RotorWay Talon A600 Avionics and monitoring system

Document revisions

This document was written by Slavik Krassovsky, builder of N306RW.

The latest version of this document can be found at http://tinyurl.com/A600Avionics

Revision	Date	Author and comments
1.0	12/4/23	S. Krassovsky. Initial version.

1.1	01/01/24	S.Krassovsky added mefiConfig and mefiBurn descriptions

Introduction

Buford John Schramm had founded RotorWay Aircraft in 1961. In more than 50 years, from the original Javelin prototype to the Scorpion and then to Exec, Talon and Phoenix, Rotorway helicopters made an exciting journey, improving the performance, reliability and incorporating new technology in each subsequent iteration.

This document focuses on the description of A600 Talon avionics and system monitoring as this is the model that was built by the author between May 2020 and Aug 2023. Bunch of the information here was learnt by the author first hand during the build and troubleshooting various issues encountered during the construction. The author received a lot of help from Al Yard (special thanks!), Wade Ramesy (the factory) and fellow Rotorway owners and builders. Huge thank you!

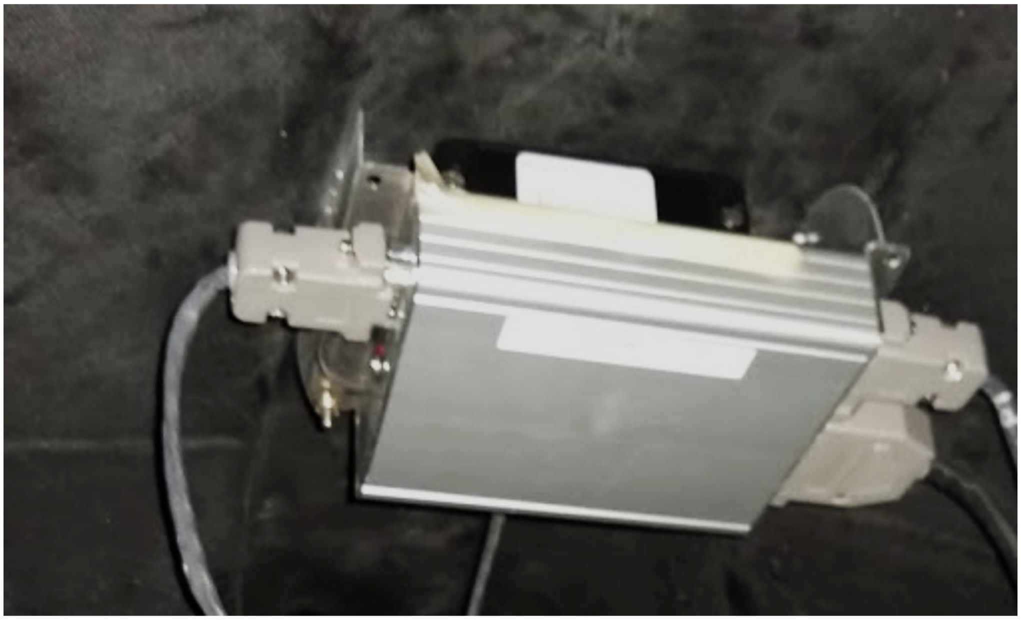
High level overview

Here we would describe what components that comprise the avionics and monitoring system.

In A600 Talon the top level pilot interaction interface is MGL Avionics Discovery Lite Electronic Flight Information System (**EFIS**). This unit is packed with functionality: it provides to the pilot flight information (attitude, altitude, airspeed, VSI, heading, manifold pressure, etc), navigation (GPS location and maps), system monitoring (engine rpm, rotor rpm, operating temperatures, fuel level) and much more.

EFIS is able to provide these functions based on the inputs from various sensors, some of the sensors are built-in into the unit (for example Outside Air Temperature), and some are received signals.

In A600 Talon most of the sensors' inputs are received by the EFIS from a unit called mefiCAN Bridge Controller. mefiCAN Bridge Controller was developed by Al Yard and is a quite remarkable piece of hardware and software that helps bridge the communications that come from the Engine Control Units (ECUs), which are 2 on the ship and certain other sensors into a single stream of sensor inputs that could be understood by the EFIS.



Engine-specific sensor inputs are being produced by two ECUs (ECU1 and ECU2 which are programmed similarly (but not identically) for redundancy). The ECUs come from the marine industry and are GM/Delphi/ACDelco **Marine Electronic Fuel Injection** (MEFI) which are used to control Volvo Penta, Indmar and other marine engines. In Talon A600 version 4 of the MEFI is used.


The ECUs provide Full Authority Digital Control (FADEC) over the engine, i.e. it controls the amount of fuel being injected (fuel mixture ratio), timing advance and other parameters based on the sensor inputs.

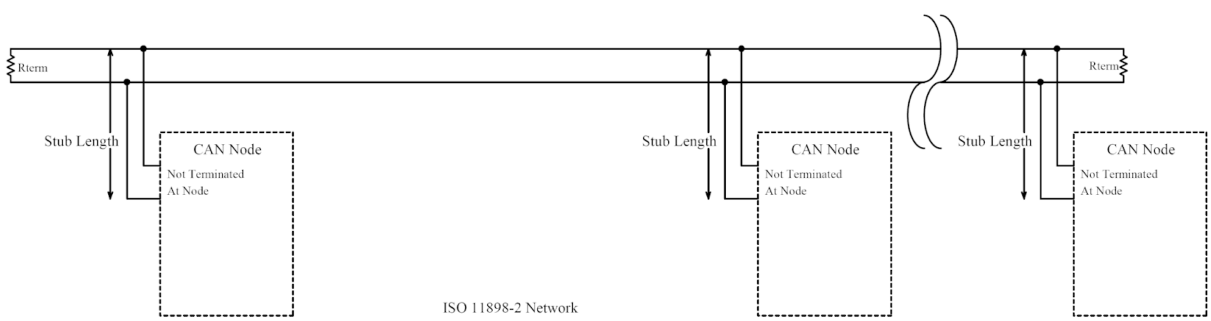
Normally ECU 1 is in full control, however, when it fails or when the pilot switches it off, ECU2 assumes control over the engine. In addition to using the sensor inputs to control the engine, ECUs package the sensor's readings into digital messages (packets) and send them over the CAN Bus Network to the mefiCAN Bridge Controller.

CAN Bus Network

CAN Bus Network was developed by Bosch, an automotive technology company in late 1980s and early 1990s. It is a digital serial network technology that allows multiple on-board computer systems to exchange information in a realtime, priority-based fashion. CAN Bus is used extensively in automotive applications (basically all modern cars use it).

Marine industry also embraced CAN Bus networks and it is used for engine and navigation systems.

Aviation avionics companies like Garmin took advantage of CAN Bus as well for communicating between the components of the aircraft avionics (ex. redundant Garmin G5s, GI275s, G3X, autopilot servos, magnetometer, etc)



CAN Bus network consists of a single two wire line with the ability of Nodes to be connected to that line, thus forming a sort of Christmas lights string of devices that could communicate to each other via the line.

Each Node creates a digital message, called a ‘packet' and transmits it over the CAN Bus.

3 CAN Buses in A600 Talon

In A600 Talon there are actually 3 distinct CAN Buses: EFIS CAN Bus, Primary CAN Bus and Secondary CAN Bus.

EFIS CAN Bus

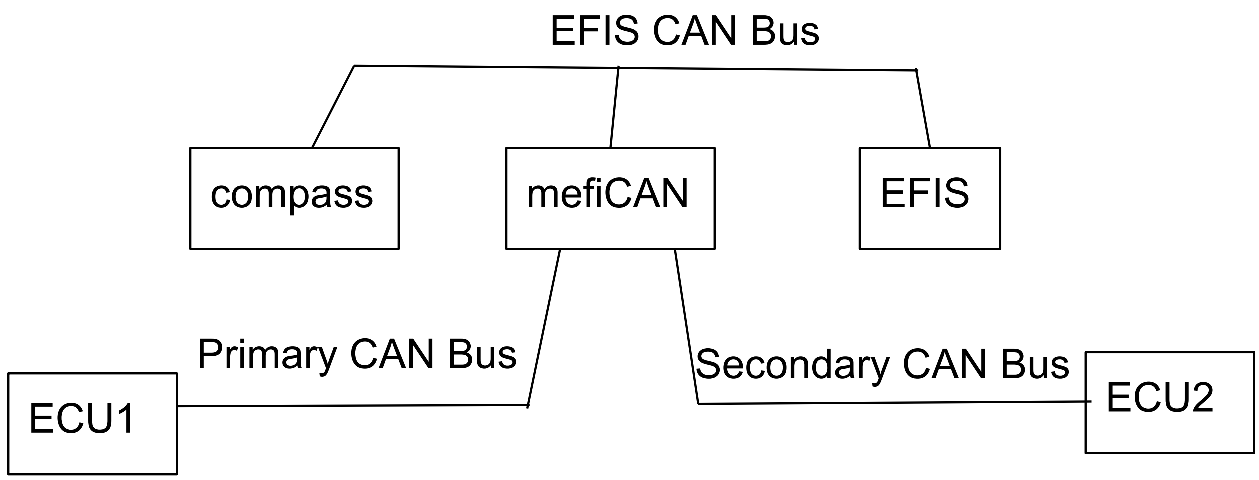
EFIS CAN Bus, has 3 devices: MGL Discovery EFIS – mefiCAN Bridge – MGC Compass

Note: builders can choose to add additional devices, like Radio or Transponder to this CAN Bus. In the author’s Talon, the author had added MGL radio and Trig transponder, which then are being controlled by the MGL EFIS.

