ECUs for Race Cars

2/3/2019 © Richard Gray **Moorpark CA 0**

- 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.)

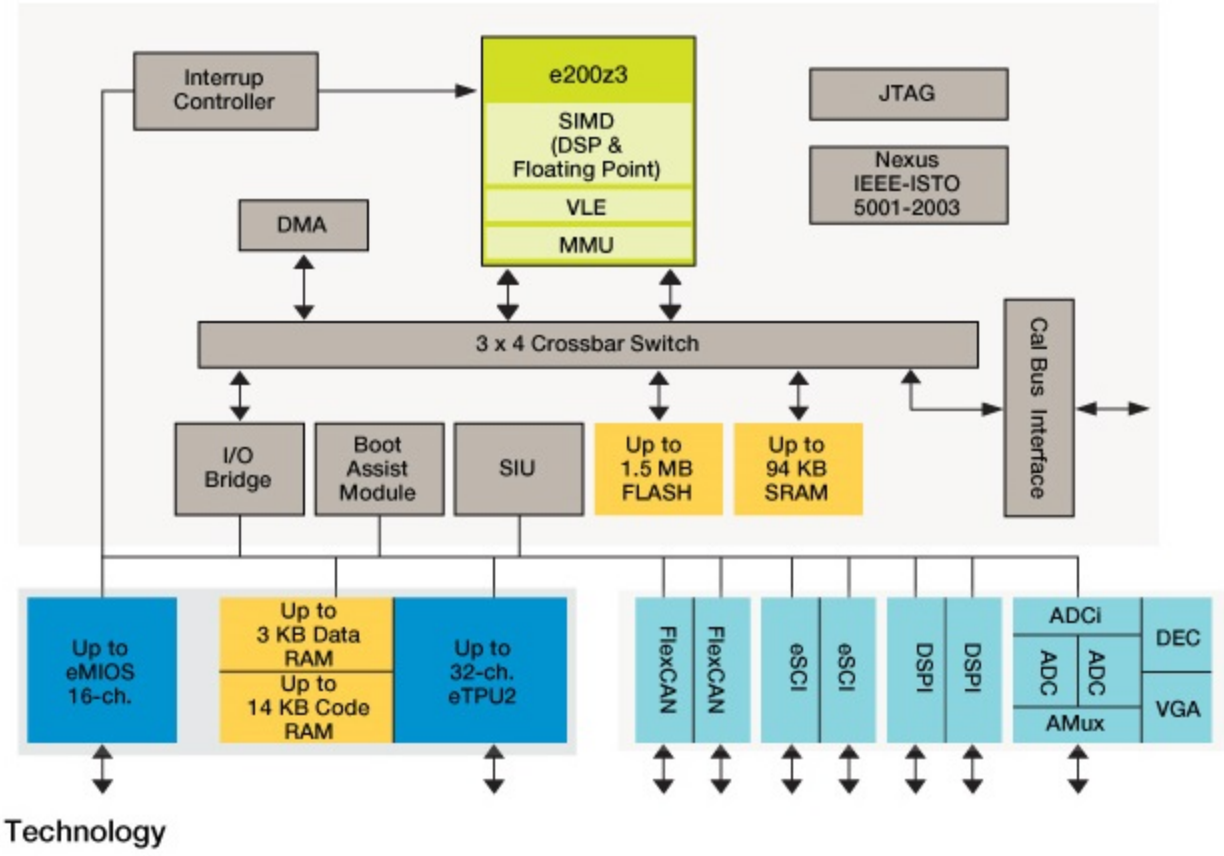
AEM ECU – INFINITY MODEL 516

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

