Application Report

Motor Module Design for IP Network Camera Based on MSP430FR2155

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ABSTRACT

Motor control module for Internet Protocol (IP) camera is discussed in this application report. The design provides a solution to automatically control camera's focus, tilt, and iris.

The motor module includes an MSP430FR2155 microcontroller (MCU), a DRV8837C or DRV8210P brushed DC motor driver, and DRV8428 stepper motor driver. The size of the module is 52 mm x 63 mm, excluding the motor, making it ideal for applications that require small size. Several configuration options allow for easy control over the speed of rotation, direction of rotation, position of the stepper motor, decay modes for ultra-smooth and quiet motion profile, and low-power state to reduce power consumption. The motor drive stage has an integrated over-current protection, short-circuit protection, under-voltage lockout, and over-temperature protection.

Project collateral discussed in this document can be downloaded from the following URL: https://www.ti.com/lit/zip/slaae27.

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1 Introduction

Video surveillance cameras are ubiquitous for commercial building security and are becoming more prevalent in home security systems. An IP network camera is a type of video surveillance camera with networking and video processing combined into one unit. It captures and transmits live images over the network enabling remote viewing and control from anywhere at any time. The camera must support user controlled focus, tilt, and iris to maximize coverage.

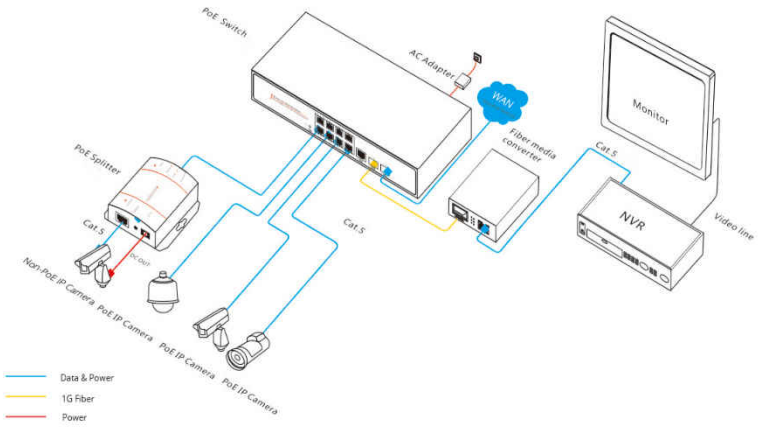

Figure 1-1. Block Diagram for IP Network Camera

IP network cameras can be used to monitor an entire area by manual or electronic motorized control of direction and angle. The camera may tilt up and down or swivel to the left and right, preferably with less vibration and noise. It uses motorized control of camera lens for zoom and focus functions to allow for image clarity and better field of view. Such fine movements use stepper motors driven as open loop systems with no sensors required for position and speed control.

Camera iris control adjusts the amount of light that comes through the lens. If the iris creates a larger opening, more light can get through; a smaller opening allows less light through. The light that the iris allows through hits the image sensor and that light gets recorded as electrical impulses that create the video. Iris control is motorized using simple brushed DC motors to automatically adjust the iris opening.

Figure 1-2. IP Network Camera

2 Design Description

Figure 2-1 and Figure 2-2 show the block diagram and the PCB design of the motor module based on MSP430 and motor drivers to control the focus, tilt, and iris for an IP network camera.

The motor module operates from an external 5 V, 2 A power supply input. MSP430FR2155 communicates with the motor drivers to generate the control signals for their operation. Two DRV8428 drive stepper motors each for focus and tilt control and a DRV8837C drives a DC motor for iris control. TLV742P LDO generates 3.3 V supply from the 5 V input for logic operations of MSP430FR2155 and motor drivers.

