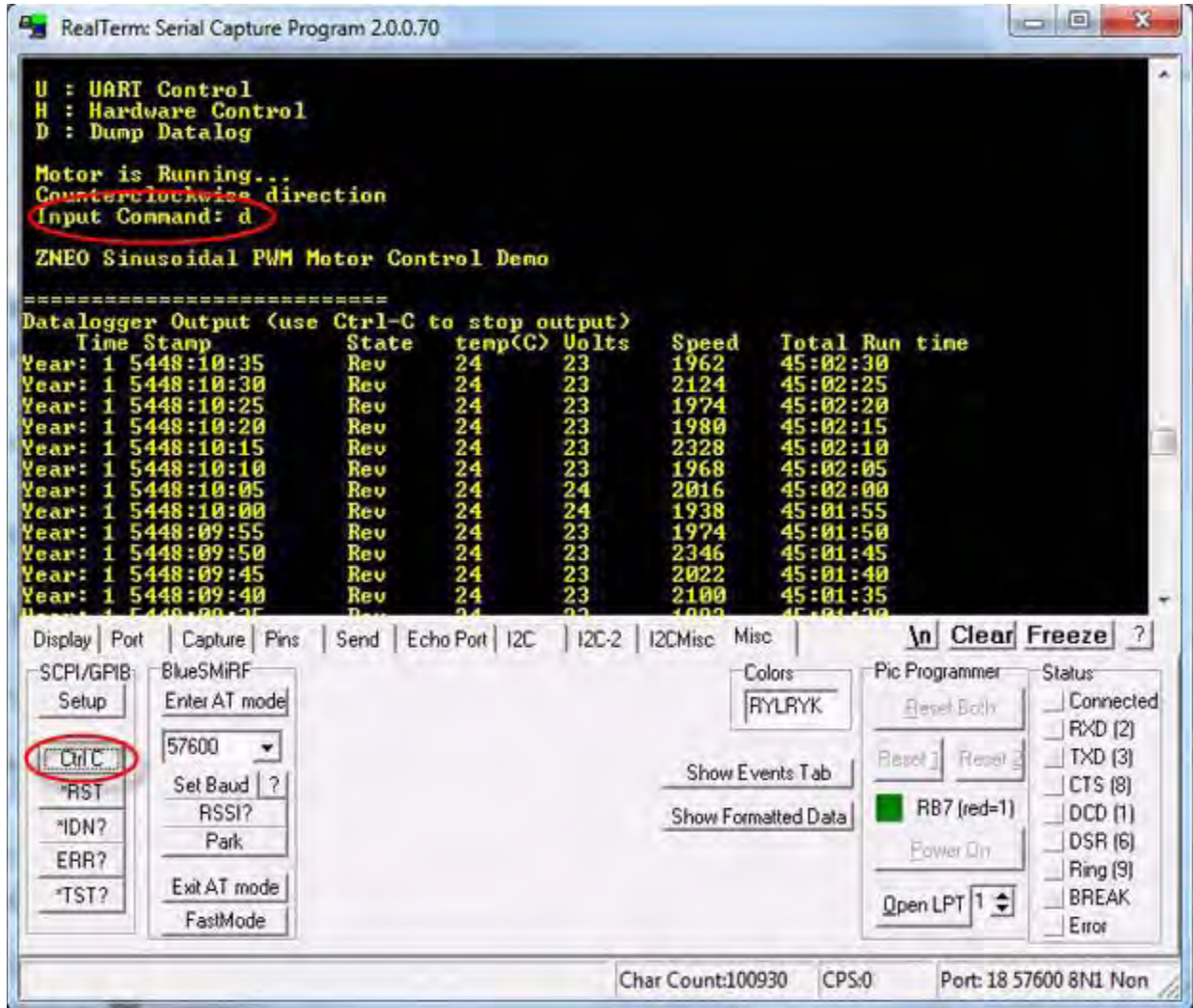


Figure 6. Commands for Viewing Logged Data

14. Click the **Ctrl+C** button, as indicated in Figure 6, to halt the data dump and view the logged data, which is shown in Figure 7.