Primary and Secondary CAN Busses

Primary CAN Bus has 2 Devices: mefiCAN Bridge – ECU1

Secondary CAN Bus has 2 Devices: mefiCAN Bridge – ECU2

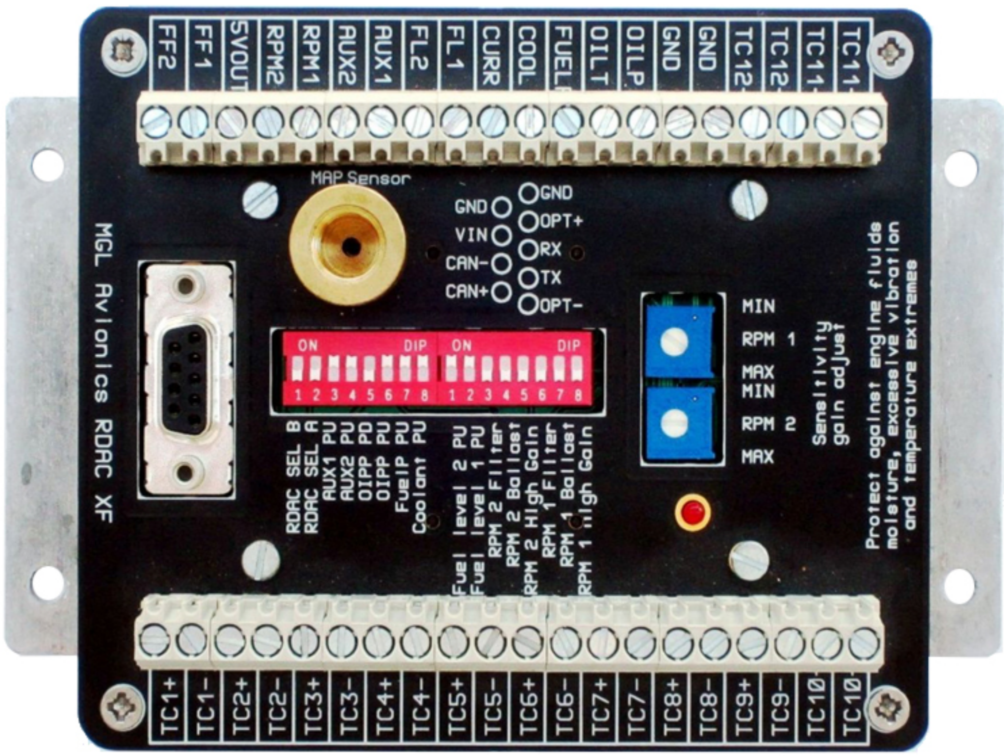


Both ECUs read the following sensor inputs and make engine operating decisions. Then, pack sensor inputs and decision outcomes into digital packets and send them to the mefiCAN Brige controller, these are the values the ECUs send:

- MAP - manifold pressure sensor reading
- ECT - engine coolant temperature reading
- RPM engine reading
- Knock retard information
- Spark Advance information
- BARO - barometric (atmospheric) pressure sensor reading
- IAT - intake air temperature reading
- TPS - throttle position sensor reading
- Fuel flow information

Typically, per MGL Avionics original design, EFIS expects to work with units called Remote Data Acquisition Computers (RDACs) that convert sensor inputs into the CAN Bus packets.

RDACs look like this:



The author's understanding was that some ships had RDACs prior to the development of the mefiCAN Bridge, however RotorWay ran into a bunch of compatibility issues between versions of EFIS and versions of RDACs, which led to the development of the mefiCAN Bridge controller.

mefiCAN Bridge, thus, emulates RDACs, which means that the EFIS thinks it receives the data from 2 RDACs, but in fact it receives the data from the mefiCAN Brige. This is cheaper, but there is some loss of redundancy as mefiCAN is a single unit. Loss of the mefiCAN Bridge in flight, however, should not be considered a catastrophic failure - the engine would continue to work, only the instrument indications would be affected, so it's similar to an instrument failure in flight.

When this system was developed, the Discovery could only recognize 2 RDACs. This did not allow enough non-traditional (i.e. non-aviation) input values to be sent to Discovery, so Al decided to reuse some of the TC (thermo-couple) inputs. Thermocouple inputs are temperature inputs of either Cylinder head temperature or exhaust gas temperatures.

RDAC1 and RDAC2 inputs	ECU output
MAP	manifold pressure
COOLANT	engine coolant temp
TC6	engine RPM
TC7	knock retard
TC8	spark advance
TC9	BARO (kPa x 10)
TC10	MAP (kPa x 10)
TC11	Intake air temp
TC12	TPS (%) - throttle position
FF2	Fuel flow

In addition, several sensors are connected to the mefiCAN Bridge directly and then mapped by the mefiCAN Bridge controller in the following way:

RDAC 1:

RPM1	engine RPM
RPM2	rotor RPM

OILT	oil temp
OILP	oil pressure
AUX1	secondary bearing temp
AUX2	outside air temp
FUELP	fuel pressure

RDAC 2:

AUX1	front gearbox temp
AUX2	rear gearbox temp

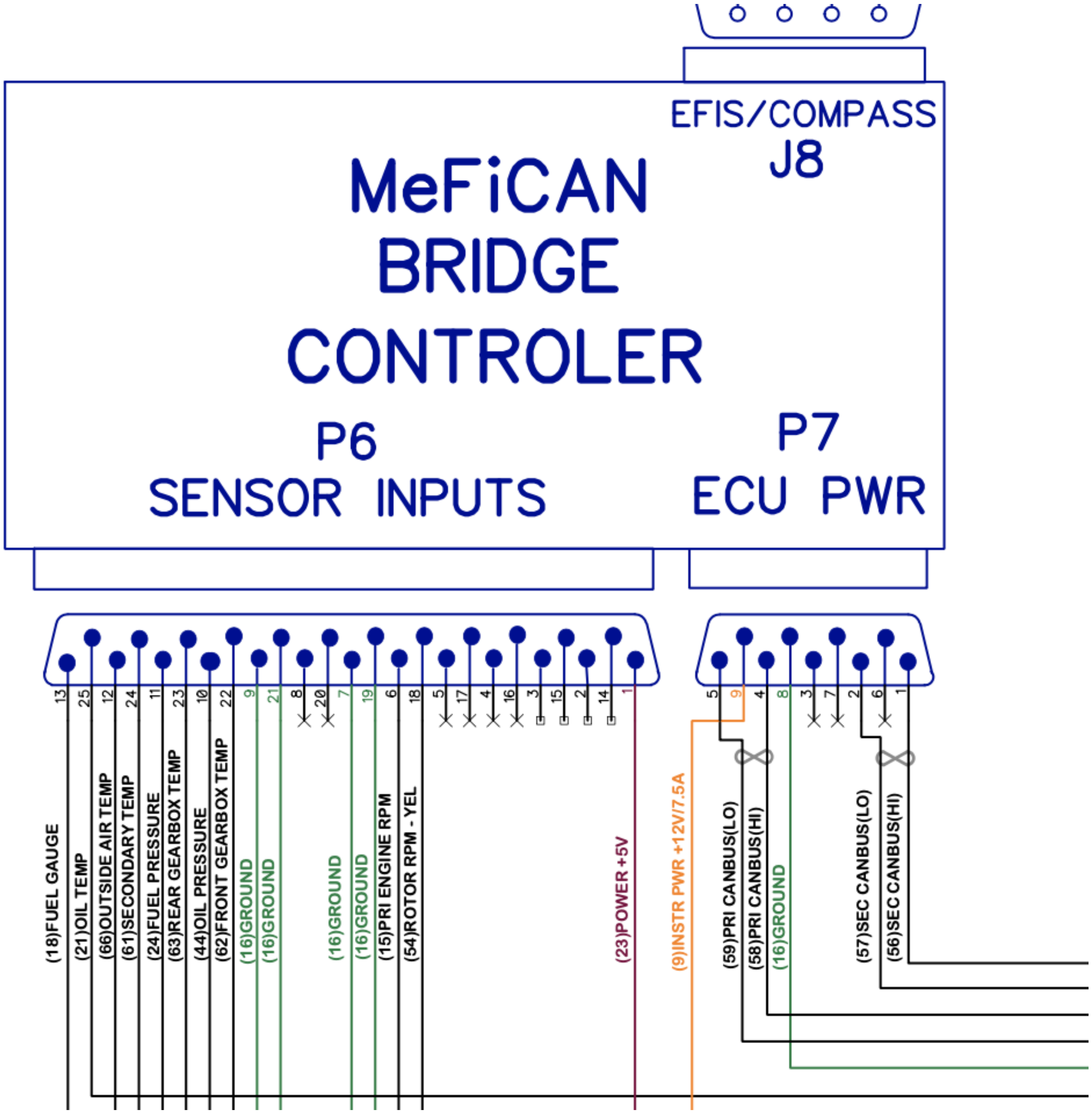
Note: All temp sensors are LM335 type. All pressure sensors are 0.5 to 4.5 volts.