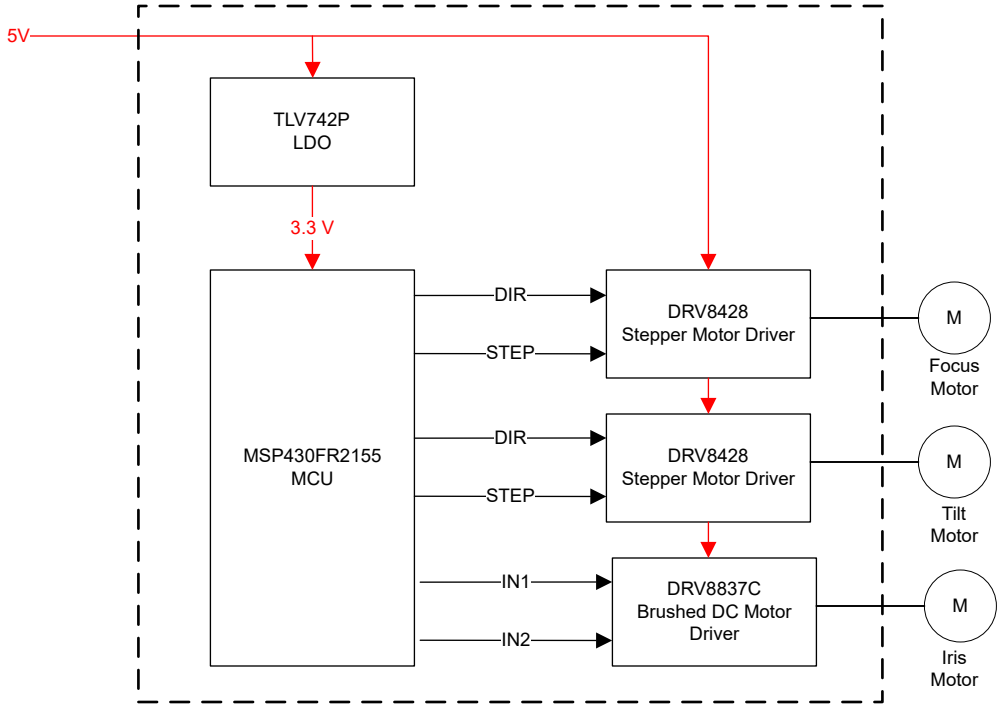

Figure 2-1. Block Diagram of Motor Module

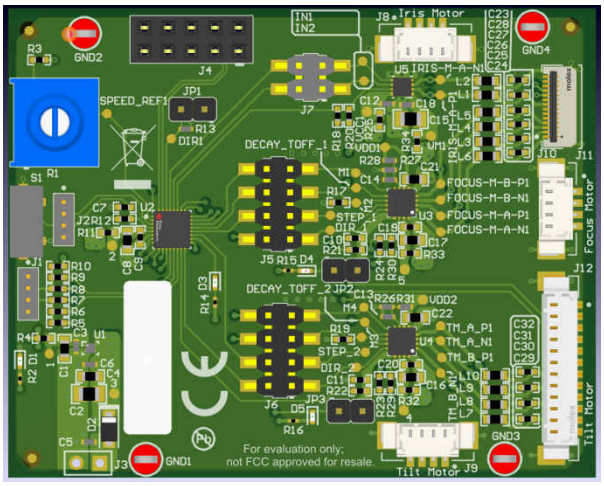

Figure 2-2. Motor Module PCB

Key features:

- Motor module is implemented using:
  - MSP430FR2155 microcontroller
  - DRV8837C brushed DC motor driver
  - two DRV8428 stepper motor drivers
  - 3.3-V power-supply (using TLV742P LDO)
- Configuration software to control the following:
  - Speed of rotation
  - Direction of rotation
  - Low-power state to reduce power consumption
  - Micro-stepping mode for stepper motors
  - Voltage for DC motor
  - Position using stepper motors
- Brushed DC motor driver DRV8837C for iris control:
  - 1 A max current
  - Integrated protection for over-current, short-circuit, under-voltage, and over-temperature

  The DRV8210P is a family of devices which is pin-compatible with DRV8837C. The DRV8210P supports 1.76 A peak current with ultra low-power sleep current of < 84.5 nA.
- Stepper motor driver DRV8428 for focus and tilt control:
  - 1 A max current
  - Integrated micro-stepping indexer,
  - Supports up to 1/256 micro step
  - Integrated current-sense to simplify design and improve efficiency
  - Small size 3.0 x 3.0mm QFN package
  - No charge pump caps required
  - Adjustable current regulation
  - Smart tune technology for ultra-smooth and quiet motion profile
  - Integrated protection for supply under-voltage, over-current, short-circuit, and over-temperature

Schematic, design files and software discussed in this document can be downloaded from the following URL: https://www.ti.com/lit/zip/slaae27.