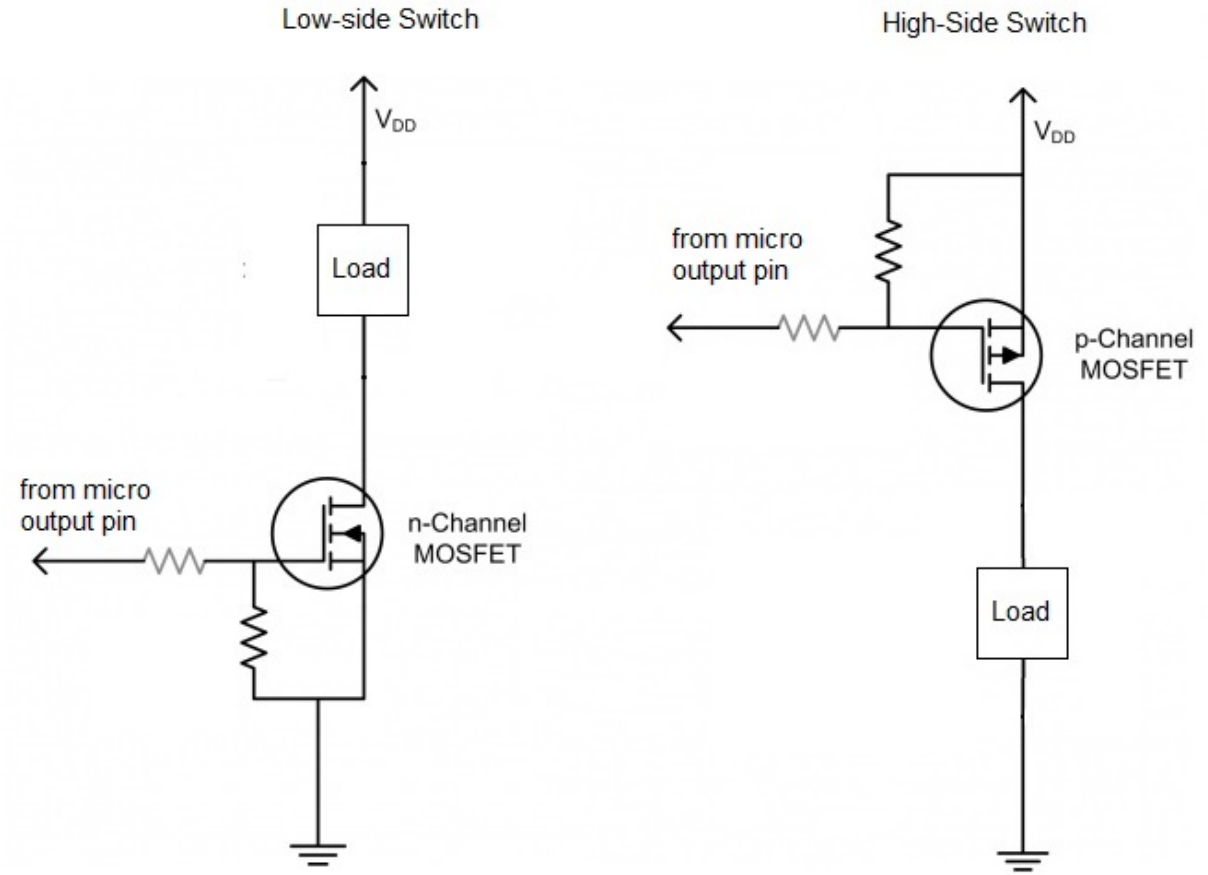
ECU INPUTS

- **Driver:**
  Throttle Gear Brake Steering Settings
- **Engine:**
  Temperatures Pressures RPM Positions
- **Chassis:**
  Pressures Positions RPMs GPS