Note: mefiCAN Bridge controller has two lights on it - you an look at the lights on the end of the mefiCAN Bridge controller(next to the USB plug). The green will flash if the mefiCAN is receiving valid CAN Bus J1939 packets from the primary ECU. Flashing red indicates valid data from the secondary ECU. They should flash regularly, no skips, when everything operates normally.

Note: Over the past few years, there were a few corrections to the wiring harness diagrams. These were just errors in the wiring diagram, not the harness. However some harnesses were made as per the erroneous diagrams.

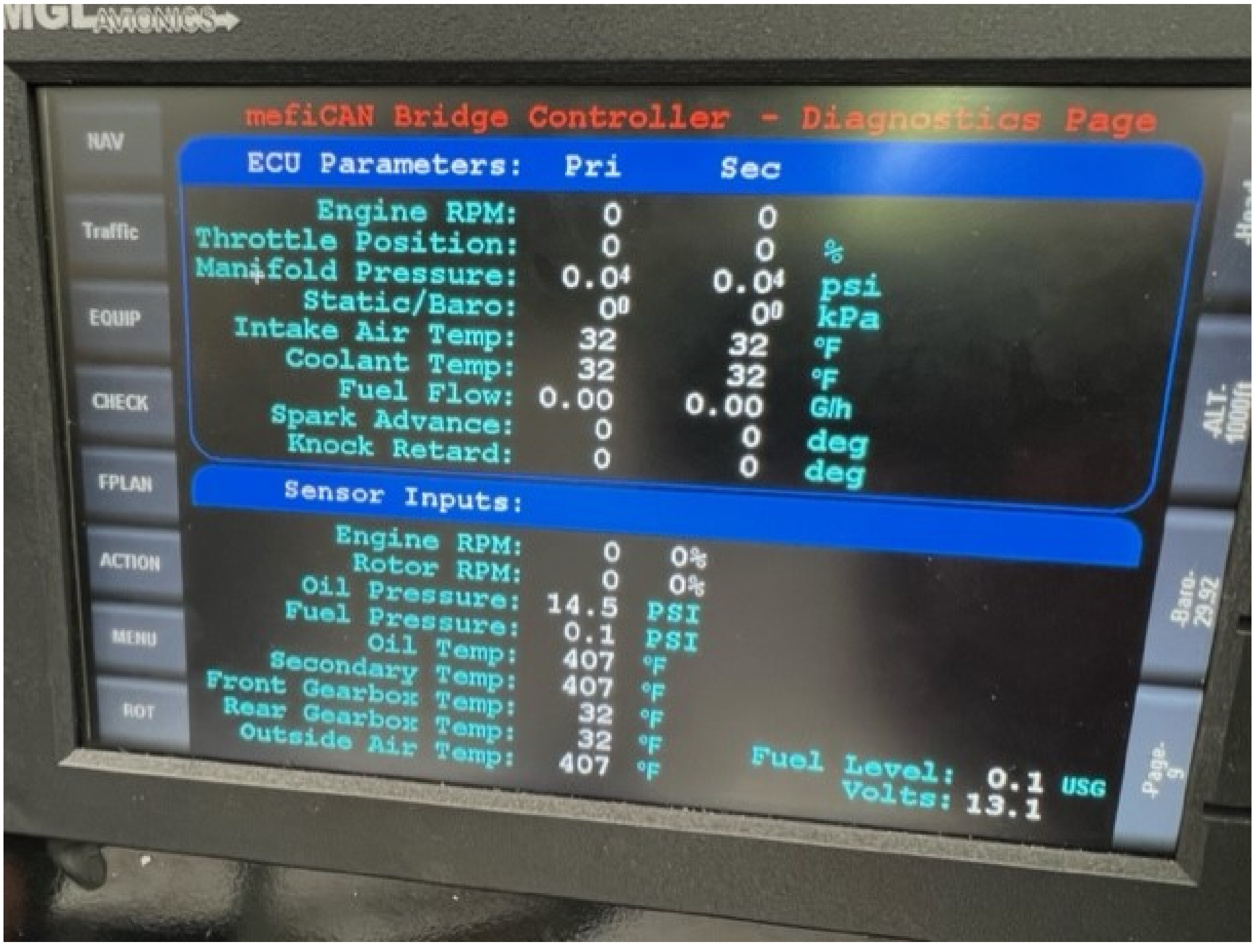
If you have an ECU2 fault light indiation, check pins 6 and 8 on the secondary P1 (J1S) connector, they are swapped on some harnesses.

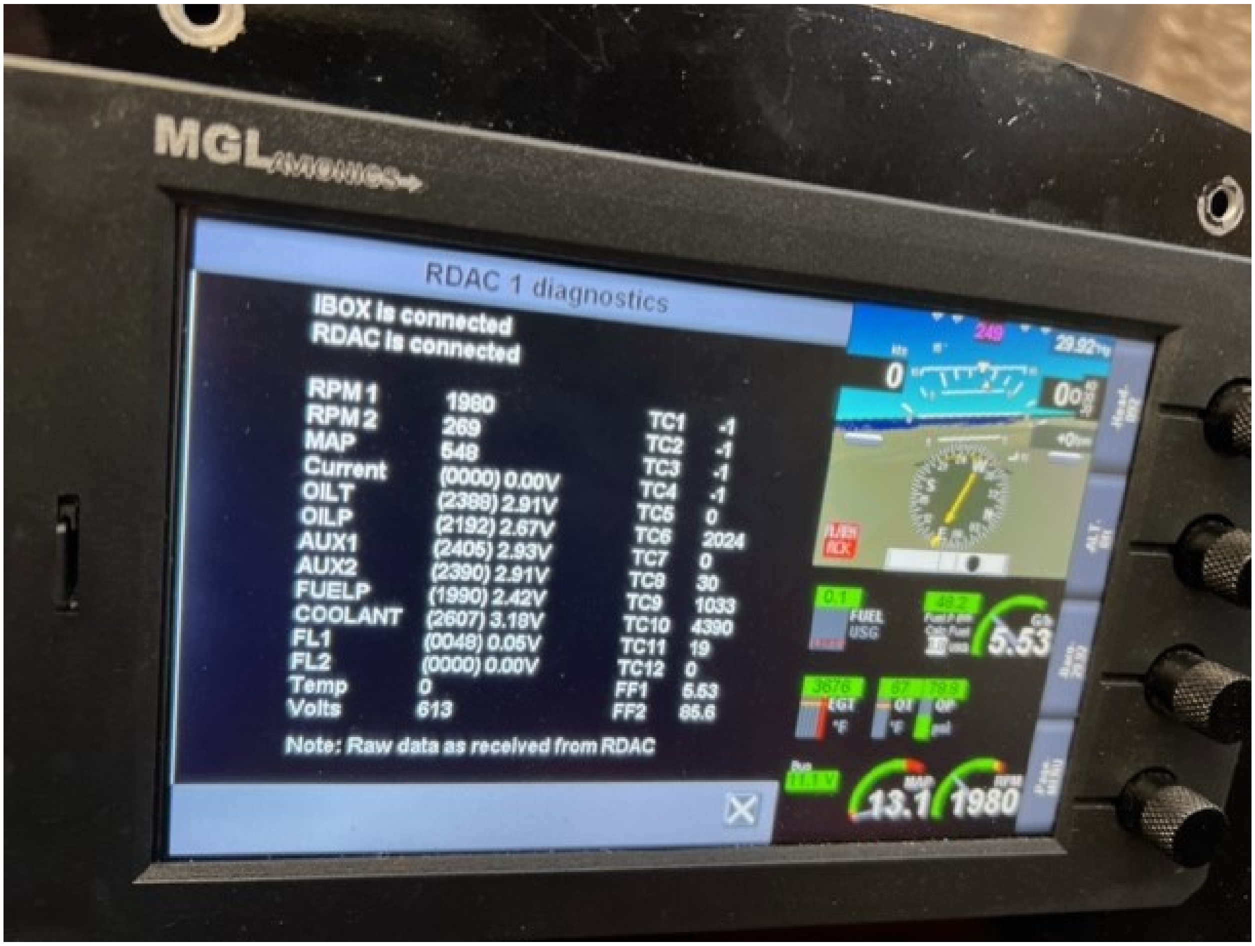
Here is the snippet of the engine harness schematic, outlining mefiCAN Bridge controller inputs:



