Permanent Magnet Synchronous Motor Drive Control Experimental Module

PEK-190

Experimental Manual

GW Instek Part Number

ISO-9001 Certified Enterprise

GW INSTEK

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Table of Contents

Introduction

The PEK-190 is a Three-Phase Permanent Magnet Synchronous Motor Drive Development Kit, as shown in Figure 0.1. It is a fully digital control system. The implementation method is illustrated in Figure 0.2. Its purpose is to provide a learning platform for digital control of power converters. Using PSIM software, users can learn the principles, analysis, and design of power converters through simulation. Additionally, the SimCoder tool in PSIM allows the conversion of control circuits into digital control programs. These programs can then be simulated again using DSP as a replacement for the circuit. Finally, the control programs verified through simulation can be programmed into DSP chips, enabling control and communication via DSP to validate the correctness of the designed circuits and controllers.

Figure 0.1 Three-Phase Permanent Magnet Synchronous Motor Drive Development Kit

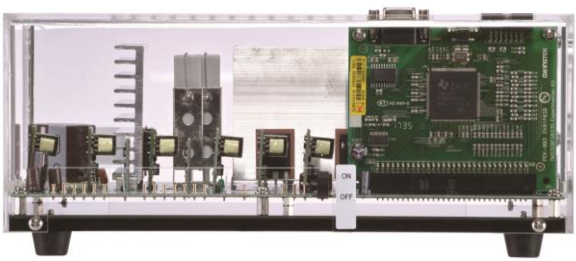
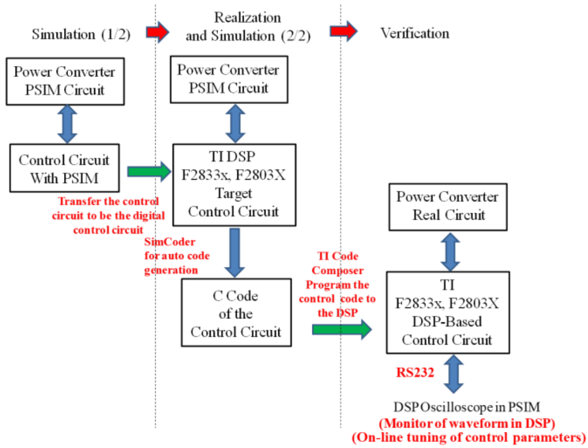


Figure 0.2
Teaching Aid
Usage Procedure



The PEK-190 can complete six experiments, as follows:

1. Vector Control of Permanent Magnet Synchronous Motor
2. Initial Rotor Position Detection and Starting of Permanent Magnet Synchronous Motor
3. Parameter Identification of Permanent Magnet Synchronous Motor
4. Position Sensor-less Speed Control (Conventional Sliding Mode Observer Method)
5. Position Sensor-less Speed Control (Self-adaptive Sliding Mode Observer Method)
6. Position Sensor-less Speed Control (Model Reference Adaptive System (MRAS) Observer Method)

During the experiment, in addition to the PEK-190 itself, it is necessary to use PEK-005A (auxiliary power supply, as shown in Figure 0.3) and PEK-006 (JTAG programmer, as shown in Figure 0.4) and complete the setup on the PTS-3000 experimental platform, as shown in Figure 0.5.

Figure 0.3
Auxiliary Power
Module

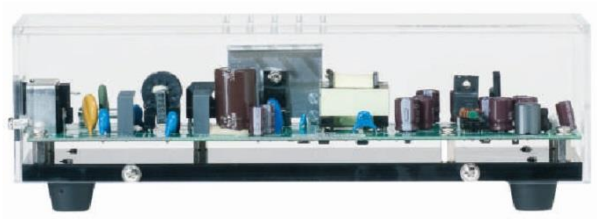


Figure 0.4
JTAG
Programmer

Figure 0.5
PTS-3000
Experimental
Platform

The circuit diagram of PEK-190 can be referred to in Appendix A, which can be divided into power circuit, sensing circuit, driving circuit, and protection circuit. The sensing circuit is divided into two parts: one for test point measurement and the other for DSP control feedback. Their attenuation ratios differ, as shown in Tables 0-1 and 0-2.

Figure 0.6 PEK-190 I/O Configuration

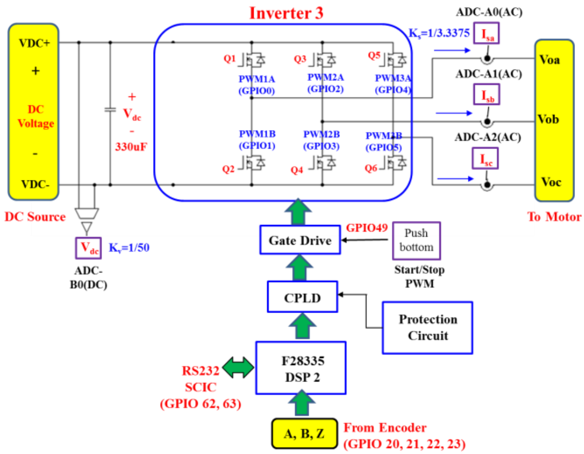


Figure 0.7 PEK-190 I/O Configuration

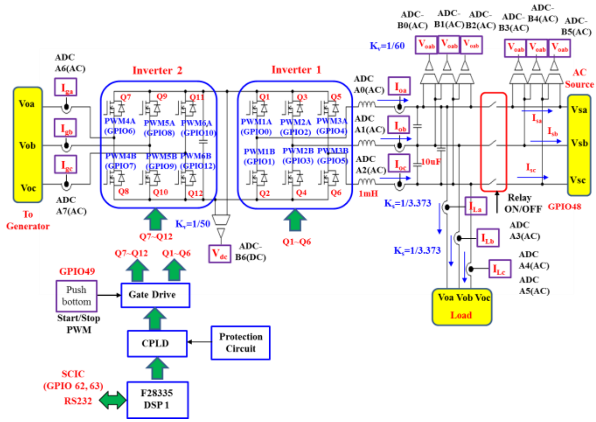


Table 0.1 Measurement Ratios of PEK-190 Test Points

	Sensing Items	Sensing Ratios
1	DC Link Voltage (VDC)	0.0373
2	Inverter Phase A Output Current (IO-A)	0.8
3	Inverter Phase B Output Current (IO-B)	0.8
4	Inverter Phase C Output Current (IO-C)	0.8

Table 0.2 Measurement Ratios of PEK-190 Test Points

	Sensing Items	Sensing Ratios
1	DC Link Voltage (VDC)	0.0139
2	Inverter Phase A Output Current (IO-A)	0.2996
3	Inverter Phase B Output Current (IO-B)	0.2996
4	Inverter Phase C Output Current (IO-C)	0.2996

Chapter Description

Chapter Arrangement

Introduction	Brief introduction to the experimental methods, experimental items, circuit composition, and chapter contents of this module.
Experiment 1 Vector Control of Permanent Magnet Synchronous Motor	Primarily focuses on learning Space Vector Pulse Width Modulation (SVPWM) technology, understanding voltage and current measurement methods through the PEK-190 module, learning the configuration of TI F28335 DSP IC pins, PWM, and A/D hardware, and understanding how to use RS-232 for DSP internal signal control and measurement.
Experiment 2 Rotor Initial Position Detection and Startup	Primarily focuses on accurately obtaining the initial position information of the rotor in a Permanent Magnet Synchronous Motor (PMSM), achieving smooth motor startup, proposing a method for detecting the initial rotor position of PMSM, ensuring smooth startup and reliable operation, and planning hardware followed by programming through SimCoder.

Experiment 3 Online Measurement and Estimation of Permanent Magnet Synchronous Motor Parameters	Focuses on learning how to estimate motor impedance, reactance, back electromotive force, and mechanical parameters such as torque, rotor inertia, and mechanical constants, followed by algorithm planning and programming through SimCoder.
Experiment 4 Position Sensor-less Speed Control (Conventional Sliding Mode Observer Method)	Study the traditional sliding mode observer method and perform programming using SimCoder.
Experiment 5 Speed control without position sensors (adaptive sliding mode observer method)	Study the adaptive sliding mode observer method and perform programming using SimCoder.
Experiment 6 Speed control without position sensors (model reference adaptive method)	Study the model reference adaptive method and perform programming using SimCoder.

Experiment 1 Vector Control of Permanent Magnet Synchronous Motor

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

fs = 20kHz, Vtri = 5Vpp (PWM)

Ks = 0.2996 (current sensing factor)

Kv = 0.0139 (voltage sensing factor)

The analog circuit established based on the above parameters is shown in Figure 1.1.

PSIM file name: PEK-190_Sim1_VC_PMSM_KingServo_V2022.1_V1.1

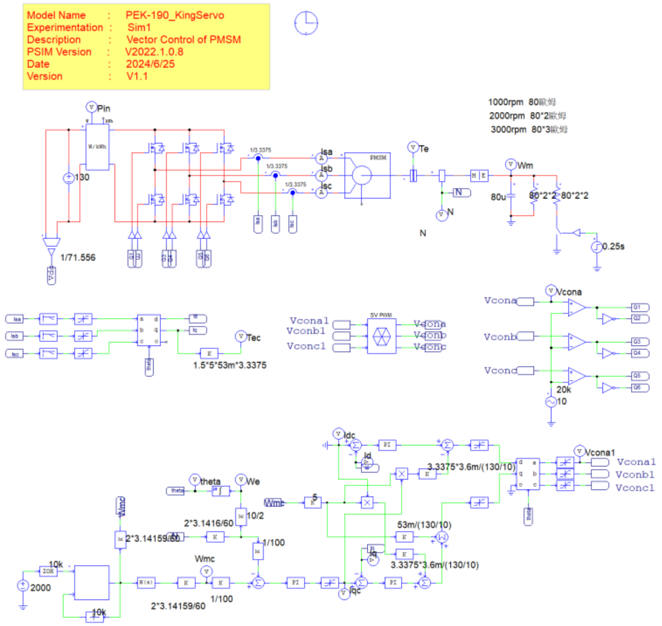


Figure 1.1 Analog circuit diagram for Experiment 1 in PSIM

The simulation results are shown in Figures 1.2, 1.3, and 1.4.

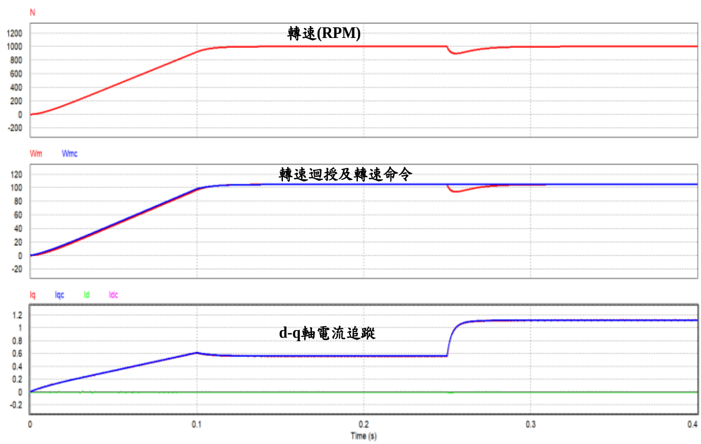


Figure 1.2 Analog circuit simulation waveform for Experiment 1

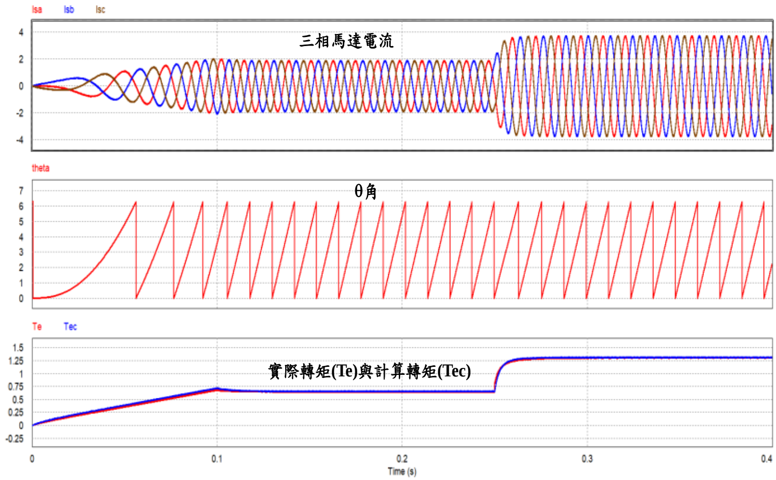


Figure 1.3 Analog circuit simulation waveform for Experiment 1

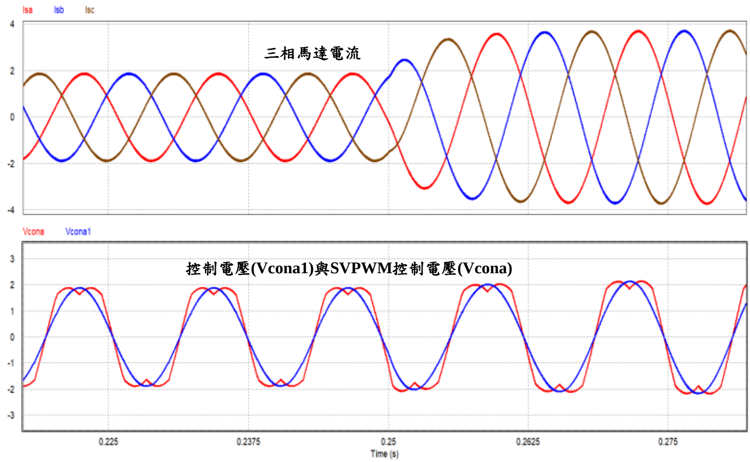


Figure 1.4 Analog circuit simulation waveform for Experiment 1

The digital circuit established based on the analog circuit is shown in Figure 1.5.
PSIM file name: PEK-190_Lab1_VC_PMSM_KingServo_V2022.1_V1.1

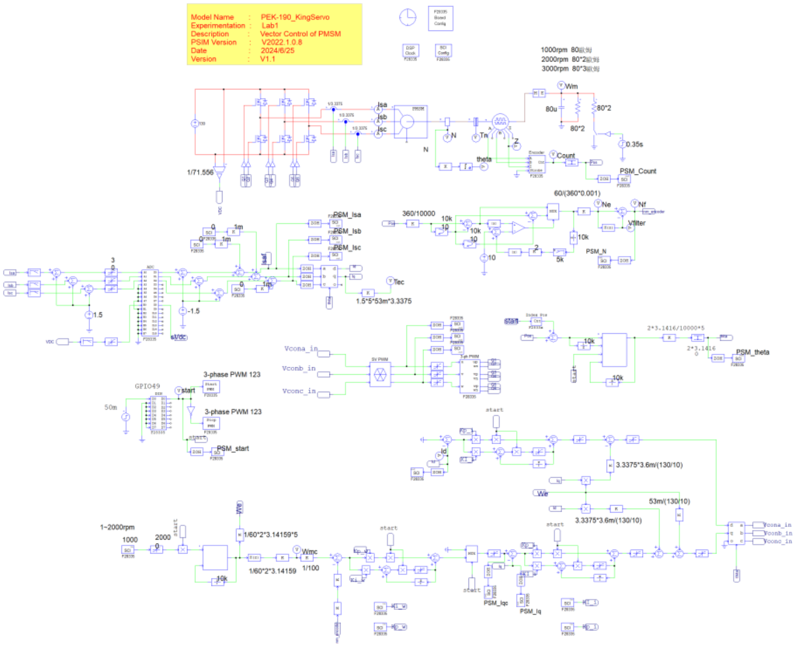


Figure 1.5 Digital circuit diagram for Experiment 1 in PSIM

The simulation results are shown in Figure 1.6.

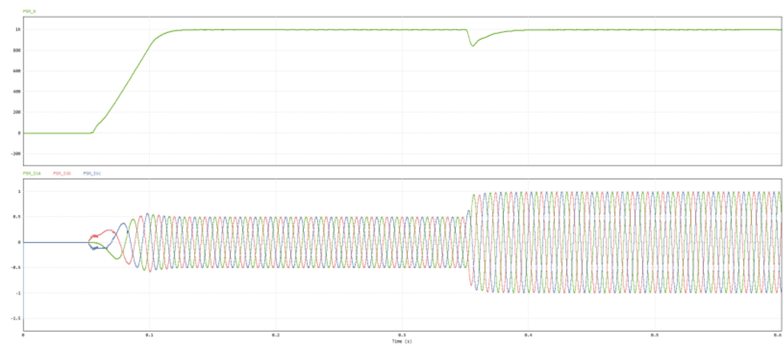


Figure 1.6 Digital circuit simulation waveform for Experiment 1

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- One PTS-3000 (including GDS-2204E, PSW160-7.2, GPL-300A)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 1.7. Please complete the wiring according to this diagram.

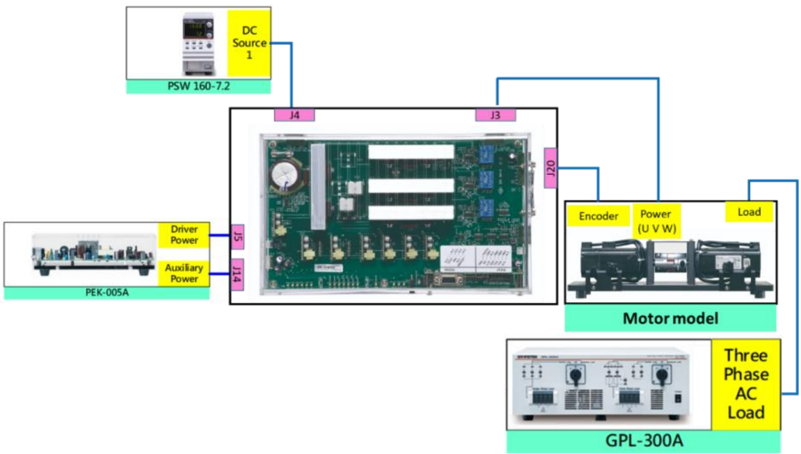
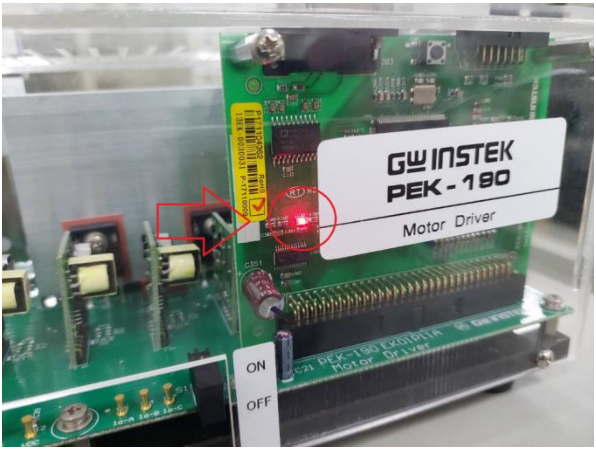


Figure 1.7 Wiring diagram for Experiment 1

2. After completing the wiring, first confirm that the PEK-190 switch is set to OFF. Then, turn on the PEK-005A switch. Once turned on, the red indicator light on the DSP will illuminate, as shown in Figure 1.8, indicating that the DSP power supply is

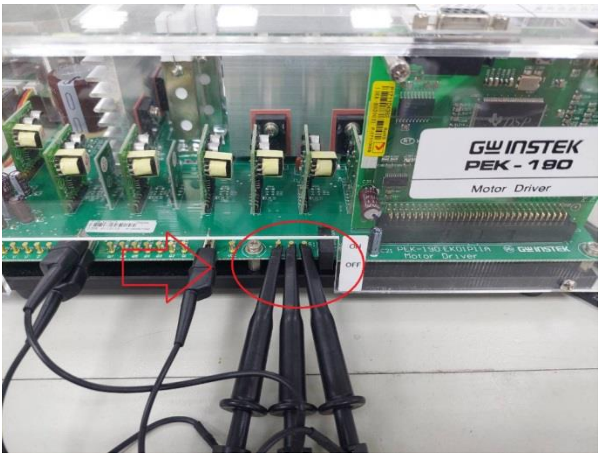
functioning normally.

