**THE MARVIN GROUP**

**MARVIN LAND SYSTEMS**

**LOS ANGELES, CALIFORNIA**

Acceptance Test Procedure and Functional Verification

for the

Controller, 28 Vdc, Engine Bay, Part No. 414-8005-95

ATP414-8005-95 Rev - E

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**RECORD OF REVISIONS**

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| **REVISION NO.** | **DATE** | **AFFECTED**  **PAGE/PARA.** | **REASON FOR REVISION** |
| NC | Mar 2015 | All | Review |
| A | Apr 2015 | 7.5.4 | Updated Temperature Calibration Test |
|  |  | 7.5.6 | Changed Auxiliary Fan Switching Points |
|  |  | Appendix A | Updated Test Data Sheet |
| B | Apr 2015 | 7.2 | Updated Insulation Resistance Test |
|  |  | 7.5.3, 7.5.5 and 7.5.6 | Updated E-Bay Fan High Speed Setting |
| C | Dec 2015 | 7.2.1 | Added Canbus Resistance Test |
| D | Aug 2016 | 7.5.3  7.5.6  All | Added Stop time Test  Burn In Time Changed to 30 min.  Speed Point 3 changed from 13500 to 15100 |
| E | Jan 2017 | 7.2, 7.5.5, 7.5.7,  Appendix A | Added ambient temperature measurement. Bonding test added. Calibration Offset and supply current range specified. Expected values specified in Test Data Sheet. PN changed |
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# INTRODUCTION

The Engine Bay (E-Bay) Motor Controller (Marvin P/N 414-8005-95) is brushless motor driver responsible for driving E-Bay fan while executing temperature control algorithm and sending and receiving motor and air temperature information. The Controller also has the responsibility for communicating with the CAN bus and reporting the status of motor drive system and is equipped with an auxiliary cooling fan. Figure 1 shows the electric schematics of the E-Bay Fan assembly.

|  |
| --- |
|  |
| Figure 1: Electric Schematics of the E-Bay Fan Assembly |

The purpose of this document is to provide an acceptance test procedure used by Marvin’s supplier to verify the hardware and software design of the Controller. It establishes a series of tests to be performed on the Controller. These tests verify Controller functionality as well as design functionality. The design accuracy is established through analysis. The motor controller shall be connected to an adjustable DC voltage power supply, an actual fan load and a PC through a CAN interface, as shown in Figure 2.

This document also establishes the test equipment needed for this plan and the test setup required for the Controller.

|  |
| --- |
|  |
| Figure 2: E-Bay Fan Assembly Test Set-Up |

# SCOPE

The scope of this document is to provide information for ambient bench testing which includes a basic check and power tests along with functional testing for the E-Bay motor controller.

# APPLICABLE DOCUMENTS (reference latest revision)

| **Document** | **Description** | **Source** |
| --- | --- | --- |
| 414-9920 | E-Bay Controller Assembly | Marvin |
| 414-9910 | E-Bay Fan Assembly | Marvin |
| 414-8005-95 | Controller, 28 Vdc, Engine Bay | Marvin |
| 414-9001 | Cooling Fan Assembly | Marvin |
| 414-5201 | E-Bay Motor Cable, Drive to Bulkhead | Marvin |
| 414-5202 | E-Bay Motor Cable, Bulkhead to Fan | Marvin |
| 414-4501 | E-Bay Controller CAN ICD | Marvin |
| KTY83/110 | Silicon Temperature Sensor Product Datasheet | NXP |

# TEST EQUIPMENT

| **Item** | **Model** | **Manufacturer** |
| --- | --- | --- |
| Power Supply (0 – 40VDC @0-60A) | SPS40-250A017 | Amrel1 |
| Digital Multi Meter (DMM) | 179 | Fluke1 |
| CAN Interface | CANcaseXL | Vector1 |
| Resistance Decade Box | RS-201 | IET Labs1 |
| PC | N/A | N/A |

1 An equivalent may be substituted

# TEST CONDITIONS

**CAUTION:**

**Place or connect test equipment, scope probes to the UUT firmly before turning on power to avoid accidental short circuits.**

The unit shall be tested at an ambient temperature between 53 and 100 deg F (25 +/- 13 deg C) and relative humidity between 25 and 50%. All tests shall be performed in sequence to eliminate any errors or omissions, or as otherwise specified.

# BOARD LEVEL TEST PROCEDURE

The board level hardware tests are provided in functional sections as described below. During these tests the check-out of the fabricated printed circuit boards is accomplished. The checking/testing will be done in two steps. The first step is visual inspection and basically involves board inspection and comparison to the planned lay-out. The purpose of the latter test is to check the board with a digital multimeter at the power supply inputs to ensure there is no short across these pins.