3 Software

Figure 3-1 show the software flow chart for the motor module:

1. 5 V power input is required to generate the necessary on-board supplies for all logic operations.
2. Software initialization tristates the motor driver outputs and puts the motor drivers to sleep mode. Default motor voltage, speed, direction, pulse-count, PWM frequency, and step-mode are set as shown in Figure 3-1.
3. Tilt, focus, and iris motors are enabled as per the start or enable user variable for the respective motors.
   a. Tilt and focus motor: Direction, pulse-count (or number of steps) and micro-stepping are set for the respective motor. Outputs are enabled to drive the respective motor.
   b. Iris motor: Duty cycle required to achieve the required motor voltage is calculated and set. Output is enabled and PWM pulses are generated to drive the iris motor in the chosen direction.
4. Operation is repeated until the pulse counter reaches zero or until time-out.

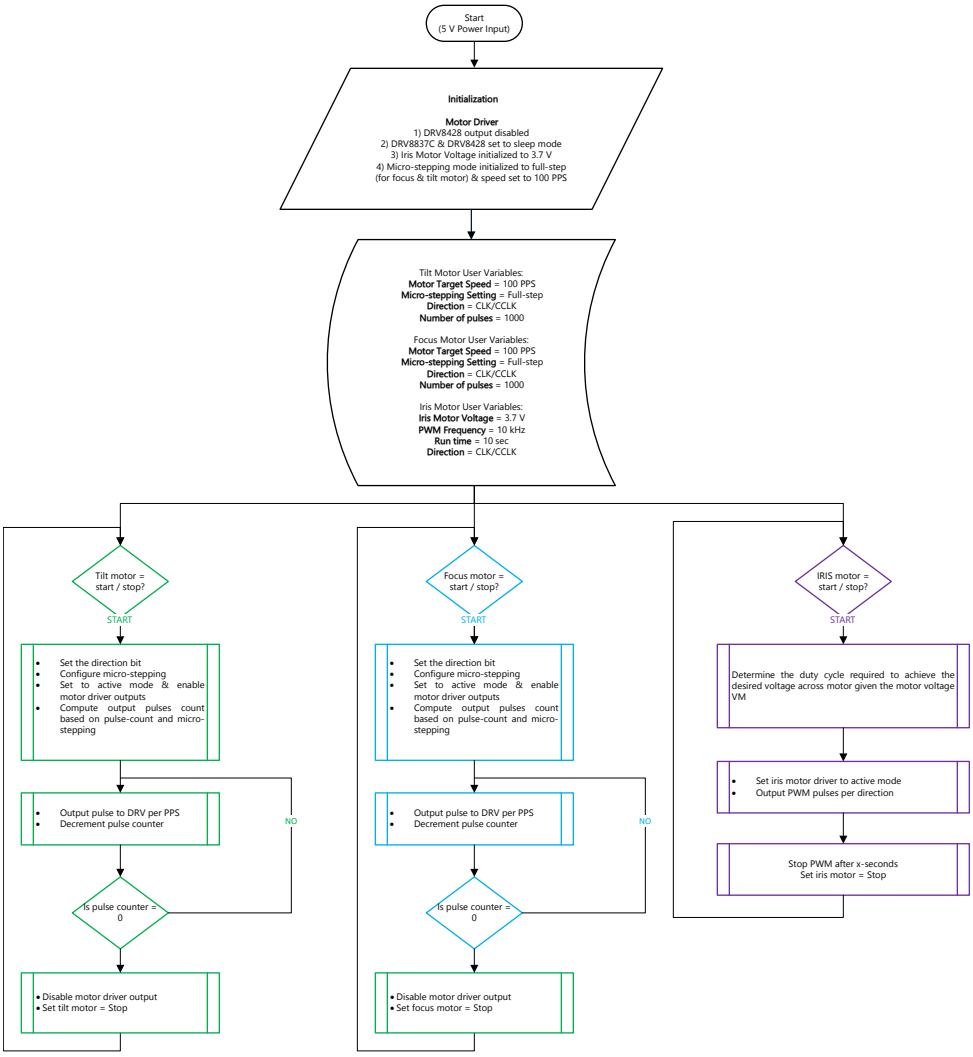

Figure 3-1. Software Flow Chart

The following steps are required to program the camera motor module:

1. Pre-requisites: Download the software 'Motor_Module_Software' available at https://www.ti.com/lit/zip/slaae27. Install and launch the Code Composer Studio IDE. Unzip and import the Motor_Module_Software project in CCS.
2. Variables: The control macros for controlling the speed, direction, step-mode, pulse-count and run-time for the motor drivers can be found in "Camera_Motor_EVM.h". These values can be set as per application requirements.
3. Connections: Connect 5-V Power input to the motor control module. Connect a programmer from the PC (using MSP-FET JTAG or any MSP430 Launchpad) to the MSP430FR2155 on the motor module with jumper wires. It is required to connect GND, SBWTDIO, and SBWTCK.
4. Program: In CCS, debug and build the code to program the motor module. This will run the code based on the input control macros from step 2.
5. Using UART commands:
   a. Program the motor module's MSP430FR2155 (as described in steps above).
   b. Hardware connections: Connect the UART lines (RX and TX) from any MSP430 Launchpad's programming header to the motor module's UART pins.
   c. PC settings: Plug the MSP430 Launchpad to the USB port of the PC. Open any serial terminal and connect to the MSP430 serial port. Port settings: 115200 kbps, 8 bit, 1 stop, and no parity.
   d. Hex commands can be used to control the module as shown in Table 3-1, Table 3-2, and Figure 3-2.

Table 3-1. UART Commands

Command	Hex Value	Notes
Reset_Position	0x01	Sets motor position counter to 0
Read_Current_Position	0x02	Returns current motor position value
Step_Command	0x04	Steps motor forward or backwards. Send 16-bit signed number for # of steps and direction. (+ = Clockwise, - = Counter Clockwise)
Set_Position	0x05	Sets motor to a desired position. Send 16 bit signed number to indicate target position.

Table 3-2. Motor Enable

Motor	Motor Select Bit
Focus motor	0
Tilt motor	1

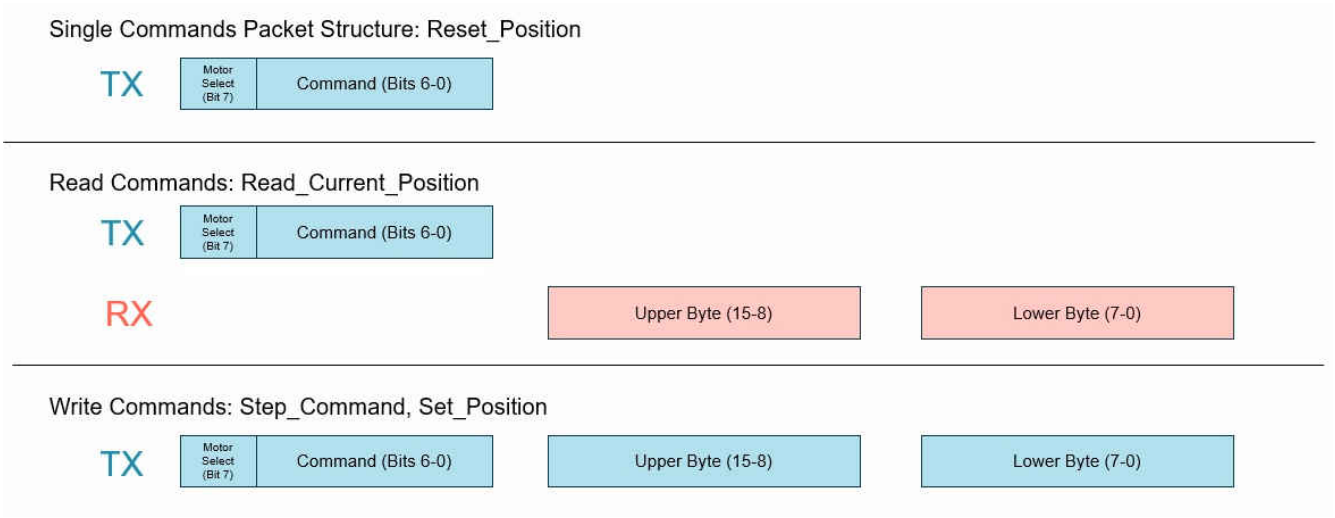

Figure 3-2. UART Commands

4 Test Results

4.1 Stepper Motor Output

The DRV8428 is used as the stepper motor driver for focus and tilt motor control. MSP430FR2155 controls M0 and M1 pins to configure the step mode for each of the stepper motor as shown in the Table 4-1.

