
RTEC

Real Time Engine Controller



A Microcontroller Peripheral Optimized for Real Time Control of Internal Combustion Engines



AIEC Automotive
Integrated Electronics Corporation

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Introduction

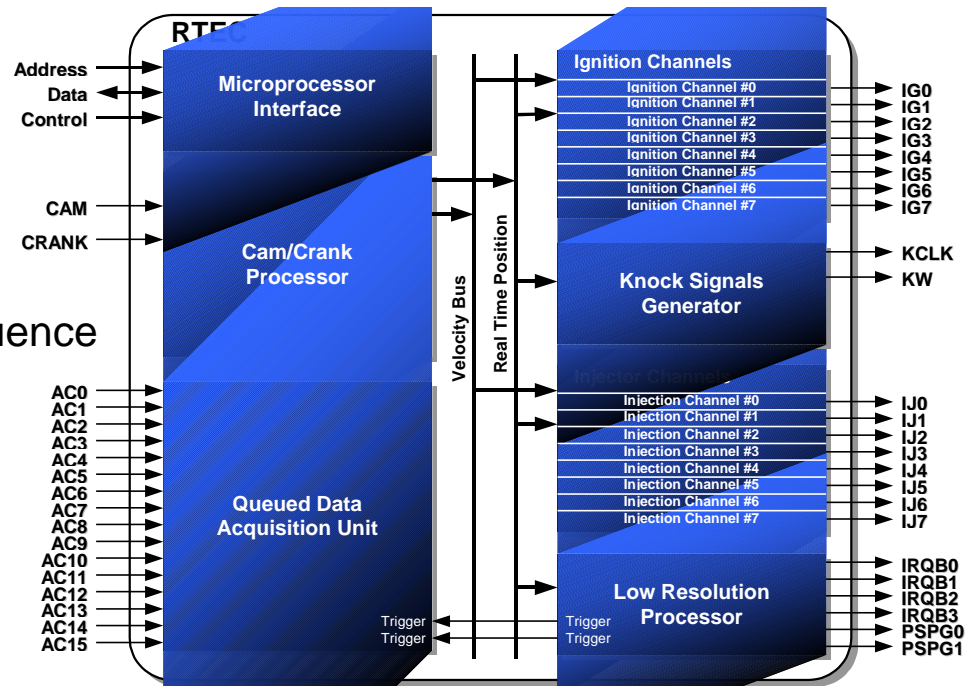
- **Internal Combustion Engine Innovations Now Approaching Manufacturability**
 - ✓ **Ion Sensing**
 - ✓ **In-Cylinder Pressure Measurement**
- **Impact on Control Algorithm Operation**
 - ✓ **Per Cylinder Control**
 - ✓ **Cycle-by-Cycle Basis**
- **Microprocessor Throughput Requirements Increase**
 - ✓ **Increased I/O Burden**
 - ✓ **Increased Algorithm Complexity**

Introduction (Continued)

- **Intelligent Peripherals**
 - ✓ **Remove I/O Burden**
 - ✓ **Perform Control Functions**
 - ✓ **Preserves Microprocessor Bandwidth for Complex, High Level Control Functions**
- **Current Approaches**
 - ✓ **General Purpose Timing Peripherals Require Complex Abstract Programming**
 - ✓ **Second I/O Microprocessor Introduces Complex Interface and Difficult Debug Environment**