**General Test Conditions**

1. 10% tolerance unless stated otherwise.

2. All measurements are made with reference to J3.B (Power Return) unless otherwise stated.

VISUAL INSPECTION

### Verification of Components Not Installed

On the PCB under test, verify all DNP (Do Not Populate) parts are not installed.

Record the results on the Test Data Sheet.

### Manufacturing Defects

Thoroughly examine the PCB under test and verify the following conditions do not exist:

- missing components

- component orientation (SMD mounting, connectors, electrolytic capacitors)

- integrated circuits pin No. 1 placement

- solder defects and cleaning quality

- coating

Record the results on the Test Data Sheet.

POWER SUPPLY TESTING

### Input Current Drawn

Connect the positive side of the 28VDC to J3.A and return to J3.B. Apply 28 +/- 0.2 Vdc power, set the power supply current limit to 0.5 Adc, and perform the following measurement.

| **Verification Parameter** | **Condition** | **Expected Reading** |
| --- | --- | --- |
| DC Input Current | Measured using PS current meter | < 150 mA |

Record the results on the Test Data Sheet.

### Power Supply Voltages

Verify each of the following power supply voltages below.

| **Verification Parameter** | **PCB Location** | **Expected Reading** |
| --- | --- | --- |
| +12V | As applicable | 12 ± 0.5 Vdc |
| +5V | As applicable | 5 ± 0.2 Vdc |
| +3.3V | As applicable | 3.3 ± 0.1 Vdc |
| +1.8V | As applicable | 1.8 ± 0.1 Vdc |

Record the results on the Test Data Sheet.

# FUNCTIONAL TEST PROCEDURE

The purpose of the functional testing for the motor controller is to establish its basic functionality as well as to establish its mechanical integrity.

## PHYSICAL DIMENSIONAL CHECK AND WEIGHT

During this test the overall dimensions of the motor controller assembly, the interface/connection dimension, and the total weight of the assembly shall be determined.

Record the results on the Test Data Sheet.

## INSULATION RESISTANCE TEST

The purpose of these tests is to check the ability of the motor controller assembly to operate safely at the voltage levels expected. The insulation resistance is limited to the leakage resistance of the filter capacitors. Bonding resistance is limited to 2 mOhm .Using the digital multi meter, verify the minimum insulation and bonding resistance below.

| **Verification Parameter** | **Location** | **Expected Reading** |
| --- | --- | --- |
| Insulation Resistance | J3.B | > 1M ohms |
| Insulation Resistance | J1.16 | > 100k ohms |
| Bonding Resistance | J1- Body | < 2 mOhm |
| Bonding Resistance | J2 - Body | < 2 mOhm |
| Bonding Resistance | J3 - Body | < 2 mOhm |

Note: With reference to Chassis.

Record the results on the Test Data Sheet.

### CANBUS RESISTANCE TEST

The purpose of this test is to verify that there is no CanBus resistor installed in the Redler Drive.

| **Verification Parameter** | **Location** | **Expected Reading** |
| --- | --- | --- |
| CanBus Resistance | J1.17 to J1.18 | > 10K ohms |

## SEALING TEST

The controller assembly shall be splashed with the water and the pressure raised to 5 PSI. This pressure shall be maintained for 5 minutes. The system has passed the sealing check if no leakage occurs during the test.

Record the results on the Test Data Sheet.

## COMMUNICATION TESTS

The purpose of these tests is to establish communication of the motor controller.

### Serial RS-232 Communication Test

Connect the motor controller to a PC through a serial interface and verify there is communication in both ways.

Record the results on the Test Data Sheet.

### CAN Bus Communication Test

Connect the motor controller to a PC through a CAN interface and verify there is communication in both ways.

Record the results on the Test Data Sheet.

## PERFORMANCE TESTS

The purpose of these tests is to establish functionality of the motor controller including the air and motor temperature sensor readings. Under this effort the performance of the motor controller under software control will be tested. This will be done with an actual fan load. The electrical and thermal performance of the motor controller will be tested under three fan speed conditions (low, medium and high). During these tests representative temperatures and DC power supply/input current shall be monitored and recorded.

After the above performance tests, the system shall be set-up to operate for 30 min under the high fan speed (15100 rpm) conditions. This test will serve as a burn-in test.

### Reverse Polarity Test

Connect the positive side of the 28VDC to J3.B and return to J3.A. Apply 28 +/- 0.2 Vdc power, set the power supply current limit to 5 Adc and perform the following measurement.

| **Verification Parameter** | **Condition** | **Expected Reading** |
| --- | --- | --- |
| DC Input Current | Measured using PS current meter | < 1 mA |

Record the results on the Test Data Sheet.

