Freescale Technology Forum

Design Innovation.

November 5th, 2008

Motorbikes: Entry-Level Automotive Powertrain Solutions for Emerging Markets and Emissions Reduction

PA102

Bin Yang

Asia Technical Marketing, Automotive

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Market Dynamics Driving Small Engine Control

- The World's transportation needs are growing fast, driving demand for gas powered vehicles
- The demand is high for both Industrialized and Emerging (or Newly Industrialized) Markets
- Air pollution emissions remain a growing problem in these markets, as well fuel consumption
- World Governments are driving pollution control mandates to the smallest of internal combustion engines (Moped, gas power generators, personal watercraft etc.)
- Consumers also will expect everything to be environmentally friendly






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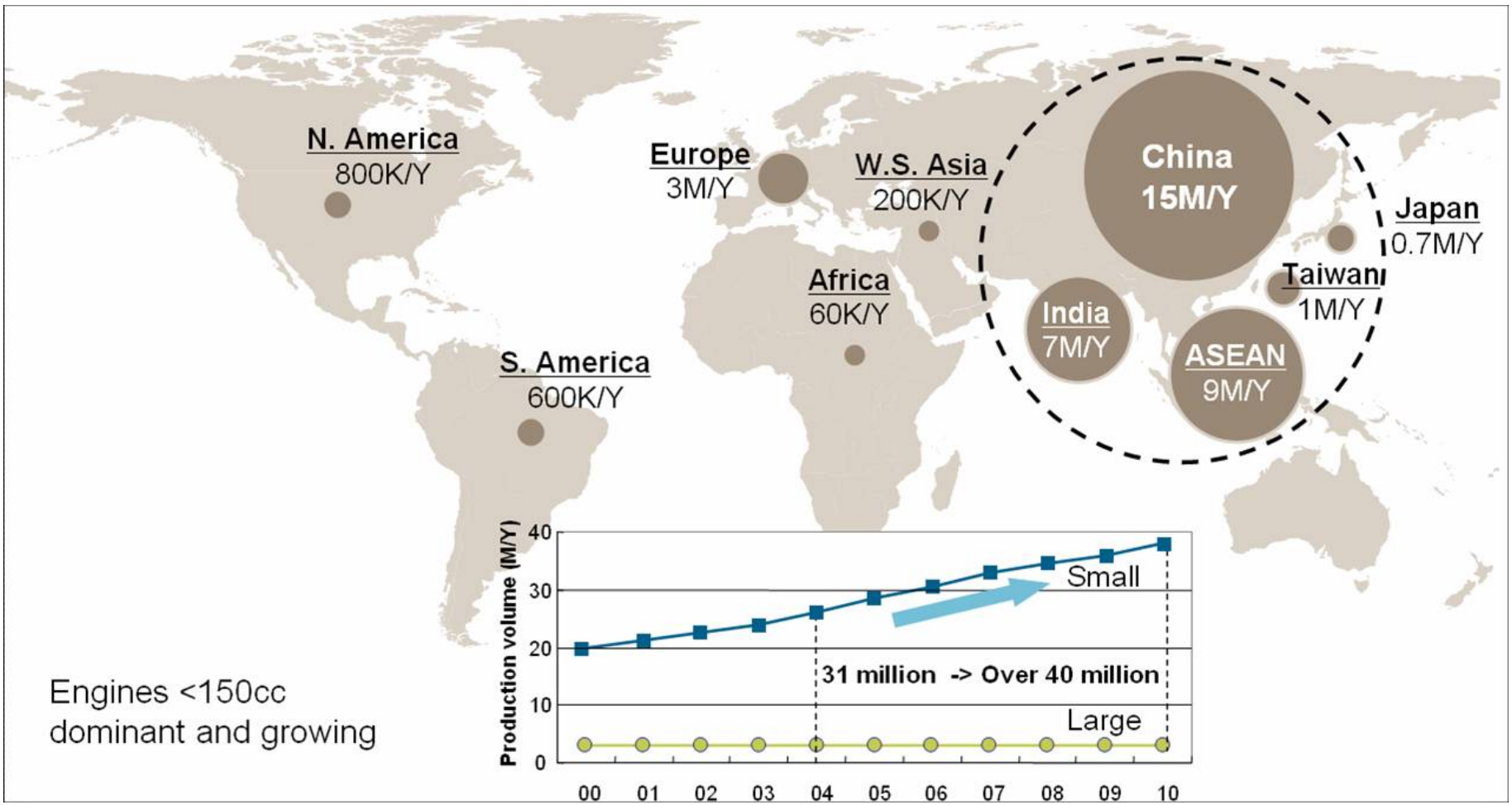
WW Small Engine Motorcycle/Scooter Sales



Engines <150cc dominant and growing

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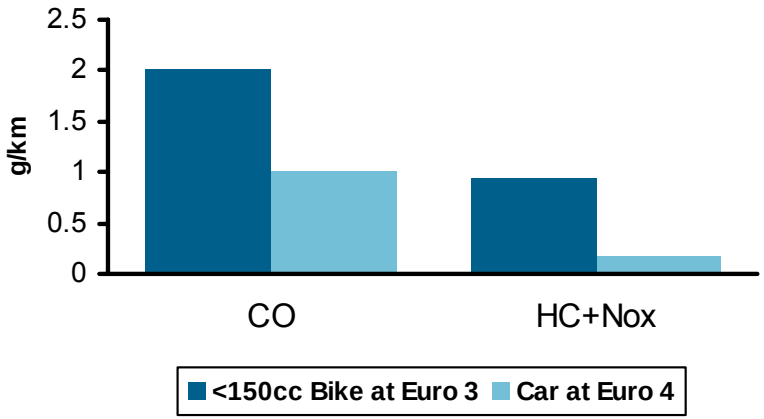
Emissions Standards

2006 Snapshot of EU Emissions



Emission Standards for New Vehicles (Light Duty)

Country	95	96	97	98	99	2000	01	02	03	04	05	06	07	08	09	10
European Union	Euro 1		Euro 2			Euro 3					Euro 4			Euro 5		
Bangladesh									Euro 2 (under discussion)							
Hong Kong, China		Euro 1		Euro 2			Euro 3				Euro 4					
India[a]							Euro 1				Euro 2					E3
India[b]					E1		Euro 2				Euro 3					
Indonesia											Euro 2					
Malaysia			Euro 1			Euro 2										
Nepal						Euro 1										
Philippines									Euro 1							
PRC[d]							Euro 1				Euro 2					
PRC[c]							Euro 1		Euro 2		Euro 3					
Singapore	Euro 1						Euro 2									
Sri Lanka									Euro 1							
Taipei,China					US Tier 1								US Tier 2 for diesel[e]			
Thailand	Euro 1						Euro 2			Euro 3				Euro4		
Viet Nam[e]				Euro 1							Euro 4 (under consideration)					
Viet Nam[f]											Euro 1		Euro 2	E3	E4	

► Rationale for Legislation:

- Differing just 1 level in Euro standard, <150cc Motorbike is allowed to produce twice the emissions of a typical car
- Multiple emerging markets are moving to Euro 3 by 2009 for Motorbikes
- In order to achieve Euro 3, electronic control and EFI is required

Trend from automobiles shows that emerging markets follow the precedents set by Europe

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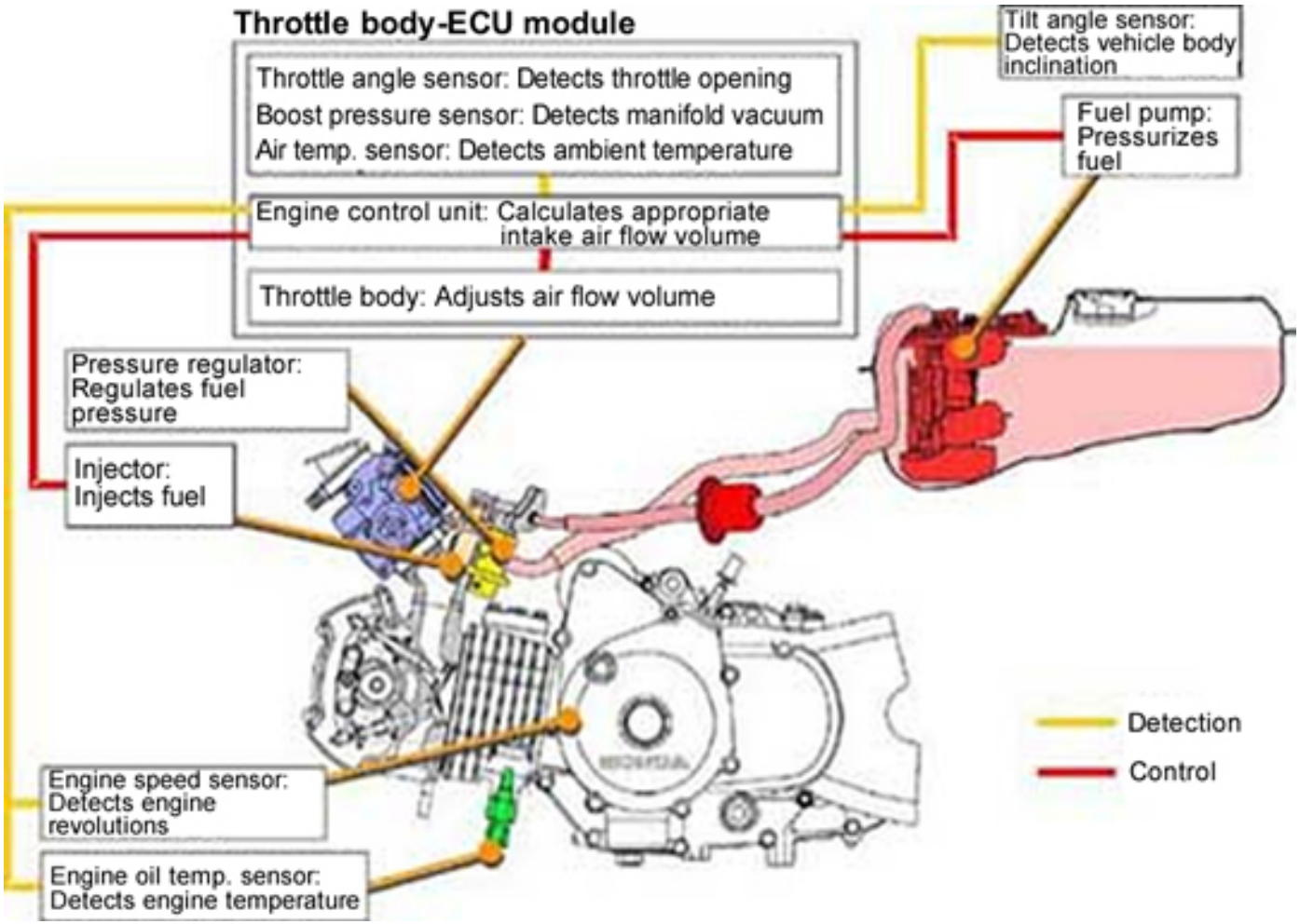
FI System for 1-cyl. Motorcycle Example