Figure 1.8
DSP normal operation display



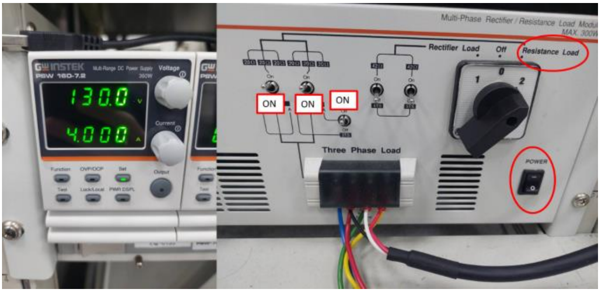
3. Please follow Appendix B (programming procedure) to perform the programming.
4. Connect the oscilloscope probes to IO-A, IO-B, and IO-C respectively, as shown in Figure 1.9.

Figure 1.9
Oscilloscope probe wiring diagram



5. Set the PSW160-7.2 to a voltage of 130V and a current of 4A. After turning on the GPL-300A power supply, configure the Three Phase Load to Resistance Load. Set 1TS, 2TS, and 3TS to ON. At this point, the load for each phase is 10 ohms, as shown in Figure 1.10.

Figure 1.10
PSW and GPL-300A configuration diagram



After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Objective

Study the principles of three-phase SVPWM and PMSM, as well as the open-loop voltage and current measurement methods for three-phase inverter modules.

Start the motor without resetting to the initial position and observe the conditions generated during non-zero initialization.

Experimental Results

When the motor is started without resetting to the initial position, it can be observed that the motor speed may sometimes become uncontrollable and fail to reach the target speed. The primary purpose is to help learners understand the potential issues caused by non-zero initialization.

Conclusion

From the above results, it can be observed that when the initial position is not reset, the motor speed may become uncontrollable.

Experiment 2 Initial Rotor Position Detection and Starting

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

fs = 20kHz, Vtri = 5Vpp (PWM)

Ks = 0.2996 (current sensing factor)

Kv = 0.0139 (voltage sensing factor)

The analog circuit established based on the above parameters is shown in Figure 2.1.

The PSIM file name is:PEK-190_Sim2_IAD_Start_PMSM_KingServo_V2022.1_V1.1

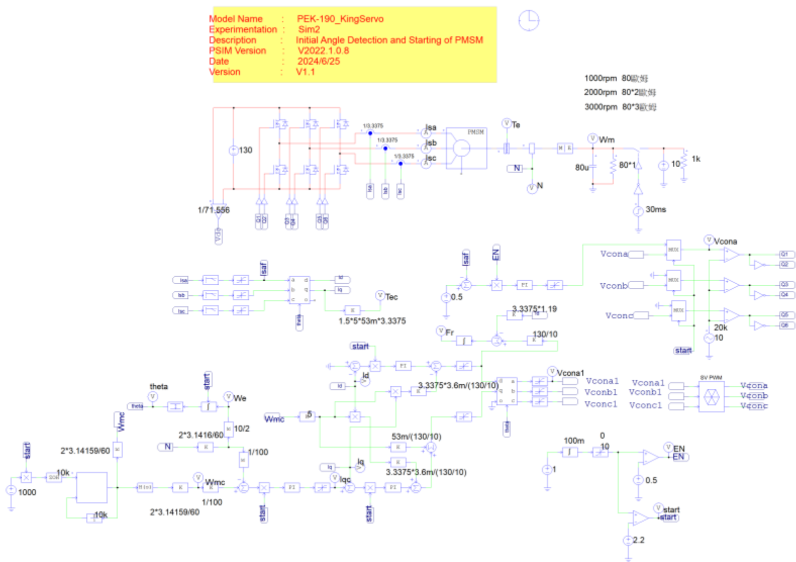


Figure 2.1 Experimental Setup for PSIM Analog Circuit Diagram

The simulation results are shown in Figure 2.2.

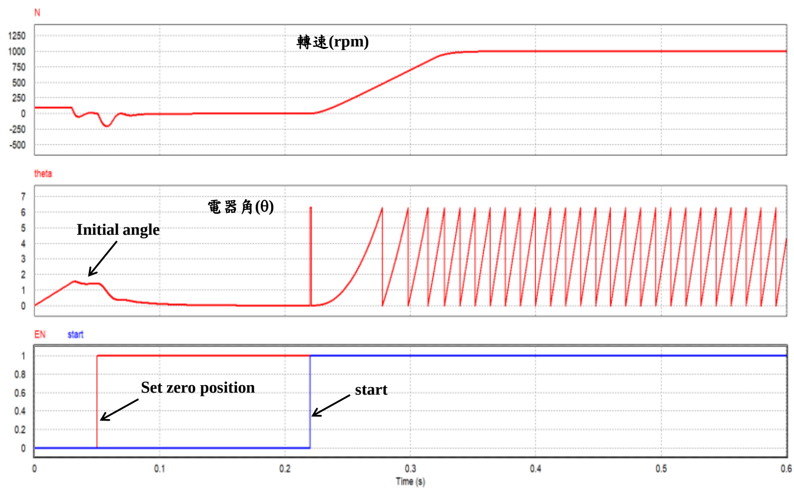


Figure 2.2 Simulation Waveform of Experimental Analog Circuit

Referencing the analog circuit, the digital circuit established is shown in Figure 2.3.

The PSIM file name is:PEK-190_Lab2_IAD_Start_PMSM_KingServo_V2022.1_V1.1

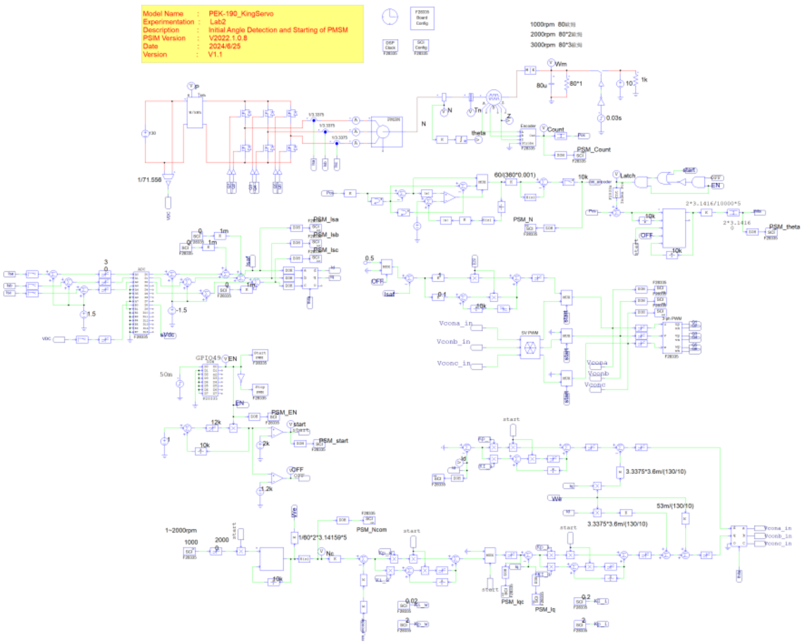


Figure 2.3 Experimental Setup for PSIM Digital Circuit Diagram

The simulation results are shown in Figure 2.4.

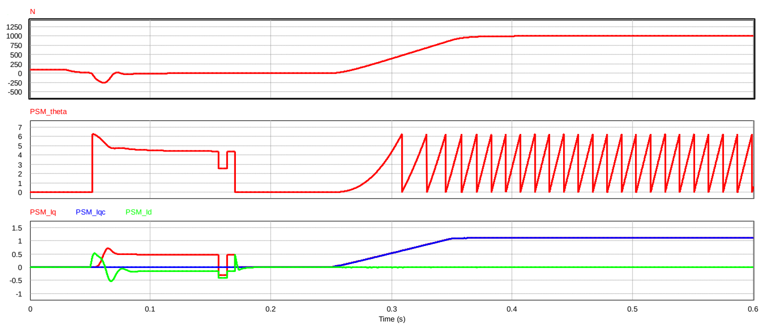


Figure 2.4 Simulation Waveform of Experimental Digital Circuit

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- One PTS-3000 (including GDS-2204E, PSW160-7.2, GPL-300A)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 2.5. Please complete the wiring according to this diagram.

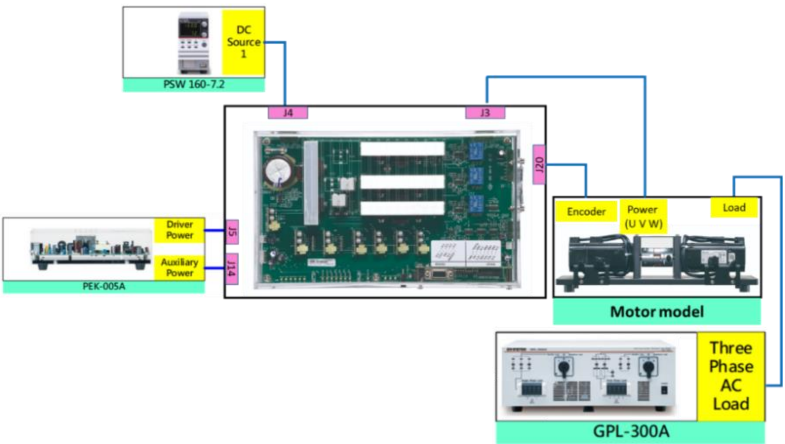
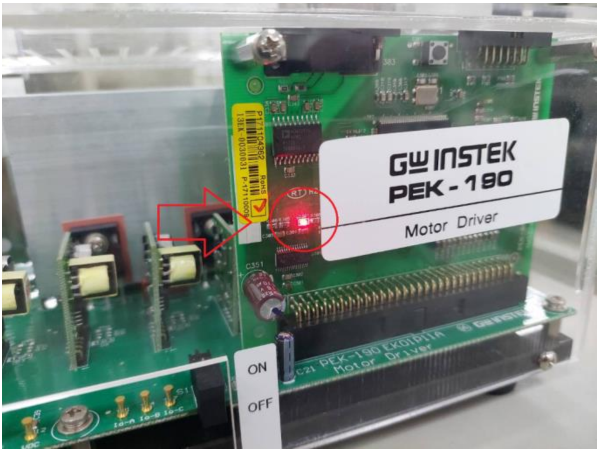


Figure 2.5 Experimental Wiring Diagram

2. After completing the wiring, first confirm that the PEK-190 switch is set to OFF. Then, turn on the PEK-005A switch. Once activated, the red indicator light on the DSP will illuminate, as shown in Figure 2.6, indicating that the DSP power supply is functioning normally.

Figure 2.6

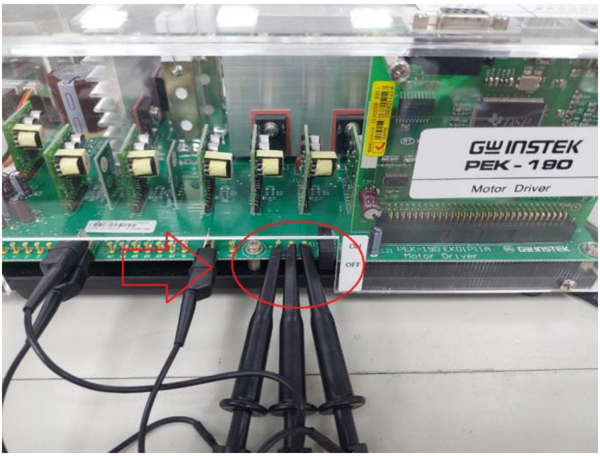
DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.
4. Connect the oscilloscope probes to IO-A, IO-B, and IO-C respectively, as shown in Figure 2.7.

Figure 2.7

Oscilloscope probe wiring diagram



5. Set the PSW160-7.2 to a voltage of 130V and a current of 4A. After turning on the GPL-300A power supply, configure the Three Phase Load to Resistance Load. Set 1TS, 2TS, and 3TS to ON. At this point, the load for each phase is 10 ohms, as shown in Figure 2.8.

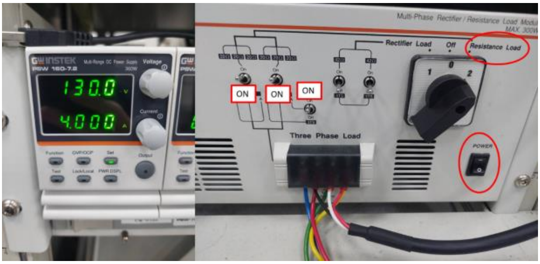


Figure 2.8

Configuration Diagram for PSW and GPL-300A

After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Objective

The primary objective is to accurately obtain the initial position information of the rotor in a Permanent Magnet Synchronous Motor (PMSM), enabling smooth motor startup. A method for detecting and resetting the initial rotor position of PMSM is proposed to achieve stable startup and reliable operation.

Experimental Results

(1) IO-A, IO-B, IO-C Waveforms

CH1 corresponds to IO-A; CH2 corresponds to IO-B; CH3 corresponds to IO-C, as shown in Figure 2.9.

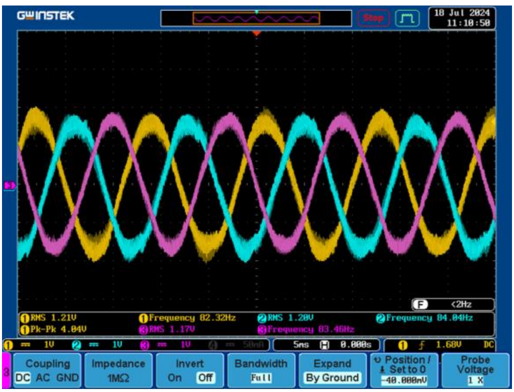


Figure 2.9

Three-Phase Drive Current Waveforms

Conclusion

Due to the inclusion of the initial rotor position detection and reset mechanism in Experiment 2, the motor startup does not experience speed instability.

Experiment 3 Online Measurement and Estimation of Permanent Magnet Synchronous Motor Parameters

Experimental Objective

Learn how to estimate motor impedance, reactance, back electromotive force, and mechanical parameters such as torque, rotor inertia, and mechanical constants. Experiment 3 is divided into four distinct programs, which are individually explained below.

1 Measurement of Permanent Magnet Synchronous Motor Impedance

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

fs = 20kHz, Vtri = 5Vpp (PWM)

Ks = 0.2996 (current sensing factor)

Kv = 0.0139 (voltage sensing factor)

The analog circuit established based on the aforementioned parameters is shown in Figure 3-1.1:

PSIM file name: PEK-190_Lab3-1_EST_R_KingServo_V2022.1_V1.1

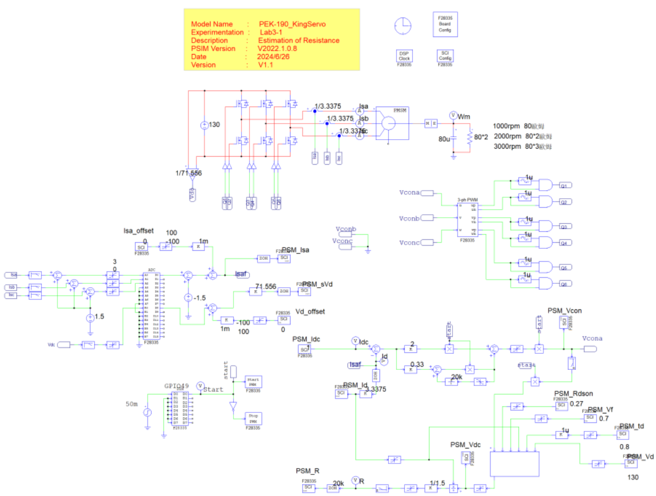


Figure 3-1.1 Analog Circuit Diagram for Experiment 3-1

The simulation results are shown in Figure 3-1.2:

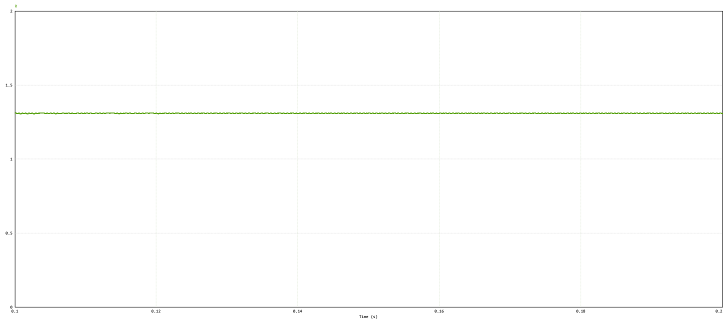


Figure 3-1.2 Analog Circuit Simulation Waveform for Experiment 3-1

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- One PTS-5000 unit (PSW160-7.2)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 3-1.3. Please complete the wiring according to this diagram.

