Develop a **Motor Control** Application with Freescale MCUs

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Agenda

• Freescale Motor Control Processor Selection
• Kinetis V Family Quick Review
• DSC Family Update
• Carcassonne Family
Freescale Motor Control
Processor Selection
Sub Agenda

• Freescale Motor Control Processor Selection
  - How to Select Right Processor for Applications
  - Processor Positioning
Typical Control System for Motor Control Applications

Gate Driver with Isolation

Current Feedback

Speed/Position Feedback

PWM Generation

Control Algorithm

Feedback Processing

Controller

Motor

Speed/Torque Command
Processor Requirements for Motor Control Applications

- **ADC module**
  - We need to measure DC Bus voltage, Back-EMF voltage, phase currents, DC Bus current, heating temperature

- **PWM module**
  - We need to generate 1 up 8 PWM according to motor type

- **Timer/Quadrature decoder**
  - We need to measure speed and rotor position from different sensors (hall sensors, quadrature encoder, tacho generator, sin/cos interface, etc.)

- **User interface**
  - Communication interfaces, if required (SCI, SPI, CAN, I2C)
  - GPIO pins

- **Build-in analog devices**
  - We need to detect fault conditions (over-current, over-voltage)
  - Allows to eliminate external comparators
  - Build in DAC allows SW control of fault level
How to Select Right Processor

**Type of the Motor**

- Number of PWM channels
  - DC Motors 1 or 4 channels
  - BLDC motor, PMSM and ACIM: 6 channels
- Sine wave generation (PMSM, ACIM)
  - Complementary logic pair
  - Automatic dead time insertion
- Electronic commutation (BLDC motors, SR motors)
  - Mask, swap, restart PWM features
    These features enable commutation without change of duty cycle
- Fault control

**Sensor Interfaces**

- Speed/Position measurement
  - If quadrature encoder used, decoding of quadrature signals is necessary
- Current measurement
  - If there is current loop, a fast ADC (<2.5us) is advantage (the less time spent by ADC conversion, the more time for control loop calculation. Typically the current control loop is 50 – 150 us
  - If shunts used for current sensing the PWM to ADC synchronization necessary
Freescale Motor Control MCU Offerings

**S08P– 8-bit**
- **Positioning:** S08 Family – Entry Level Motor Control
- **Key Message:** 5V drive, Robust EMC/EMI, Low Cost
- **Example:** Sensored, Sensorless BLDC

**Kinetis Basic Motor Control**
- **Positioning:** General Purpose Motor Control
- **Key Message:** Fractional Arithmetic, Parallel Processing, Optimized cost and performance for advanced motor control
- **Example:** Sensored, Sensorless BLDC

**Freescale DSC**
- **Positioning:** Dedicated High Performance Motor Control
- **Key Message:** Fractional Arithmetic, Parallel Processing, Optimized cost and performance for advanced motor control
- **Example:** Sensorless Vector Control/FOC, High and Low Speed Optimizations

**Kinetis Advanced Motor Control**
- **Positioning:** Advanced motor control while multi-tasking on the most popular ecosystem in the world
- **Key Message:** MQX RTOS and motor control, Scalability for any application, DSP instructions, Floating Point, ARM ecosystem
- **Example:** Sensorless Vector Control/FOC

**PX Series**
- **Positioning:** Motor control for high end robotics or industrial machinery needing the highest level of quality, safety, and reliability
- **Key Message:** or highest memory needs. Typically replacing ASICs, FPGA, MPU, and other motor control implementations
  - Scalable: 512K – 4MB Flash, 144-489 pin packages
  - Performance: Multi-core and >600 DMIPS
- **Example:** Sensorless Vector Control/FOC
SR Motor Roadmap

motor control, PWM, ADC, timer, analog comparator

fast math, motor control, PWM, 2xADC, TMR+QDec, analog comparator

fast math, motor control PWM, 2xADC, timer, analog comparator

50MHz Kinetis

MC56F82xxx

MC56F800x

S08P

Hall Sensor

Encoder and Current Control

Sensor less

8-bit

Freescale DSC

Kinetis
BLDC Motor Roadmap

<table>
<thead>
<tr>
<th>Pricing</th>
<th>Hall Sensor</th>
<th>Sensorless Back-EMF</th>
<th>Variable DC-link 6-step Inverter</th>
</tr>
</thead>
<tbody>
<tr>
<td>$5</td>
<td>PX Series (multiple motors)</td>
<td>MCF5441x (MPU) - Vybird</td>
<td>MQX</td>
</tr>
<tr>
<td>$5</td>
<td>100MHz+ Kinetis K &amp; X (FPU)</td>
<td>MC56F84xx (dual motors)</td>
<td>MQX</td>
</tr>
<tr>
<td>$1</td>
<td>72MHz Kinetis K</td>
<td>MC56F84xx</td>
<td>MQX</td>
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<tr>
<td></td>
<td>MC56F82xx</td>
<td>50MHz Kinetis K</td>
<td>MQX</td>
</tr>
<tr>
<td></td>
<td>MC56F800x</td>
<td>S08P</td>
<td>8 bit, Freescale DSC, Kinetis, ColdFire MPU, PX Series</td>
</tr>
</tbody>
</table>

Motor Control: PWM, ADC, timer, analog comparator

Freescale DS-ColdFire MPUPX Series:
- PX Series (multiple motors)
- MCF5441x (MPU) - Vybrid
- 100MHz+ Kinetis K & X (FPU)
- MC56F84xx (dual motors)
- 72MHz Kinetis K
- MC56F84xx
- MC56F82xx
- 50MHz Kinetis K
- MC56F800x
- S08P

S08P: 8-bit
Freescale DSC
Kinetis
ColdFire MPU
PX Series
Three-Phase ACIM Roadmap