Source: Honda

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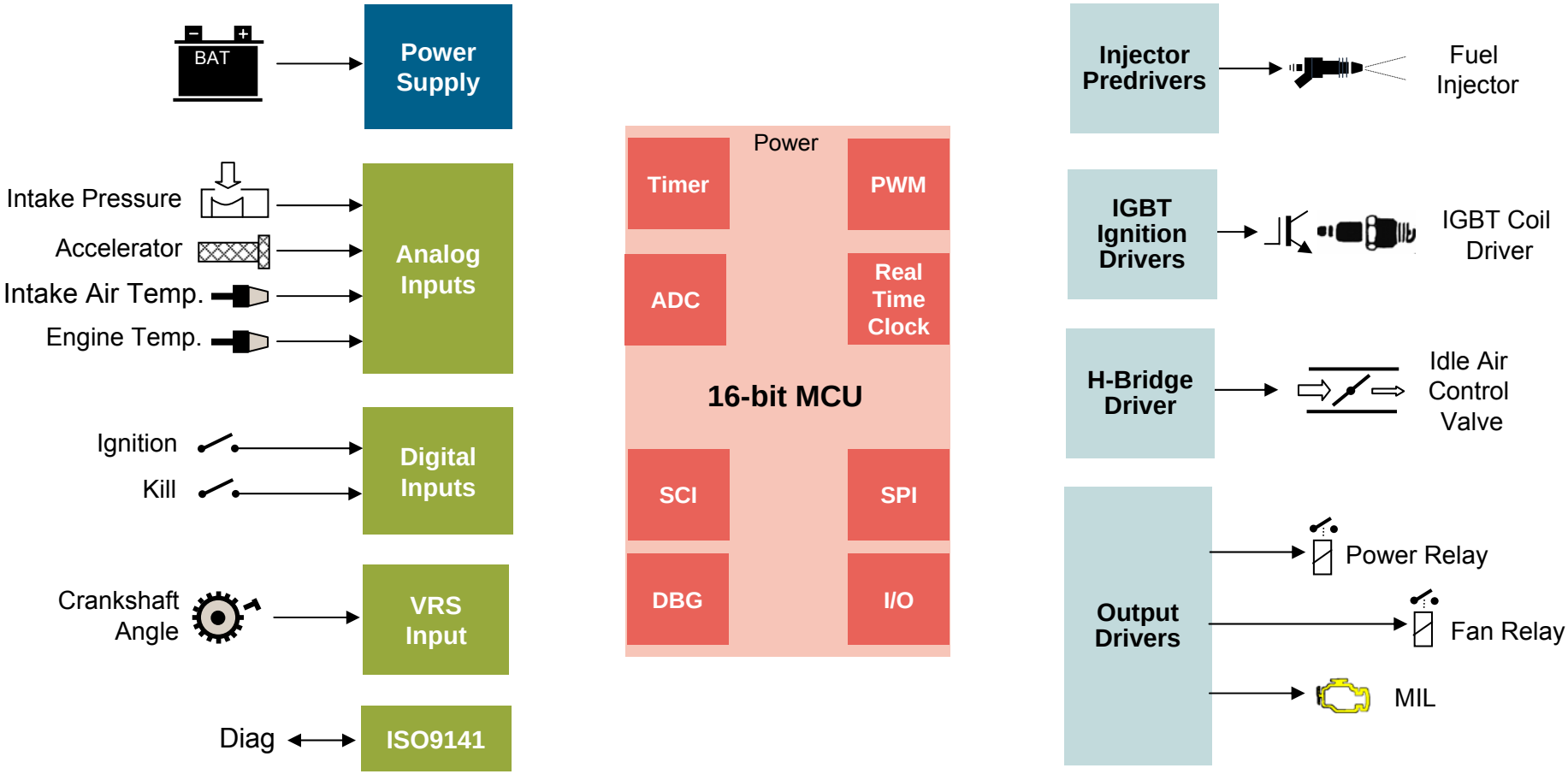
Typical 1-cylinder Motorcyle Engine Application



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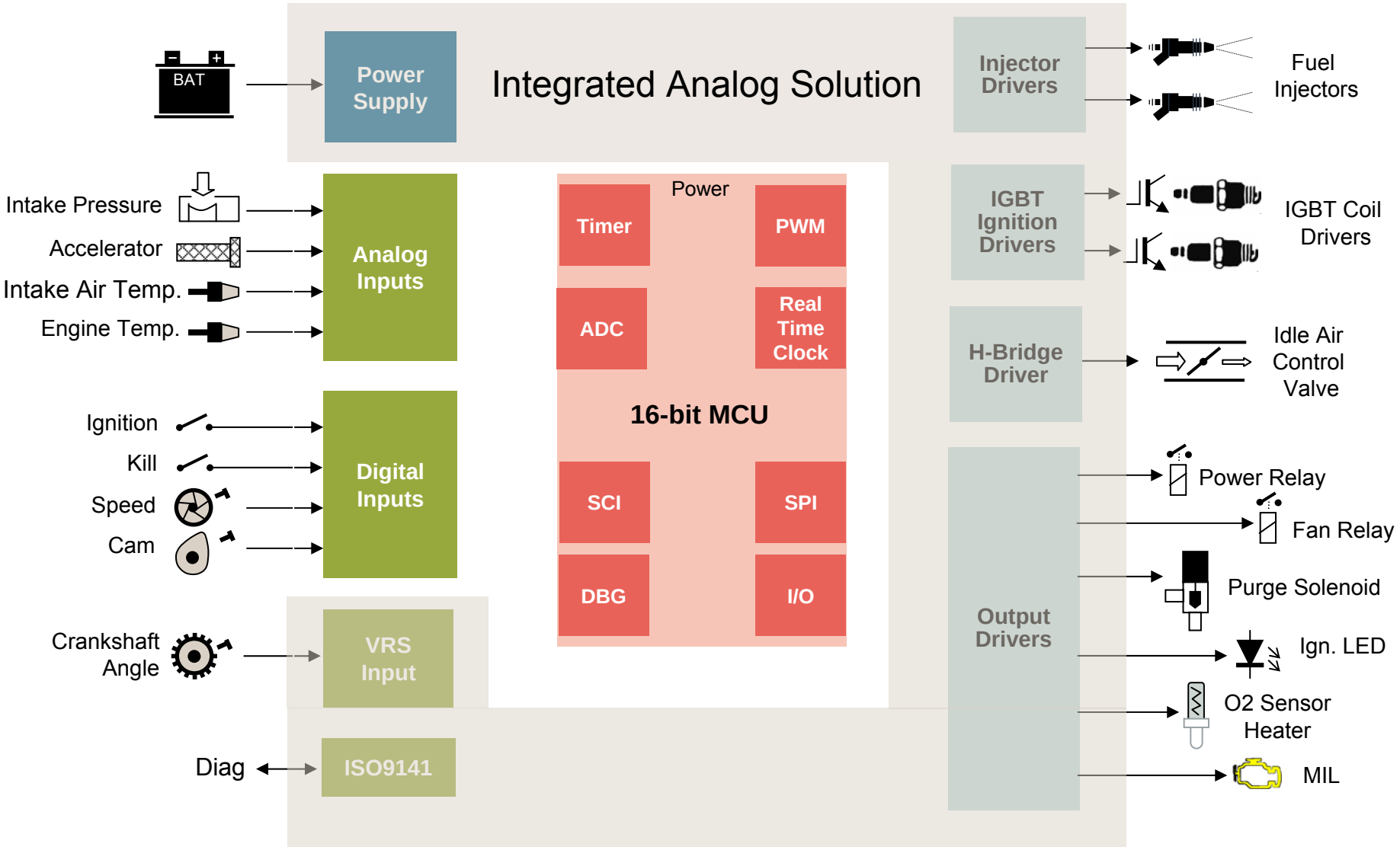
Typical 2-cylinder Motorcyle Engine Application



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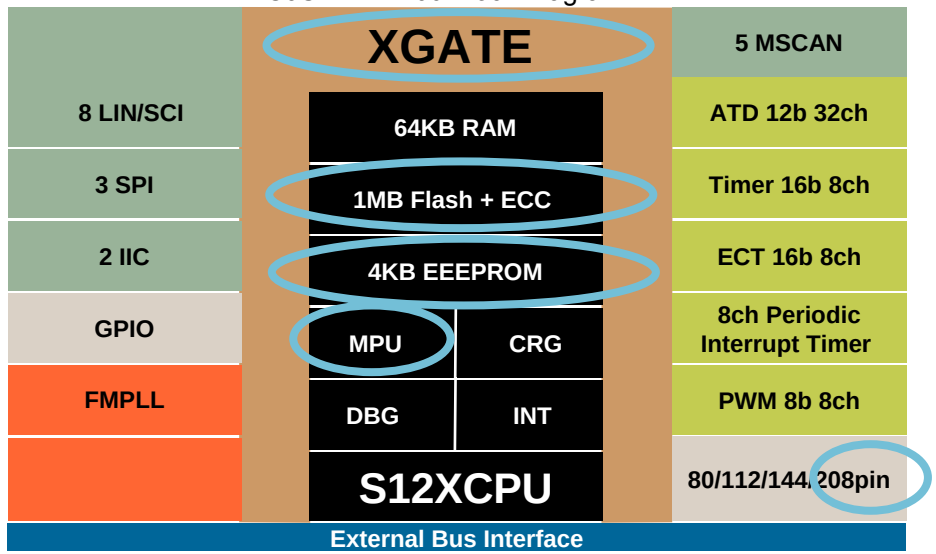
S12XE Family

Introducing S12XE Family

- Next generation of S12XD-Family
- Higher system integrity
- Higher memory sizes & new package options
- Higher performance / functionality
  - Max speed 50MHz,
  - 12bit ATD, More peripherals, More I/Os
- Enhanced XGate allows one level of interruptability
- New Emulated EEPROM