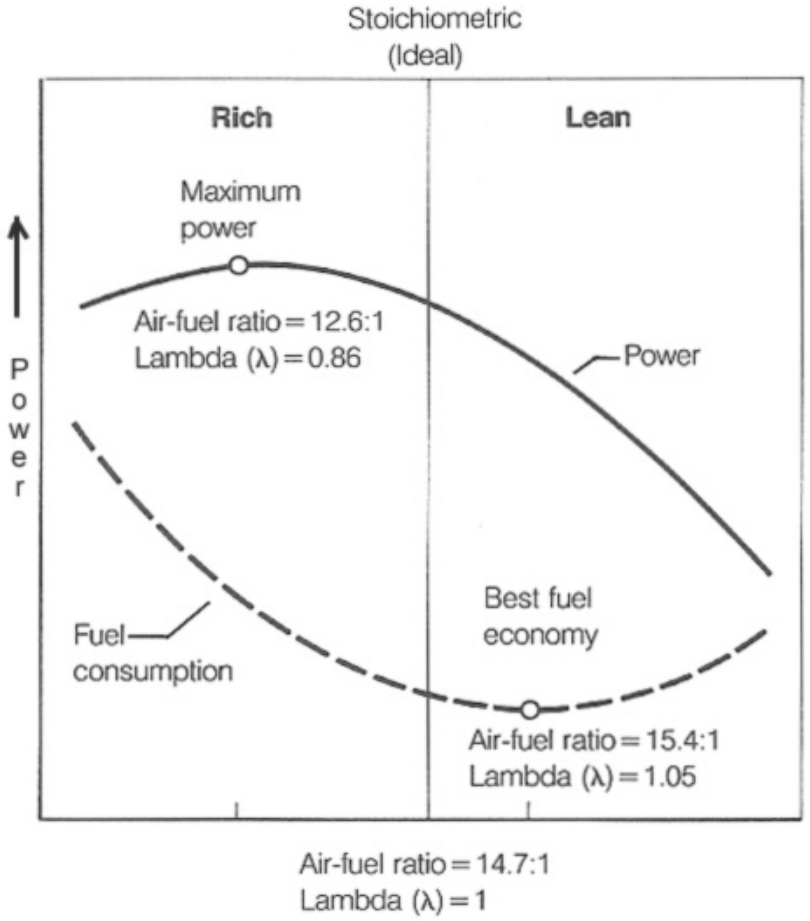
ECU OUTPUTS

- **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



POWER VS AIR-FUEL RATIO

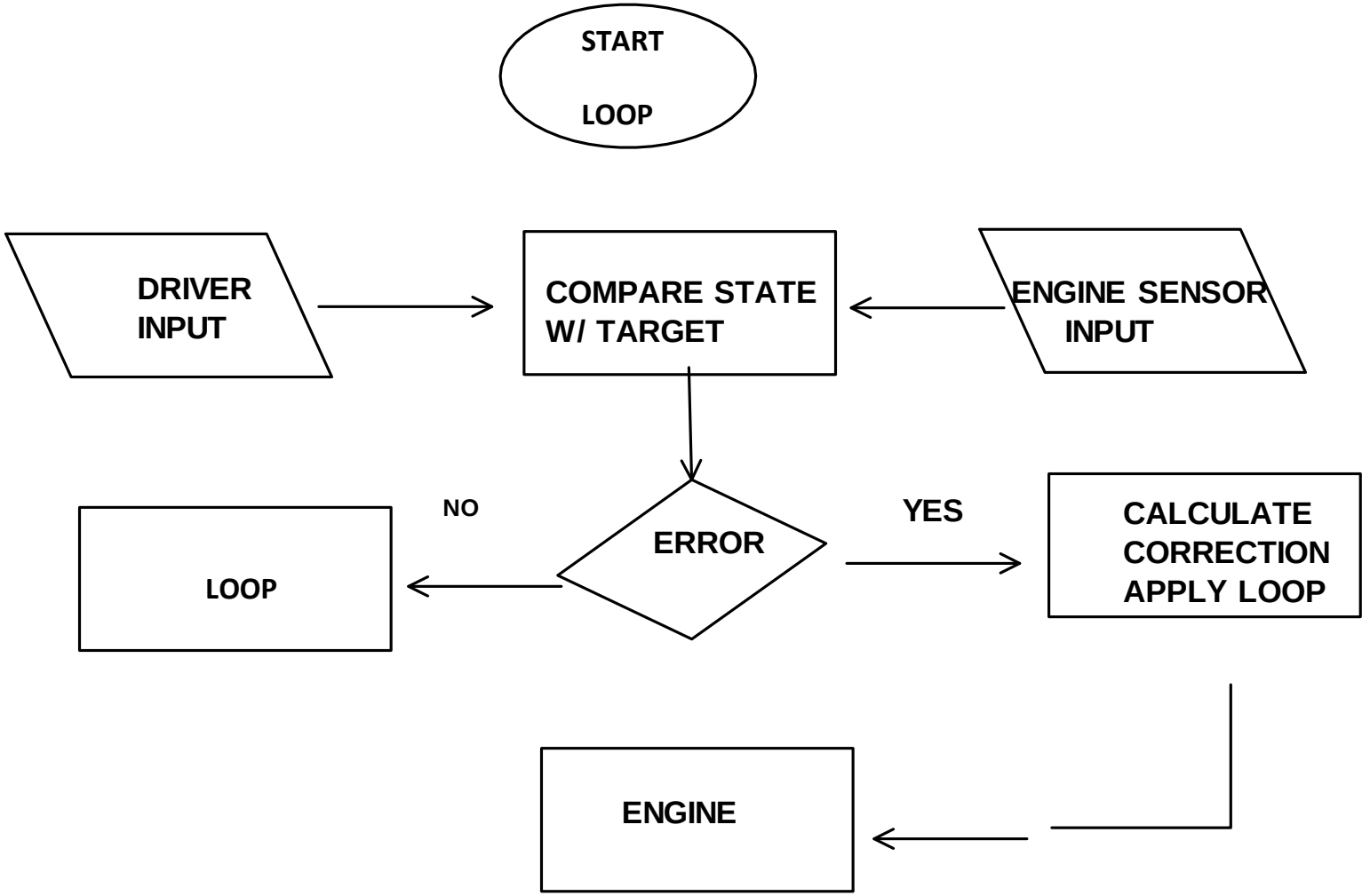


2 C8H18 + 25 O2 = 16 CO2 + 18 H2O + energy 46.7 MJ/kg

CONTROL

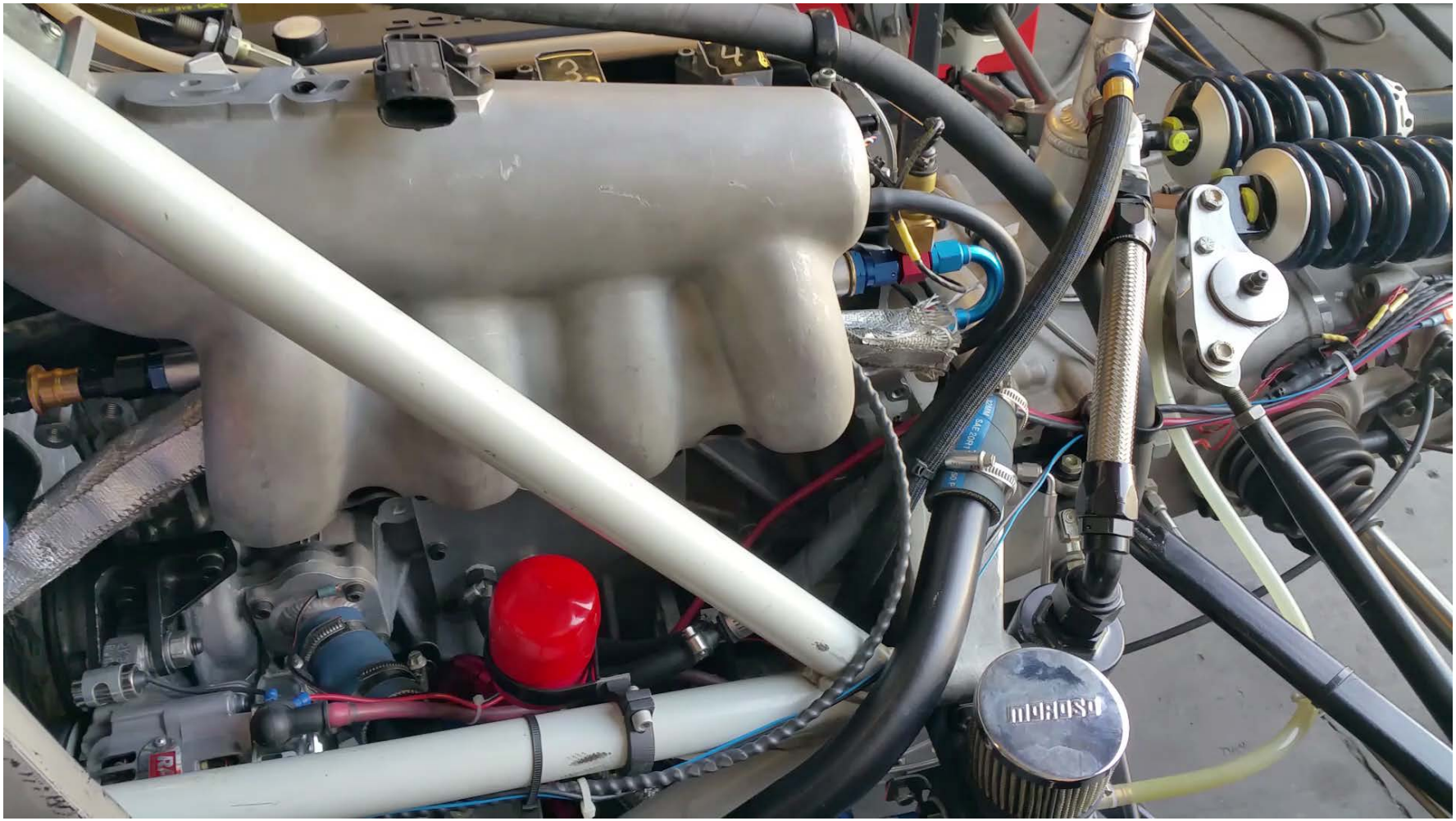
- What is Control? Providing signals to engine to obtain desired performance.
- Optimization target (power) is found on dyno
- Servo control theory requires some closed loop feedback (O2 sensor for Air/Fuel ratio)
- Dynamic adaptation allowed by new powerful chips
- Stability in AEM is from bounded adaption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