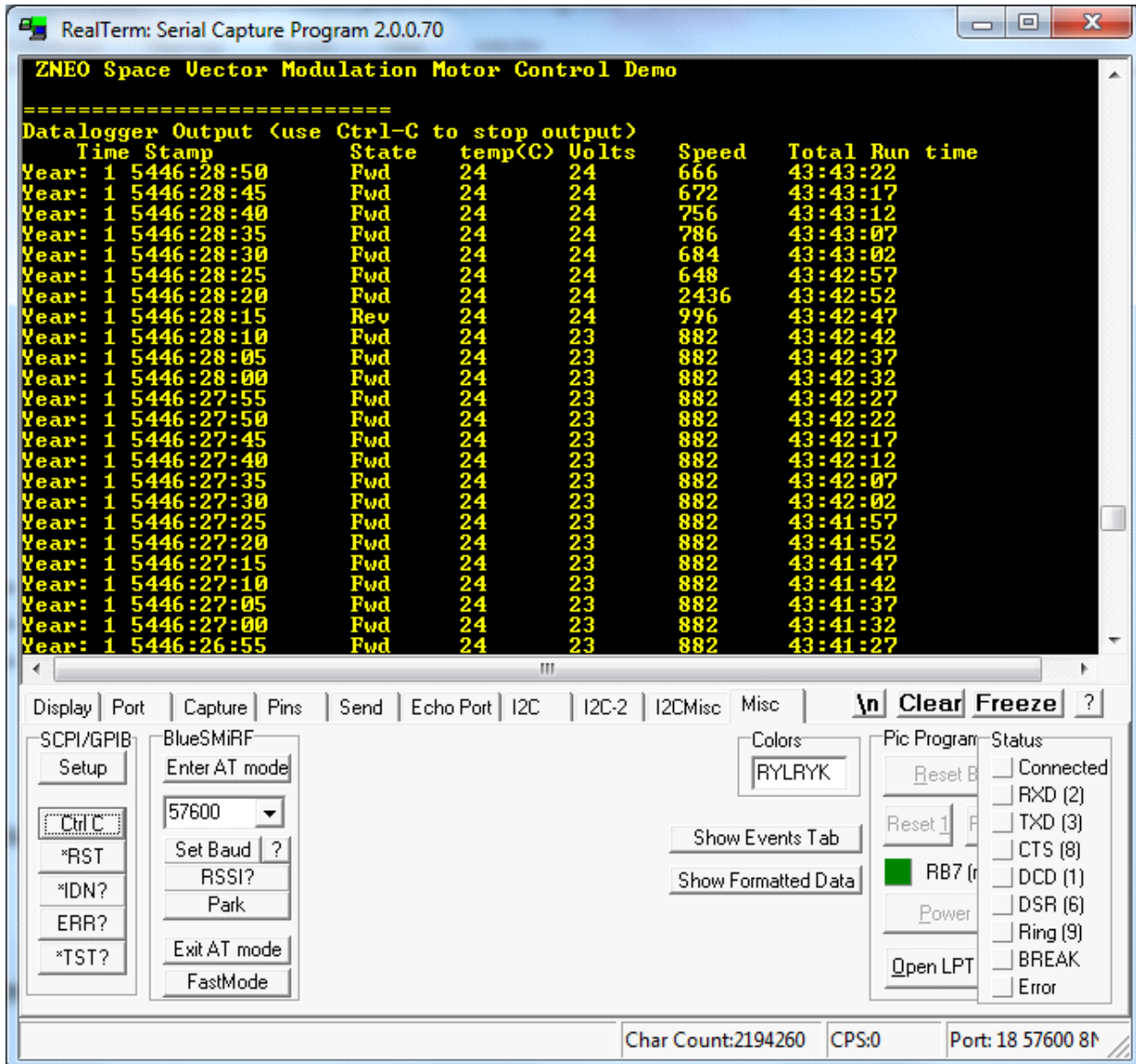


Figure 7. Logged Data Displayed in the RealTerm Terminal

## Results

The RealTerm terminal displays the results of monitoring the following data:

- Motor spin direction
- Temperature

- $V_{BUS}$
- Speed

## Summary

Monitoring vital motor control parameters enables the user to view a motor's operations to assess operating conditions and to determine its potential lifetime margins and maintenance schedules. The motor that is included in the MultiMotor Series Development Kit can operate within the following four different driving schemes:

- Space Vector Modulation
- Sinusoidal PWM Modulation
- 3-Phase Sensorless Mode
- 3-Phase Hall Sensor Mode

Each of these four BLDC motor operating modes monitors the following parameters:

- Temperature monitoring
- Over/under voltage monitoring
- Total motor run time reporting
- Speed reporting
- Forward/reverse reporting

The parameters listed above are just five examples of the potential parameters that can be created and modified using this application, as defined by the user.

In all driving schemes, the user can choose to control and monitor the motor in Terminal Mode or Standalone Mode and to log the motor parameters and indicate this logged data.

## References

The following documents are associated with the Z16FMC Series of Motor Control MCUs; each is available for download from the Zilog website.

- [Z16FMC Series Motor Control MCU Product Specification \(PS0287\)](#)
- [MultiMotor Series Development Kit Quick Start Guide \(QS0091\)](#)
- [MultiMotor Series Development Kit User Manual \(UM0262\)](#)
- [ZNEO CPU Core User Manual \(UM0188\)](#)
- [Sensorless Brushless DC Motor Control with the Z16FMC MCU \(AN0353\)](#)
- [FOC Vector Control of a 3-Phase AC Induction Motor Application Note \(AN0354\)](#)

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- [BLDC Motor Control Using Sensored Sinusoidal PWM Modulation with the Z16FMC MCU \(AN0355\)](#)
  - [Three-Phase Hall Sensor BLDC Driver Using The Z16FMC MCU Application Note \(AN0356\)](#)
  - [Implementing a Data Logger with Spansion SPI Flash Application Note \(AN0360\)](#)
  - [Zilog Developer Studio II – ZNEO User Manual \(UM0171\)](#)

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