Table 4-1. Micro Stepping Indexer Settings

M0	M1	Step Mode
0	0	Full step (2-phase excitation) with 100% current
0	330kΩ to GND	Full step (2-phase excitation) with 71% current
1	0	Non-circular 1/2 step
Hi-Z	0	1/2 step
0	1	1/4 step
1	1	1/8 step
Hi-Z	1	1/16 step
0	Hi-Z	1/32 step
Hi-Z	330kΩ to GND	1/64 step
Hi-Z	Hi-Z	1/128 step
1	Hi-Z	1/256 step

Decay mode for the stepper motor driver can be chosen for the required operation and noise. For more details, see *DRV8428 Stepper Driver With Integrated Current Sense, 1/256 Microstepping, STEP/DIR Interface and smart tune Technology Data Sheet*.

MSP430FR2155 sets the direction, speed and pulse-count to control the angle and speed of the rotation. Direction, speed and pulse count are configurable in the software. Figure 4-1 and Figure 4-2 show the step and direction inputs, and voltage outputs for full-step mode at 100 PPS.

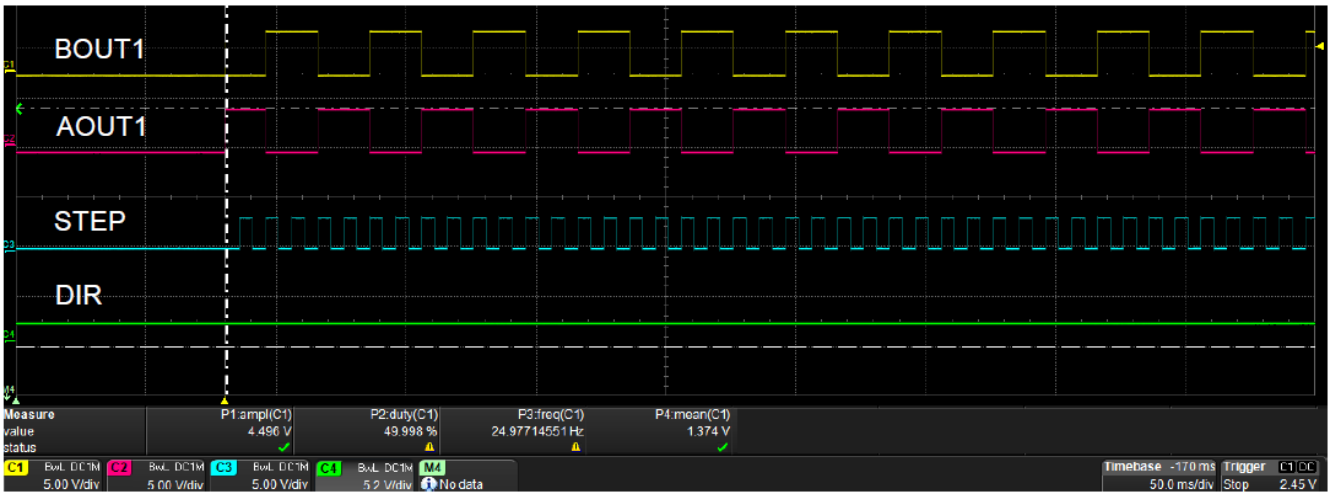

Figure 4-1. STEP Input, DIR Input, Voltage Outputs AOUT1, BOUT1 for Full-Step Mode (M0 = M1 = 0), 100 PPS