BASIC PROGRAM OF ECU



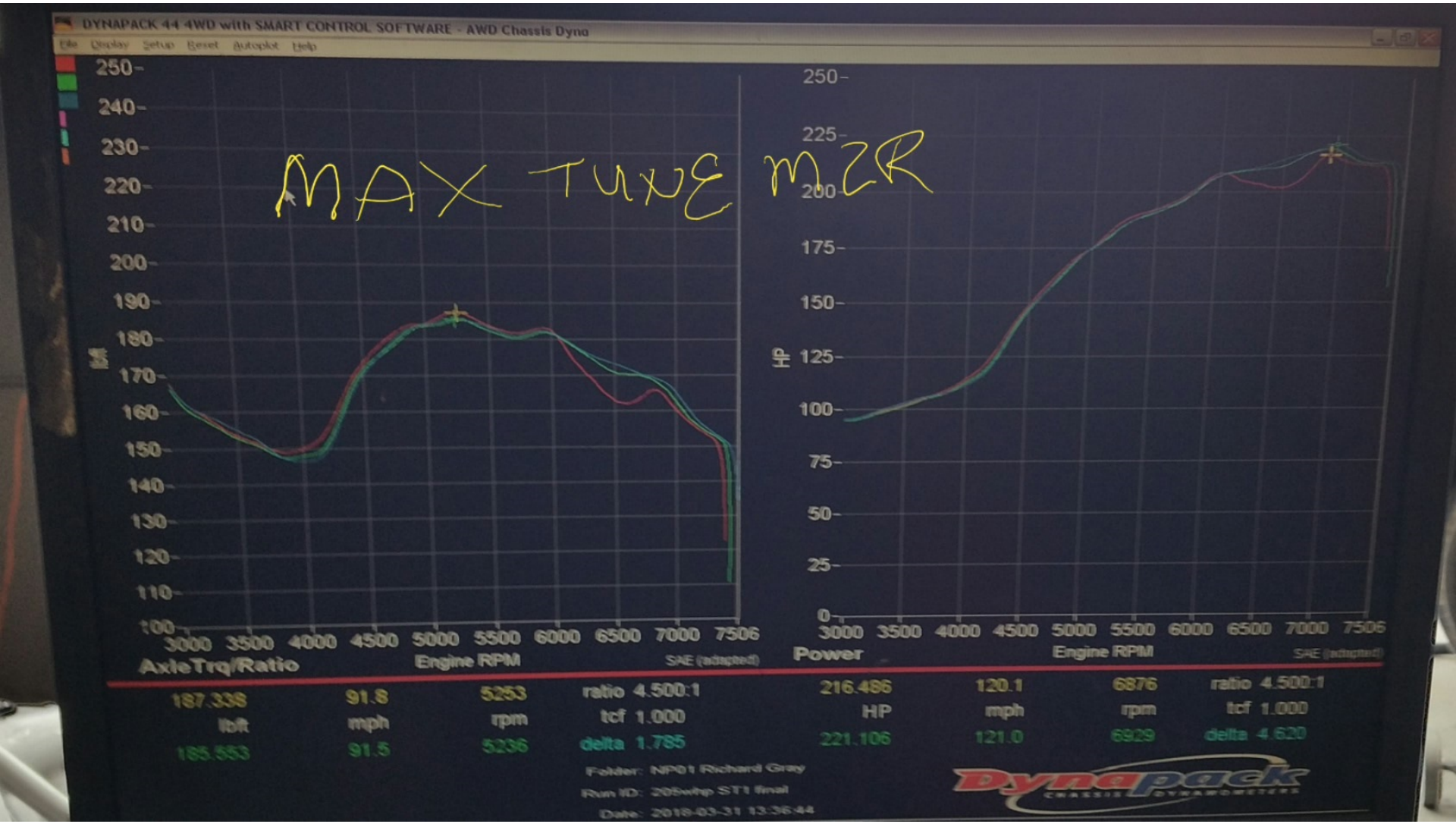
- $u(t) = kp\ e(t) + ki \int_{t0} e(\tau)d\tau + kd\ de/dt$
- PROPORTIONAL INTEGRAL DERIVATIVE