- Applications:
- Central body + some chassis & low-end Powertrain

MC9S12XEP100 Block Diagram



Device	Flash	ROM	RAM	EE	XGATE	MPU	EBI	CAN	SCI (LIN)	SPI	IIC	ECT	TIM	PIT	PWM	ATD	Max Speed (MHz)	Package
9S12XEP100	1Mb		64	4	1	1	y	5	8	3	2	16b8ch	16b8ch	8ch	8b8c	32	50	112 LQFP 144QFP 208PBGA
9S12XEP768	768		48	4	1	1	y	5	8	3	2	16b8ch	16b8ch	8ch	8b8c	32	50	112 LQFP 144QFP 208PBGA
9S12XEQ512	512		32	4	1	1	y	4	6	3	2	16b8ch	-	4ch	8b8c	24	50	112 LQFP 144QFP 208PBGA
9S12XEQ384	384		20	4	1	1	y	4	4	3	1	16b8ch	-	4ch	8b8c	24	50	80QFP 112LQFP 144LQFP
9S12XET256	256		16	4	1	1	y	3	4	3	1	16b8ch	-	4ch	8b8c	24	50	80QFP 112LQFP 144LQFP
9S12XEG128	128		12	2	1	1	y	2	2	2	1	16b8ch	-	2ch	8b8c	16	50	80QFP 112LQFP

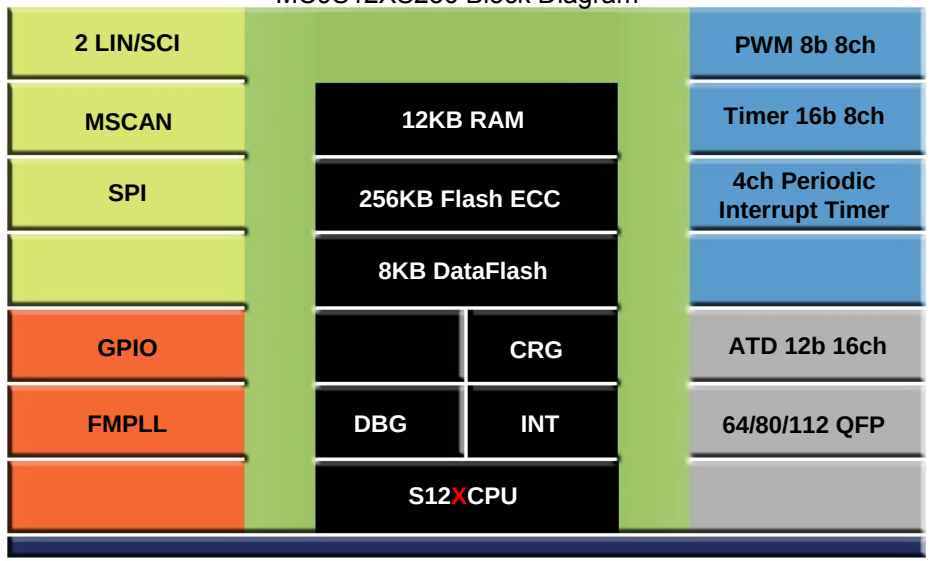
S12XS Family

Introducing S12XS Family

- Cost reduced version of S12XE
- Removed XGATE, MPU
- Slimmed down peripheral set
- Available down to 64QFP
- Pin for Pin compatible with S12XE family in 80pin/112pin package

- Applications:
- Single CAN central body, some chassis, Safety, Low end Powertrain

MC9S12XS256 Block Diagram



Device	Flash	ROM	RAM	EE	XGATE	MPU	EBI	CAN	SCI (LIN)	SPI	IIC	ECT	TIM	PIT	PWM	ATD	Max Speed (MHz)	Package
9S12XS256	256		12	8k DataFlash				1	2	1			16b8ch	4ch	8b8c	16	40	80QFP 112LQFP
3S12XS256		256	12	-				1	2	1			16b8ch	4ch	8b8c	16	40	80QFP 112LQFP
9S12XS128	128		8	8k DataFlash				1	2	1			16b8ch	4ch	8b8c	16	40	64LQFP 80QFP 112LQFP
3S12XS128		128	8	-				1	2	1			16b8ch	4ch	8b8c	8	40	64LQFP 80QFP
9S12XS64	64		4	4k DataFlash				1	2	1			16b8ch	4ch	8b8c	16	40	64LQFP 80QFP 112LQFP
3S12XS64		64	4	-				1	2	1			16b8ch	4ch	8b8c	8	40	64LQFP 80QFP

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Design Innovation.

Sea Breeze

New Analog Product for Small Engine Control

Ralph Ferrara

Product Definition Engineer

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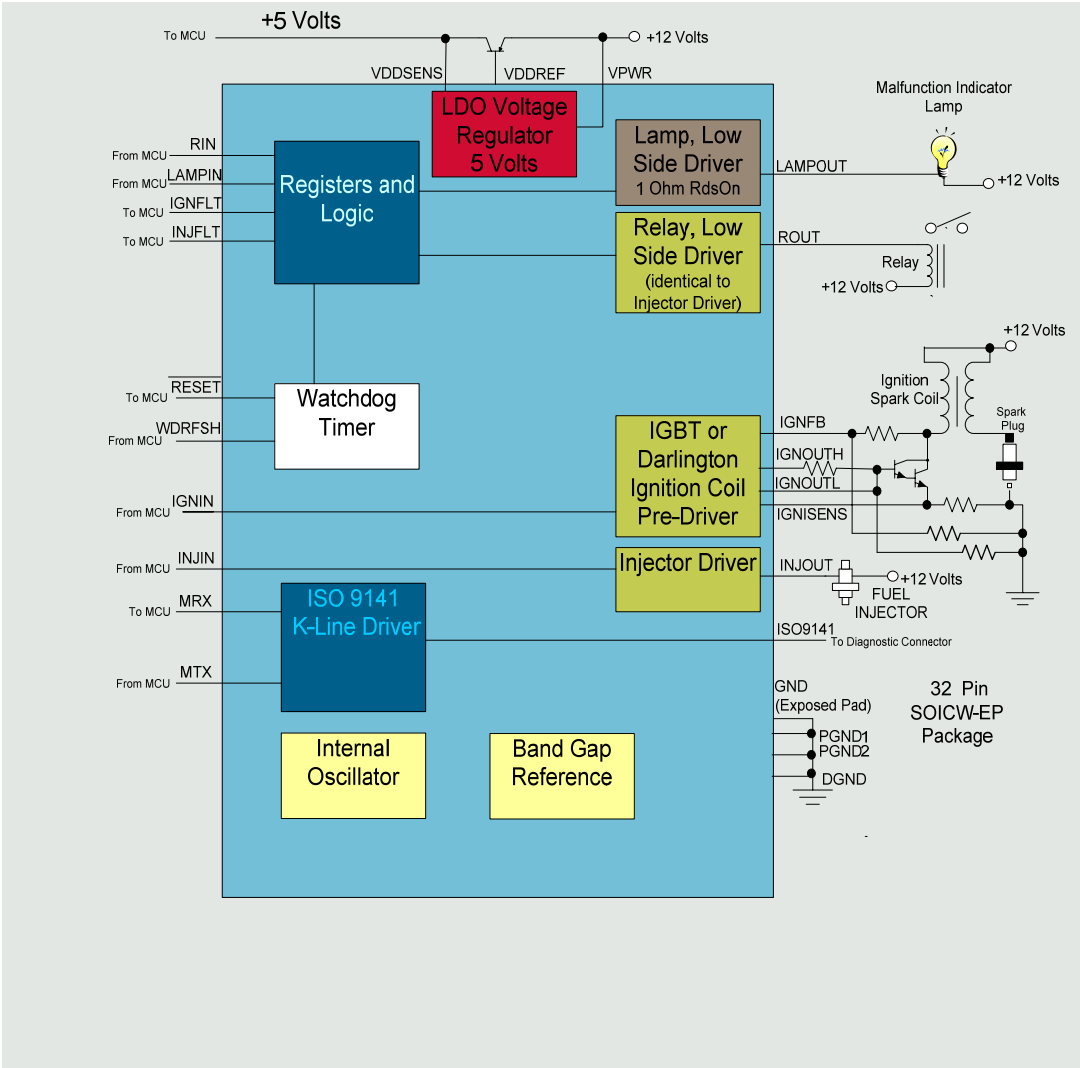
Small Engine Analog Circuit Road Map

- MCZ33812 – Due to be sampled 4th Quarter 2008
  - ASSP targeted at single cylinder fuel injected gas engines
  - Reduces number of discretes in the Engine Control Unit (ECU)
  - Allows reduction of size and cost of ECU PC Board
  - Increases reliability by reducing complexity.
  - First part in a family of circuits targeted at small engine control
  - Provides drivers for injector, relay, lamp, pre-driver for ignition,
  - Contains programmable watchdog, power supply, ISO9141
- MCZ33813 – In planning
  - Add-on to MCZ33812 to further reduce number of discretes
  - Can be used alone or with MCZ33812 for 1 and/or 2 cylinder applications.
  - Includes most needed functions for small engine control
  - Provides dual H-Bridge, drivers for relays or injector, pre-drivers for HEGO and ignition, and VRS conditioning for crankshaft sensor.

MCZ33812 - 1 or 2 Cylinder



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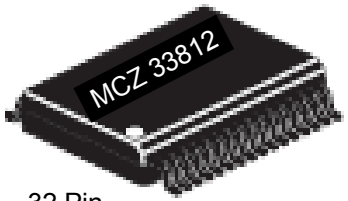
MCZ33812 – 1 or 2 Cylinder, 2 Chip Solution

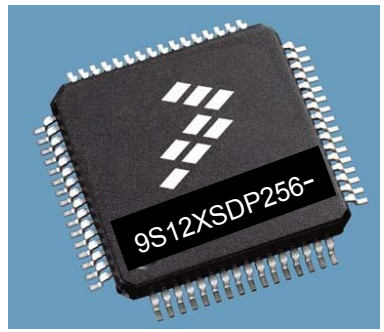
MCZ33812



32 Pin
Package

+

MCU



64 Pin
Package

- 1 Cylinder solution
- Replaces many discrete components
- Reduces PC Board area
- Lowers System Cost