RTEC Overview

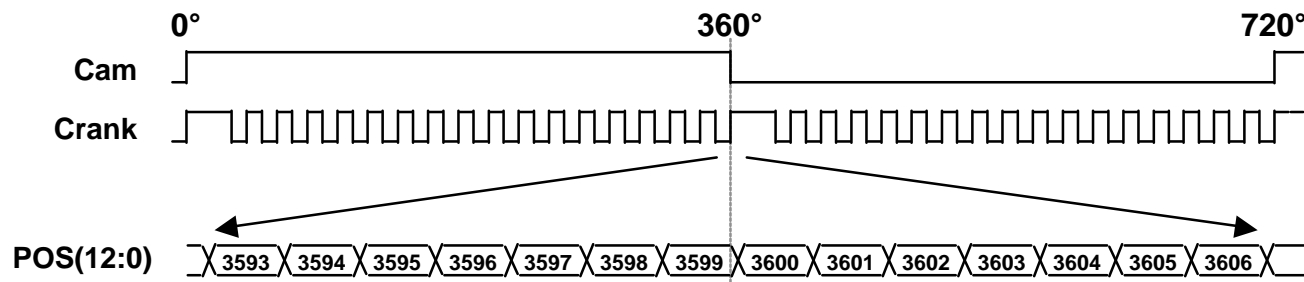
- **Microprocessor Interface**
 - ✓ Register Read/Write Interface
- **Cam / Crank Processor (CCP)**
 - ✓ Real Time Engine Position Tracking
- **Queued Data Acquisition (QDA)**
 - ✓ Automated A-to-D Conversion
- **Ignition Channels (IGC)**
 - ✓ Two uP Writes Control Ignition Sequence
- **Knock Control Signal Generator**
 - ✓ Automatic Knock Control Signal Generation Independent of uP
- **Injection Channels (IJC)**
 - ✓ Single uP Write Controls Injection Sequence
- **Low Resolution Processor**
 - ✓ Precision Timing (Misfire Detection)



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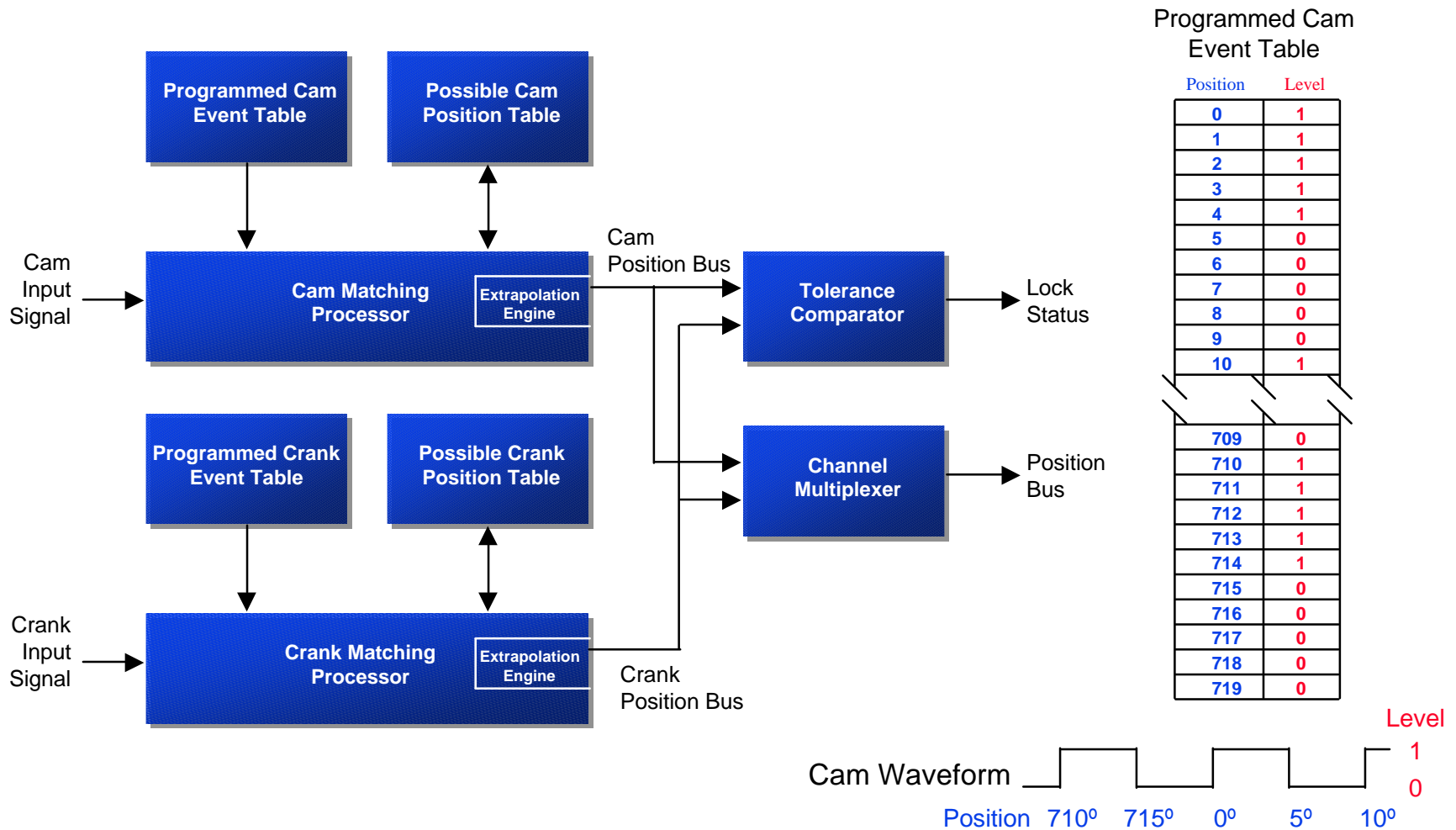
Cam / Crank Processor Functionality