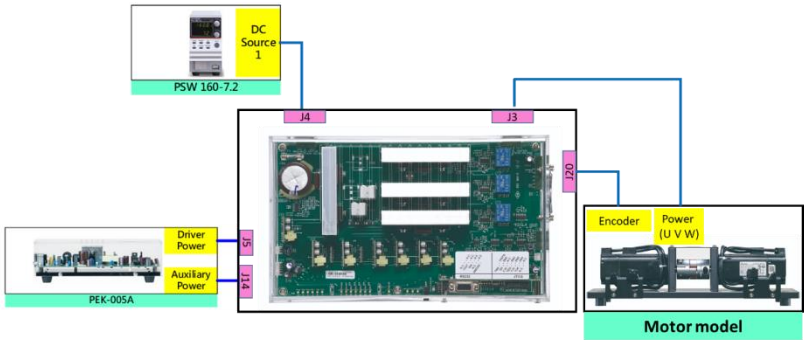
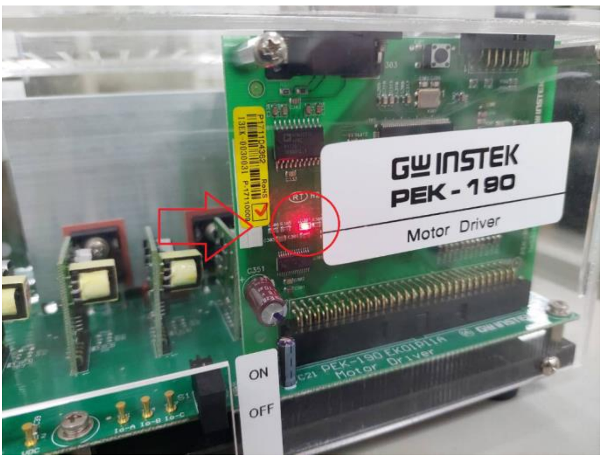


Figure 3-1.3 Wiring Diagram for Experiment 3-1

2. After completing the wiring, first ensure that the switch of PEK-190 is set to OFF. Then, turn on the switch of PEK-005A. Once turned on, the red indicator light on the DSP will illuminate, as shown in Figure 3-1.4, indicating that the DSP power supply is functioning normally.

Figure 3-1.4 DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.

4. Set the PSW160-7.2 to a voltage of 130V and adjust the current knob to 4A, as shown in Figure 3-1.5.

Figure 3-1.5PSW Configuration Diagram

After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Results

The values measured via RS232 are shown in Figure 3-1.6.

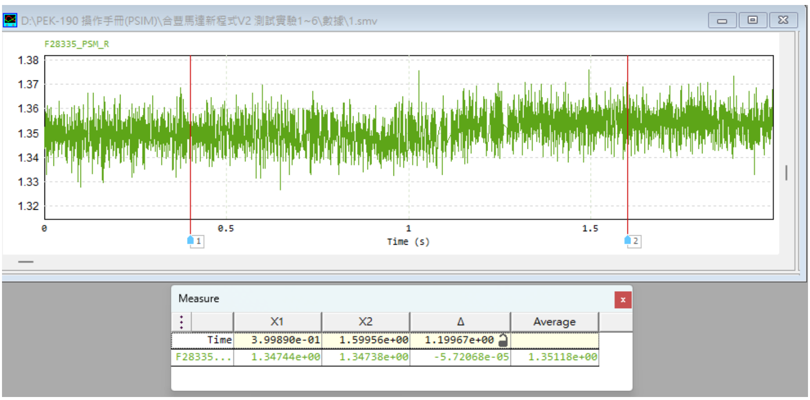


Figure 3-1.6 Actual Measurement Values via RS232 (PSM_R)

It can be observed that the measured values are similar to the actual values. The motor does not rotate during this experiment.

2 Measurement of Permanent Magnet Synchronous Motor Inductance and Magnetic Flux

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

fs = 20kHz, Vtri = 5Vpp (PWM)

Ks = 0.2996 (current sensing factor)

Kv = 0.0139 (voltage sensing factor)

The analog circuit established based on the aforementioned parameters is shown in Figure 3-2.1:
PSIM file name: PEK-190_Lab3-2_EST_R_KingServo_V2022.1_V1.1

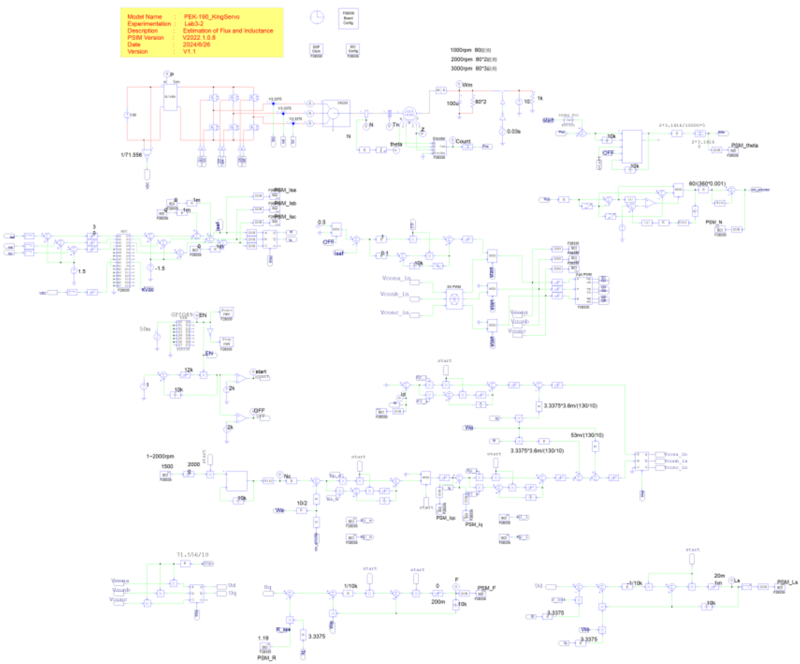
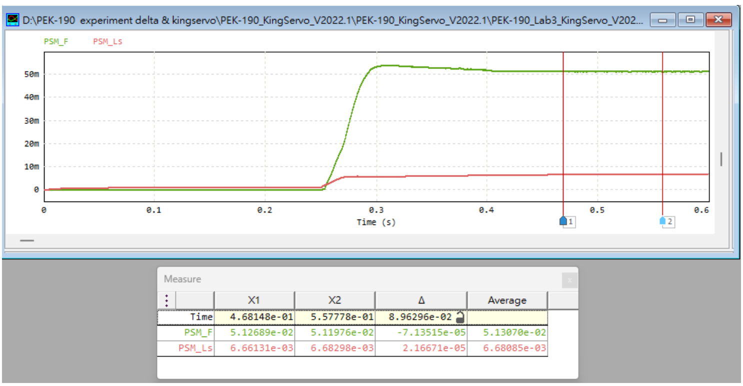


Figure 3-2.1 Analog Circuit Diagram for Experiment 3-2

The simulation results are shown in Figure 3-2.2:



	X1	X2	Δ	Average
Time	4.68148e-01	5.57778e-01	8.96296e-02	
PSM_F	5.12689e-02	5.11976e-02	-7.13515e-05	5.13070e-02
PSM_Ls	6.66131e-03	6.68298e-03	2.16671e-05	6.68085e-03

Figure 3-2.2 Analog Circuit Simulation Waveform for Experiment 3-2

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- One PTS-5000 unit (PSW160-7.2, GPL-300A)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 3-2.3. Please complete the wiring according to this diagram.

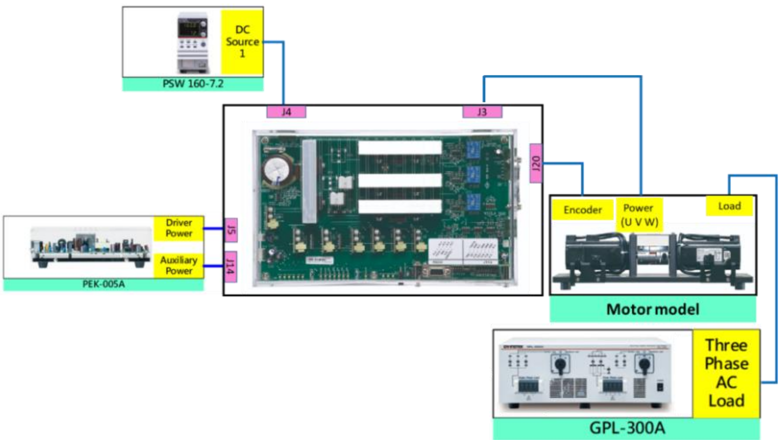
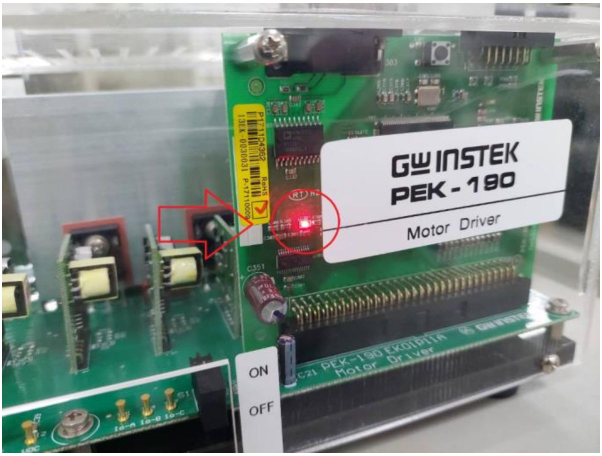


Figure 3-2.3 Wiring Diagram for Experiment 3-2

2. After completing the wiring, first ensure that the switch of PEK-190 is set to OFF. Then, turn on the switch of PEK-005A. Once turned on, the red indicator light on the DSP will illuminate, as shown in Figure 3-2.4, indicating that the DSP power supply is functioning normally.

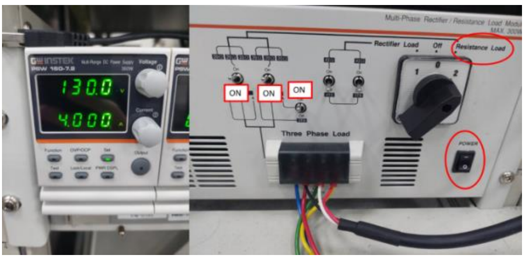
Figure 3-2.4DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.
4. Set the PSW160-7.2 to a voltage of 130V and a current of 4A. After turning on the GPL-300A power supply, configure the Three Phase Load to Resistance Load. Set 1TS, 2TS, and 3TS to ON. At this point, the load for each phase is 10 ohms, as shown in Figure 3-2.5.

Figure 3-2.5

PSW and GPL-300A configuration diagram



After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Results

The values measured via RS232 are shown in Figure 3-2.6.

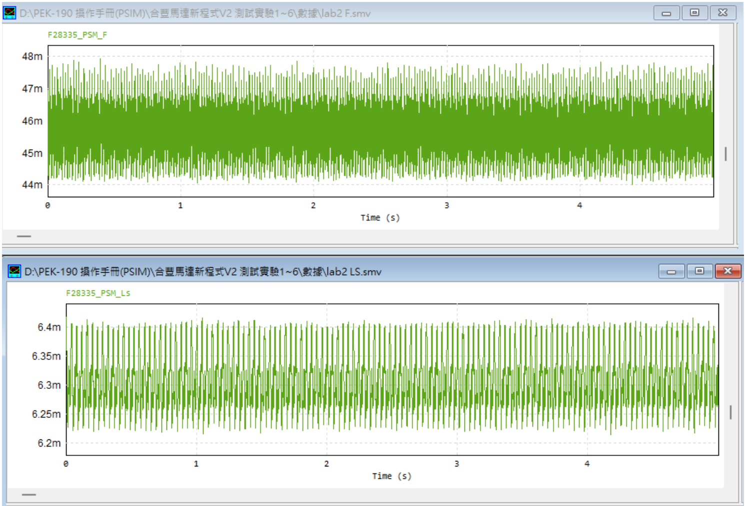


Figure 3-2.6 Actual Measurement Values via RS232 (PSM_F, RSM_Ls)

It can be observed that the measured values are similar to the actual values. The motor continuously rotates during this experiment.

3 Measurement of Mechanical Parameters of Permanent Magnet Synchronous Motor

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

fs = 20kHz, Vtri = 5Vpp (PWM)

Ks = 0.2996 (current sensing factor)

Kv = 0.0139 (voltage sensing factor)

The analog circuit established based on the aforementioned parameters is shown in Figure 3-3.1:
PSIM file name: PEK-190_Lab3-3_EST_Mech_KingServo_V2022.1_V1.1

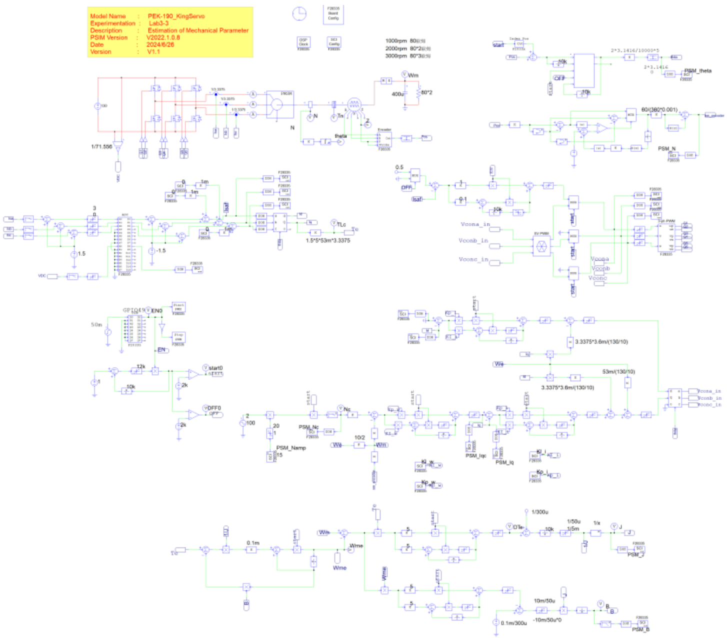


Figure 3-3.1 Digital Circuit Diagram of Experiment 3-3 in PSIM

The simulation results are shown in Figure 3-3.2:

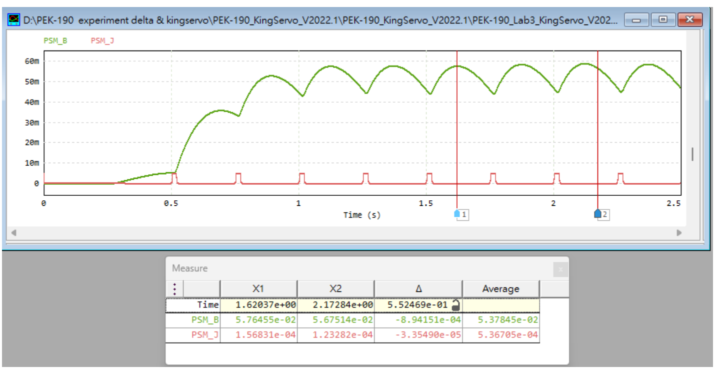


Figure 3-2.2 Analog Circuit Simulation Waveform of Experiment 3-3

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- One PTS-5000 unit (PSW160-7.2)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 3-3.3. Please complete the wiring according to this diagram.

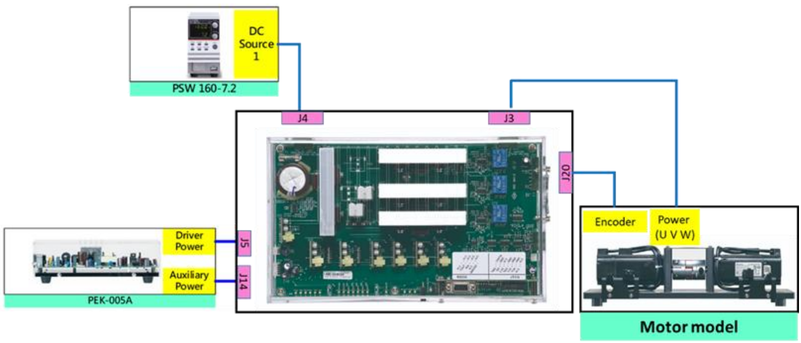
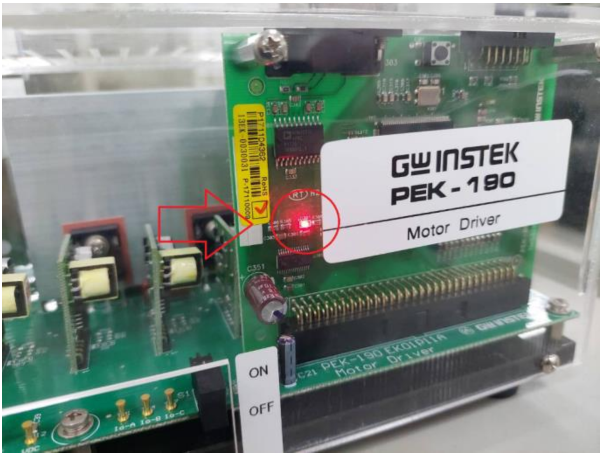


Figure 3-3.3 Wiring Diagram of Experiment 3-3

2. After completing the wiring, first ensure that the PEK-190 switch is set to OFF. Then, turn on the PEK-005A switch. Once turned on, the red indicator light of the DSP will illuminate, as shown in Figure 3-3.4, indicating that the DSP power supply is functioning normally.

Figure 3-3.4

DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.
4. Set PSW160-7.2 to a voltage of 130V and a current of 4A, as shown in Figure 3-3.5.

Figure 3-3.5

PSW Configuration Diagram

After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Results

The values measured by RS232 are shown in Figure 3-3.6.

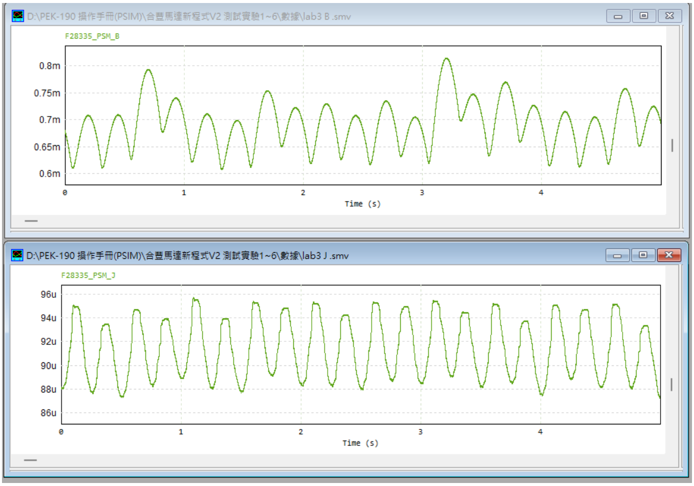


Figure 3-3.6 Actual Measurement Values via RS232 (PSM_B, RSM_J)

In this experiment, the motor will continuously rotate forward and backward.