DYNO TUNING (DYNAPACK)



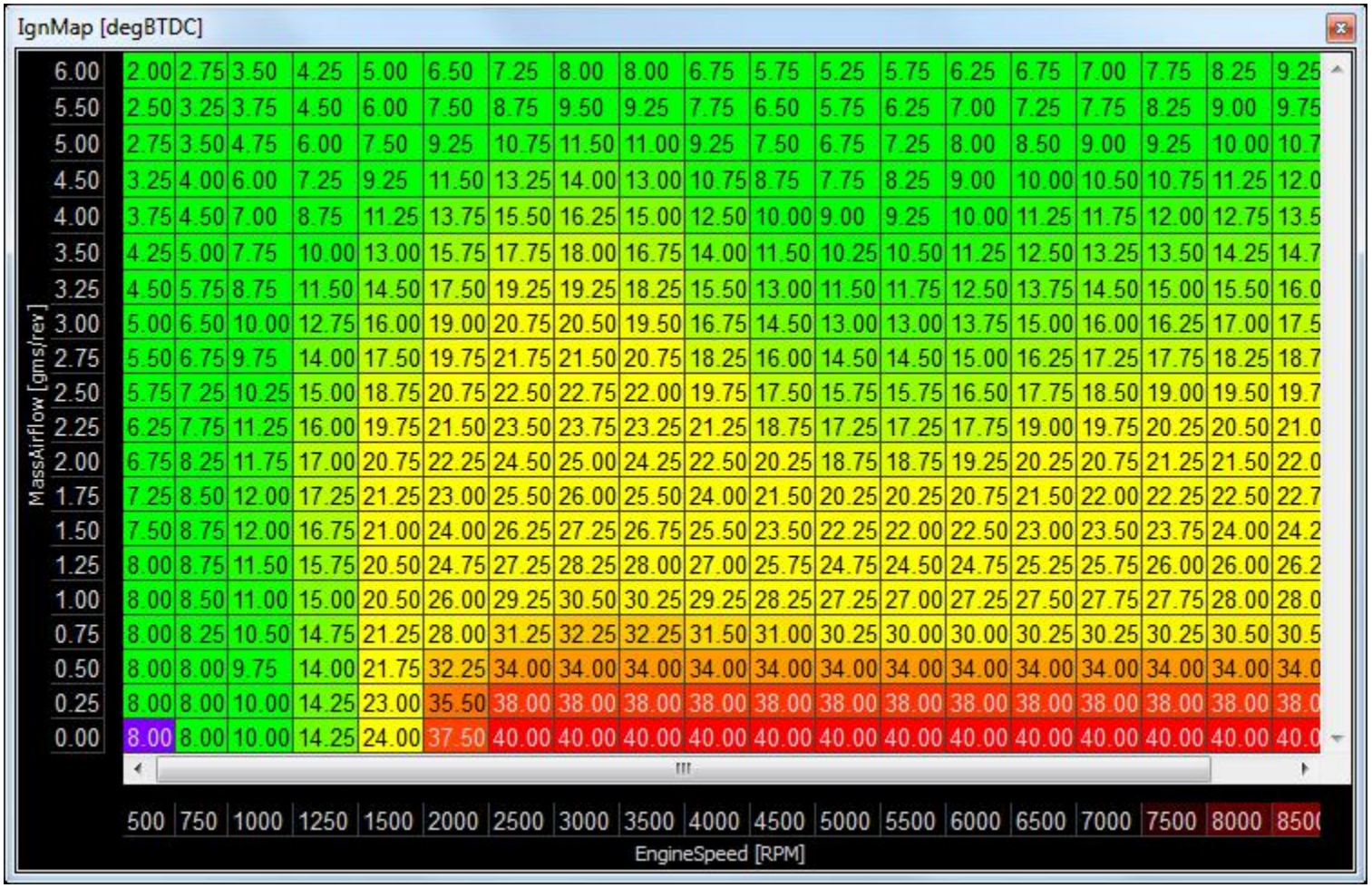
- HUB DYNO REAL TIME EDITING OF ECU TABLES