- **Angular Position Tracking**
 - ✓ Angular Position Tracked Without Microprocessor Intervention
 - ✓ Real Time Position Bus (Range = 0.0°-719.9°, Resolution = 0.1°)
- **Independent Cam and Crank Channels**
 - ✓ Position Extrapolation On Cam Only, or Crank Only Input Signals
- **Arbitrary Cam and Crank Waveforms**
 - ✓ Simple Configuration Through Table Programming



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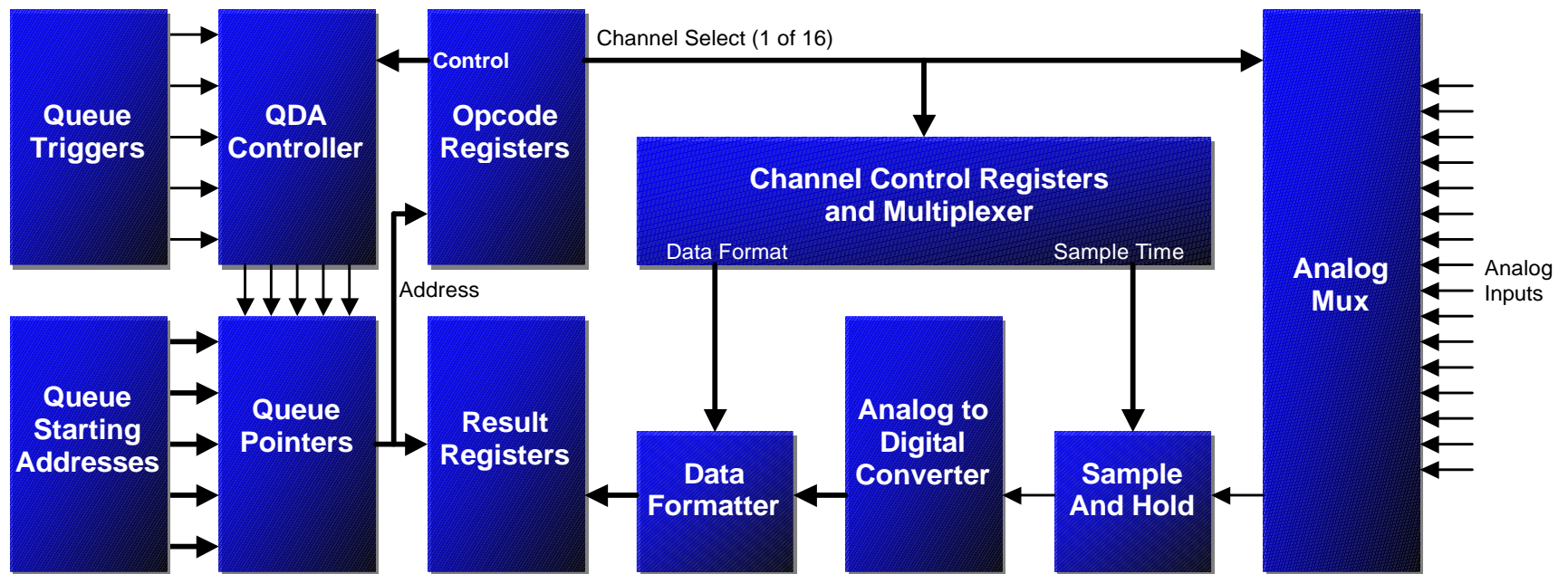
Cam / Crank Processor Block Diagram