Diagnostic pages

A600 Discovery programming has several helpful pages:


MGL AVIONICS
mefiCAN Bridge Controller - Diagnostics Page
ECU Parameters: Pri Sec
Engine RPM: 0 0
Throttle Position: 0 0 %
Manifold Pressure: 0.04 0.04 psi
Static/Baro: 00 00 kPa
Intake Air Temp: 32 32 °F
Coolant Temp: 32 32 °F
Fuel Flow: 0.00 0.00 G/h
Spark Advance: 0 0 deg
Knock Retard: 0 0 deg
Sensor Inputs:
Engine RPM: 0 0%
Rotor RPM: 0 0%
Oil Pressure: 14.5 PSI
Fuel Pressure: 0.1 PSI
Oil Temp: 407 °F
Secondary Temp: 407 °F
Front Gearbox Temp: 407 °F
Rear Gearbox Temp: 32 °F
Outside Air Temp: 32 °F
407 °F
Fuel Level: 0.1 USG
Volts: 13.1
NAV
Traffic
EQUIP
CHECK
FPLAN
ACTION
MENU
ROT
ALT. 1000ft
Baro-29.92
Page-9

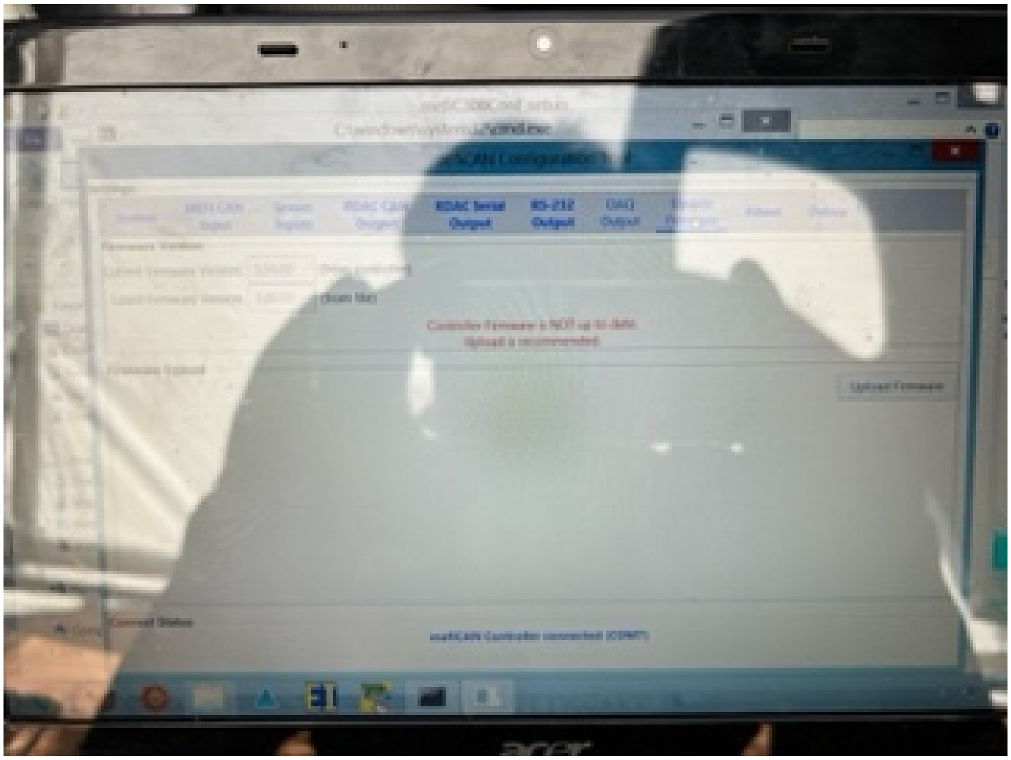


Note: RDAC1/RPM2 has to be set to 0.0 pulses per revolution. This causes the RPM2 input (ie. Rotor input) to be passed to the rotor RPM module.

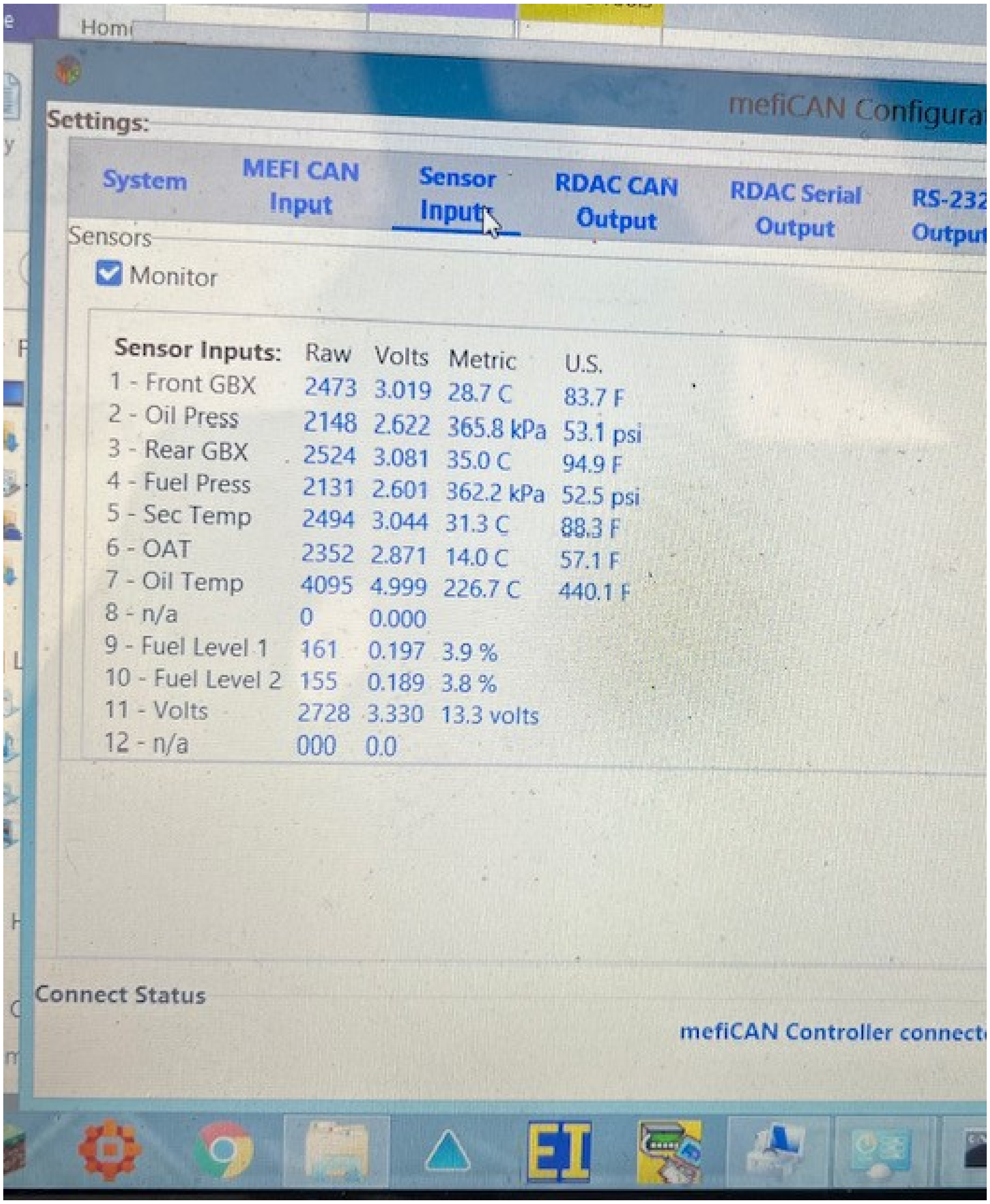
Below it’s set to 1 and this will cause no rotor indication (the author had a lot of trouble with it):