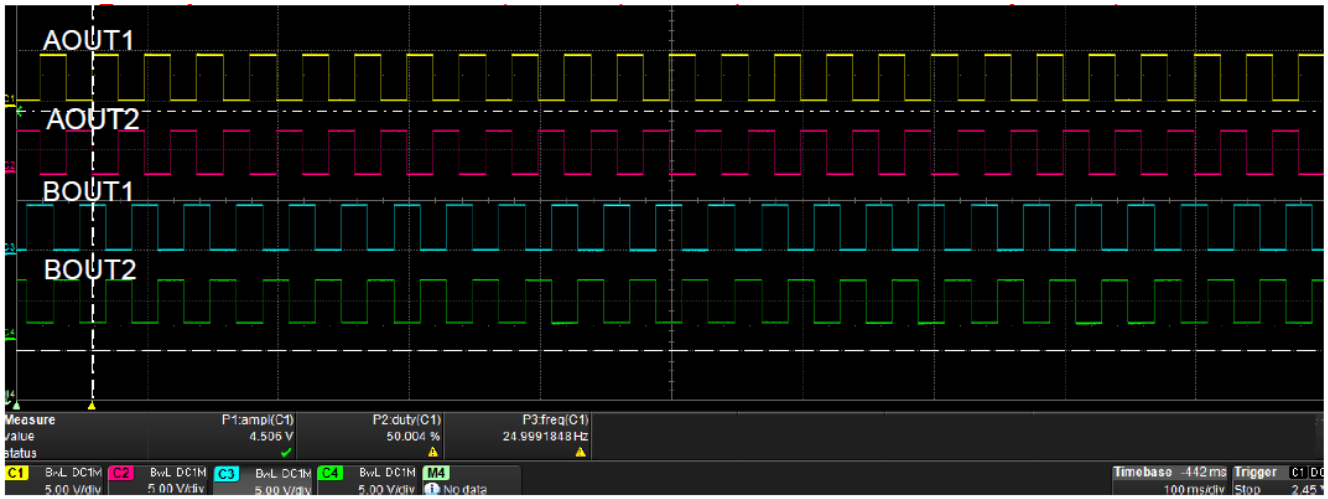

Figure 4-2. Voltage Outputs at No-Load AOUT1, AOUT2, BOUT1, BOUT2 for Full-Step Mode, 100 PPS

Figure 4-3, Figure 4-4, and Figure 4-5 show the coils currents (I-AOUT, I-BOUT) for different stepping modes.