Queued Data Acquisition Functionality

- **Automatically Acquires Analog Signals**
 - ✓ Once Initialized, Requires No Further Microprocessor Intervention for Signal Acquisition
- **A-to-D Conversion - Position, Time, and Software Triggered**
 - ✓ 2 Independent Position Queues from 1 to 64 Acquisitions
 - ✓ 2 Independent Time Based Queues with Programmable Intervals
 - ✓ 1 Software Triggered Queue for On Demand Data Acquisition
- **A-to-D Converter Specifications (-40° to +125°, ±10% Supply)**
 - ✓ 16 Channels, 10-Bit Resolution, ±2 LSB Accuracy
 - ✓ 5uS Conversion Time, Guaranteed Monotonicity and No Missing Codes

Queued Data Acquisition Block Diagram



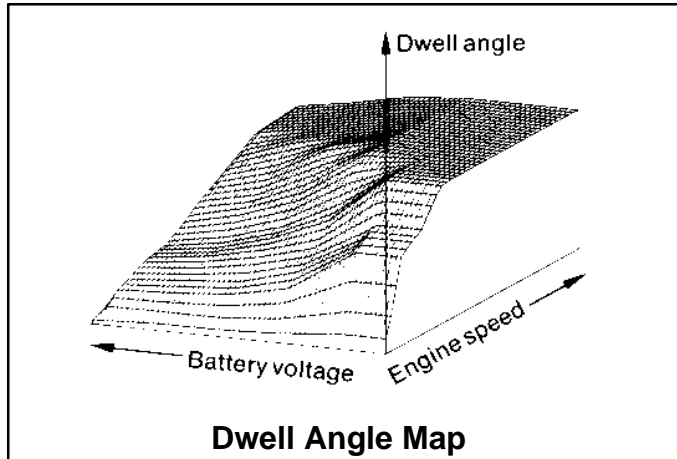
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Ignition Channel Functionality

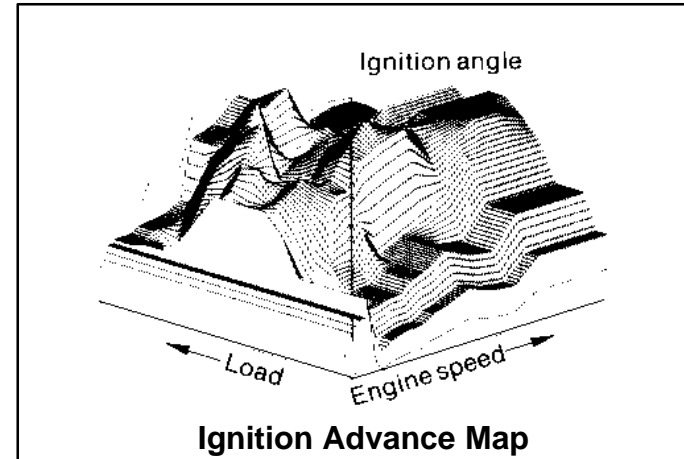
- **Precision Ignition Timing**
 - ✓ 30uS Resolution Dwell Time Over Entire Operating Range (>500RPM)
 - ✓ 0.1° Resolution Ignition Advance Angle
- **Simplified Programming**
 - ✓ Single Write to Program Dwell Time
 - ✓ Single Write to Program Ignition Advance Angle
 - ✓ Ignition Channel Continues Without uP Intervention
 - ✓ Dwell Time and Advance Angles Programmed Synchronous or Asynchronous to Engine Events
- **Increased Performance**
 - ✓ Real Time Ignition Timing Per Spark for Increased Fuel Economy and Reduced Emissions

Ignition Programming

(Dwell and Ignition Advance Angles)