### Enable Test

The system shall be set-up to operate at room temperature. Apply 28 +/- 0.2 Vdc power, set the power supply current limit to 10 Adc, and command speed of 6000 rpm through CAN interface. Verify the following functional parameters below.

| **Verification Parameter** | **Condition** | **Expected Reading** |
| --- | --- | --- |
| Fan Speed | When Enable = Open | 0 rpm |
| Fan Speed | When Enable = High | 6000 ± 200 rpm |
| Motor Rotation Direction | When Enable = High | Counterclockwise (Inlet) |

Record the results on the Test Data Sheet.

### Stop Time Test

The system should operate at maximum speed and then 0 RPM command should be sent through CAN BUS interface. The time to complete stop of the motor will measured and it should be no more than 50 sec.

### Speed Command Test

The system shall be set-up to operate under different fan speed conditions at room temperature. Apply 28 +/- 0.2 Vdc power, set the power supply current limit to 60 Adc, and command speed of 6000 rpm, 11500 rpm and 15100 rpm respectively through CAN interface. Verify the following functional parameters below.

| **Verification Parameter** | **Condition** | **Expected Reading** |
| --- | --- | --- |
| Fan Speed | When Tamb = Room Temperature | 6000 ± 200 rpm |
| Fan Speed | When Tamb = Room Temperature | 11500 ± 200 rpm |
| Fan Speed | When Tamb = Room Temperature | 15100 ± 400 rpm |

Record the results on the Test Data Sheet.

### Temperature Sensor Calibration Test

The system shall be set-up to operate under different fan speed conditions at room temperature. Apply 28 +/- 0.2 Vdc power, set the power supply current limit to 60 Adc, and set-up the system to emulate the motor temperature sensor resistance (T1 on Figure 1) and air temperature sensor resistance (T2 on Figure 1) with a calibrated resistor decade box. Verify both temperature sensor readings below (only three to five values are required) and calibrate the software by programming the analog offset if required. The Offset value should be in range: -0.1 < offset < 0.1.

| **Sensor Resistance** | **Datasheet Reading** | **Expected Reading** |
| --- | --- | --- |
| 525 ± 15 ohms | -50 oC | -50 ± 3 oC |
| 632 ± 15 ohms | -30 oC | -30 ± 3 oC |
| 820 ± 13 ohms | 0 oC | 0 ± 3 oC |
| 1000 ± 10 ohms | 25 oC | 25 ± 2 oC |
| 1288 ± 21 ohms | 60 oC | 60 ± 2 oC |
| 1360 ± 21 ohms | 68 oC | 68 ± 2 oC |
| 1472 ± 32 ohms | 80 oC | 80 ± 2 oC |
| 1550 ± 32 ohms | 88 oC | 88 ± 2 oC |
| 1774 ± 42 ohms | 110 oC | 110 ± 2 oC |
| 1937 ± 50 ohms | 125 oC | 125 ± 2 oC |
| 2408 ± 74 ohms | 165 oC | 165 ± 3 oC |

Record the results on the Test Data Sheet.

### Temperature Control Algorithm Test

The system shall be set-up to operate under different fan speed conditions at room temperature. Apply 28 +/- 0.2 Vdc power, set the power supply current limit to 60 Adc, and set-up the system to operate under temperature control algorithm by emulating the air temperature sensor resistance (T2 on Figure 1) with a calibrated resistor decade box. Verify the following functional parameters below.

| **Verification Parameter** | **Condition** | **Expected Reading** |
| --- | --- | --- |
| Fan Speed | When Tair < 68 ± 2 oC | 6000 ± 200 rpm |
| Fan Speed | When Tair >= 68 ± 2 oC | 11500 ± 200 rpm |
| Fan Speed | When Tair >= 88 ± 2 oC | 15100 ± 400 rpm |
| Fan Speed | When Tair <= 80 ± 2 oC | 11500 ± 200 rpm |
| Fan Speed | When Tair <= 60 ± 2 oC | 6000 ± 200 rpm |

Record the results on the Test Data Sheet.

### Burn-in Test

The system shall be set-up to operate under different fan speed conditions at room temperature. Apply 28 +/- 0.2 Vdc power, set the power supply current limit to 60 Adc, and set-up the system to operate for 30 min under the high fan speed (15100 rpm) conditions at room temperature. This test will serve as a burn-in test. Record and verify the following functional parameters below. Measured current should be 50±5 ADC. Measured temperature at the end of the test should be no more than 25 C° above ambient temperature.

| **Verification Parameter** | **Condition** | **Reading** |
| --- | --- | --- |
| DC Input Current | Fan Speed = 15100 rpm ± 400 rpm | To be recorded |
| Controller Temperature | After 10 min of operation | To be recorded |
| Controller Temperature | After 20 min of operation | To be recorded |
| Controller Temperature | After 30 min of operation | To be recorded |
| Auxiliary Cooling Fan | When Tcontroller > 60 ± 2 oC | On |
| Auxiliary Cooling Fan | When Tcontroller < 55 ± 2 oC | Off |

Record the results on the Test Data Sheet.