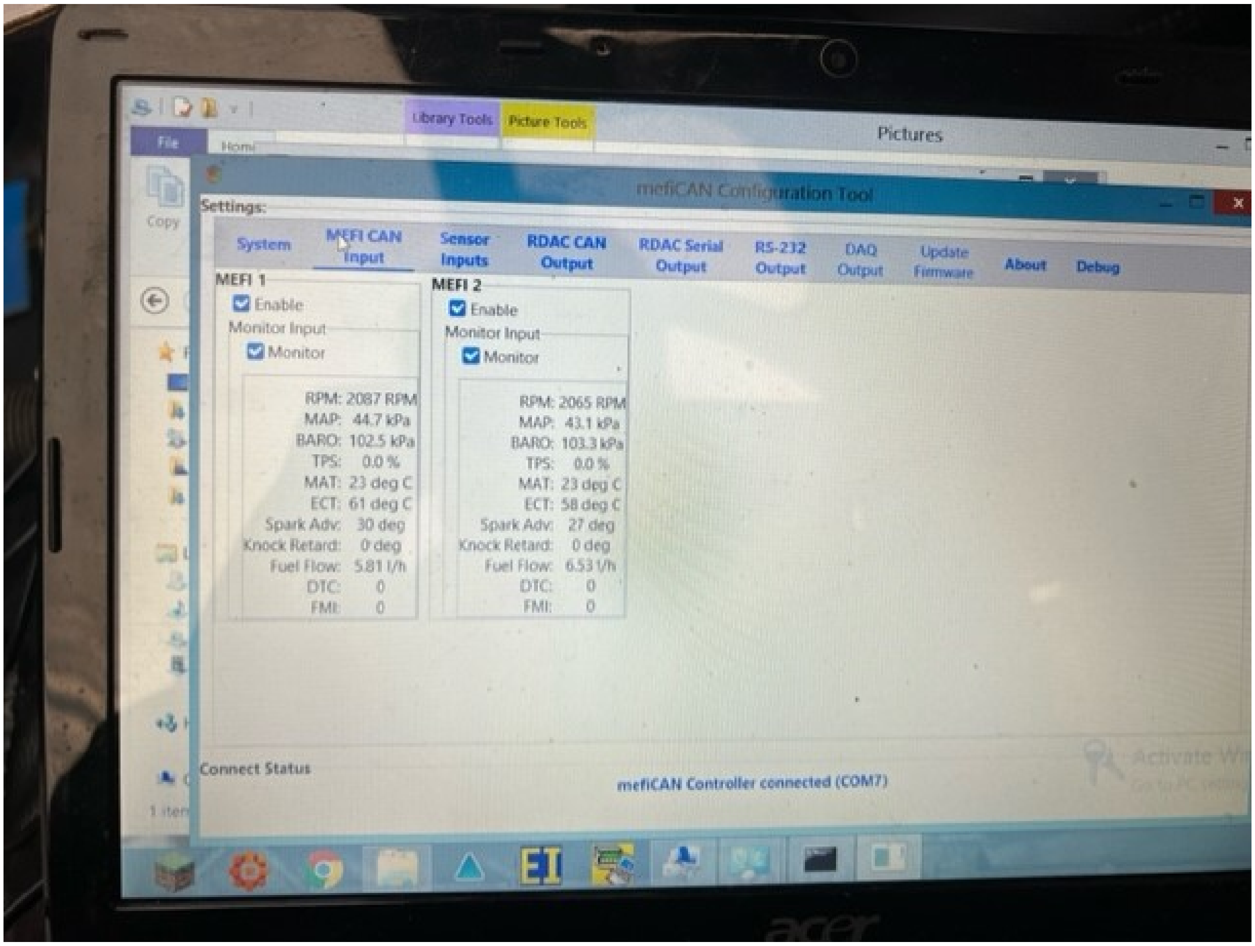
mefiConfig Software utility

Al Yard had developed a software utility that can update firmware on the mefiCAN Bridge controller as well as help with troubleshooting issues, it's called mefiConfig.



it was 3.00.00 and the new version is 3.00.05.


mefiCAN Configura
Settings:
System
MEFI CAN Input
Sensor Input
RDAC CAN Output
RDAC Serial Output
RS-232 Output
Sensors
Monitor
Sensor Inputs: Raw Volts Metric U.S.
1 - Front GBX 2473 3.019 28.7 C 83.7 F
2 - Oil Press 2148 2.622 365.8 kPa 53.1 psi
3 - Rear GBX 2524 3.081 35.0 C 94.9 F
4 - Fuel Press 2131 2.601 362.2 kPa 52.5 psi
5 - Sec Temp 2494 3.044 31.3 C 88.3 F
6 - OAT 2352 2.871 14.0 C 57.1 F
7 - Oil Temp 4095 4.999 226.7 C 440.1 F
8 - n/a 0 0.000
9 - Fuel Level 1 161 0.197 3.9 %
10 - Fuel Level 2 155 0.189 3.8 %
11 - Volts 2728 3.330 13.3 volts
12 - n/a 000 0.0
Connect Status
mefiCAN Controller connect



mefiBurn software

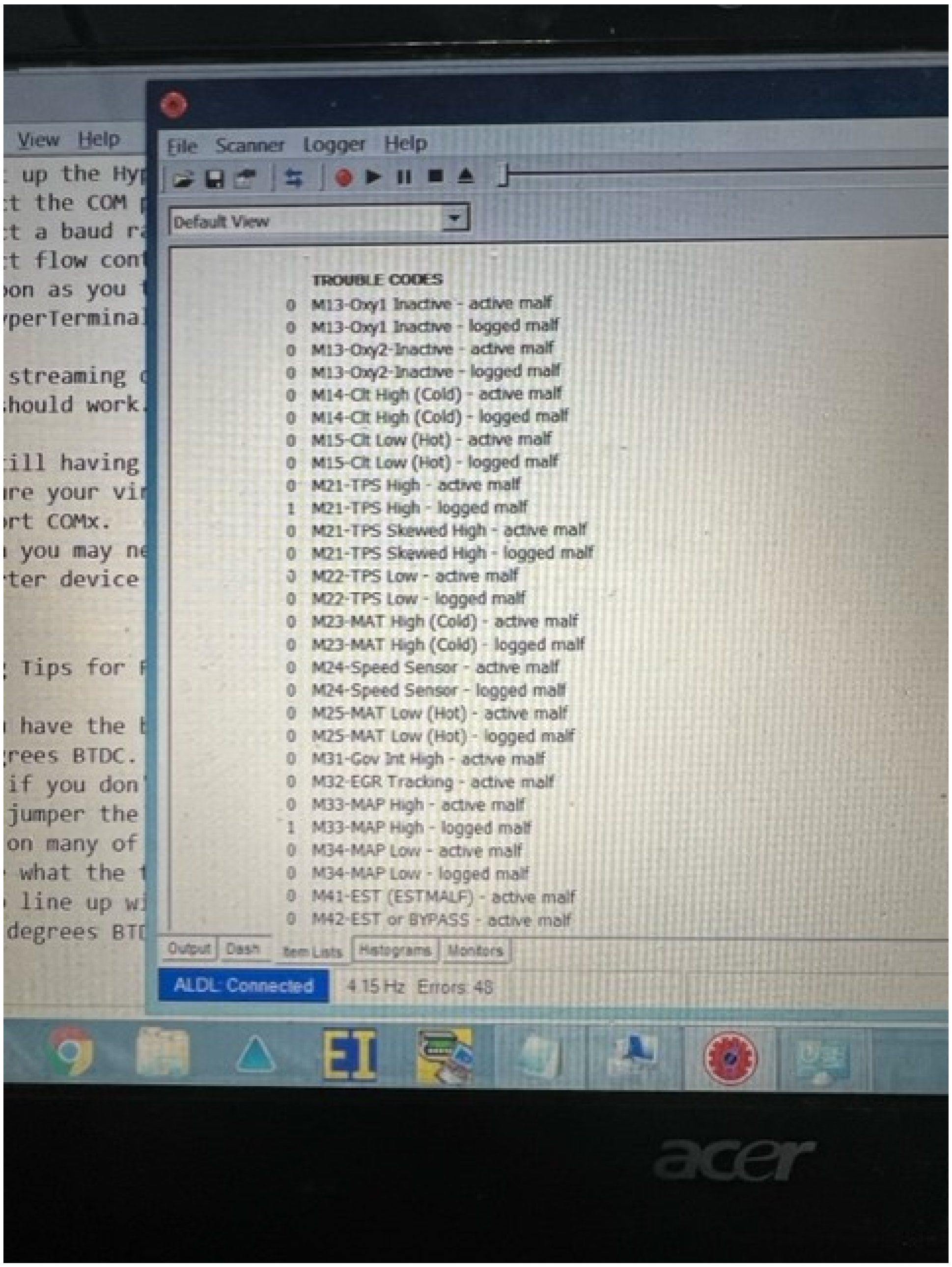
One of the advantages of the relatively modern MEFI 4 ECU is an ability to read Diagnostic Trouble Codes (DTCs). It can be done using mefiBurn software.