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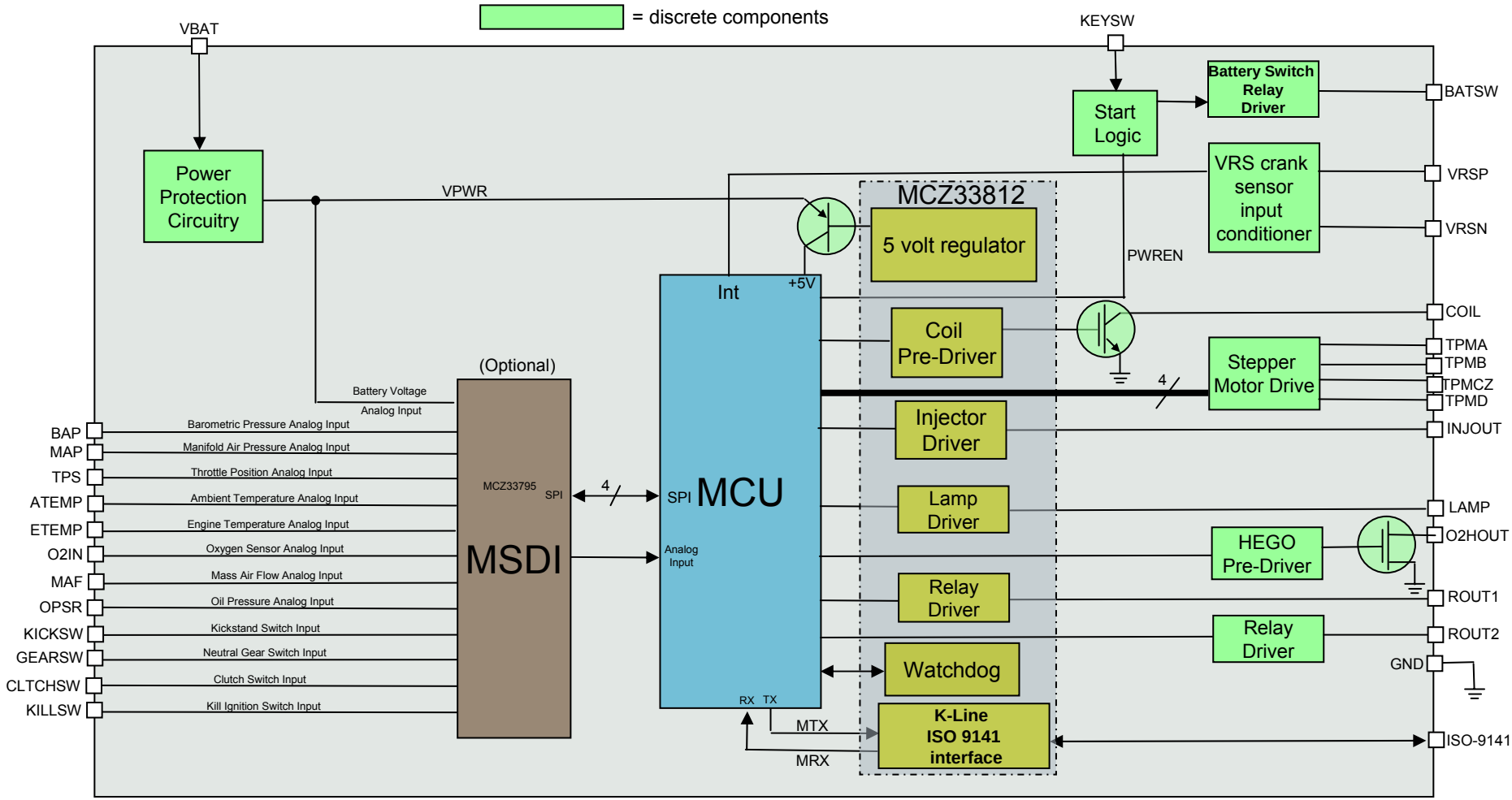
1 Cylinder ECU Using MCZ33812



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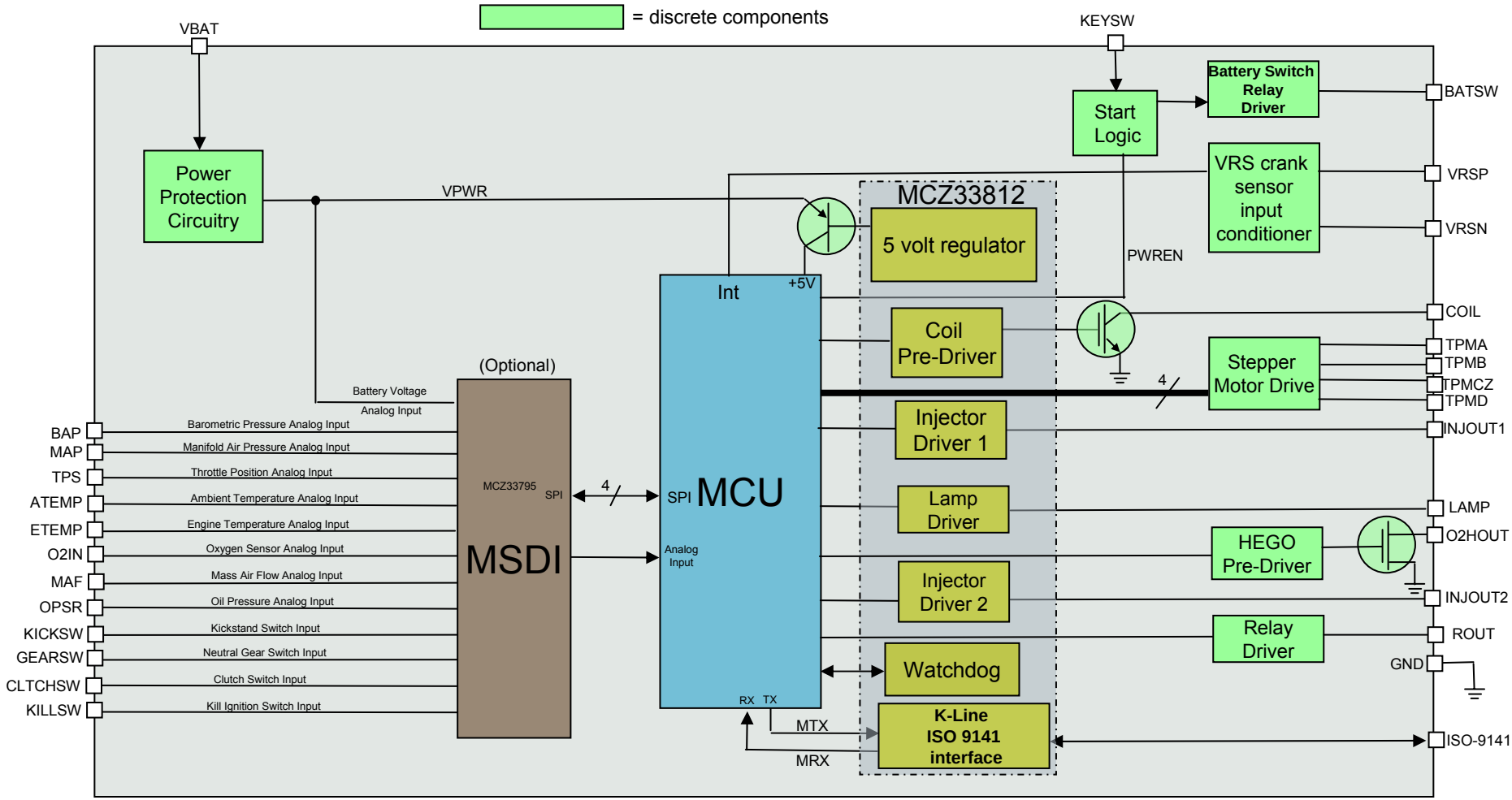
2 Cylinder ECU Using MCZ33812

Note: Both cylinders share 1 coil driver



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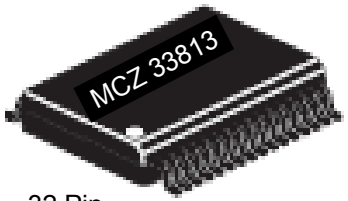
MCZ33813: Alternate 1 Cylinder, 2 Chip Solution

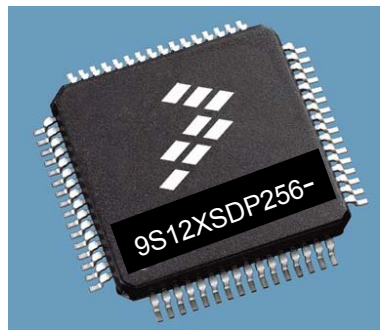
MCZ33813



32 Pin
Package

+

MCU



64 Pin
Package

- 1 Cylinder solution
- Replaces many discrete components
- Reduces PC Board area
- Lowers System Cost

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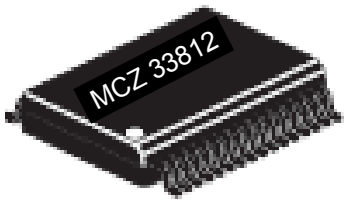
MCZ33812 and MCZ33813: 1 or 2 Cylinder, 3 Chip Solution

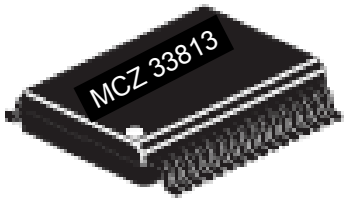
MCZ33812



32 Pin
Package

+

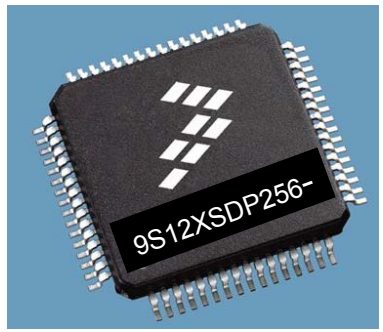
MCZ33813



32 Pin
Package

+

MCU



64 Pin
Package

- 1 or 2 Cylinder solution
- Less PC Board area
- Lowers System Cost
- Flexible solution
- Replaces more discrete components

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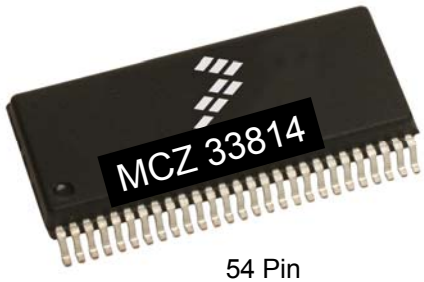
MCZ33814: (Proposed) 2 Chip, 2 Cylinder Solution

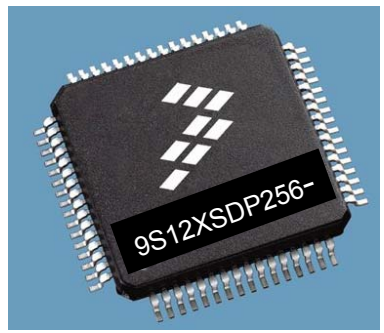
MCZ33814



54 Pin
SOICW EP
Package

+

MCU



64 Pin
Package

- High End 2 Cylinder solution
- Replaces many discrete components
- Reduces PC Board area
- Lowers System Cost

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Design Innovation.