# APPENDIX A – CONTROLLER Test Data SHEET

P/N 414-8005-95 Date \_\_\_\_\_\_\_\_\_\_\_\_

S/N \_\_\_\_\_\_\_\_\_\_\_\_ Tested by \_\_\_\_\_\_\_\_\_\_\_\_

UA \_\_\_\_95\_\_\_\_\_\_

Hardware Rev \_\_\_\_\_\_\_\_\_\_\_

Software Rev \_\_\_\_\_\_\_\_\_\_\_\_

**Equipments Used**

**Equipments Model No Serial No**

Power Supply

Digital Multimeter

CAN Interface

Resistance Decade Box

PC

| **Para.** | **Test Description** | **Verification Parameter** | **Expected** | **Accept** | **Reject** |
| --- | --- | --- | --- | --- | --- |
| 6.1.1 | Verification of Components Not Installed | N/A | No DNP Components Placed |  |  |
| 6.1.2 | Manufacturing Defects | N/A | No Defects |  |  |
| 6.2.1 | Input Current Drawn | DC Input Current | < 150 mA |  |  |
| 6.2.2 | Power Supply Voltages | 12V  5V  3.3V  1.8V | 12V ± 0.5V  5V ± 0.2V  3.3V ± 0.1V  1.8V ± 0.1V |  |  |
| 7.1 | Weight Check | Driver Weight | 4180 gr ± 100 gr |  |  |
| 7.2 | Insulation Resistance Test | J3.B to Chassis  J1.16 to Chassis | > 1MΩ  > 100KΩ |  |  |
| 7.2 | Bonding Test | J1 Body to Chassis  J2 Body to Chassis  J3 Body to Chassis | <2mΩ  <2mΩ  <2mΩ |  |  |
| 7.2.1 | CANbus Resistance Test | J1.17 to J1.18 | >10KΩ |  |  |
| 7.3 | Sealing Test | N/A | No leakage for specified condition |  |  |
| 7.4.1 | Serial RS-232 Communication Test | N/A | Communication verified |  |  |
| 7.4.2 | CAN Bus Communication Test | N/A | Communication verified |  |  |
| 7.5.1 | Reverse Polarity Test | DC Input Current | < 1 mA |  |  |
| 7.5.2 | Enable Test | Fan Speed at Opened Enable  Fan Speed at Closed Enable | 0 RPM  6000 ± 200 RPM |  |  |
| 7.5.2 | Motor Rotation Direction | Rotation Direction | Counter-clockwise (Inlet) |  |  |
| 7.5.3 | Stop Time Test | Motor Stop time | < 50 sec |  |  |
| 7.5.4 | Speed Command Test | Fan Speed | 6000 ± 200 rpm  11500 ± 200 rpm  15100 ± 200 rpm |  |  |

| **Para** | **Test Description** | **Verification Parameter** | **Expected** | **Measured** | **Accept** | **Reject** |
| --- | --- | --- | --- | --- | --- | --- |
| 7.5.5 | Temperature Sensor Calibration Test | Sensor Reading  Analog Offset | -0.1<x <0.1 | Offset = |  |  |
| 7.5.6 | Temperature Control Algorithm Test | Fan Speed at:  Tair < 68 ± 2 oC  Tair >= 68 ± 2 oC  Tair >= 88 ± 2 oC  Tair <= 80 ± 2 oC  Tair <= 60 ± 2 oC | 6000 ± 200 rpm  11500 ± 200 rpm  15100 ± 400 rpm  11500 ± 200 rpm  6000 ± 200 rpm |  |  |  |
| 7.5.7 | Burn-in Test | DC Input Current  Ambient Temperature  After 10 min of operation  After 20 min of operation  After 30 min of operation  Auxiliary Cooling Fan | 50 ± 5 ADC  25 ± 13 C°  < 25 C° Above Ambient Temperature  After 30 min  On@60± 2 C°  Off@55± 2 C° | Idc =  Tambient  =  Tcontroller =  Tcontroller =  Tcontroller =  Ton =  Toff = |  |  |

# APPENDIX B – kty83/110 silicon Temperature SEnsor resistance table

|  |
| --- |
| KTY83-110 Table |
| Figure 3: KTY83/110 Silicon Temperature Sensor Resistance vs. Temperature Table |