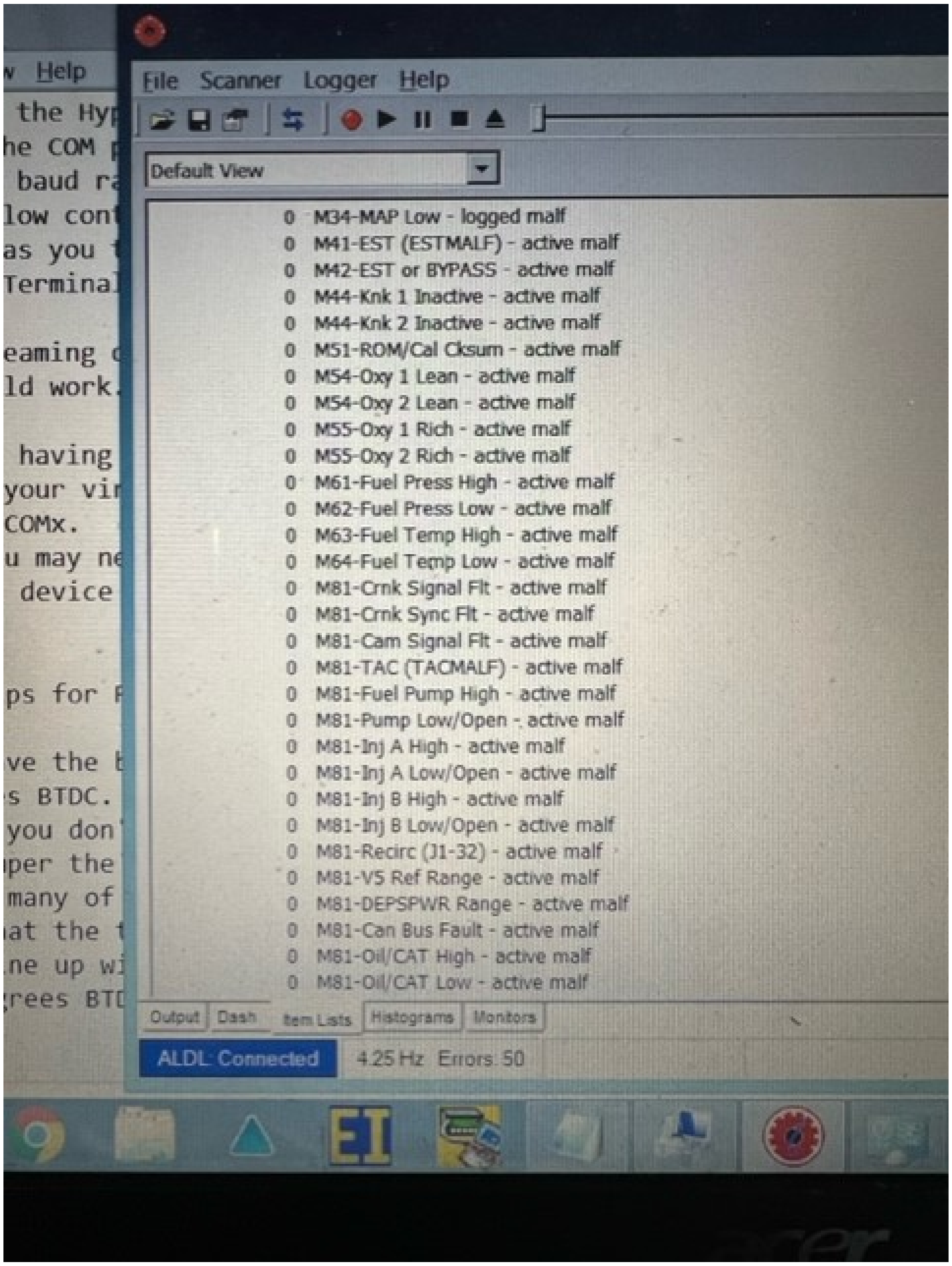
One could purchase the mefiBurn scan software, it comes with a USB to ALDL (10 pin) adapter that you plug into the ALDL port on your machine, it's the plug labeled as 'ALDL' and is usually under the pax seat. This will only works for the primary ECU, you need to make up a little adapter to read the secondary ECU, the data is on a different pin.

This doesn't connect to the mefiCAN, it reads the DTCs directly from the ECUs.

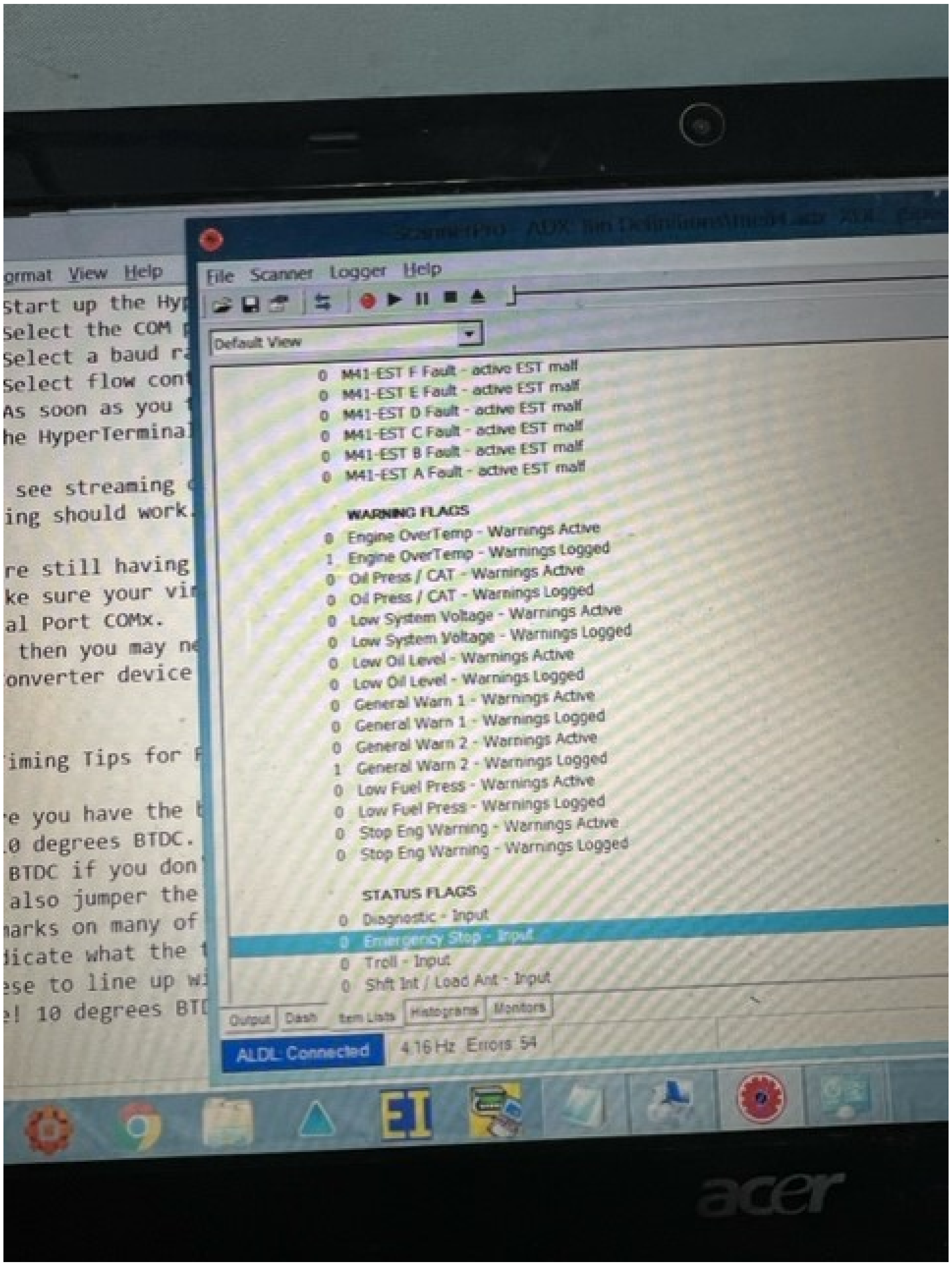
Make sure you get the MEFI Scan 4 kit (mefiscan4-u), it's further down the page here: http://mefiburn.com/mefiscan

This is a screenshot of the various DTC codes:

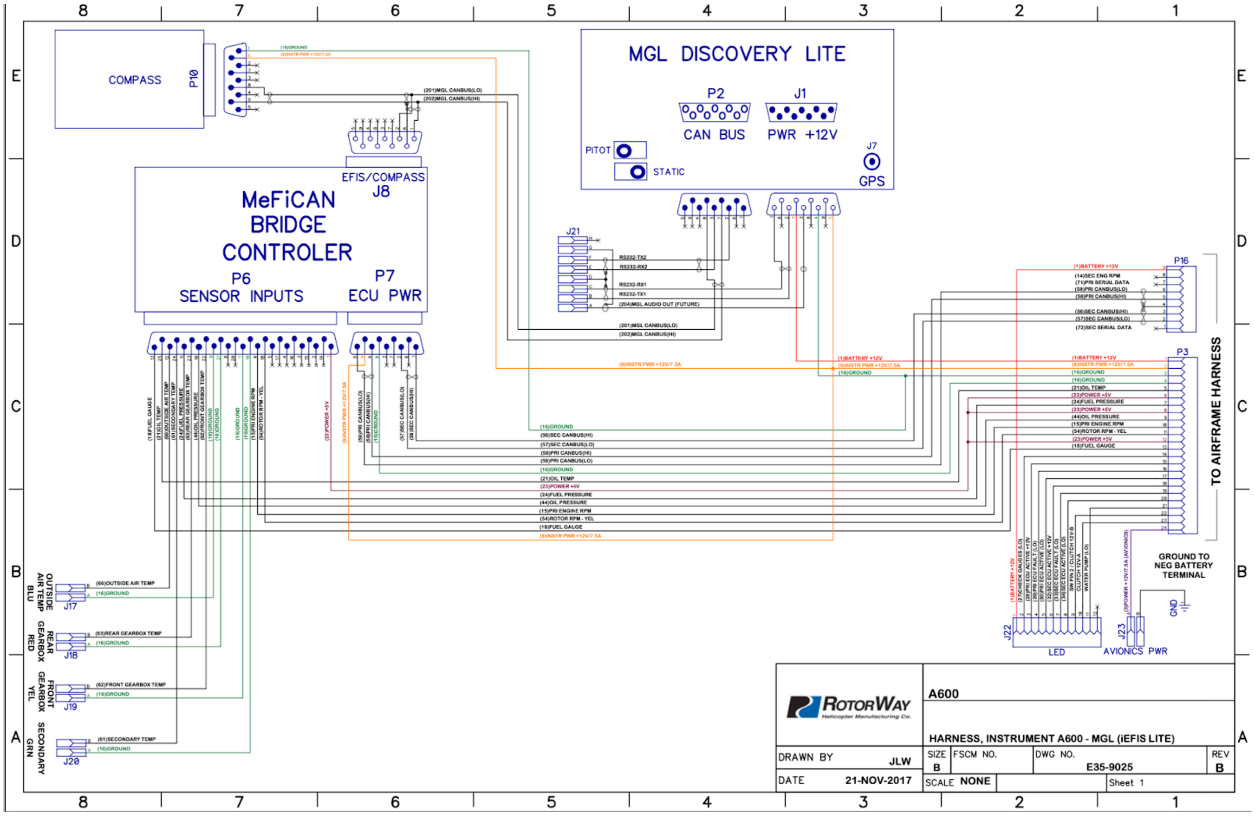




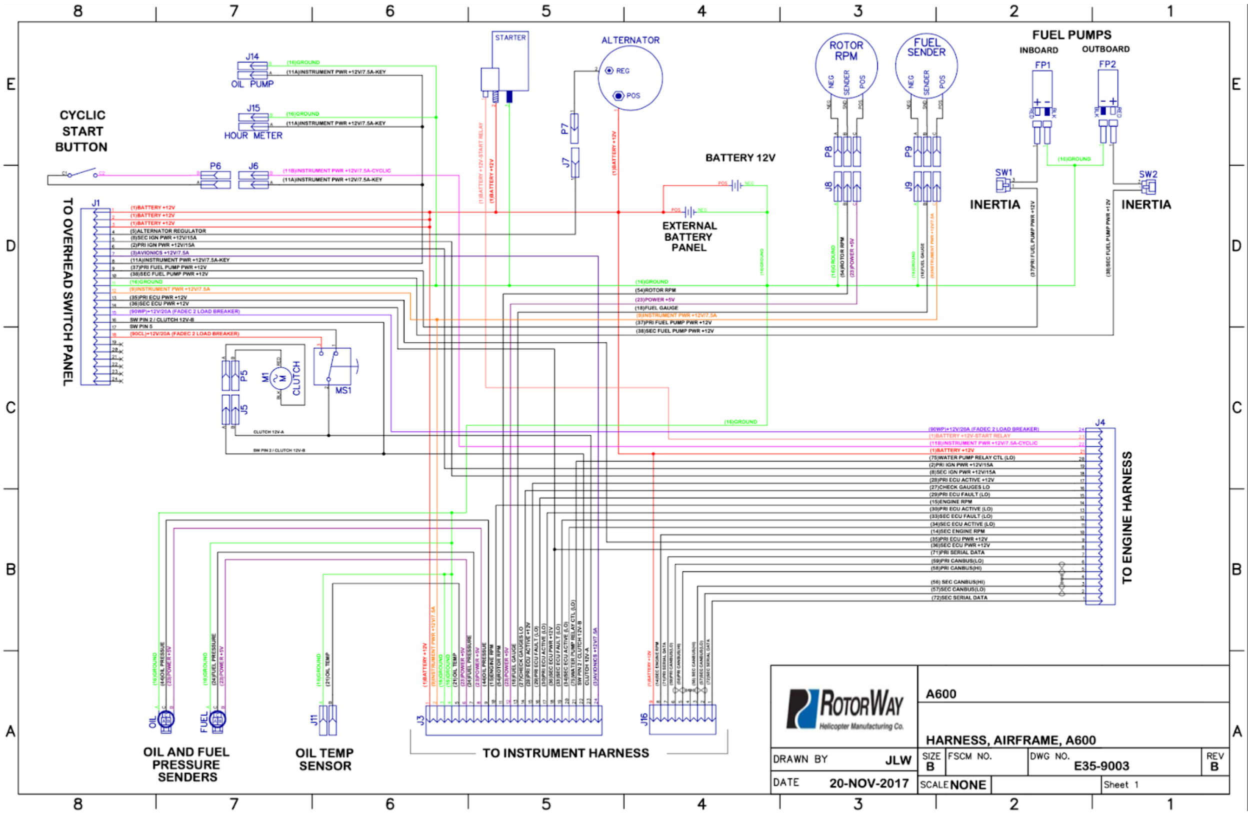
File Scanner Logger Help
Default View
0 M34-MAP Low - logged malf
0 M41-EST (ESTMALF) - active malf
0 M42-EST or BYPASS - active malf
0 M44-Knk 1 Inactive - active malf
0 M44-Knk 2 Inactive - active malf
0 M51-ROM/Cal Cksum - active malf
0 M54-Oxy 1 Lean - active malf
0 M54-Oxy 2 Lean - active malf
0 M55-Oxy 1 Rich - active malf
0 M55-Oxy 2 Rich - active malf
0 M61-Fuel Press High - active malf
0 M62-Fuel Press Low - active malf
0 M63-Fuel Temp High - active malf
0 M64-Fuel Temp Low - active malf
0 M81-Crnk Signal Flt - active malf
0 M81-Crnk Sync Flt - active malf
0 M81-Cam Signal Flt - active malf
0 M81-TAC (TACMALF) - active malf
0 M81-Fuel Pump High - active malf
0 M81-Pump Low/Open - active malf
0 M81-Inj A High - active malf
0 M81-Inj A Low/Open - active malf
0 M81-Inj B High - active malf
0 M81-Inj B Low/Open - active malf
0 M81-Recirc (J1-32) - active malf
0 M81-V5 Ref Range - active malf
0 M81-DEPSPWR Range - active malf
0 M81-Can Bus Fault - active malf
0 M81-Oil/CAT High - active malf
0 M81-Oil/CAT Low - active malf
Output Dash Item Lists Histograms Monitors
ALDL Connected 4.25 Hz Errors: 50