DYNO CURVE



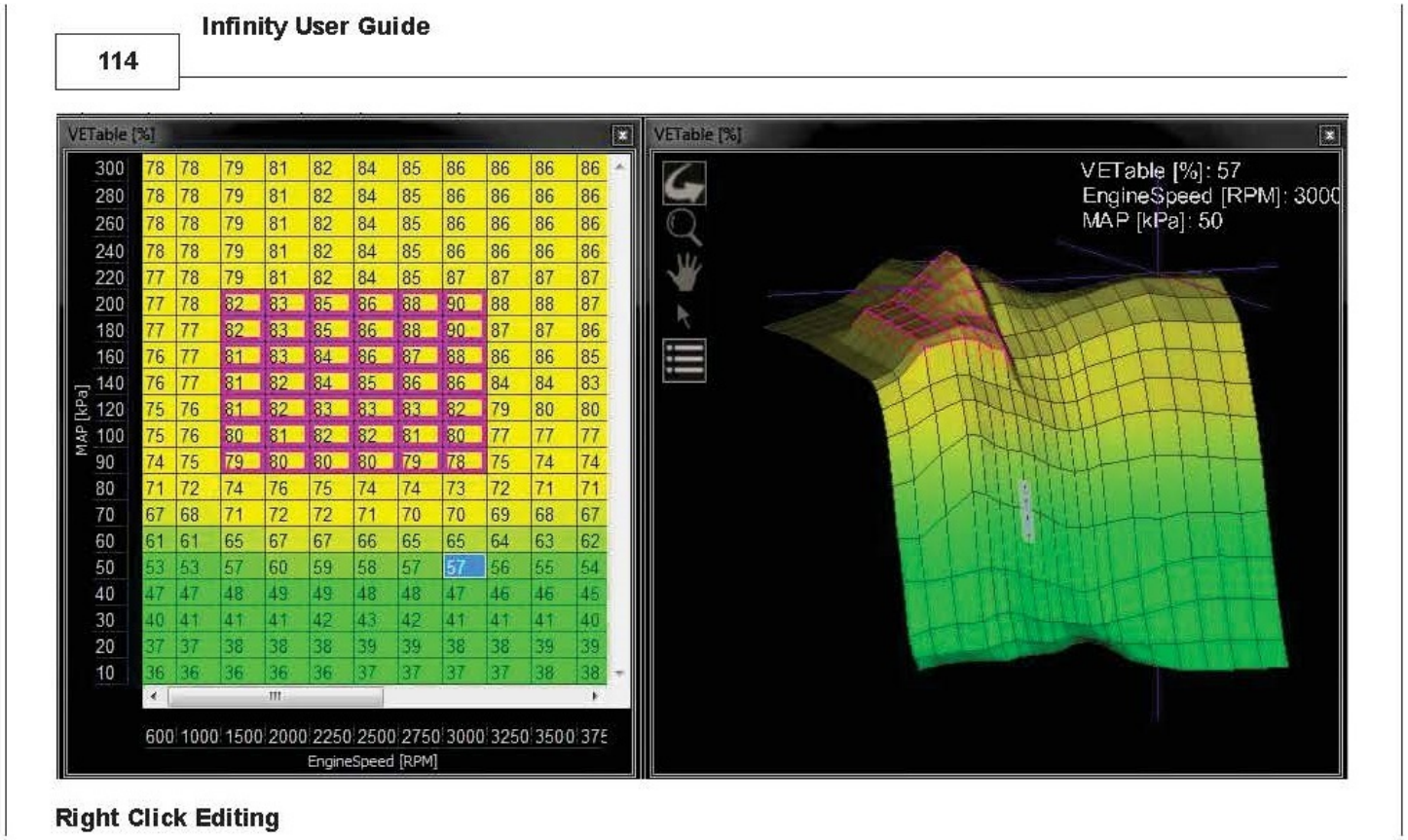
- TORQUE HORSEPOWER

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