Seabreeze Emulator Demo
Engine Control Application Hardware Overview

Jesse Beeker

Senior Field Application Engineer

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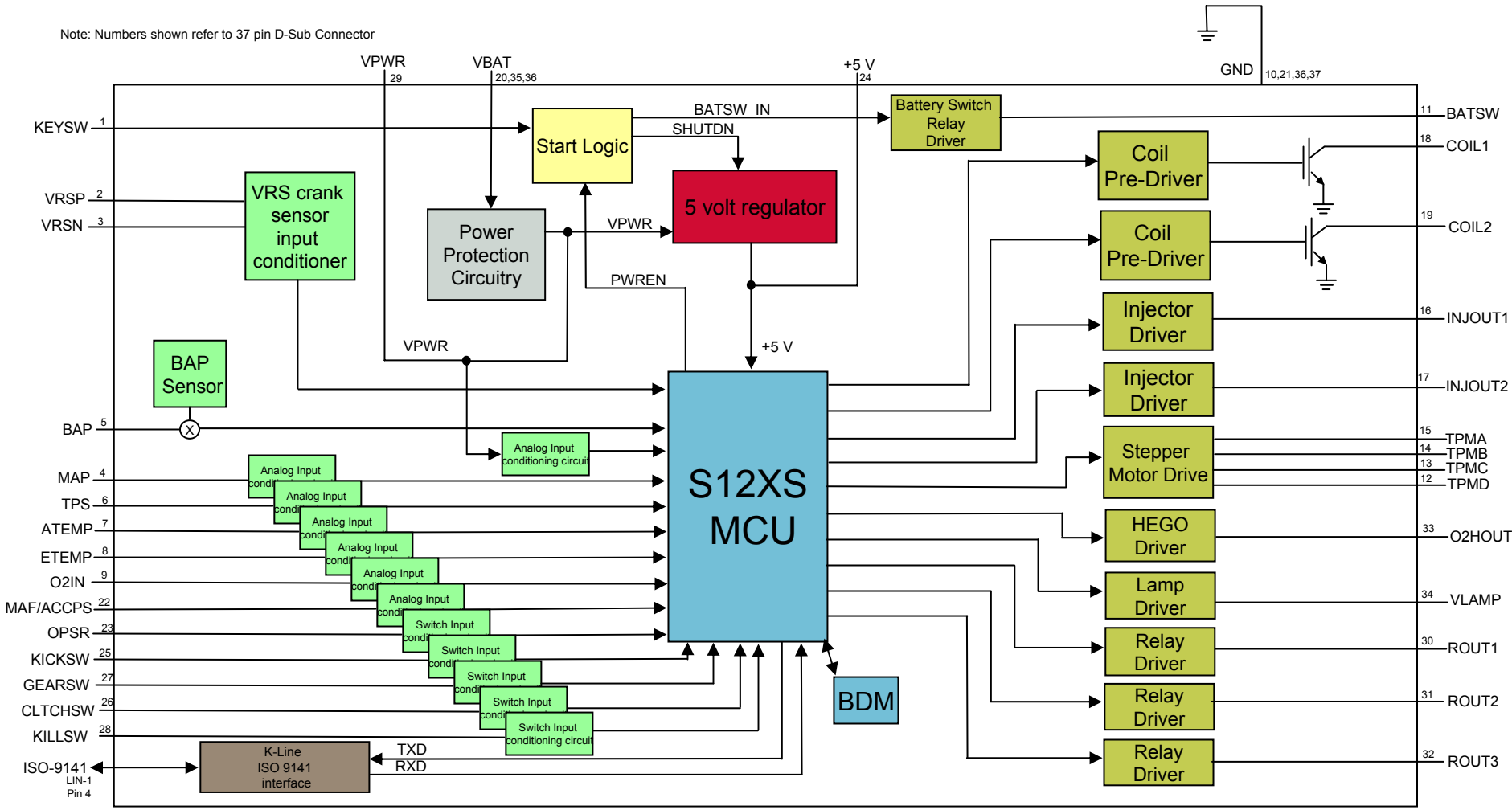
Sea Breeze Emulator Description

- **To assist customers in developing small engine ECUs:**
  - Emulator board provides a way to evaluate the Sea Breeze products prior to actual silicon being available
  - Contains an S12XS MCU plus all of the functionality of the high end Sea Breeze product.
  - Drives 2 Injectors, 2 Spark Coils, Throttle Stepper Motor, 3 Relays, 1 Lamp, 1 HEGO, etc.
  - Provides a +5 Volt Regulator, with start logic
  - Conditions Crankshaft VRS sensor, 8 Analog Inputs and 5 Switches.
  - Contains ISO 9141 K-Line interface for Diagnostics.
  - Communicates with MCU via parallel and SPI interface.
  - Comes with example software and documentation to run an actual engine
  - Allows customer to develop calibration tables and other software using device drivers provided.

Sea Breeze Emulator Block Diagram



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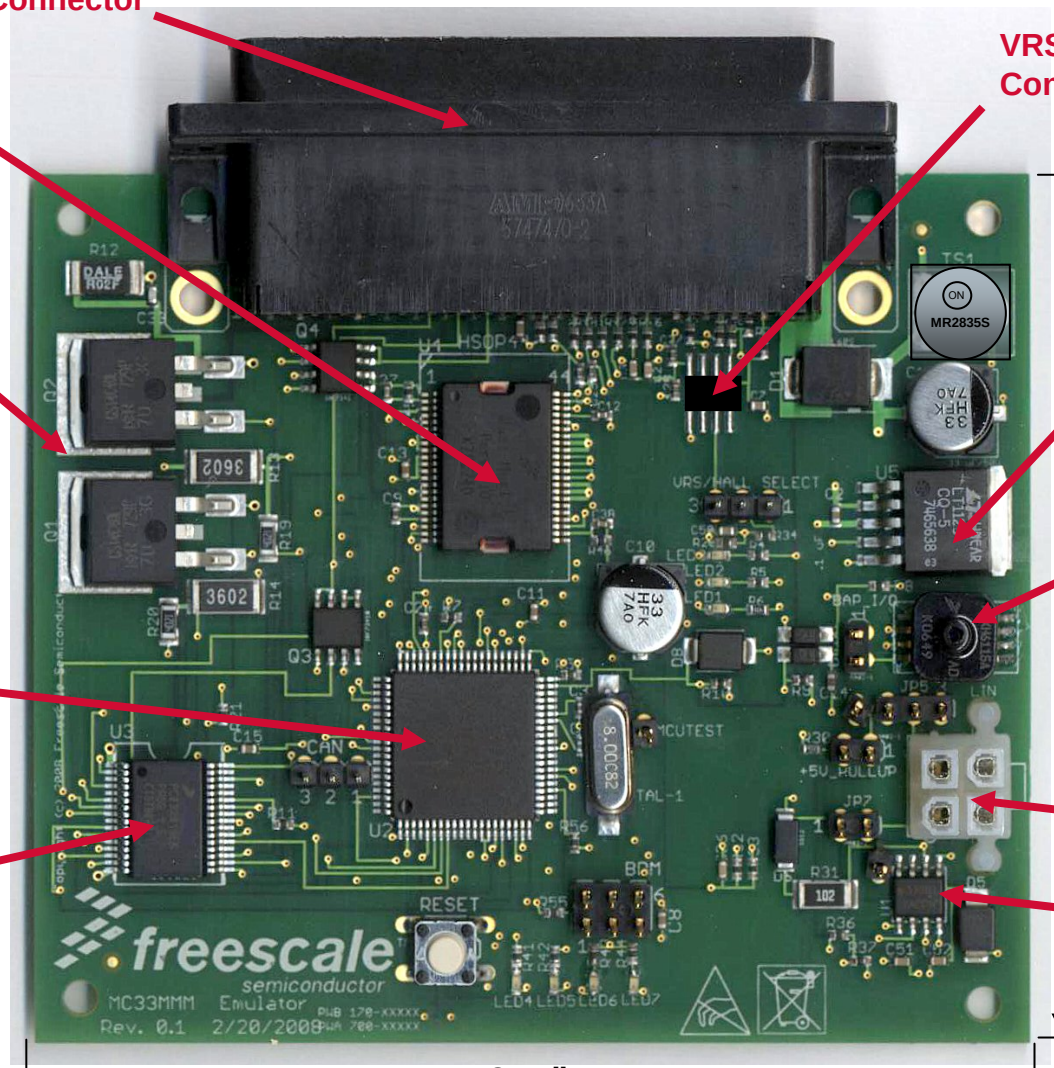
MCZ33812,13,14 Emulator PC Board Picture



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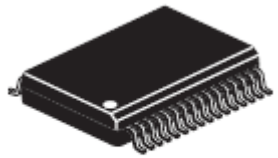
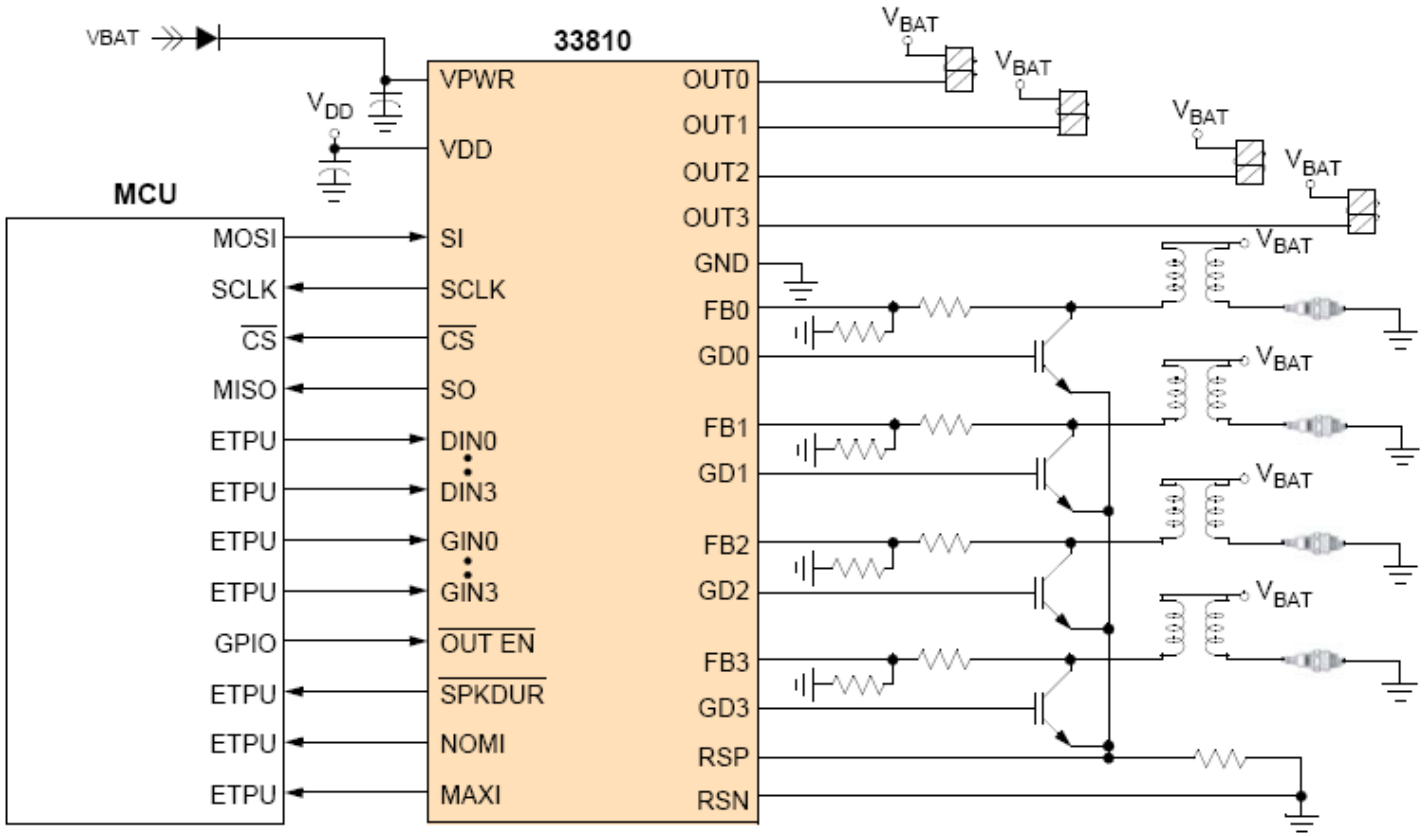
MC33810 – Automotive Engine IC