4 Online Estimation of Permanent Magnet Synchronous Motor Parameters

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

fs = 20kHz, Vtri = 5Vpp (PWM)

Ks = 0.2996 (current sensing factor)

Kv = 0.0139 (voltage sensing factor)

The analog circuit established based on the aforementioned parameters is shown in Figure 3-4.1.
PSIM file name:
PEK-190_Lab3-4_ID_RLF_KingServo_V2022.1_V1.1

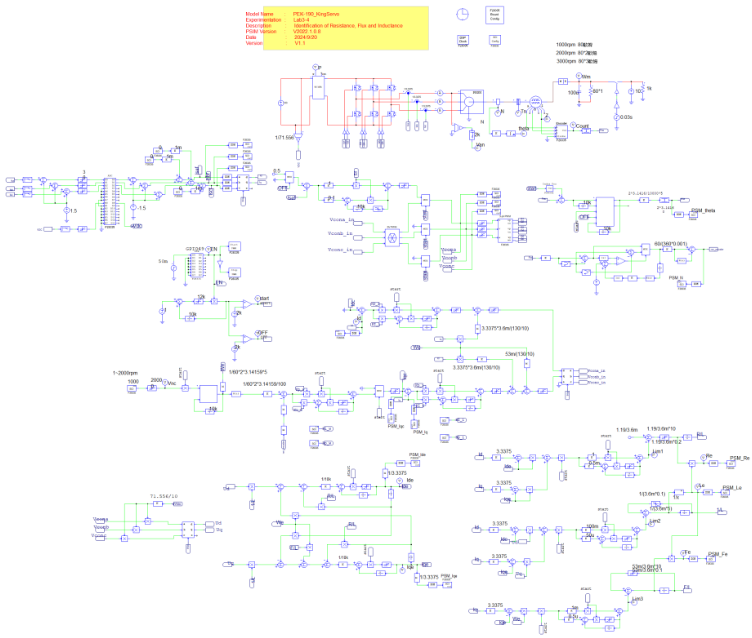
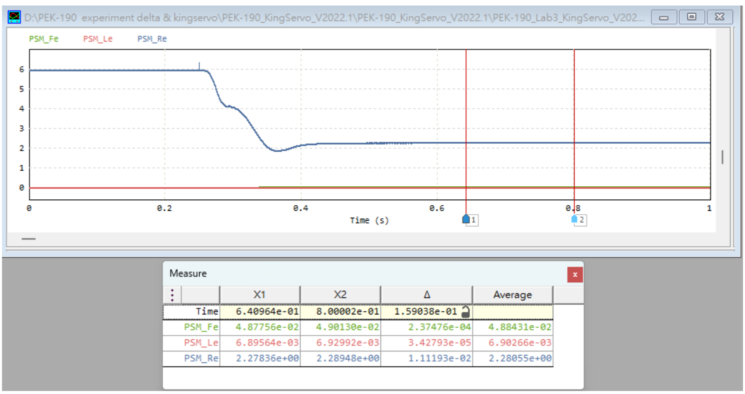


Figure 3-4.1 Analog Circuit Diagram of Experiment 3-4 in PSIM

The simulation results are shown in Figure 3-4.2.



	X1	X2	Δ	Average
Time	6.40964e-01	8.00002e-01	1.59038e-01	
PSM_Fe	4.87756e-02	4.90130e-02	2.37476e-04	4.88431e-02
PSM_Le	6.89564e-03	6.92992e-03	3.42793e-05	6.90266e-03
PSM_Re	2.27836e+00	2.28948e+00	1.11193e-02	2.28055e+00

Figure 3-4.2 Analog Circuit Simulation Waveform of Experiment 3-4

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- One PTS-5000 unit (PSW160-7.2, GPL-300A)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 3-4.3. Please complete the wiring according to this diagram.

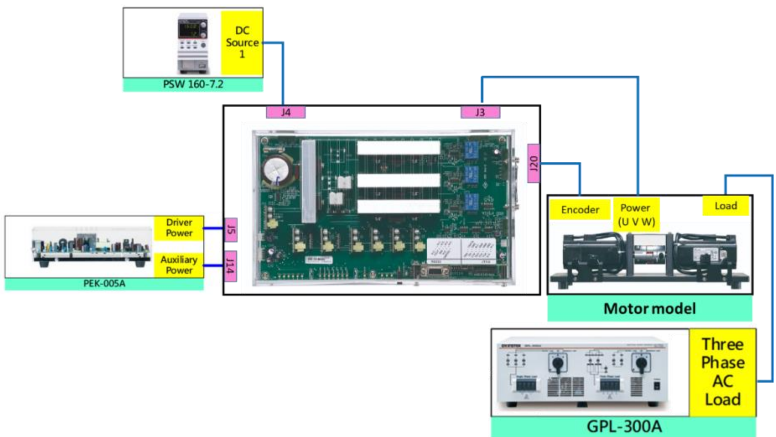
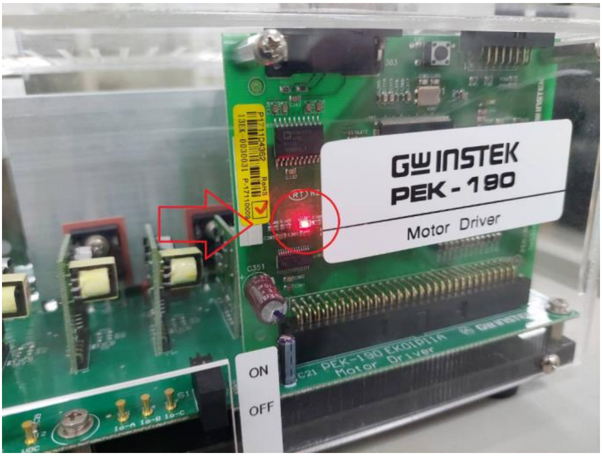


Figure 3-4.3 Wiring Diagram of Experiment 3-4

2. After completing the wiring, first ensure that the PEK-190 switch is set to OFF. Then, turn on the PEK-005A switch. Once turned on, the red indicator light of the DSP will illuminate, as shown in Figure 3-4.4, indicating that the DSP power supply is functioning normally.

Figure 3-4.4

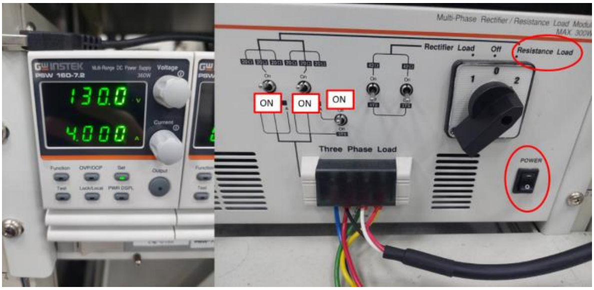
DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.
4. Set PSW160-7.2 to a voltage of 130V and a current of 4A. After turning on the GPL-300A power supply, configure the Three Phase Load to Resistance Load. Set 1TS, 2TS, and 3TS to ON. At this point, the load for each phase is 10 ohms, as shown in Figure 3-4.5.

Figure 3-4.5

PSW and GPL-300A configuration diagram



After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Results

The values measured by RS232 are shown in Figure 3-4.6.

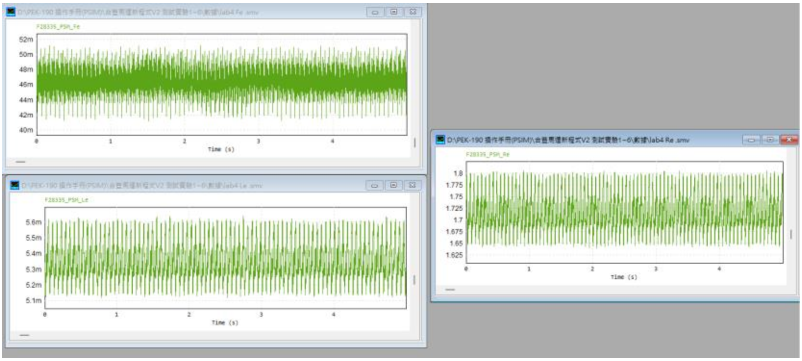


Figure 3-4.6 Actual Measurement Values via RS232 (PSM_Fe, RSM_Le, PSM_Re)

It can be observed that the measured values are similar to the actual values. The motor continuously rotates during this experiment.

Experiment 4 Sensorless Speed Control (Conventional Sliding Mode Observer Method)

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

Fs = 20kHz, Vtri = 10V pp (PWM)

Cb = 330uF

Ks = 0.3 (AC current sensing factor)

Kv = 1/50 (DC voltage sensing factor)

The analog circuit established based on the aforementioned parameters is shown in Figure 4.1.
PSIM file name: PEK-190_Sim4_SL_SMO_KingServo_V2022.1_V1.1

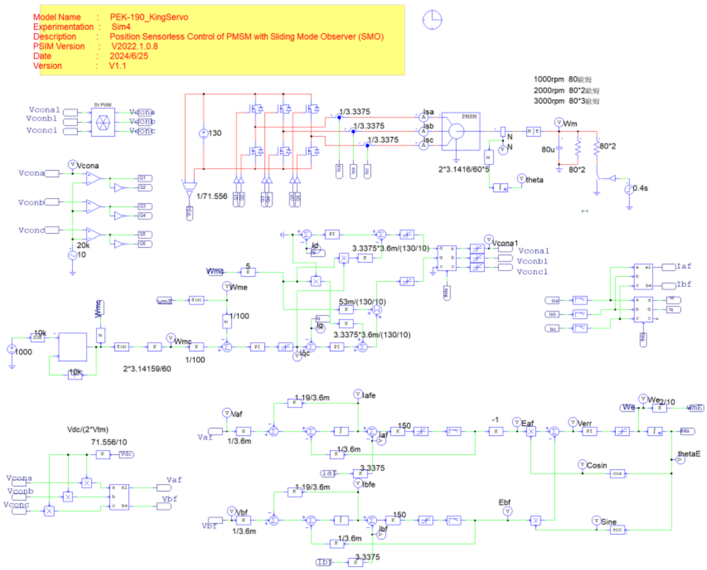


Figure 4.1 Analog Circuit Diagram of Experiment 4 in PSIM

The simulation results are shown in Figure 4.2.

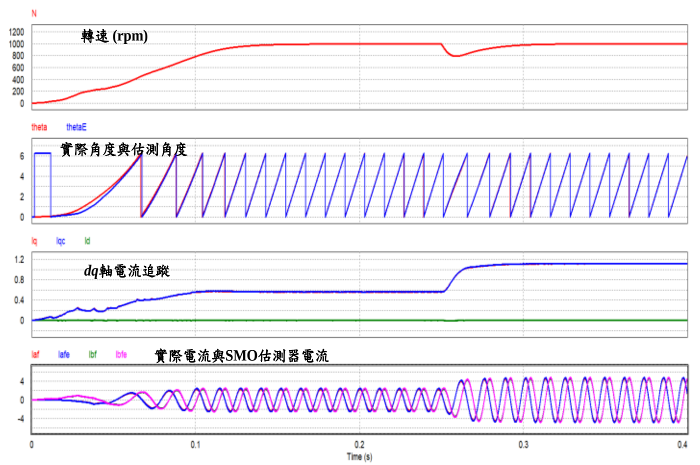


Figure 4.2 Analog Circuit Simulation Waveform of Experiment 4

The digital circuit established based on the analog circuit is shown in Figure 4.3.
PSIM file name: PEK-190_Lab4_SL_SMO_KingServo_V2022.1_V1.1

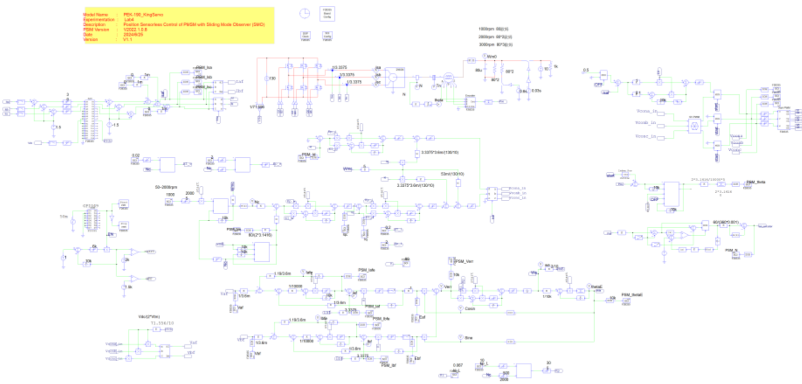


Figure 4.3 Digital Circuit Diagram of Experiment 4 in PSIM

The simulation results are shown in Figure 4.4.

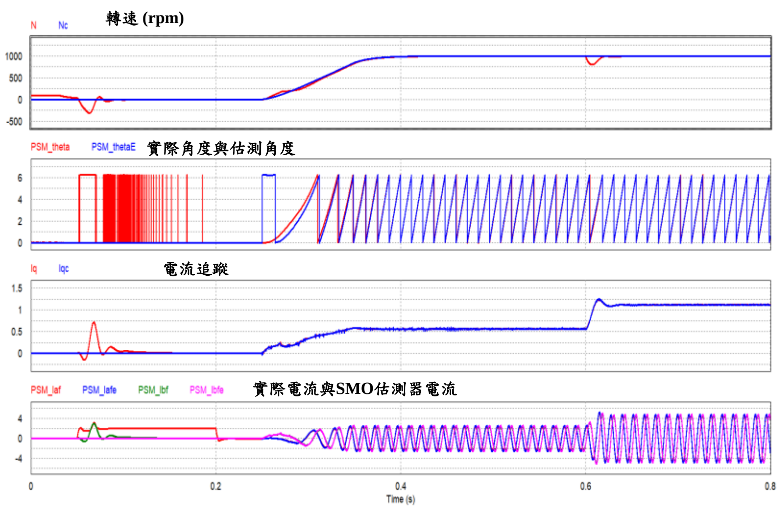


Figure 4.4 Experimental Digital Circuit Simulation Waveform

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- One PTS-3000 (including GDS-2204E, PSW160-7.2, GPL-300A)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 4.5. Please complete the wiring according to this diagram.

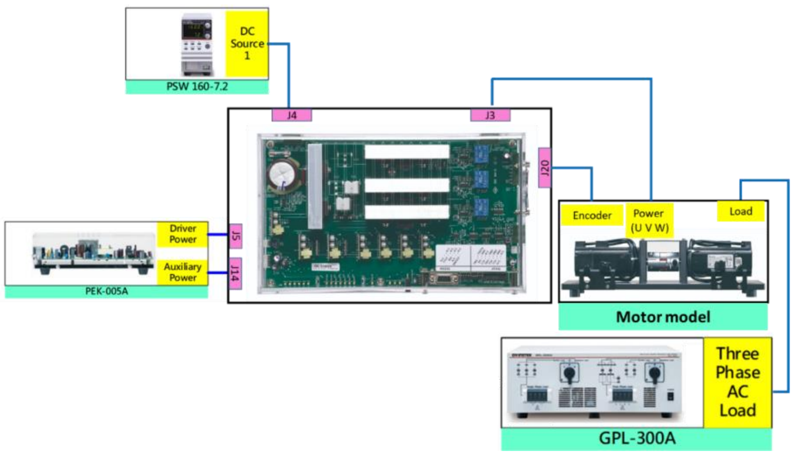
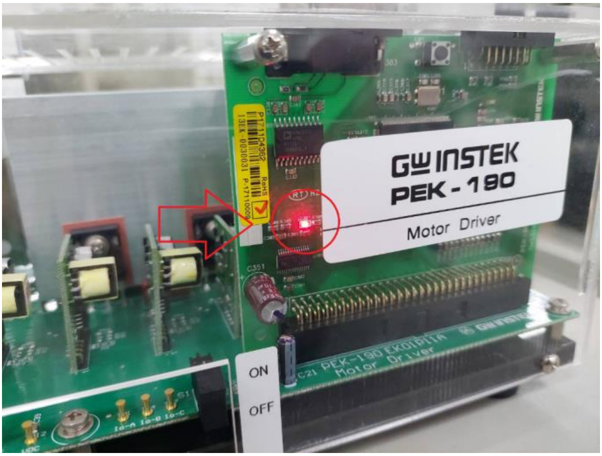


Figure 4.5 Experimental Wiring Diagram for Experiment 4

2. After completing the wiring, first ensure that the PEK-190 switch is set to OFF. Then, turn on the PEK-005A switch. Once turned on, the red indicator light on the DSP will illuminate, as shown in Figure 4.6, indicating that the DSP power supply is functioning normally.

Figure 4.6

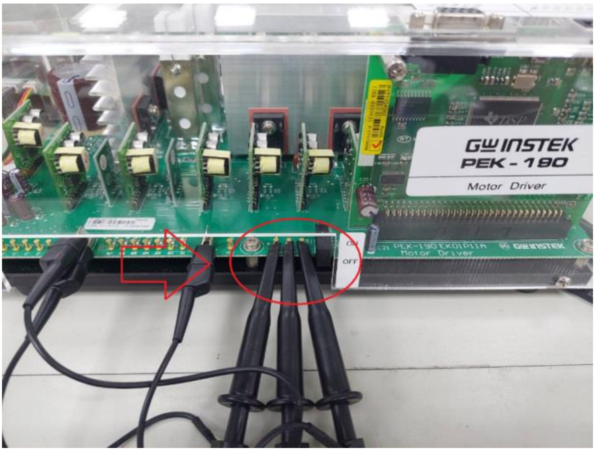
DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.
4. As shown in Figure 4.7, connect the oscilloscope probes to VOA, VOB, VOC, and IOA respectively.

Figure 4.7

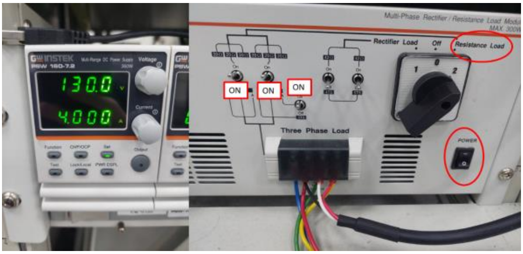
Oscilloscope Probe Wiring



5. Set PSW160-7.2 to a voltage of 130V and a current of 4A. After turning on the GPL-300A power supply, configure the Three Phase Load to Resistance Load. Set 1TS, 2TS, and 3TS to ON. At this point, the load for each phase is 10 ohms, as shown in Figure 4.8.

Figure 4.8

PSW and GPL-300A configuration diagram



After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Objective

Study the "Traditional Sliding Mode Observer Method," which does not use a motor encoder but instead employs SMO+PLL estimation to predict the angular position of the motor.

Experimental Results

Use PISM to connect RS232 for observing and estimating the motor angle.

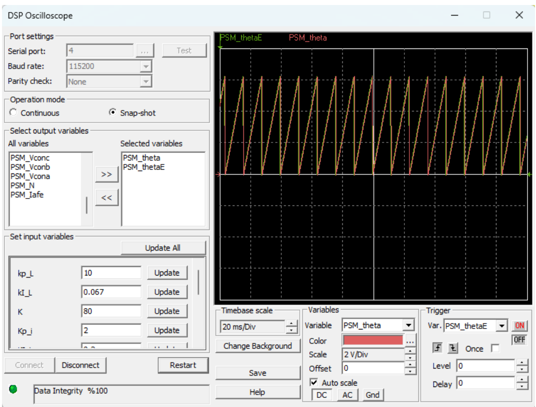
thetaE: Program-estimated position

theta: Actual position output by the encoder

As shown in Figure 4.9

Figure 4.9

Waveform diagram obtained through RS232 connection



Conclusion

The program-estimated position almost overlaps with the actual position output by the encoder, confirming the feasibility of SMO+PLL.

