ECUs for Race Cars

Elan NP01 Mazda 2.3l AEM ECU 240hp 1700lb w/driver (Richard Gray) 1.75 G’s 150 mph max
ECUs for Race Cars
WHAT IS AN ECU?

• Engine Control Unit
• A COMPUTER SYSTEM THAT RECEIVES DRIVER INPUT,
• AND MEASURES THE STATE OF THE ENGINE,
• AND SENDS APPROPRIATE SIGNALS TO THE ENGINE CONTROLS
• TO IMPLEMENT THE DRIVER’S COMMANDS
• (THROTTLE, FUEL MAP, ANTI-SLIP, ETC.)
AEM ECU – INFINITY MODEL 516
INSTALLATION IN ELAN RACE CAR
ECU Design Parameters

• Automotive Environment: Heat, Vibration, Moisture, Oil, Voltage, EMI
• Signal Speed: 10,000 RPM = millisecond cycle time with microsecond response
• Multiple In – Multiple Out
• Mixed Signal I/O
• Real Time Processing
• Cost
GUTS OF ECU – NXP CHIP

32 BIT 80 Mhz 80 GPIO AD/DA CAN FLASH SYSTEM ON CHIP
1181 PAGE REFERENCE MANUAL 4 CYLINDER VERSION
ECU SIGNALS – I/O

• Data – CAN UART
• Driver – High - Low side  P vs N  SiC MOSFET
• Digital:
• Analog: Sensor current or voltage
• AD levels and bits and speeds
• Protections: Short, over voltage, EMI
ECU INPUTS

• Driver:
  Throttle Gear Brake Steering Settings

• Engine:
  Temperatures Pressures RPM Positions

• Chassis:
  Pressures Positions RPMs GPS
ECU OUTPUTS

• **Engine:** Triggers & Data
  Ignition, Throttle, Fuel Injection, Fans, Pumps

• **Driver:** Data
  Dash Display, Data Logs
N vs P Channel MOSFET
High Side vs Low Side Drivers

Low-side Switch

High-side Switch

from micro output pin

n-Channel MOSFET

p-Channel MOSFET
POWER VS AIR-FUEL RATIO

2 C8H18 + 25 O2 = 16 CO2 + 18 H2O + energy  46.7 MJ/kg
CONTROL

• What is Control? Providing signals to engine to obtain desired performance.
• Optimization target (power) is found on dyno
• Servo control theory requires some closed loop feedback (O2 sensor for Air/Fuel ratio)
• Dynamic adaptation allowed by new powerful chips
• Stability in AEM is from bounded adaption
• Primary design parameter is volumetric efficiency at each throttle position or manifold pressure vs rpm
BASIC PROGRAM OF ECU

\[ u(t) = kp \, e(t) + ki \int_{0}^{t} e(\tau) \, d\tau + kd \, \frac{de}{dt} \]

- PROPORTIONAL INTEGRAL DERIVATIVE DRIVER

1. DRIVER INPUT
2. COMPARE STATE W/ TARGET
3. ENGINE SENSOR INPUT
4. ERROR
   - NO: LOOP
   - YES: CALCULATE CORRECTION APPLY LOOP
5. ENGINE

START LOOP

• PROPORTIONAL INTEGRAL DERIVATIVE
DYNO TUNING (DYNAPACK)

• HUB DYNO REAL TIME EDITING OF ECU TABLES
DYNO CURVE

• TORQUE
• HORSEPOWER

MAX TUNE MZR
TARGET LOOKUP TABLE

• IGNITION TIMING FOR MASS AIR FLOW VS RPM
VOLUMETRIC EFFICIENCY TABLE

**VS RPMVE** IS THEORETICAL PERCENT OF CYLINDER FILLING

- 0 AT CLOSED THROTTLE TO 300+ W/TURBO
- VE FOR MANIFOLD PRESSURE
ECU FUTURE

• End of era for internal combustion engine
• Electric motor control is already here
• EEG to ECU brain activity precedes motor activity. Faster reaction time
• Avatar racing.
• Autonomous race cars – VR racing
• More distributed processors. IOT for each component of car.
ECUs for Race Cars

THANK’S FOR YOUR INTEREST, AND THANK YOU IEEE FOR THIS FORUM