- **Features:**
  - Designed to operate over the range of 4.5V ≤ VPWR ≤ 36V
  - Quad ignition IGBT or MOSFET gate pre-driver with Parallel/SPI and/or PWM control
  - Quad injector driver with Parallel/SPI control
  - Interfaces directly to MCU using 3.3V / 5.0V SPI protocol
  - Injector driver current limit - 4.5A max.
  - Independent fault protection and diagnostics
  - VPWR standby current 10µA max.
  - Pb-free packaging designated by suffix code EK



EK SUFFIX (Pb-FREE)
98ARL10543D
32 PIN SOICW EP

MC33810 Simplified Application Diagram



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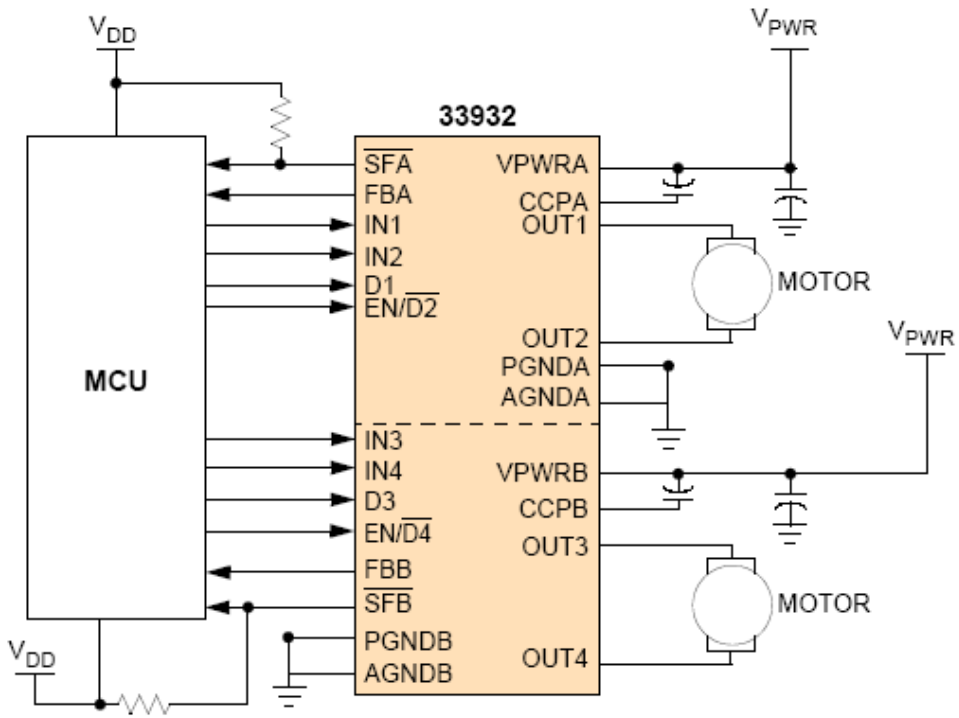
MC33932 - 5.0 A Throttle Control H-Bridge

Features:

- 8.0V to 28V continuous operation (transient operation from 5.0V to 40V)
- 225mΩ maximum RDS(ON) @ 150°C (each H-Bridge MOSFET)
- 3.0V and 5.0V TTL / CMOS logic compatible inputs
- Over-current limiting (regulation) via internal constant-off-time PWM
- Output short-circuit protection (short to VPWR or GND)
- Temperature-dependant current-limit threshold reduction
- All inputs have an internal source/sink to define the default (floating input) states
- Sleep Mode with current draw < 50µA (each half with inputs floating or set to match default logic states)

VW SUFFIX (PB-FREE)
98ARH98330A
44-PIN HSOP
WITH PROTRUDING HEAT SINK

MC33932 – Simplified Application Diagram



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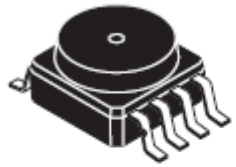
MPXHZ6115A – BAP Sensors

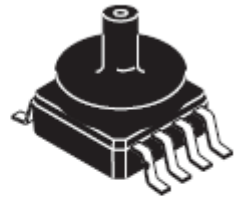
Features:

- Resistant to High Humidity and Common Automotive Media
- Improved Accuracy at High Temperature
- 1.5% Maximum Error over 0° to 85°C
- Ideally suited for Microprocessor or Microcontroller-Based Systems
- Temperature Compensated from -40° to +125°C
- Durable Thermoplastic (PPS) Surface Mount Package

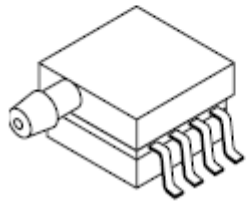
SMALL OUTLINE PACKAGE



MPXAZ6115A6U
CASE 482-01



MPXAZ6115AC6U
CASE 482A-01

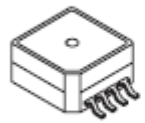


MPXAZ6115AP
CASE 1369-01

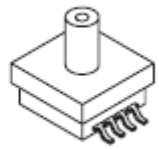
Typical Applications

- Aviation Altimeters
- Industrial Controls
- Engine Control/Manifold Absolute Pressure (MAP)
- Weather Station and Weather Reporting Devices

SUPER SMALL OUTLINE PACKAGE



MPXHZ6115A6U
CASE 1317-04



MPXHZ6115AC6U
CASE 1317A-03

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Emulator Inputs and Outputs
Can be used for 1 or 2 Cylinder MCZ33812,13,14 Emulation

Pin#	Name	MCU Name(PIN)	Voltage	I/O or Supply	Comment
1	KEYSW	KEYSW_F (39)	0 to VBAT	INPUT	Level Shifted and filtered KEYSW_F
2	VRSP	VRSOUT (13/14)	mV to 200V	INPUT	Conditioned to become CONDITIONED_VRS the selected VRSOUT
3	VRSN	VRSOUT (13/14)	mV to 200V	INPUT	Conditioned to become CONDITIONED_VRS the selected VRSOUT
4	MAP	MAP_F (54)	0 to 5 V	ANALOG INPUT	Manifold Air Pressure Sensor Input Level Shifted and filtered MAP_F
5	BAP	BAP_F (58)	0 to 5 V	ANALOG INPUT	Barometric Air Pressure Sensor Input Level Shifted and filtered BAP_F
6	TPS	TPS_F (52)	0 to 5 V	ANALOG INPUT	Throttle Plate Position Sensor Input Level Shifted and filtered TPS_F
7	ATEMP	ATEMP_F (56)	0 to 5 V	ANALOG INPUT	Ambient Temperature Sensor Input Level Shifted and filtered ATEMP_F
8	ETEMP	ETEMP_F (53)	0 to 5 V	ANALOG INPUT	Engine Coolant Temperature Sensor Input Level Shifted and filtered ETEMP_F
9	O2IN	O2IN_F(55)	0 to 5 V	ANALOG INPUT	Exhaust Gas Oxygen Sensor Input Level Shifted and filtered O2IN_F
10	GND	10, 28, 32, 50, 61,62, 67, 76	0	SUPPLY	Ground
11	BATSW	BATSWIN (48)	0 to VBAT	OUTPUT	Power Relay Output Driver controlled by MCU output BATSWIN
12	TPMD	H2INB (65)	0 to VBAT	OUTPUT	Throttle Position Motor "D" winding driver controlled by MCU output H2INB
13	TPMCZ	H2INA (66)	0 to VBAT	OUTPUT	Throttle Position Motor "C" winding driver controlled by MCU output H2INA
14	TPMB	H1INB (47)	0 to VBAT	OUTPUT	Throttle Position Motor "B" winding driver controlled by MCU output H1INB
15	TPMA	H1INA (46)	0 to VBAT	OUTPUT	Throttle Position Motor "A" winding driver controlled by MCU output H1INA
16	INJOUT1	INJIN1 (5)	0 to VBAT	OUTPUT	Fuel Injector Solenoid 1 driver controlled by MCU output INJIN1

Emulator Inputs and Outputs (con't)