Experiment 5 Sensorless Speed Control (Adaptive Sliding Mode Observer Method)

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

Fs = 20kHz, Vtri = 10V pp (PWM)

Cb = 330uF

Ks = 0.3 (AC current sensing factor)

Kv = 1/50 (DC voltage sensing factor)

The analog circuit established based on the aforementioned parameters is shown in Figure 5.1.
PSIM file name: PEK-190_Sim5_SL_SA_SMO_KingServo_V2022.1_V1.1

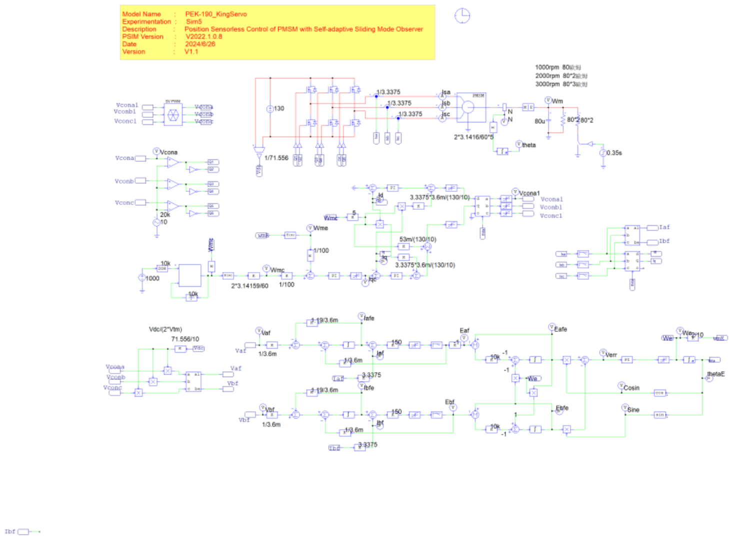


Figure 5.1 Experimental Analog Circuit Diagram for Experiment 5

The simulation results are shown in Figure 5.2.

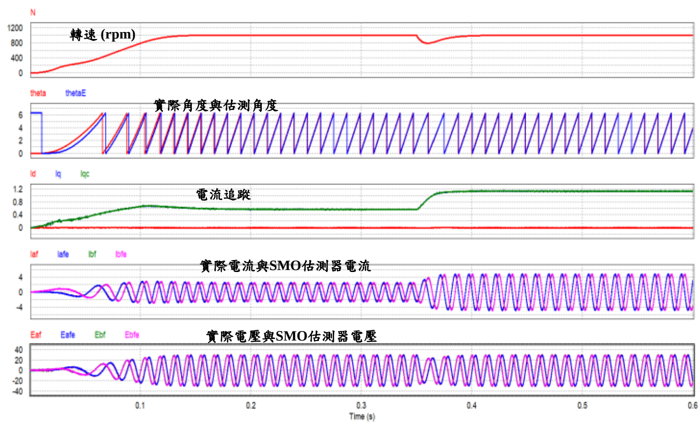


Figure 5.2 Experimental Analog Circuit Simulation Waveform for Experiment 5

Referencing the analog circuit, the digital circuit established is shown in Figure 5.3.
PSIM file name: PEK-190_Lab5_SL_SA_SMO_KingServo_V2022.1_V1.1

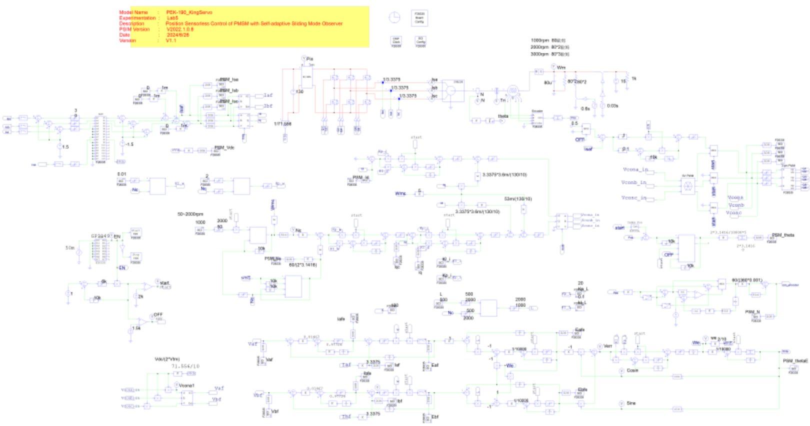


Figure 5.3 Experimental Digital Circuit Diagram for Experiment 5

The simulation results are shown in Figure 5.4.

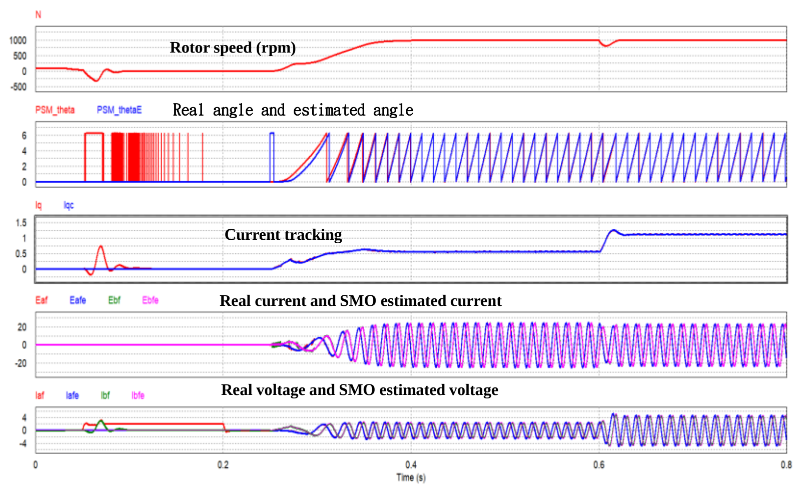


Figure 5.4 Experimental Digital Circuit Simulation Waveform for Experiment 5

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- Two PEK-005A units
- One PEK-006
- One PTS-3000 (including GDS-2204E, PSW160-7.2, GPL-300A)
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 5.5. Please complete the wiring according to this diagram.

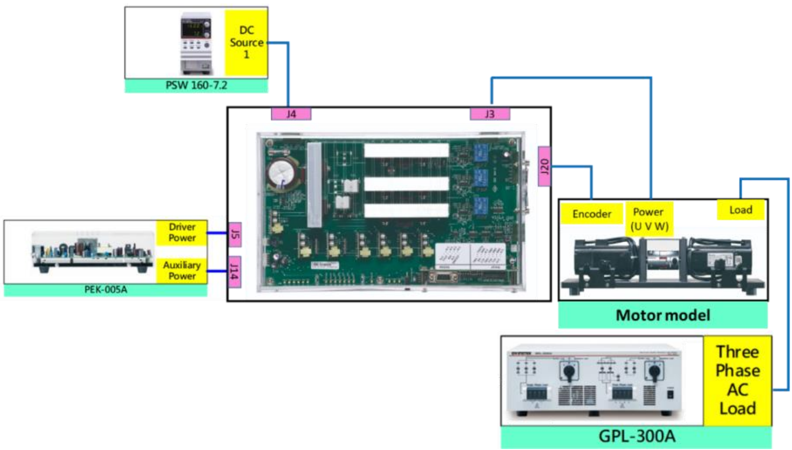
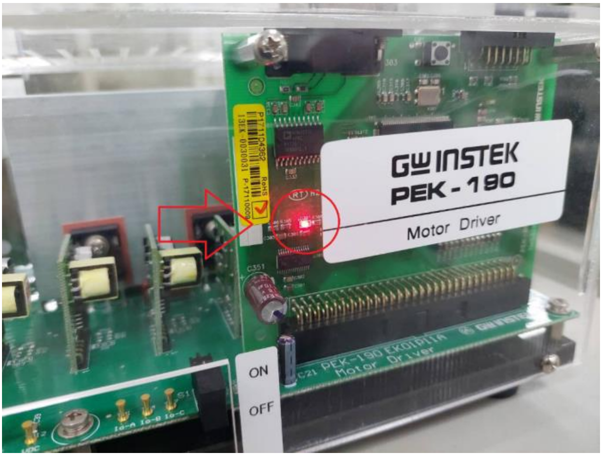


Figure 5.5 Experimental Wiring Diagram for Experiment 5

2. After completing the wiring, first ensure that the PEK-190 switch is set to OFF. Then, turn on the PEK-005A switch. Once turned on, the red indicator light on the DSP will illuminate, as

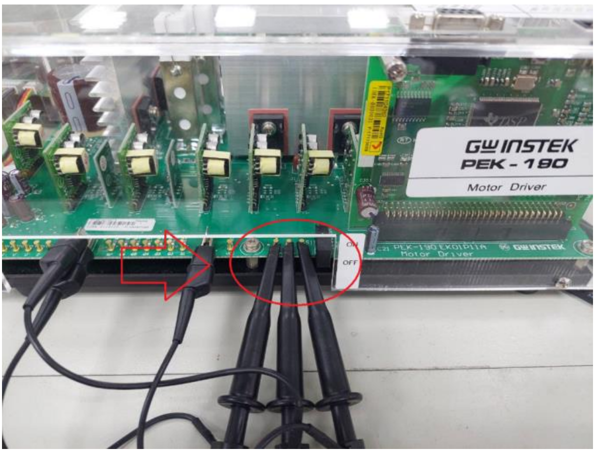
shown in Figure 5.6, indicating that the DSP power supply is functioning normally.

Figure 5.6
DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.
4. As shown in Figure 5.7, connect the oscilloscope probes to VOA, VOB, VOC, and IOA respectively.

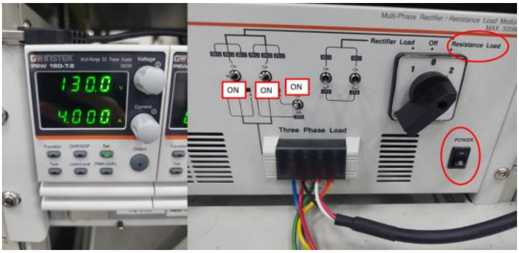
Figure 5.7
Oscilloscope Probe Wiring



5. Set PSW160-7.2 to a voltage of 130V and a current of 4A. After turning on the GPL-300A power supply, configure the Three Phase Load to Resistance Load. Set 1TS, 2TS, and 3TS to ON. At this point, the load for each phase is 10 ohms, as shown in Figure 5.8.

Figure 5.8

PSW and GPL-300A configuration diagram



After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Objective

Study the "Adaptive Sliding Mode Observer Method," which does not use a motor encoder but instead employs SMO+self-adaptive+PLL estimation to predict the angular position of the motor.

Experimental Results

Use PISM to connect RS232 for observing and estimating the motor angle.

thetaE: Program-estimated position

theta: Actual position output by the encoder

As shown in Figure 5.9

Figure 5.9

Waveform diagram obtained through RS232 connection

Conclusion

The estimated position of the program almost overlaps with the actual output position of the encoder, confirming the feasibility of SMO+self-adaptive+PLL.

Experiment 6 Sensorless Speed Control (Model Reference Adaptive Method)

Circuit Simulation

The specifications of the driver are as follows:

DC Voltage Vd = 130V

Fs = 20kHz, Vtri = 10V pp (PWM)

Cb = 330uF

Ks = 0.3 (AC current sensing factor)

Kv = 1/50 (DC voltage sensing factor)

The analog circuit constructed based on the aforementioned parameters is shown in Figure 6.1.
PSIM file name: PEK-190_Sim6_SL_MRAS_KingServo_V2022.1_V1.1

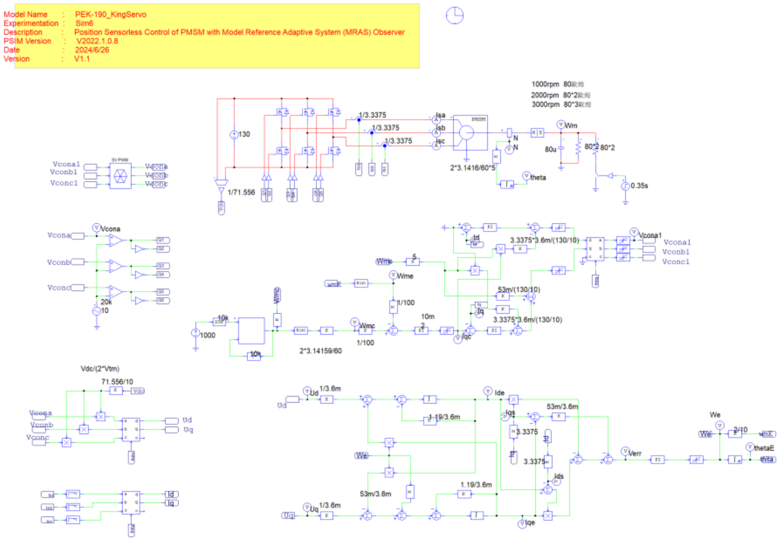


Figure 6.1 Analog Circuit Diagram of Experiment 6 PSIM Generator

The simulation results are shown in Figure 6.2.

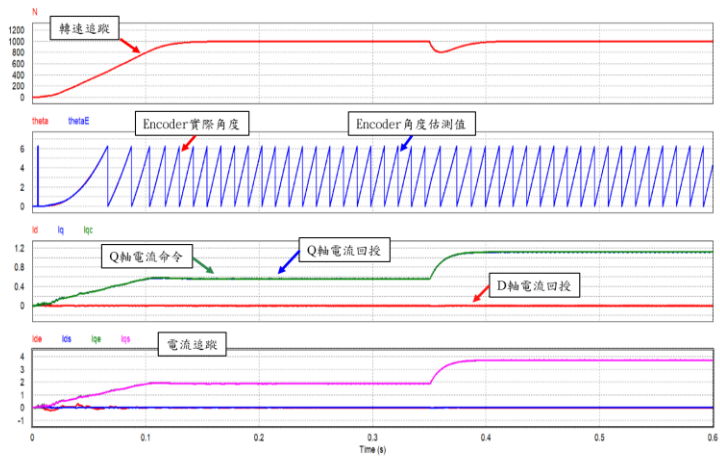


Figure 6.2 Experimental Six Analog Circuit Simulation Waveform

Refer to the digital circuit constructed based on the analog circuit, as shown in Figure 6.3.
The PSIM file name is:PEK-190 Laboratory 6 System-Level Model Reference Adaptive System King Servo Version 2022.1 Version 1.1

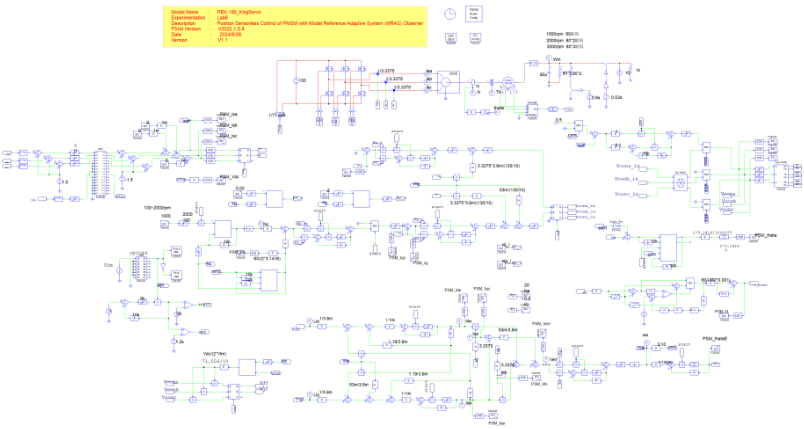


Figure 6.3 Experimental Six PSIM Digital Circuit Diagram

The simulation results are shown in Figure 6.4.

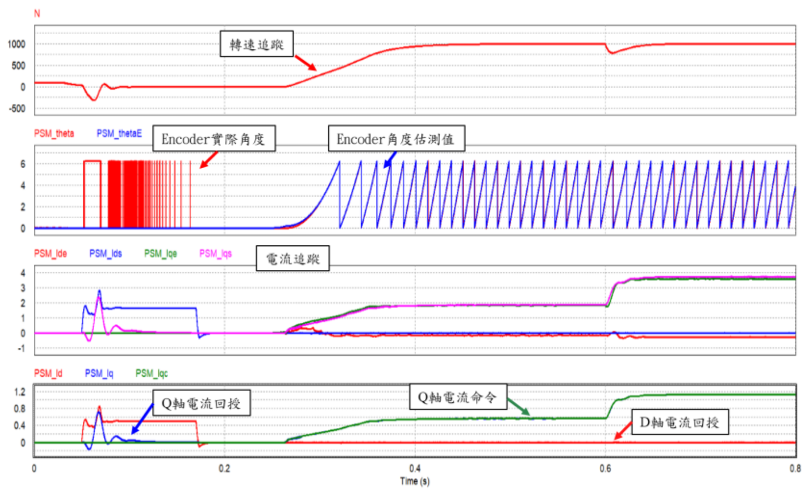


Figure 6.4 Experiment 6 Digital Circuit Simulation Waveform

After confirming the simulation is correct, use the Simulate function's Generate Code feature to automatically generate the corresponding C code.

Experimental Equipment

The equipment required for this experiment is as follows:

- One PEK-190
- One PEK-005A
- One PEK-006
- PTS-5000 unit (including GDS-2204E, PSW160-7.2, GPL-300A).
- One PC

Experimental Procedure

1. The experimental wiring diagram is shown in Figure 6.5. Please complete the wiring according to this diagram.

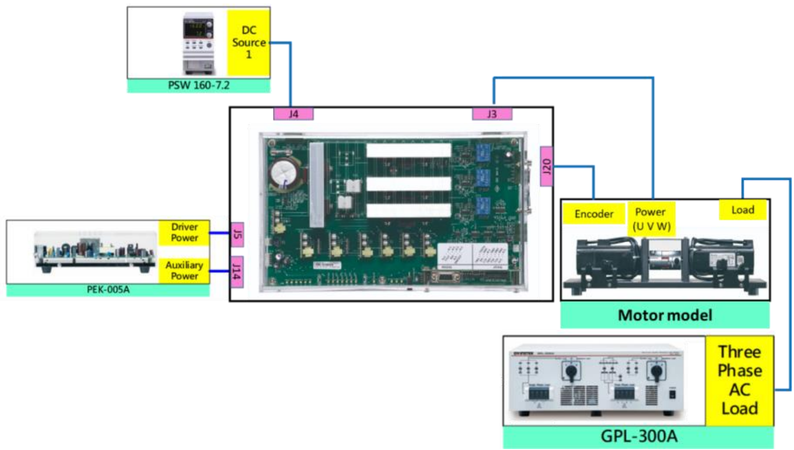
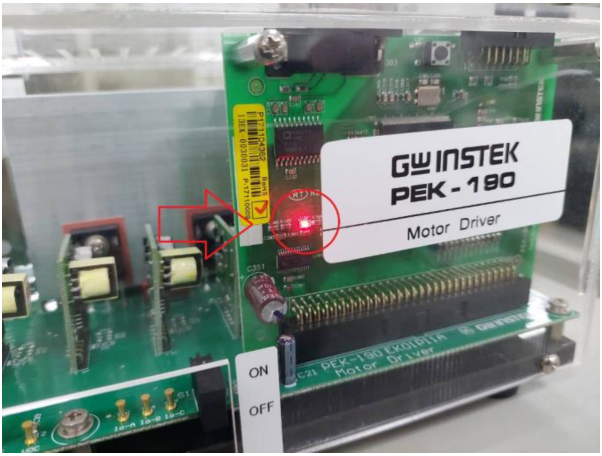


Figure 6.5 Wiring Diagram for Experiment Six

2. After completing the wiring, first ensure that the PEK-190 switch is set to OFF. Then, turn on the PEK-005A switch. Once activated, the red indicator light on the DSP will illuminate, as

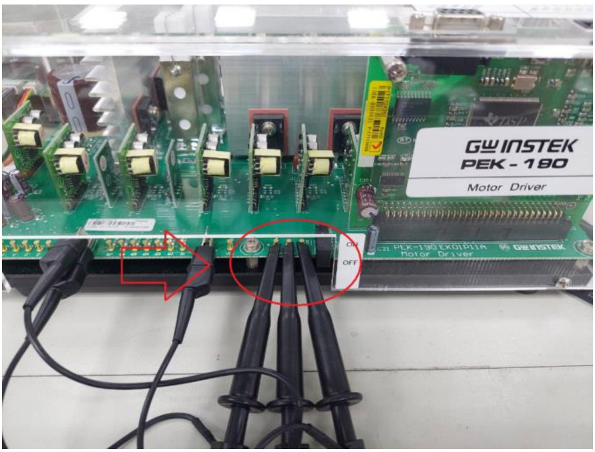
shown in Figure 6.6. This indicates that the DSP power supply is functioning normally.