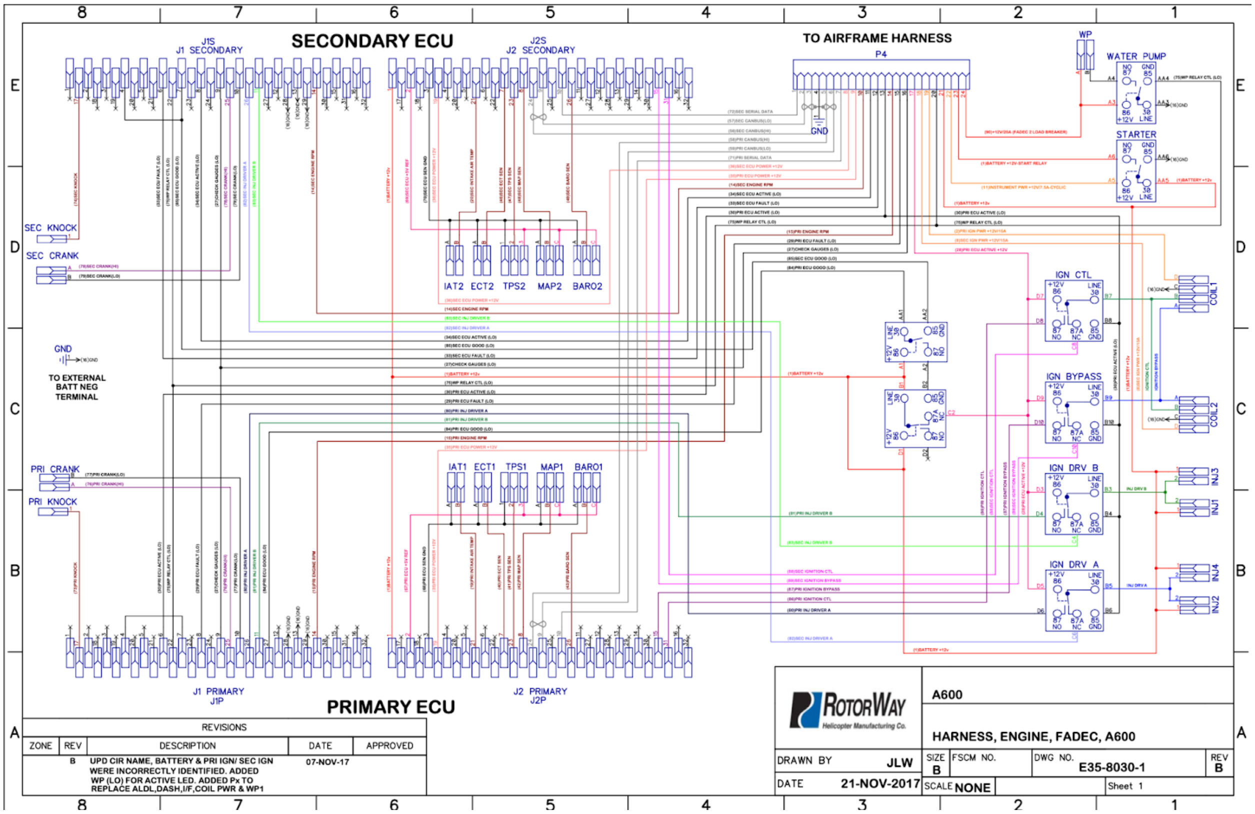


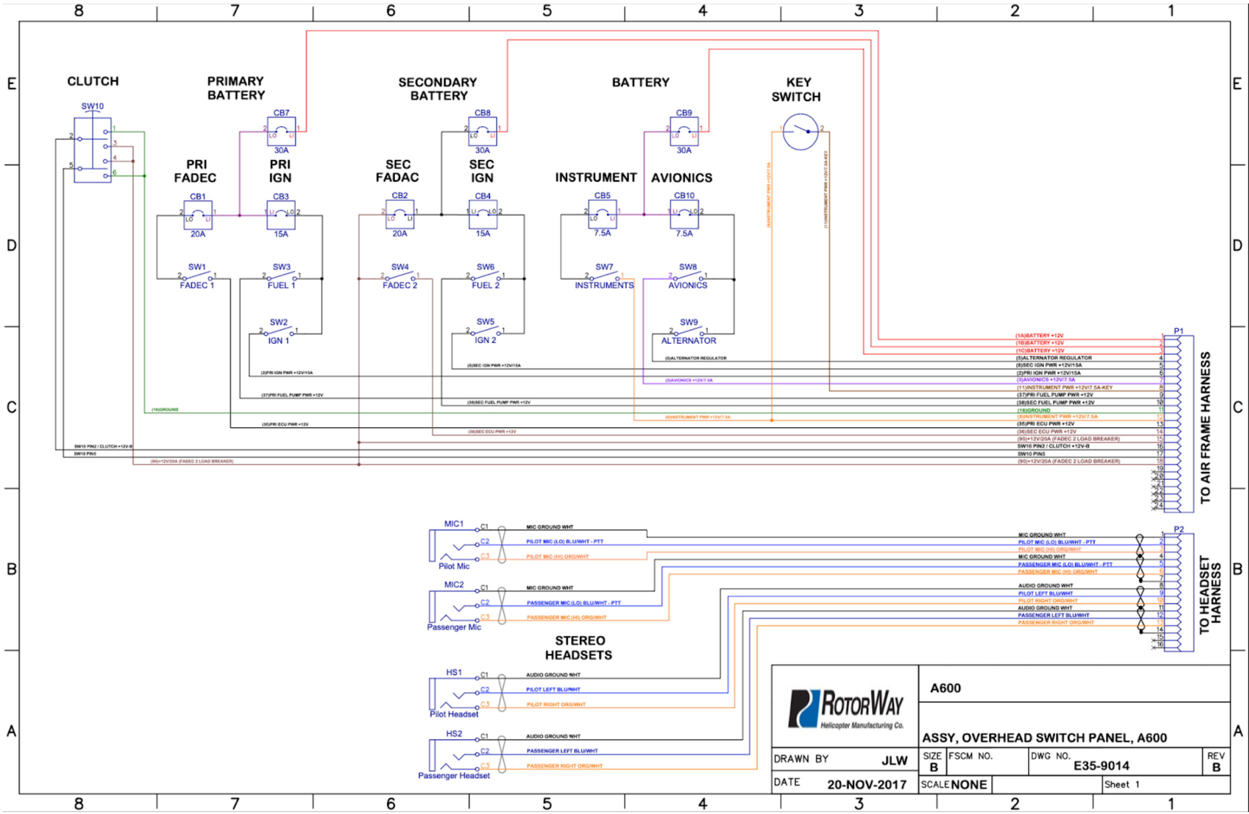
APPENDIX A Full Harness schematics:



COMPASS
P10
MGL DISCOVERY LITE
P2
CAN BUS
J1
PWR +12V
PITOT
STATIC
J7
GPS
MeFiCAN BRIDGE CONTROLER
EFIS/COMPASS
J8
P6
SENSOR INPUTS
P7
ECU PWR
J21
P16
P3
TO AIRFRAME HARNESS
GROUND TO NEG BATTERY TERMINAL
J22
LED
J23
AVIONICS PWR
OUTSIDE AIR TEMP BLU
J17
REAR GEARBOX RED
J18
FRONT GEARBOX YEL
J19
SECONDARY GRN
J20
RotorWay
A600
HARNESS, INSTRUMENT A600 - MGL (iEFIS LITE)
DRAWN BY JLW
DATE 21-NOV-2017
SIZE B
FSCM NO.
DWG NO. E35-9025
REV B
SCALE NONE
Sheet 1


CYCLIC
START
BUTTON
TO OVERHEAD SWITCH PANEL
J14
OIL PUMP
J15
HOUR METER
P6
J6
J1
STARTER
ALTERNATOR
REG
POS
P7
J7
BATTERY 12V
EXTERNAL
BATTERY
PANEL
ROTOR
RPM
FUEL
SENDER
P8
J8
P9
J9
FUEL PUMPS
INBOARD
OUTBOARD
FP1
FP2
SW1
SW2
INERTIA
INERTIA
P5
J5
M1
CLUTCH
MS1
J4
TO ENGINE HARNESS
OIL
FUEL
OIL AND FUEL
PRESSURE
SENDERS
J11
OIL TEMP
SENSOR
J3
J16
TO INSTRUMENT HARNESS
RotorWay
Helicopter Manufacturing Co.
A600
HARNESS, AIRFRAME, A600
DRAWN BY JLW
SIZE B
FSCM NO.
DWG NO. E35-9003
REV B
DATE 20-NOV-2017
SCALE NONE
Sheet 1


SECONDARY ECU
J1S
J1 SECONDARY
J2S
J2 SECONDARY
TO AIRFRAME HARNESS
P4
GND
WP
WATER PUMP
STARTER
SEC KNOCK
SEC CRANK
IAT2
ECT2
TPS2
MAP2
BARO2
IGN CTL
COIL1
GND
TO EXTERNAL BATT NEG TERMINAL
IGN BYPASS
COIL2
PRI CRANK
PRI KNOCK
IAT1
ECT1
TPS1
MAP1
BARO1
IGN DRV B
INJ3
INJ1
IGN DRV A
INJ4
INJ2
J1 PRIMARY
J1P
PRIMARY ECU
J2 PRIMARY
J2P
REVISIONS
ZONE
REV
DESCRIPTION
DATE
APPROVED
B
UPD CIR NAME, BATTERY & PRI IGN/ SEC IGN WERE INCORRECTLY IDENTIFIED. ADDED WP (LO) FOR ACTIVE LED. ADDED Px TO REPLACE ALDL,DASH,I/F,COIL PWR & WP1
07-NOV-17
ROTORWAY
Helicopter Manufacturing Co.
A600
HARNESS, ENGINE, FADEC, A600
DRAWN BY
JLW
DATE
21-NOV-2017
SIZE
B
FSCM NO.
DWG NO.
E35-8030-1
REV
B
SCALE
NONE
Sheet 1



CLUTCH
SW10
PRIMARY BATTERY
CB7
30A
SECONDARY BATTERY
CB8
30A
BATTERY
CB9
30A
KEY SWITCH
PRI FADEC
CB1
20A
PRI IGN
CB3
15A
SEC FADAC
CB2
20A
SEC IGN
CB4
15A
INSTRUMENT
CB5
7.5A
AVIONICS
CB10
7.5A
SW1
FADEC 1
SW3
FUEL 1
SW4
FADEC 2
SW6
FUEL 2
SW7
INSTRUMENTS
SW8
AVIONICS
SW2
IGN 1
SW5
IGN 2
SW9
ALTERNATOR
P1
TO AIR FRAME HARNESS
MIC1
Pilot Mic
MIC2
Passenger Mic
STEREO HEADSETS
HS1
Pilot Headset
HS2
Passenger Headset
P2
TO HEADSET HARNESS
RotorWay
Helicopter Manufacturing Co.
A600
ASSY, OVERHEAD SWITCH PANEL, A600
DRAWN BY JLW
SIZE B
FSCM NO.
DWG NO. E35-9014
REV B
DATE 20-NOV-2017
SCALE NONE
Sheet 1