PIN#	NAME	MCU Name (PIN)	VOLTAGE	I/O or SUPPLY	COMMENT
17	INJOUT2	INJIN2 (6)	0 to VBAT	OUTPUT	Fuel Injector Solenoid 2 driver controlled by MCU output INJIN2
18	COIL1	IGNIN1 (7)	0 to VBAT	OUTPUT	Ignition Spark Coil 1 driver controlled by MCU output IGNIN1
19	COIL2	IGNIN2 (8)	0 to VBAT	OUTPUT	Ignition Spark Coil 2 driver controlled by MCU output IGNIN2
20	VBAT	N/A	VBAT	SUPPLY	Battery Voltage
21	GND	10, 28, 32, 50, 61,62, 67, 76	0	SUPPLY	Ground
22	MAF/ACCPS	MAF_F (57)	0 to 5 V	ANALOG IN	Mass Air Flow Sensor OR Accelerator Position Sensor Input Level Shifted and filtered MAF_F
23	OPSR	OPSR_F (16)	0 to VBAT	INPUT	Oil Pressure Sensor Input Level Shifted and filtered OPSR_F
24	+5V	29, 31, 77	+5V	SUPPLY	+5 Volt supply output provided to analog sensors
25	KICKSW	KICKSW_F (80)	0 to VBAT	INPUT	Kickstand Switch Input Level Shifted and filtered KICKSW_F
26	CLTCHSW	CLTCHSW_F (79)	0 to VBAT	INPUT	Clutch Engaged Switch Input Level Shifted and filtered CLTCHSW_F
27	NGEARSW	NGEARSW_F (78)	0 to VBAT	INPUT	Neutral Gear Switch Input Level Shifted and filtered NGEARSW_F
28	KILLSW	KILLSW_F (69)	0 to VBAT	INPUT	Ignition Kill Switch Input Level Shifted and filtered KILLSW_F
29	VPWR	VPWR_F (51)	VBAT - .7	SUPPLY	VPWR supply Output Also VPWR Measurement Input Shifted and filtered VPWR_F
30	ROUT1	RIN1 (25)	0 to VBAT	OUTPUT	Relay 1 Output Driver from MCU output RIN1
31	ROUT2	RIN2 (1)	0 to VBAT	OUTPUT	Relay 2 Output Driver from MCU output RIN2
32	ROUT3	RIN3 (2)	0 to VBAT	OUTPUT	Relay 3 Output Driver from MCU output RIN3
33	O2HOUT	O2HIN (41)	0 to VBAT	OUTPUT	Oxygen Sensor Heater Output Driver controlled by MCU output O2HIN
34	VLAMP	VLAMPIN (26)	0 to VBAT	OUTPUT	LAMP Output Driver from MCU output VLAMPIN
35	VBAT	N/A	VBAT	SUPPLY	Battery Voltage
36	VBAT	N/A	VBAT	SUPPLY	Battery Voltage
37	GND	10, 28, 32, 50, 61,62, 67, 76	0	SUPPLY	Ground

Freescale Technology Forum

Design Innovation.

Seabreeze Emulator Demo
Engine Control Application Software Overview

Jesse Beeker

Senior Field Application Engineer

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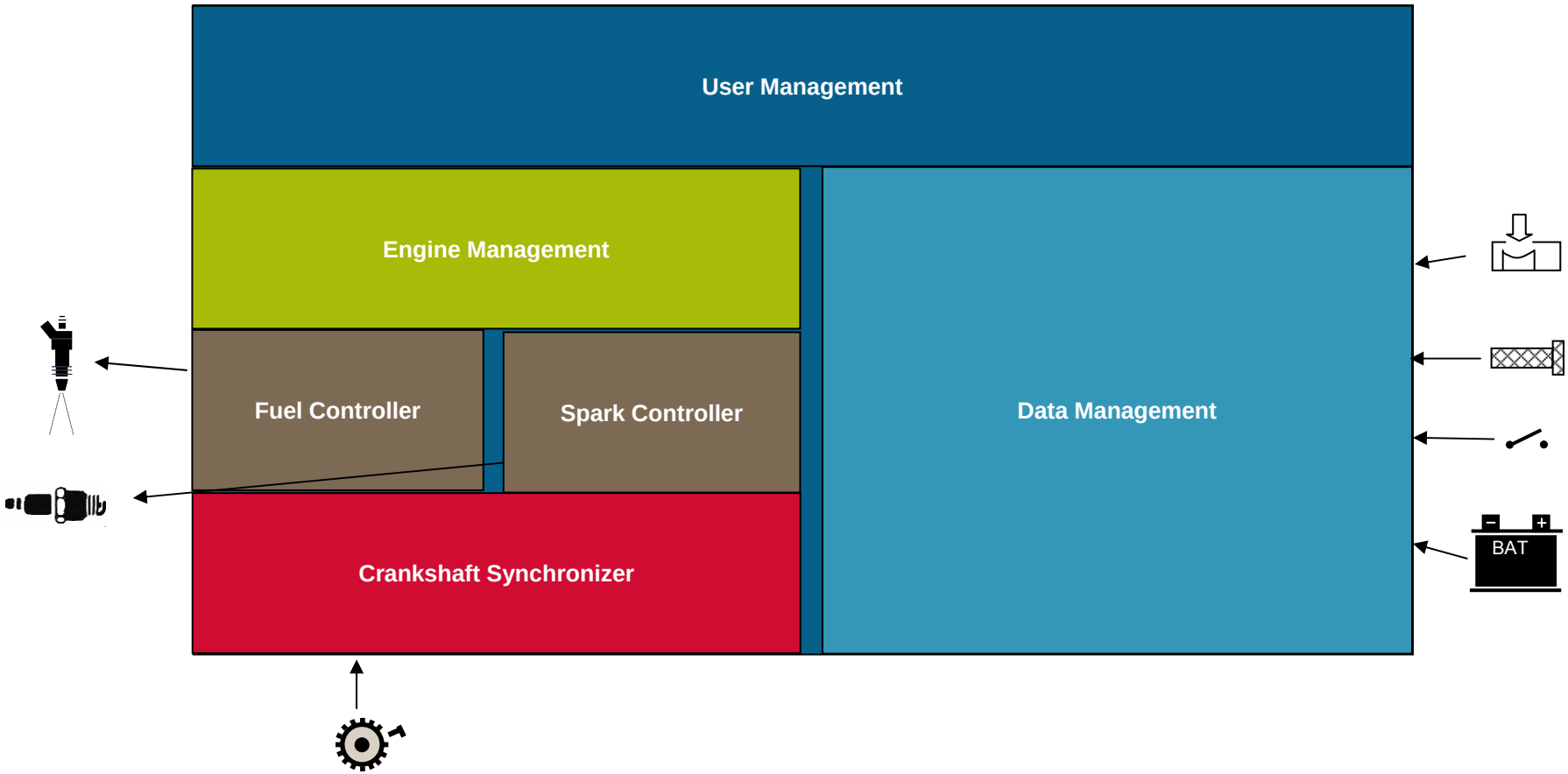
Engine Application Software Layers



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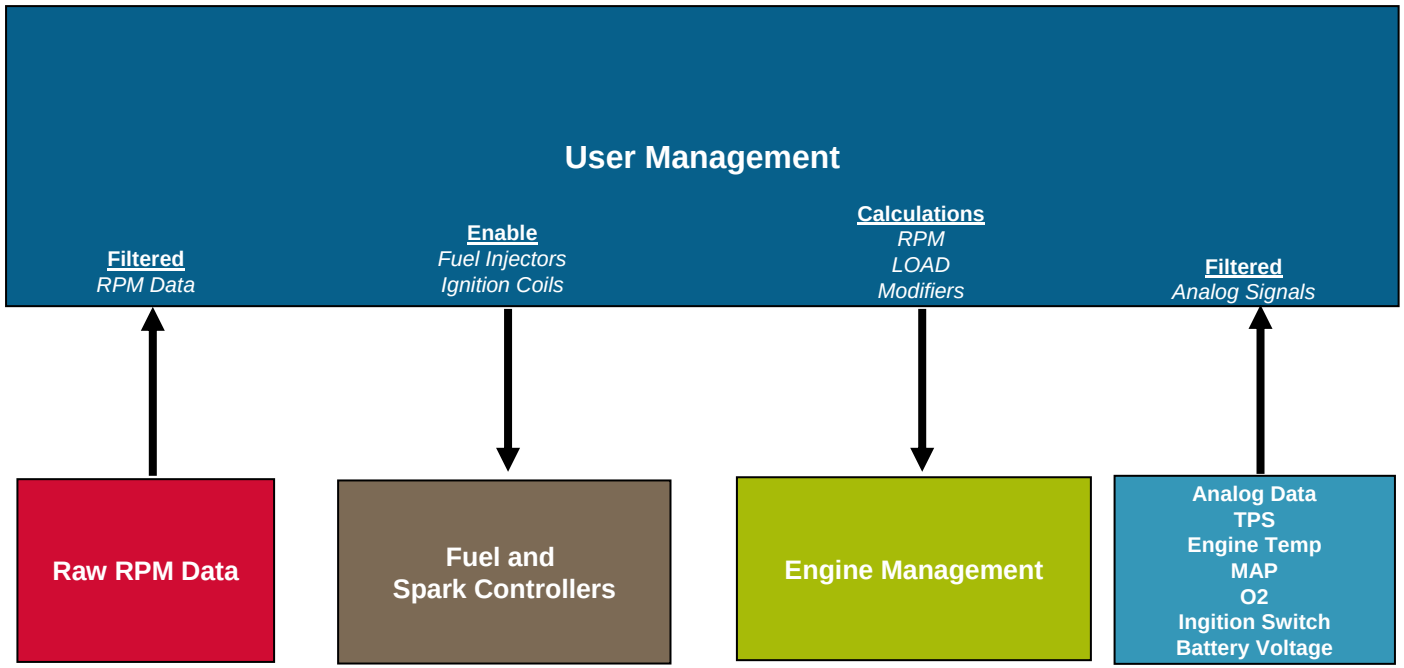
User Management

- Main system control for the engine
- Process engine operation data
- Determine system level control of the engine
  - Engine state
  - Load value
  - RPM value
  - Engine control modifier values
  - Operational Safety

User Management



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Data Management

- Periodically collect signal input data to the module
- Variable rates of data collection for each signal based on response time
- Fill data buffers with raw data
- Filter data as buffers are filled

Data Management

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Engine Management

- Use RPM and LOAD values to determine base spark and fuel values via table look up
- Calculate final values of fuel and spark based on system adders adjusted by User Management
- Modify Next fuel and spark event values

Engine Management

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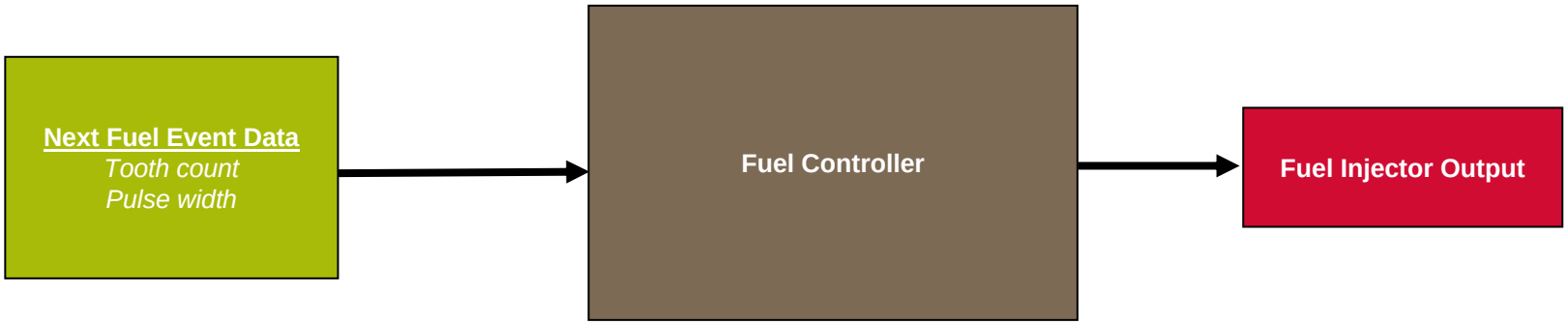
Fuel Controller