Figure 6.6
DSP normal operation display



3. Please follow Appendix B (programming procedure) to perform the programming.
4. As shown in Figure 6.7, connect the oscilloscope probes to VOA, VOB, VOC, and IOA respectively.

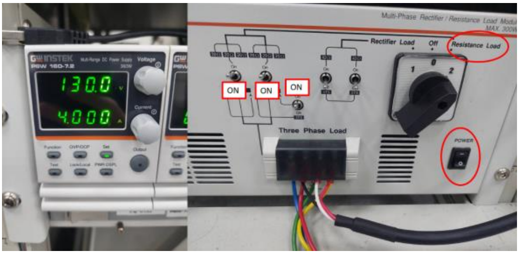
Figure 6.7
Oscilloscope Probe Wiring



5. The PSW160-7.2 is configured to a voltage of 130V and a current of 4A. After powering on the GPL-300A power supply, the

Three Phase Load is set to Resistance Load, with 1TS, 2TS, and 3TS configured to ON. At this point, the load per phase is 10 ohms, as illustrated in Figure 6.8.

Figure 6.8
PSW and GPL-300A configuration diagram



After completing the setup, turn on the PSW power output, and finally switch on the PEK-190.

Experimental Objective

Learning the Model Reference Adaptive System (MRAS) method, which eliminates the use of motor encoders and utilizes MRAS estimation to infer the angular position of the motor.

Experimental Results

Use PISM to connect RS232 for observing and estimating the motor angle.

thetaE: Program-estimated position

theta: Actual position output by the encoder

As shown in Figure 6.9

Figure 6.9

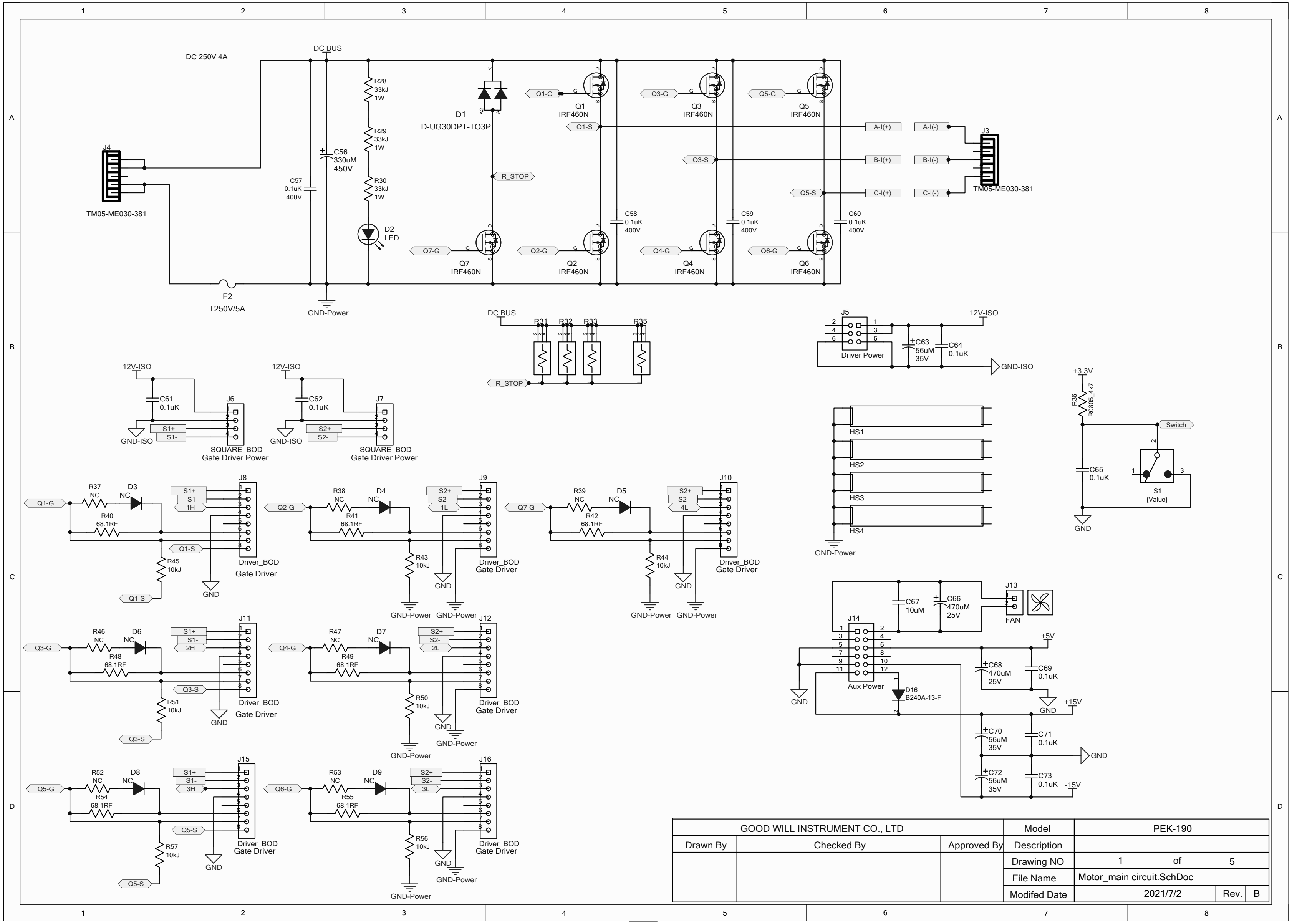
Waveform diagram obtained through RS232 connection

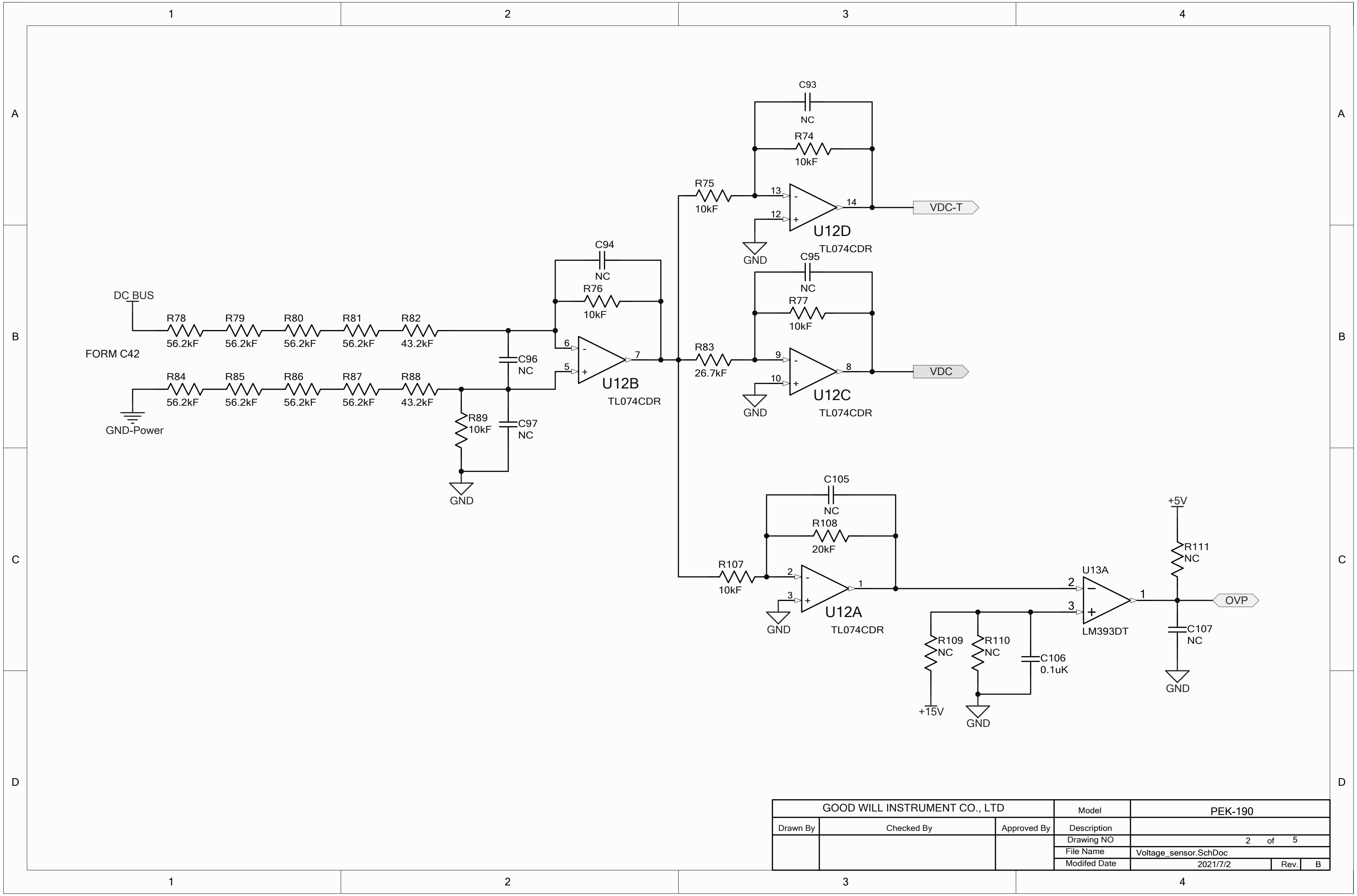
Conclusion

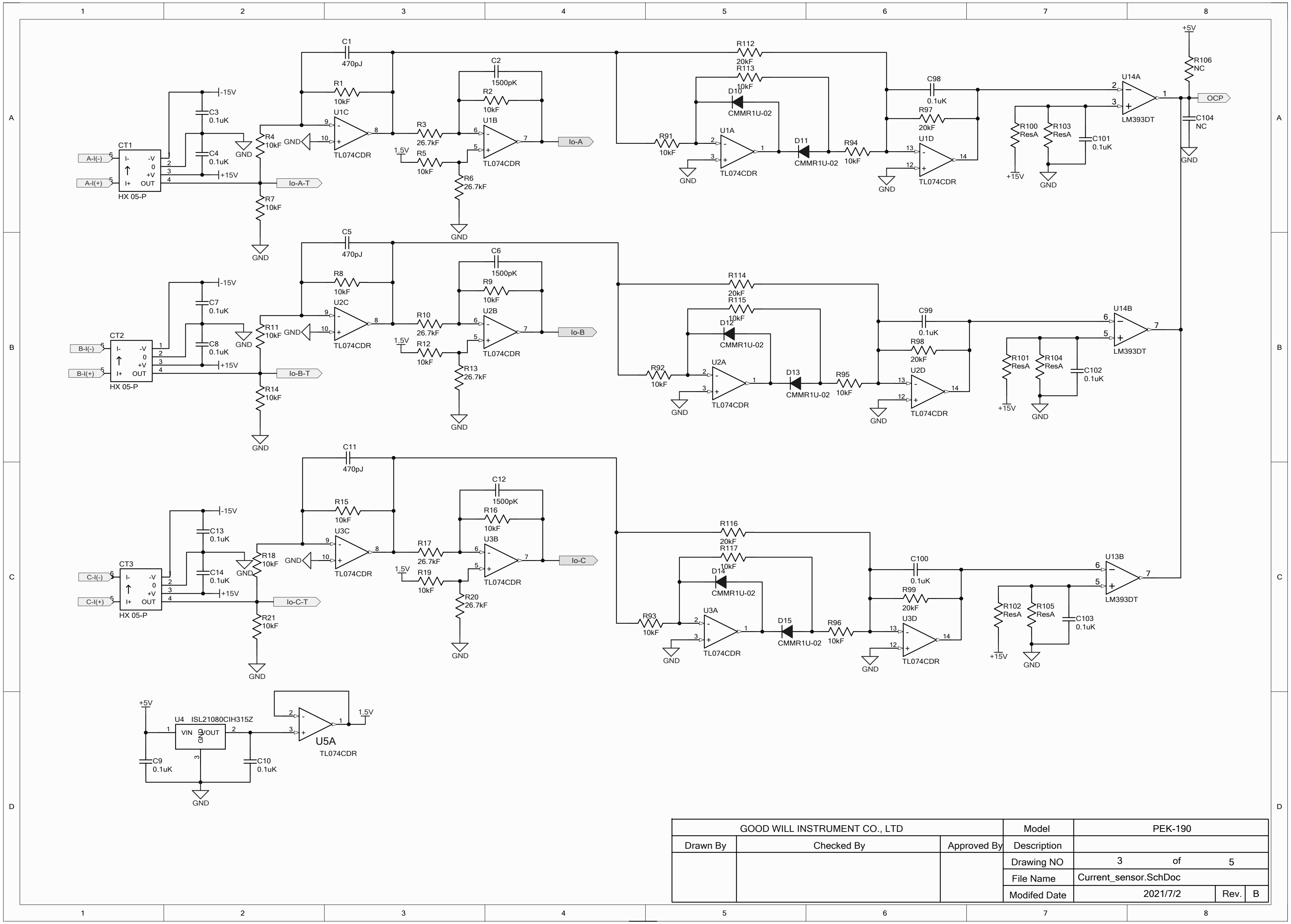
The estimated position of the program almost overlaps with the actual output position of the encoder, confirming the feasibility of MRAS.