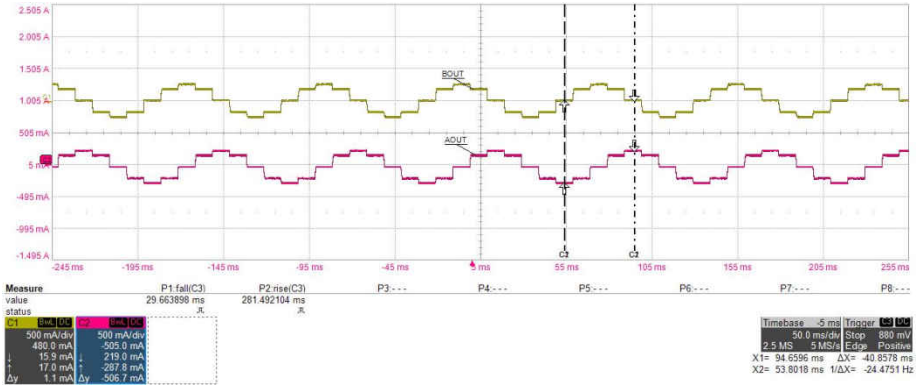

Figure 4-3. Coil Current I-AOUT, I-BOUT for 1/2 Step Mode, 100 PPS

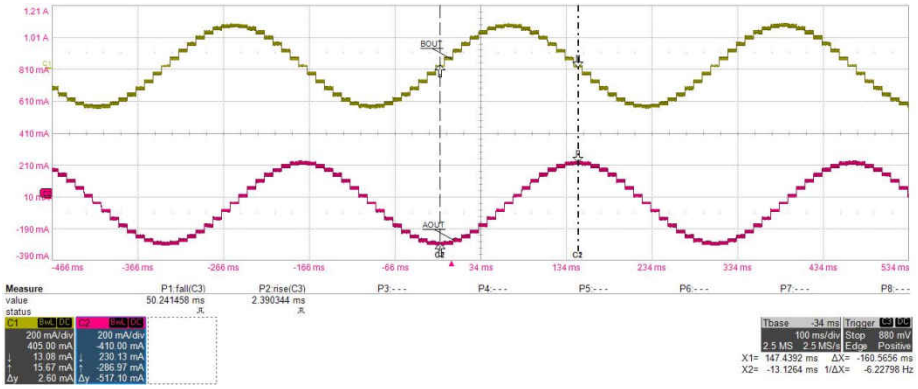

Figure 4-4. Coil Current I-AOUT, I-BOUT for 1/8 Step Mode, 100 PPS

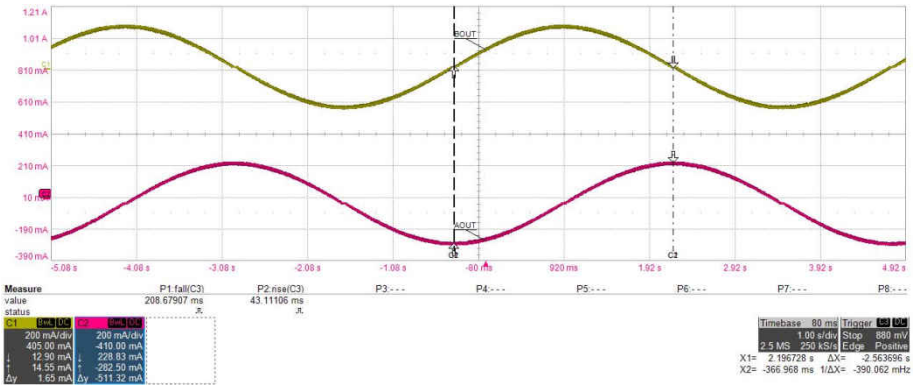

Figure 4-5. Coil Current I-AOUT, I-BOUT for 1/128 Step Mode, 100 PPS

4.2 DC Motor Output

The DRV8837C is used to drive the DC motor for iris control. The nSLEEP pin is set by MSP430FR2155 to enable DC motor drive. IN1 and IN2 pins are driven by MSP430FR2155 to control the speed and direction of the motor rotation as shown in Table 4-2.

Table 4-2. DRV8837C Device Logic

nSLEEP	IN1	IN2	OUT1	OUT2	Function (DC Motor)
0	X	X	Z	Z	Coast
1	0	0	Z	Z	Coast
1	0	1	L	H	Reverse
1	1	0	H	L	Forward
1	1	1	L	L	Brake

MSP430FR2155 generates the PWM input for IN1 and IN2 to control the motor's forward or reverse rotation. Duty cycle of PWM is calculated by the software based on the motor voltage required for the DC motor operation. Direction, PWM frequency, and time-out are configurable in the software.

Figure 4-6, Figure 4-7, and Figure 4-8 show the supply voltage (VCC), nSLEEP (enable pin), and the motor drive (IN1, IN2) for forward and reverse rotation. Figure 4-9, Figure 4-10, and Figure 4-11 show the voltage and current profiles for different PWM frequencies.