- Schedule fuel start event on the tooth before the start of the event
- Schedule end of fuel event after the fuel event has started
- Update values for the next fuel event

Fuel Controller



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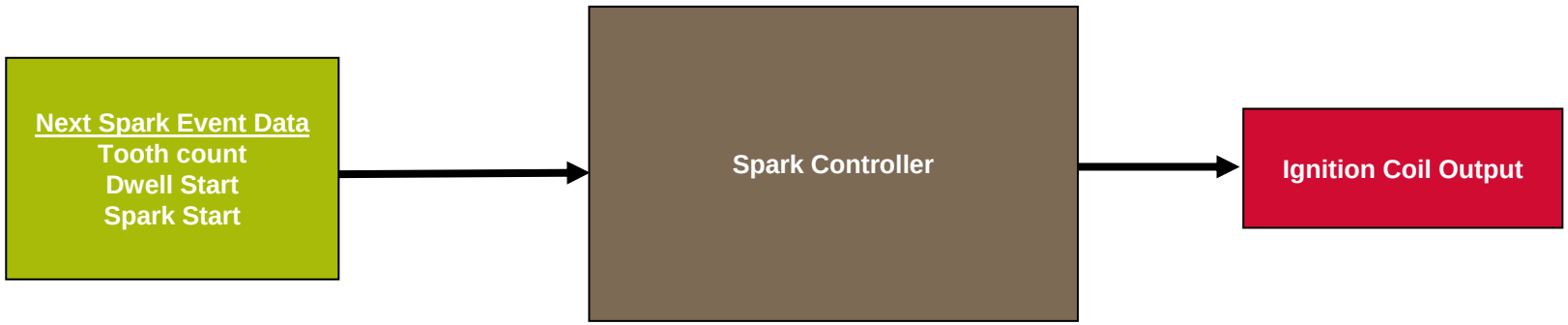
Spark Controller

- Schedule spark dwell start event on the tooth before the start of the event
- Schedule spark event after the dwell event has started
- Update values for the next spark event

Spark Controller



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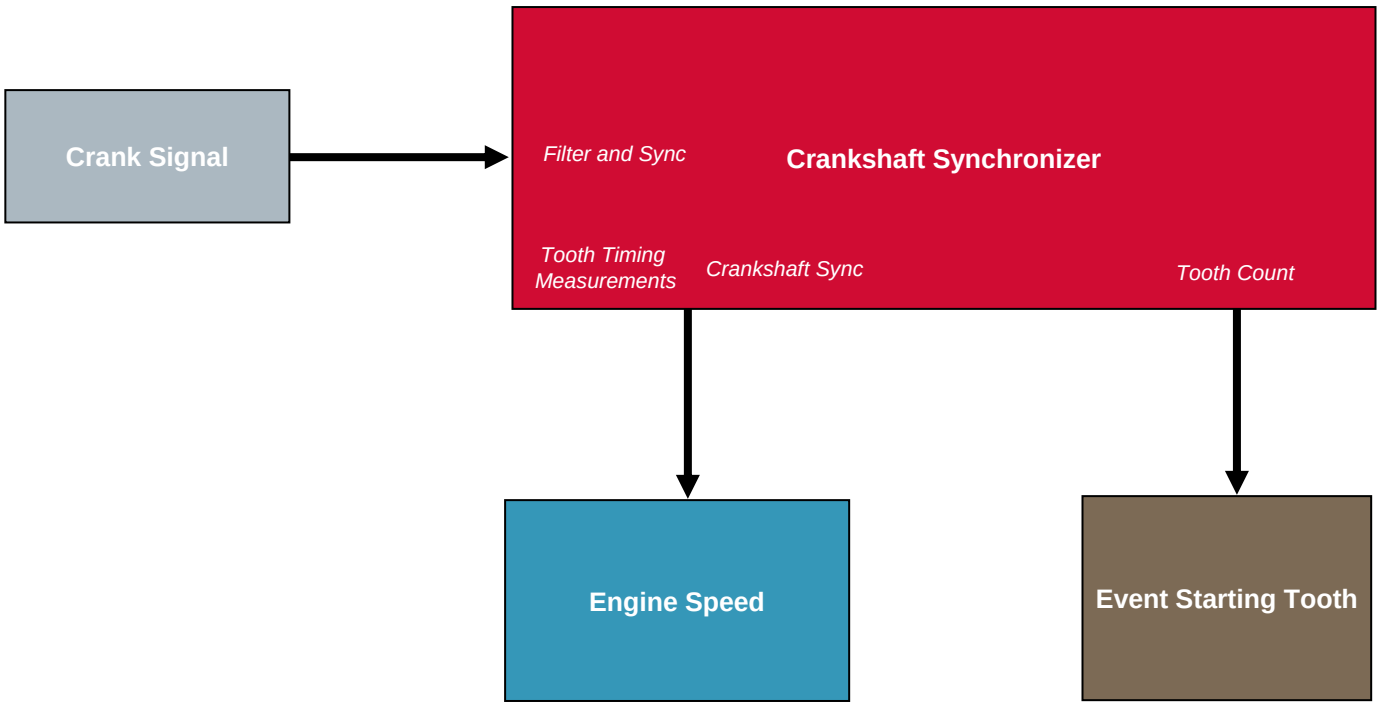
Crankshaft Synchronizer

- Respond to crankshaft toothed-wheel edges
- Filter tooth data based on system parameters
- Synchronize to the toothed-wheel
- Feed the fuel and spark controller when an event tooth is reached
- Record tooth data for RPM

Crankshaft Synchronizer



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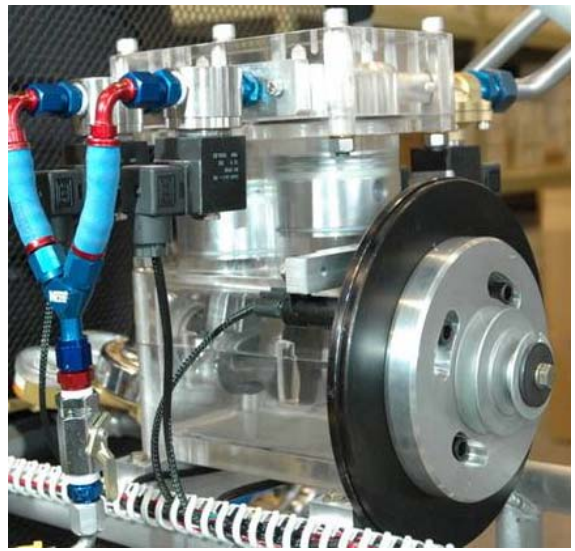
Motorcycle Demo Overview

- **Proposal:**
  - RefDes EVB operating air engine (for indoor demo)
  - RefDes installed on operating small motorcycle (Yamaha C3 50cc) *cannot be run indoors, scooter as display only.*
- **Purpose:**
  - Demonstrate FSL product capability for engine control of small engines esp. motorbikes
  - Showcases solutions from MSG and AMPD
  - Demonstrate FSL expertise in emissions control
  - Highlights available low level software drivers and complete FSL solution.

http://youtube.com/watch?v=taeVNc7-RaU



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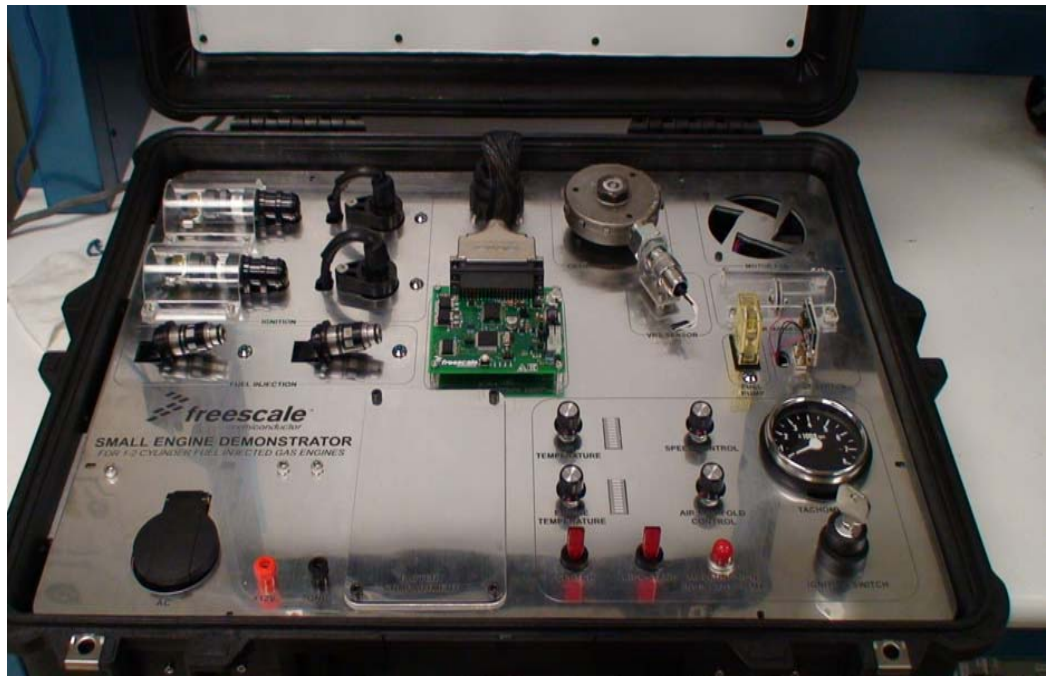
Motorcycle Chipset Suitcase Demo

- **Proposal:**
  - RefDes installed in a suitcase with Sea breeze emulator board and real injector, ignition loads.
- **Purpose:**
  - Demonstrate Sea breeze emulator board functionality
  - Showcases solutions from MSG and AMPD
  - Demonstrate FSL expertise in emissions control
  - Highlights available low level software drivers and complete FSL solution.



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Related Session Resources

Session Location – Online Literature Library

http://www.freescale.com/webapp/sps/site/homepage.jsp?nodeId=052577903644CB

Sessions

Session ID	Title
PA108	Entry-Level Powertrain MCU Solutions
PA111	S08/S12/S12X: 8- and 16-bit Automotive Solutions

Demos

Pedestal ID	Demo Title
A3	Motorcycle EFI Solutions

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