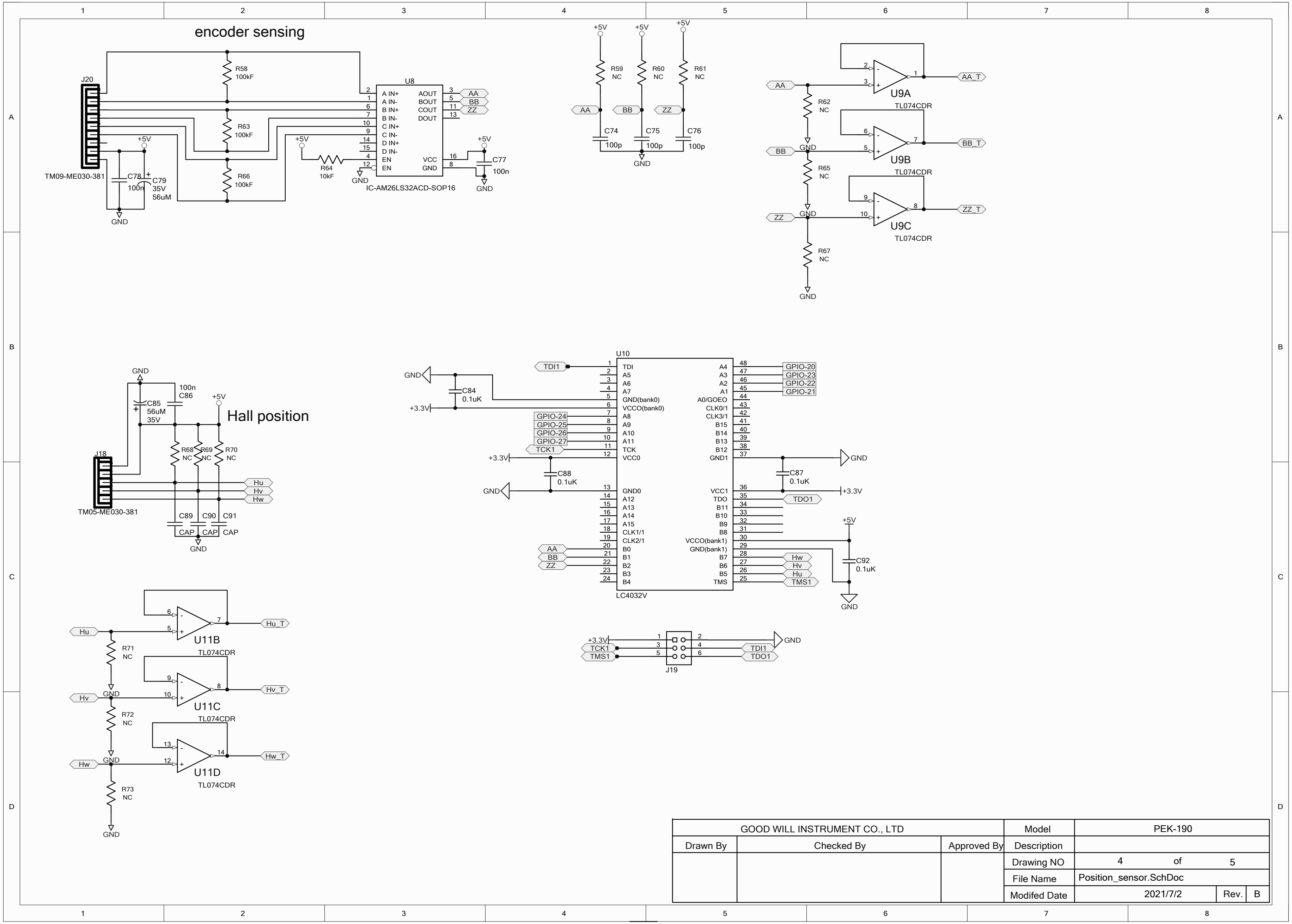
Appendix A PEK-190 Circuit Diagram

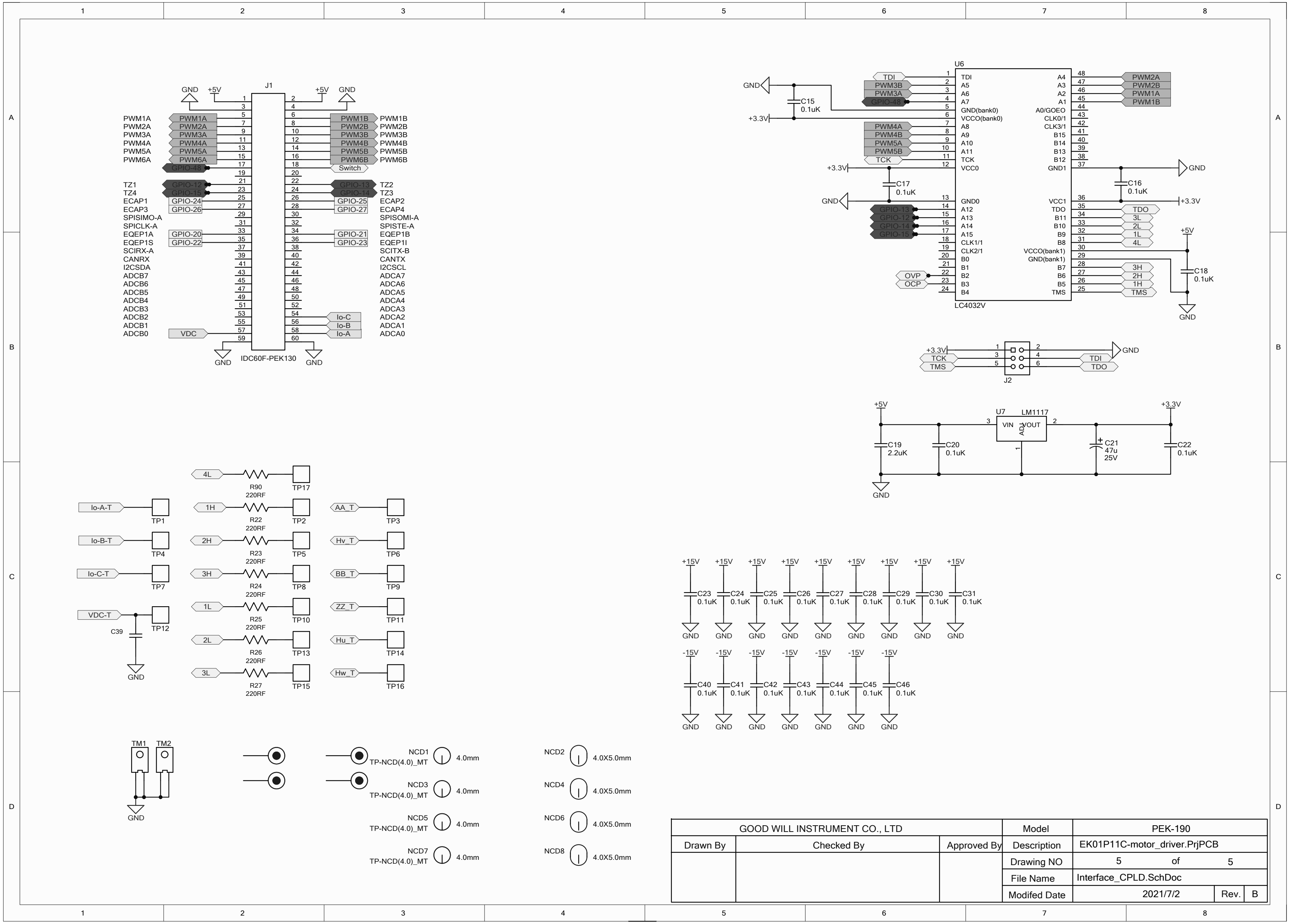
Motor Main Circuit



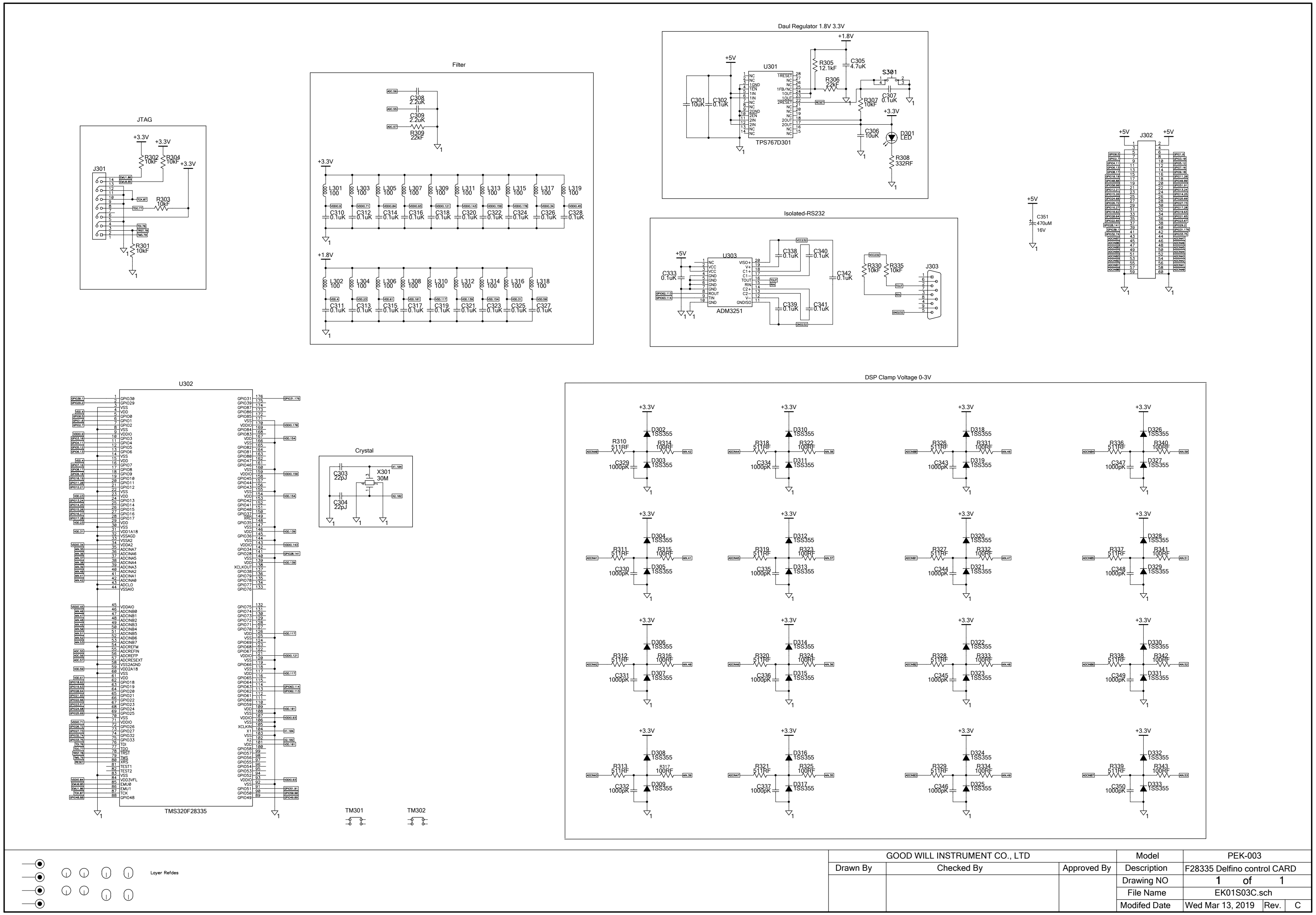

DC BUS
FORM C42
GND-Power
R78 56.2kF
R79 56.2kF
R80 56.2kF
R81 56.2kF
R82 43.2kF
R84 56.2kF
R85 56.2kF
R86 56.2kF
R87 56.2kF
R88 43.2kF
R89 10kF
C96 NC
C97 NC
GND
C94 NC
R76 10kF
U12B TL074CDR
C93 NC
R74 10kF
R75 10kF
U12D TL074CDR
VDC-T
C95 NC
R77 10kF
R83 26.7kF
U12C TL074CDR
VDC
C105 NC
R108 20kF
R107 10kF
U12A TL074CDR
U13A LM393DT
R109 NC
R110 NC
C106 0.1uK
+15V
+5V
R111 NC
C107 NC
OVP
GOOD WILL INSTRUMENT CO., LTD
Model PEK-190
Drawn By
Checked By
Approved By
Description
Drawing NO 2 of 5
File Name Voltage_sensor.SchDoc
Modifed Date 2021/7/2
Rev. B


CT1
HX 05-P
A-I(-)
A-I(+)
Io-A
Io-A-T
CT2
HX 05-P
B-I(-)
B-I(+)
Io-B
Io-B-T
CT3
HX 05-P
C-I(-)
C-I(+)
Io-C
Io-C-T
U1C
U1B
U1A
U1D
TL074CDR
U14A
U14B
U13B
LM393DT
OCP
U4 ISL21080CIH315Z
U5A
TL074CDR
+5V
1.5V
+15V
-15V
GND
GOOD WILL INSTRUMENT CO., LTD
Model
PEK-190
Drawn By
Checked By
Approved By
Description
Drawing NO
3 of 5
File Name
Current_sensor.SchDoc
Modifed Date
2021/7/2
Rev.
B

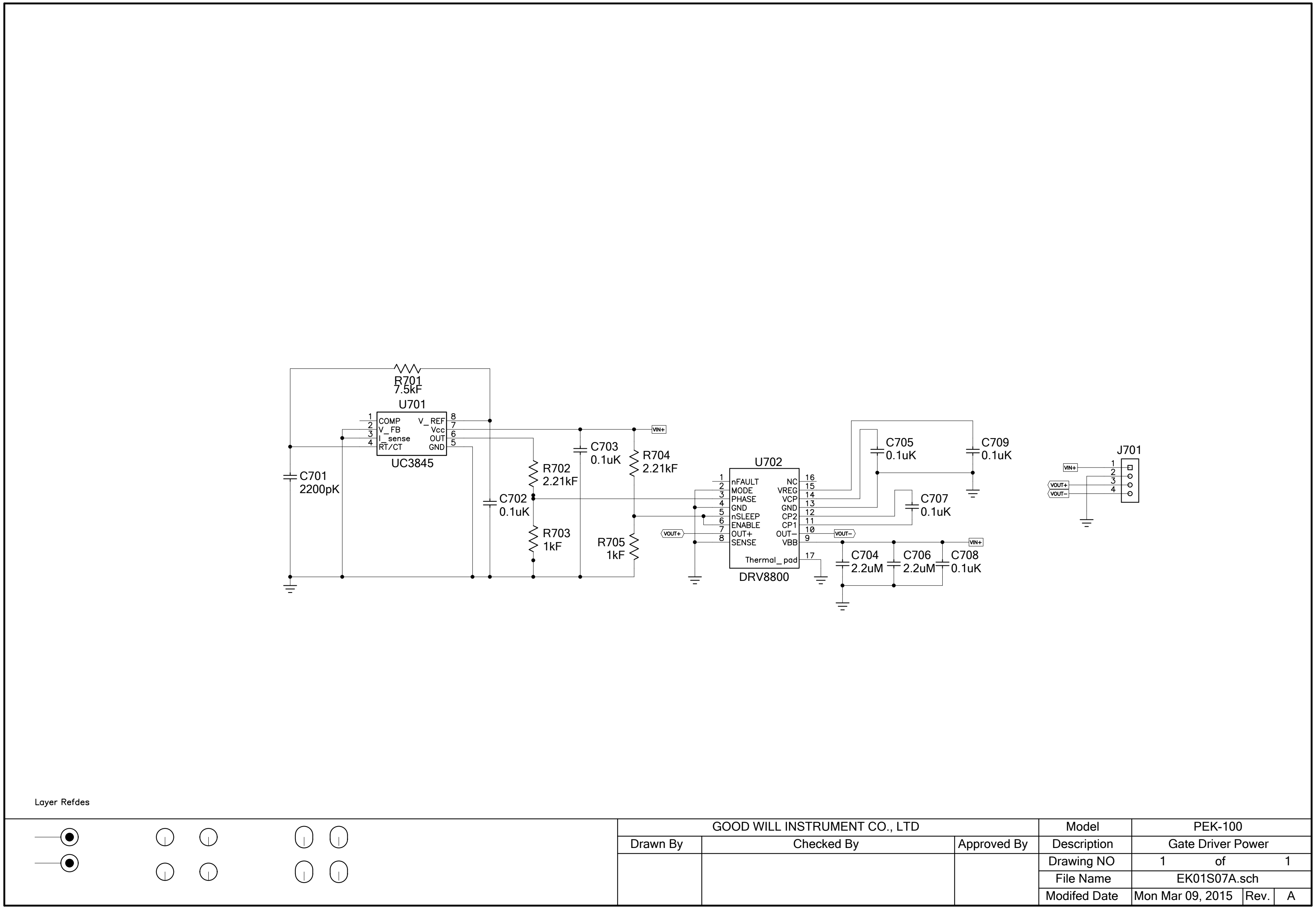

encoder sensing
J20
TM09-ME030-381
R58
100kF
R63
100kF
R66
100kF
U8
A IN+
A IN-
B IN+
B IN-
C IN+
C IN-
D IN+
D IN-
EN
EN
AOUT
BOUT
COUT
DOUT
VCC
GND
IC-AM26LS32ACD-SOP16
R64
10kF
C77
100n
C78
100n
C79
35V
56uM
+5V
GND
AA
BB
ZZ
R59
NC
R60
NC
R61
NC
C74
100p
C75
100p
C76
100p
U9A
U9B
U9C
TL074CDR
R62
NC
R65
NC
R67
NC
AA_T
BB_T
ZZ_T
Hall position
J18
TM05-ME030-381
C85
56uM
35V
C86
100n
R68
NC
R69
NC
R70
NC
C89
C90
C91
CAP
Hu
Hv
Hw
U10
LC4032V
TDI1
TDO1
TCK1
TMS1
GPIO-20
GPIO-23
GPIO-22
GPIO-21
GPIO-24
GPIO-25
GPIO-26
GPIO-27
C84
0.1uK
C88
0.1uK
C87
0.1uK
C92
0.1uK
+3.3V
U11B
U11C
U11D
R71
NC
R72
NC
R73
NC
Hu_T
Hv_T
Hw_T
J19
GOOD WILL INSTRUMENT CO., LTD
Model
PEK-190
Drawn By
Checked By
Approved By
Description
Drawing NO
4 of 5
File Name
Position_sensor.SchDoc
Modifed Date
2021/7/2
Rev.
B


J1
IDC60F-PEK130
U6
LC4032V
J2
U7
LM1117
GOOD WILL INSTRUMENT CO., LTD
Model
PEK-190
Drawn By
Checked By
Approved By
Description
EK01P11C-motor_driver.PrjPCB
Drawing NO
5
of
5
File Name
Interface_CPLD.SchDoc
Modifed Date
2021/7/2
Rev.
B

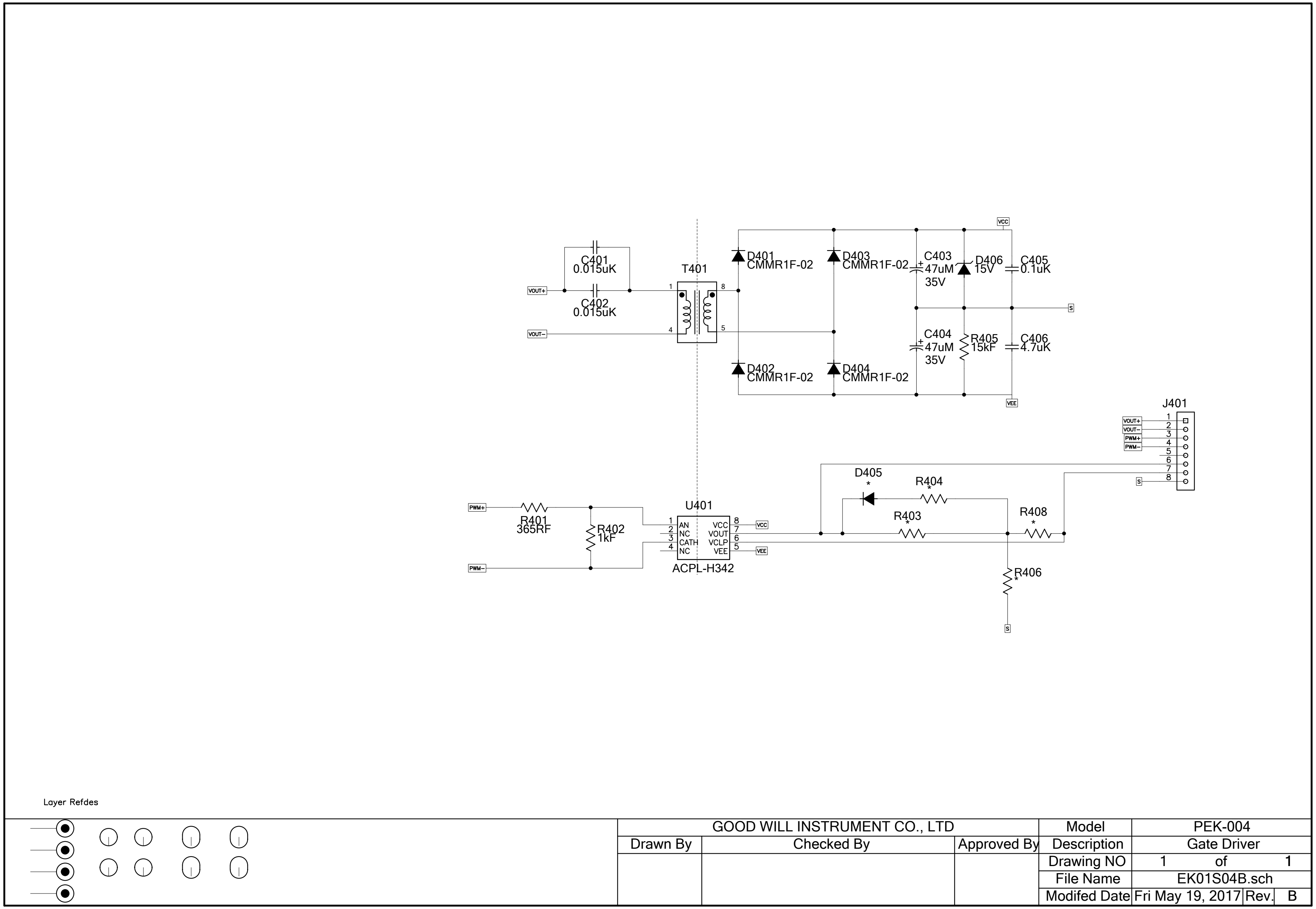
F28335 Delfino Control Card



Gate Driver Power



Gate Driver

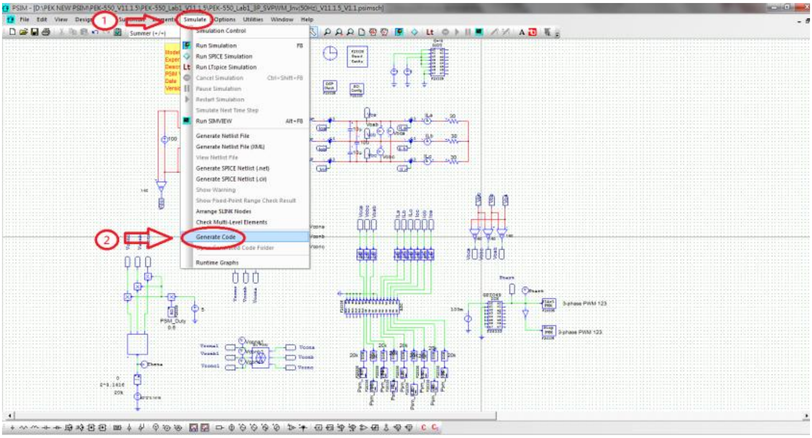

C401
0.015uK
C402
0.015uK
VOUT+
VOUT-
T401
D401
CMMR1F-02
D402
CMMR1F-02
D403
CMMR1F-02
D404
CMMR1F-02
C403
47uM
35V
C404
47uM
35V
D406
15V
C405
0.1uK
R405
15kF
C406
4.7uK
VCC
VEE
S
J401
PWM+
PWM-
D405
R404
R403
R408
R406
R401
365RF
R402
1kF
U401
AN
NC
CATH
NC
VCC
VOUT
VCLP
VEE
ACPL-H342
Layer Refdes
GOOD WILL INSTRUMENT CO., LTD
Drawn By
Checked By
Approved By
Model
PEK-004
Description
Gate Driver
Drawing NO
1 of 1
File Name
EK01S04B.sch
Modifed Date
Fri May 19, 2017
Rev.
B