Robert Bosch GmbH, Automotive Electric/Electronic Systems



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Dwell Angle Programming

- 1) Read Battery Voltage from QDA
- 2) Read Engine Velocity from CCP
- 3) Fetch Dwell Angle from Map
- 4) Write Relative Dwell Angle to IGC

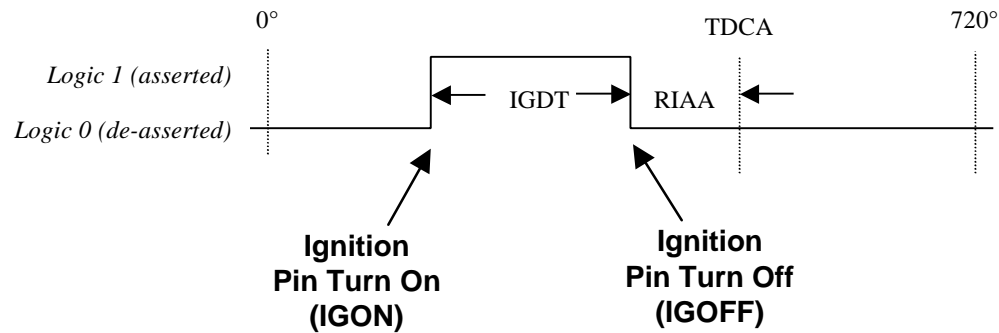
Ignition Advance Programming

- 1) Read Manifold Pressure from QDA
- 2) Read Engine Velocity from CCP
- 3) Fetch Ignition Advance from Map
- 4) Write Ignition Advance Angle to IGC

Total of 8 Operations for Ignition Programming of a Cylinder

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Ignition Channel Output Waveform



$$\text{IGOFF} = \text{TDCA} - \text{RIAA}$$

$$\text{IGON} = \text{IGOFF} - (\text{IGDT} * \text{Velocity})$$

TDCA - Top Dead Centers for Each Ignition Channel are Programmed Immediately after RESET

RIAA - Relative Ignition Advance Angle Programming Changes Take Effect Immediately

IGDT - Ignition Dwell Times Programming Changes Take Effect Immediately

Injector Channel Functionality

- **Precision Fuel Metering**

- ✓ 4uS Resolution Injector On Time Over Entire Operating Range (>500RPM)
- ✓ 0.1° Resolution Injector On/Off Angle

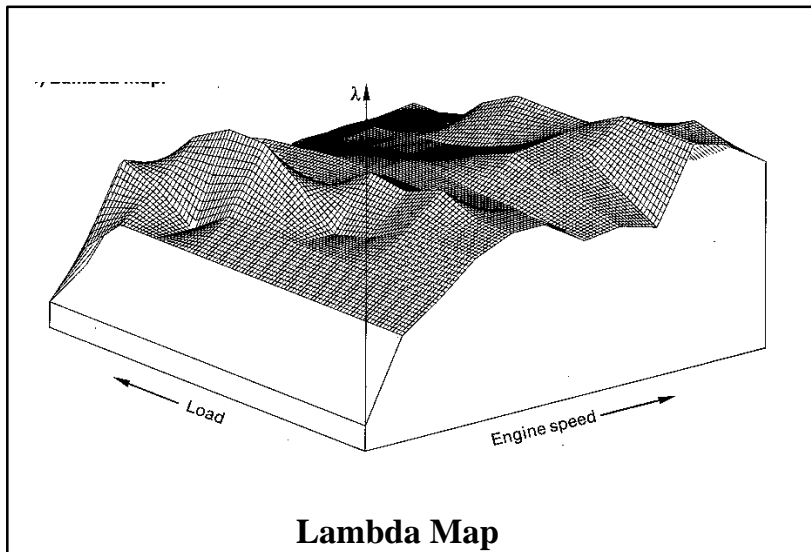
- **Simplified Programming**

- ✓ Single Write Instruction for Programming Total Commanded Pulse Width
- ✓ Injector Channel Continues Without uP Intervention
- ✓ Total Commanded Pulse Width Programmed Synchronous or Asynchronous to Engine Events

- **Increased Performance**

- ✓ Real Time Injector Timing Per Combustion for Increased Fuel Economy and Reduced Emissions