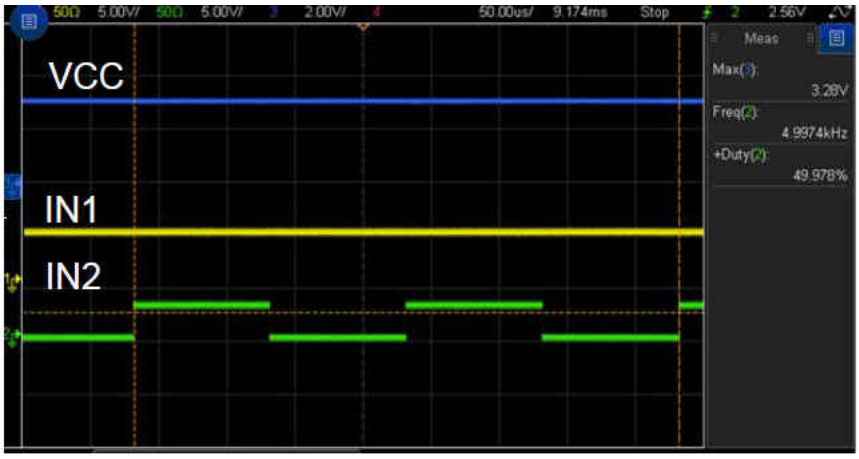

Figure 4-6. Inputs to Motor Driver: VCC, IN1, IN2 for Reverse Direction

Figure 4-7. Inputs to Motor Driver: VCC, IN1, IN2 for Forward Direction

Figure 4-8. Inputs to Motor Driver: nSLEEP, IN1, IN2

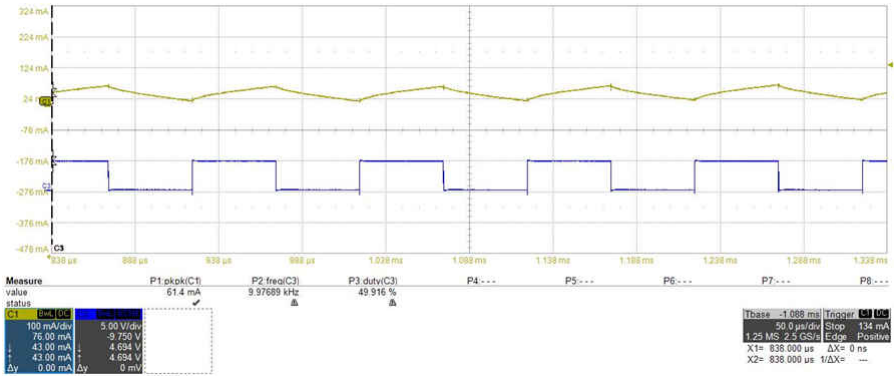

Figure 4-9. Voltage and Current, 50% Duty Cycle, 10 kHz, Reverse Direction

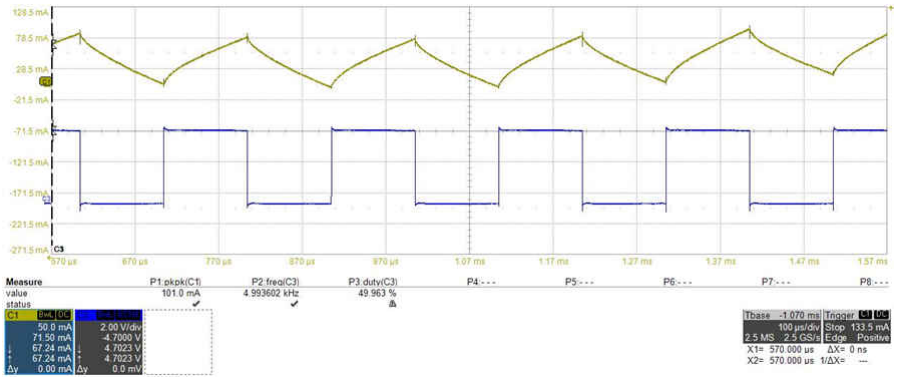

Figure 4-10. Voltage and Current, 50% Duty Cycle, 5 kHz, Reverse Direction

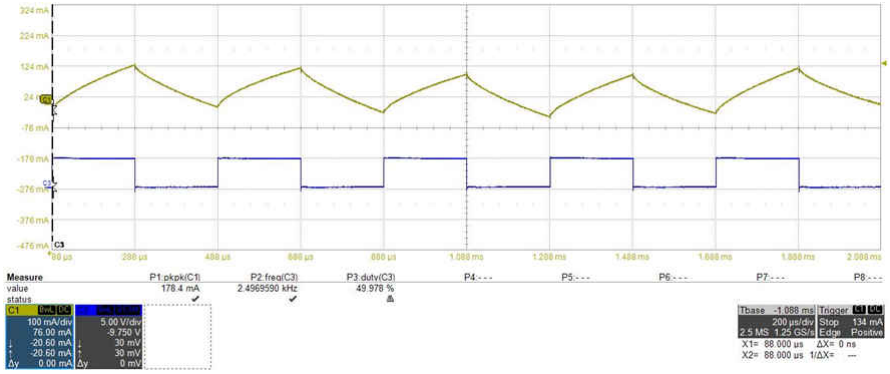

Figure 4-11. Voltage and Current, 50% Duty Cycle, 2.5 kHz, Reverse Direction

5 Summary

The motor module offers a reliable, compact, and quick design solution for motor control based on MSP430FR2155 MCU, DRV8837C and DRV8428 motor drivers to control the focus, tilt, and iris for an IP network camera.

6 References

- Texas Instruments: *MSP430FR235x, MSP430FR215x Mixed-Signal Microcontrollers Data Sheet*
- Texas Instruments: *MSP430FR4xx and MSP430FR2xx Family User's Guide*
- Digital Signal Processing (DSP) Library for MSP430 Microcontrollers.
- Texas Instruments: *TIDA-010224 Low-Power Wireless Camera Reference Design for Extended Battery Life*
- Texas Instruments: *DRV8837C 1-A Low-Voltage H-Bridge Driver Data Sheet*
- Texas Instruments: *DRV8210P 11-V H-Bridge Motor Driver with PWM Interface and Low-Power Sleep Mode Data Sheet*
- Texas Instruments: *DRV8428 Stepper Driver With Integrated Current Sense, 1/256 Microstepping, STEP/DIR Interface and smart tune Technology*
- Texas Instruments: *Stepper motors made easy with smart tune*
- Texas Instruments: *How to Reduce Audible Noise in Stepper Motors*
- Texas Instruments: *Best Practices for Board Layout of Motor Drivers*
- Texas Instruments: *TLV742P 200-mA, Small Size, Low-Dropout Linear Voltage Regulator Data Sheet*

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