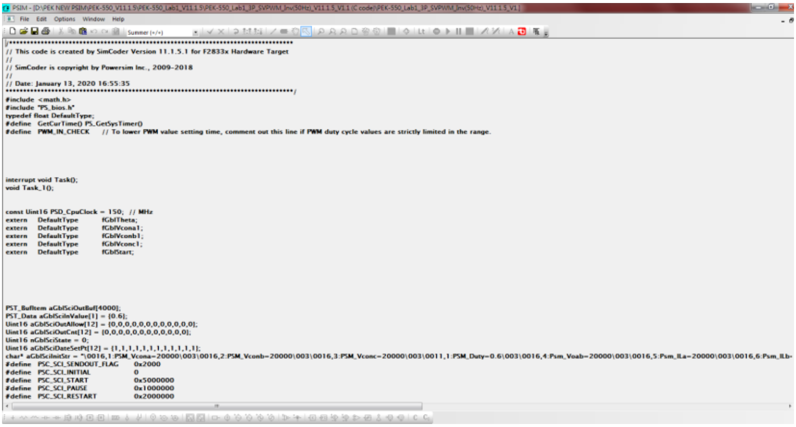
Appendix B C Code Programming Procedure

Appendix on "PEK-550_Lab1_3P_SVPWM_Inverter".Using `(50Hz)_V11.1.5_V1.1` as an example for operational instructions, the steps are as follows.

Operational Procedure

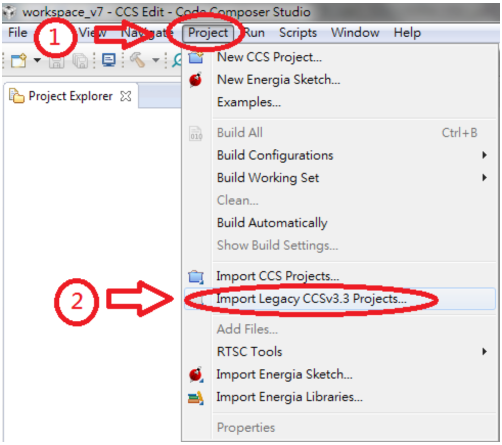
1. Open the digital circuit file PEK-550_ in the PSIM program.Lab1_3P_SVPWM_Inv(50Hz)_V11.1.5_V1.1, under the "Simulate" tab, click "Generate Code," and PSIM will automatically generate C code, as shown in the figure below.



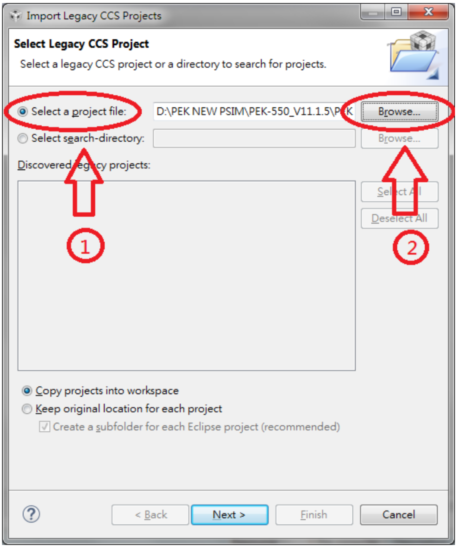


2. The system will generate a folder within the directory containing the PSIM circuit file, with the same name as the PSIM circuit file. This folder will store the C code and related files required for programming, as illustrated in the figure below.

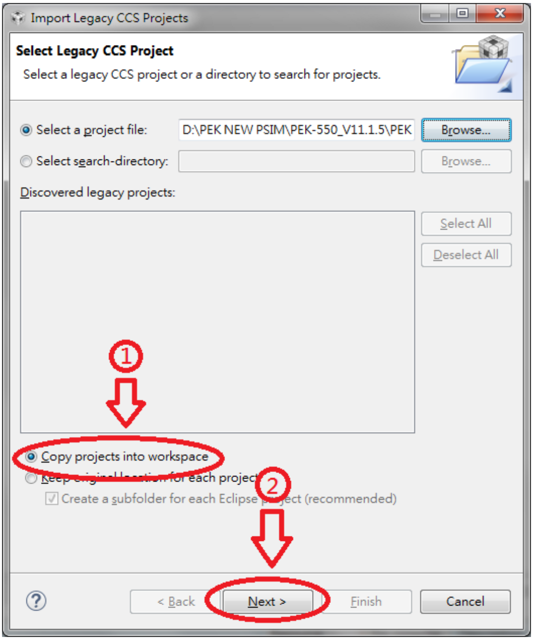
3. Launch CCS, navigate to the "Project" section, and select the "Import Legacy CCSv3.3 Projects" option, as shown in the figure below.

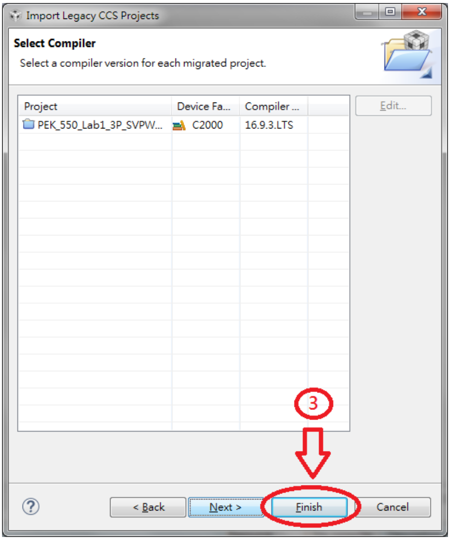


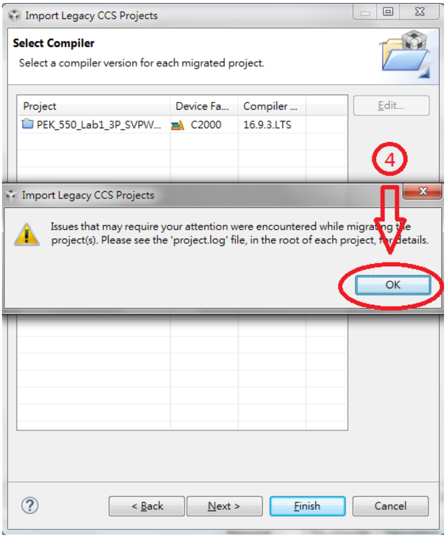
4. In the "Select a project file" section, click "Browser" to locate the folder containing the C Code and select the file with the .pjt extension, as shown in the figure below.



5. Select Copy projects into workspace, then click Next, followed by Finish, to import the C code into the CCS program, as shown in the figure below.

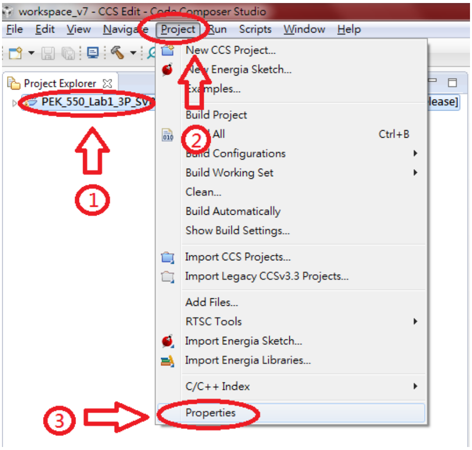


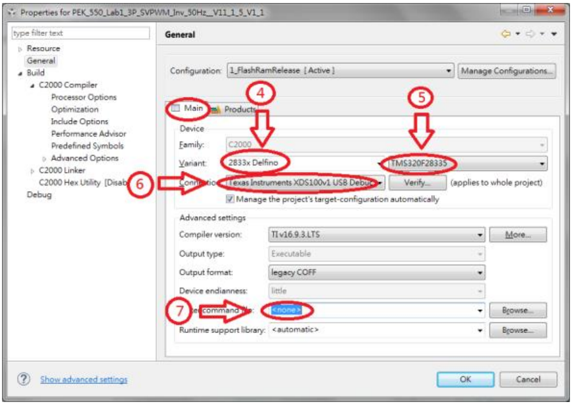

Import Legacy CCS Projects
Select Compiler
Select a compiler version for each migrated project.
Project
Device Fa...
Compiler ...
Edit...
PEK_550_Lab1_3P_SVPW...
C2000
16.9.3.LTS
3
< Back
Next >
Finish
Cancel

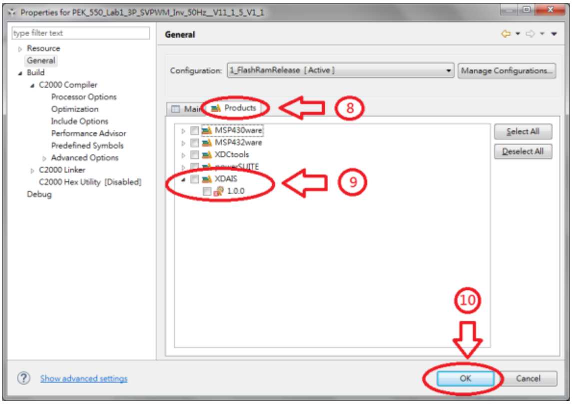

Import Legacy CCS Projects
Select Compiler
Select a compiler version for each migrated project.
Project
Device Fa...
Compiler ...
Edit...
PEK_550_Lab1_3P_SVPW...
C2000
16.9.3.LTS
4
Import Legacy CCS Projects
OK
< Back
Next >
Finish
Cancel

6. After selecting the C Code file, navigate to Project and select Properties, then configure as follows:(1) In Main, select Variant as "2833X Delfino within TMS320F28335". (2) In Main, select Connection as "Texas Instruments XDS100v1 USB Debug Probe".
(3) In Main, select Linker command file as "none".

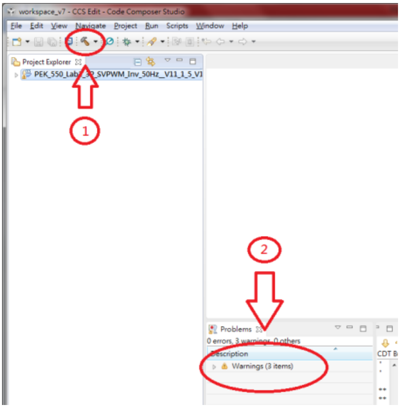
(4) In Products, deselect XDAIS (if this option is not available in your CCS version, it can be ignored).



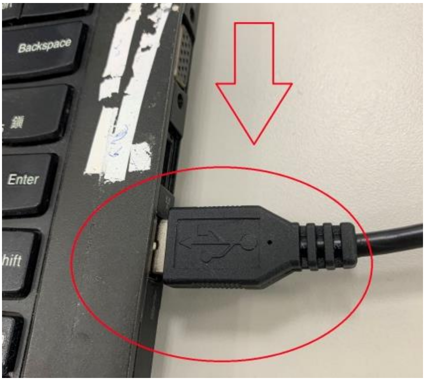


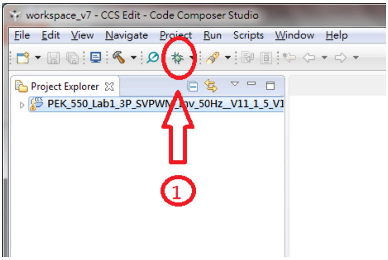


7. After completing the configuration, click Build to compile. Upon completion of the compilation, if there are no Errors, the program is ready for flashing. Warnings do not affect the flashing process and can be disregarded.

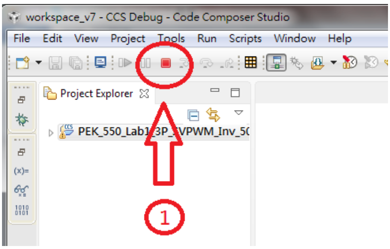


8. Connect the PEK-006 to both the PC and the PEK module, then click Debug to proceed with flashing.

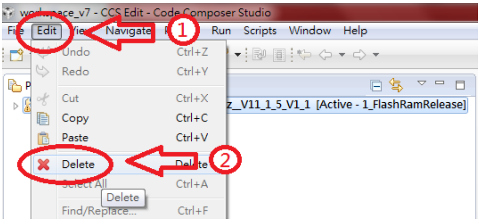


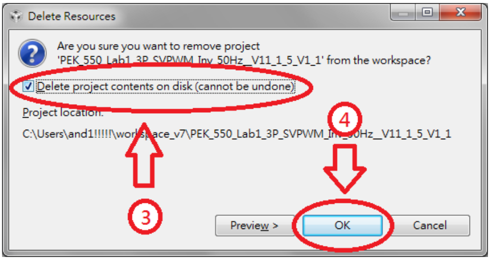


9. After flashing is complete, click Terminate and disconnect the PEK-006. This concludes the flashing procedure.



10. To delete a file, select the C Code file, navigate to Edit, select Delete, check the option Delete project contents on disk, and then click OK to complete the deletion.



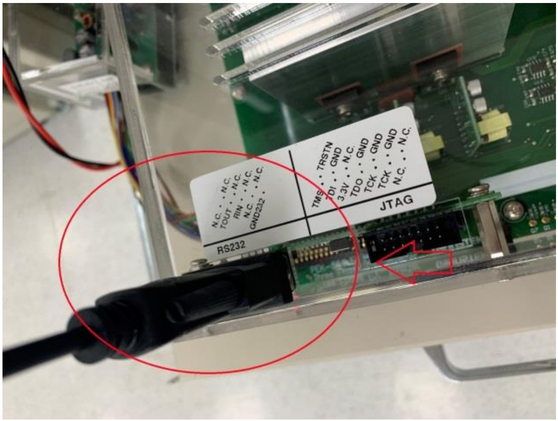


Appendix C RS232 Connection

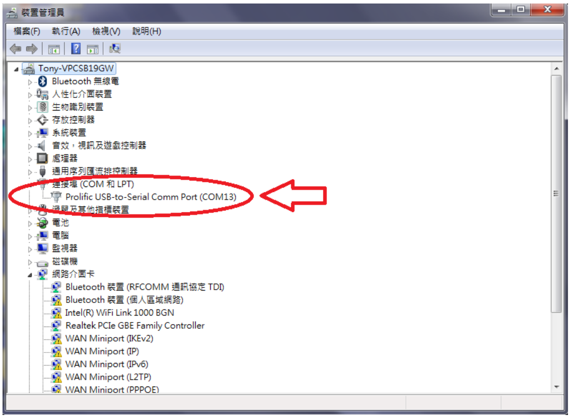
Operational Procedure

1. Connect the PEK-005A to the PEK module and ensure the DSP is operating in a normal state.

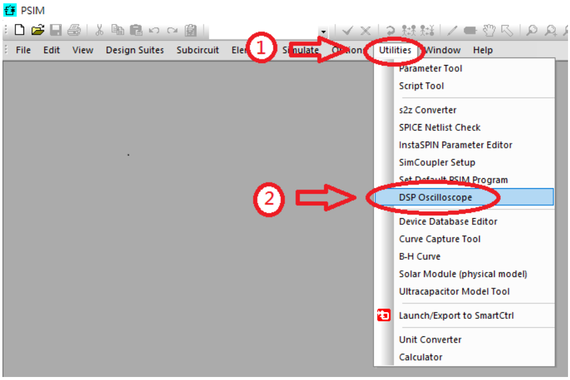
2. Connect one end of the RS232 cable to the PC and the other end to the RS232 port on the PEK module.



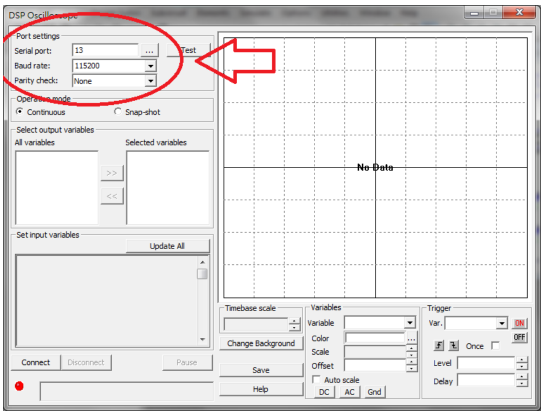
3. Open the Device Manager on the computer and verify the COM port used by the RS232 connection.



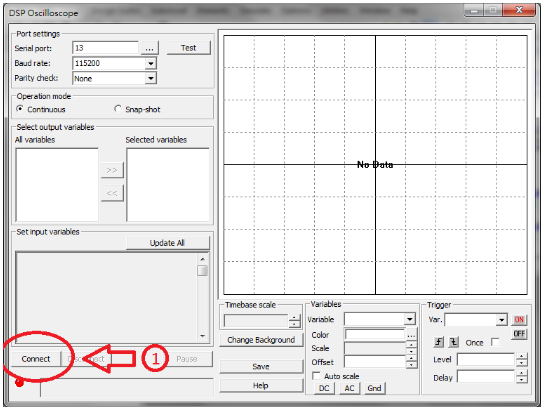
4. Launch the PSIM software and select DSP Oscilloscope from the Utilities menu in the top toolbar.



5. Configure the Port settings as follows:(1) Select the Serial port corresponding to the COM port used by the RS232 connection. (2) Set the Baud rate to 111900. (3) Set Parity check to None.



6. After completing the configuration, click Connect to establish the RS232 connection.



7. Once the connection is successfully established, the output variables and input variables defined within the PSIM circuit will be visible.