Injector Programming (On Angle and Duration)

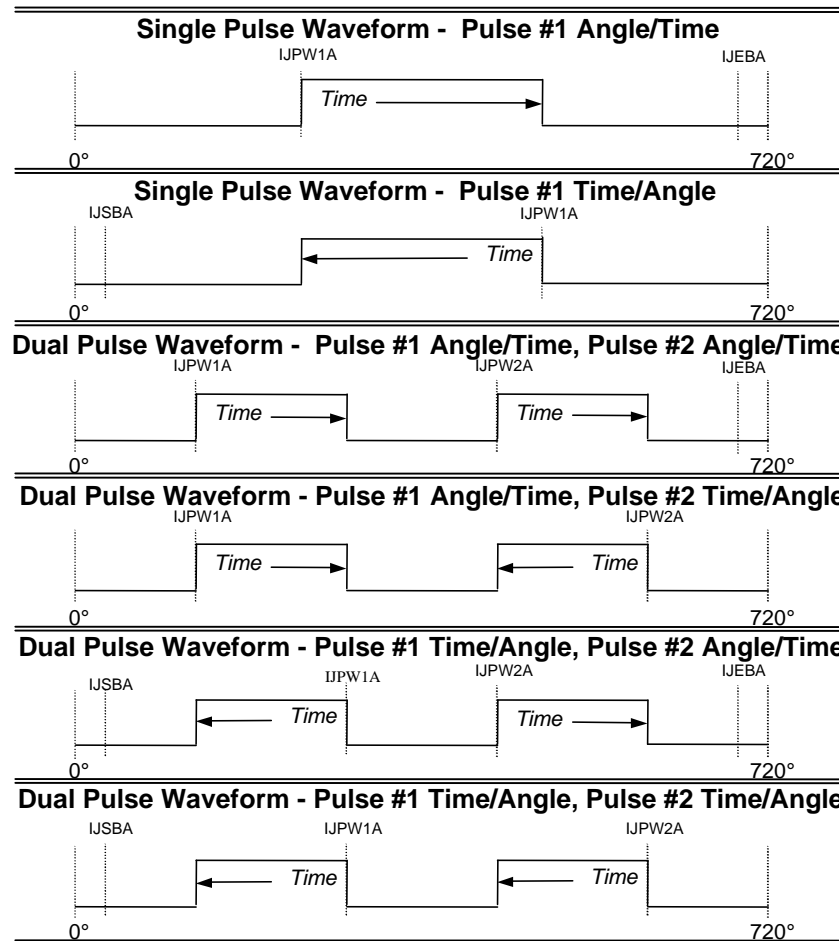


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Injector Programming

- 1) Read Manifold Absolute Pressure from QDA
- 2) Read Engine Velocity From CCP
- 3) Fetch Air/Fuel Ratio (Lambda) from Map
- 4) Read Mass Air Flow from QDA
- 5) Read Battery Voltage from QDA
- 6) Read Engine Temperature from QDA
- 7) Read Air Temperature From QDA
- 8) Read O₂ Sensor from QDA
- 9) Read Throttle Valve Angle from QDA
- 10) Read Throttle Valve Position from GPIO
- 11) Calculate Injector Period
- 12) Write Injector Total Commanded Pulse Width

Injector Channel Output Waveforms



Real Time Engine Controller Conclusion

- **Specifically Designed for Internal Combustion Engine Control**
 - ✓ Cam/Crank Processor Automatically Locks to Engine
 - ✓ Cam/Crank Processor Automatically Tracks Engine with 0.1° Resolution
 - ✓ Queued Data Acquisition Unit Automatically Converts Analog Signals
 - ✓ Ignition Programming - Two Register Writes (Dwell Time & Spark Angle)
 - ✓ Injection Programming - Single Write (Total Commanded Pulse Width)
- **High Capability Low Complexity Programming Reduces Software Development Time and Effort**
- **Dedicated Hardware for Maximum Accuracies (No Software Latencies)**
- **Offloads Controlling Microprocessor from I/O Tasks**
- **Frees Up Bandwidth for Complex Algorithms Including Per Cylinder and Cycle by Cycle Control**

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