<table>
<thead>
<tr>
<th>Pricing</th>
<th>Motor Control</th>
<th>V/Hz (Scalar Control)</th>
<th>Tacho</th>
<th>Encoder</th>
<th>Sensorless</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1</td>
<td>S08MP</td>
<td>MC56F800x</td>
<td></td>
<td>MC56F84xx</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>50MHz Kinetis</td>
<td></td>
<td>Kinetis (72MHz-100MHz)</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>MC56F824x/5x</td>
<td></td>
<td>Kinetis (100MHz-150MHz w/FPU)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PX Series (multiple motors)</td>
<td></td>
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<tr>
<td>$5</td>
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<tr>
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<td>Kinetis</td>
<td></td>
<td></td>
<td>MC56F84xx (dual motor)</td>
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<td></td>
<td></td>
<td>PX Series (multiple motors)</td>
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</tr>
</tbody>
</table>

- Motor Control: PWM, slow ADC, Timer, analog comparator
- fast math, motor control, PWM, 2xADC, Timer, analog comparator
- fast math, motor control, PWM, 2xADC, TMR+QDec, analog comparator
- intensive DSP math for matrix calc, motor control, PWM, 2xADC, timer, analog comparator

- PX Series: multiple motors
- MQX: high performance

- S08MP: 8-bit
- Freescale DSC
- Kinetis
- ColdFire MPU
- PX Series
Motor Control MCUs of Freescale

ARM based
- Kinetis V (3.3 V)
- Kinetis E (5V)

Automotive
- MagniV-Carcassonne
- Qorivva
- DSC
- S08P
Kinetis V Family Quick Review
## Kinetis Key Pillars by Family

<table>
<thead>
<tr>
<th>L</th>
<th>E</th>
<th>K</th>
<th>X</th>
<th>W</th>
<th>M</th>
<th>V</th>
</tr>
</thead>
<tbody>
<tr>
<td>48MHz Cortex M0+</td>
<td>Up to 48MHz Cortex M0+</td>
<td>Up to 180MHz Cortex M4</td>
<td>Up to 400MHz Cortex M-next</td>
<td>Up to 50MHz Cortex M4, Cortex M0+</td>
<td>Up to 48MHz Cortex M0+</td>
<td>Up to 200MHz, Cortex M4, Cortex M0+</td>
</tr>
<tr>
<td>8KB to 512kB Flash</td>
<td>8KB to 128kB Flash</td>
<td>32KB to 2MB Flash</td>
<td>0KB to 16MB Flash</td>
<td>32KB to 512kB Flash</td>
<td>32KB to 128kB Flash</td>
<td>16KB to 2MB Flash</td>
</tr>
<tr>
<td>Up to 128KB RAM</td>
<td>Up to 16KB RAM</td>
<td>Up to 256KB RAM</td>
<td>Up to 512KB RAM</td>
<td>Up to 64KB RAM</td>
<td>Up to 32KB RAM</td>
<td>Up to 256KB RAM</td>
</tr>
<tr>
<td>Now!</td>
<td>Now!</td>
<td>Now!</td>
<td>Q2’14</td>
<td>Now!</td>
<td>Now!</td>
<td>Now!</td>
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</tbody>
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**Leading Performance – Low Power – Scalability – Industrial Grade reliability & temp**

**Freescale Bundled IDE, RTOS & Middleware – Rapid Prototyping Platform – Broad ARM Ecosystem Support**
Kinetis V Series Target Applications

**Motor Control**
- Sensored BLDC / PMSM
  - High Dynamic Control
- Sensored ACIM
- Sensorless VOC
  - PMSM/BLDC
  - High Dynamic Control
  - Low Dynamic Control
- Sensorless ACIM

**Digital Power Conversion**
- Solar Inverters
  - Grid-Tied
  - Non Grid Tied
- Power factor correction
- Switch Mode Power Supplies
  - AC/DC
  - DC/DC
- UPS
  - On-Line
  - Offline
- Inductive cooking
  - Multi cook plate
Kinetis V Series Product Roadmap

Motor & Power Control specific MCUs, Based on ARM® Cortex-M™ with best-in-class Enablement

Check Freescale sales representatives for detail. (NDA required.)
Kinetis V Series: 3 Phase Motor Control

- Entry Level FOC Motor Control
- Integrated Motor Control Solutions
- Scalable Mid Range Motor Control
- High Performance Motor Control
- High Performance MC & extended memory
- Multi Domain Motor Control
- Multi Domain Motor Control w/ Comms

- + ENET
- + Management Core
- + USB
- + HS ADC
- + Advanced Timers
- + Dual Motor Control
- + FPU
- + Integrated Motor Control S/W

Baseline
KV1x
KV2x
KV3x
KV4x
KV5x
KV6x
KV7x

Core:
- ARM® Cortex™-M0+
- ARM® Cortex™-M4
- ARM® Cortex™-M4 & M0+
- Dual ARM® Cortex™-M4
## V Series: Value Proposition

<table>
<thead>
<tr>
<th>Device Family</th>
<th>Core &amp; Performance</th>
<th>Positioning</th>
</tr>
</thead>
<tbody>
<tr>
<td>KV1x</td>
<td>M0+ @ 75MHz</td>
<td>Low cost, entry level, 3 phase FOC BLDC solution,</td>
</tr>
<tr>
<td>KV2x</td>
<td>M0+ @ 75MHz 56800EX @ 100MHz</td>
<td>Black box solution for Motor Control</td>
</tr>
<tr>
<td>KV3x</td>
<td>M4 @ 100 &amp;120MHz</td>
<td>Mid Range solution building on Kinetis K family, Wide memory range, Floating Point</td>
</tr>
<tr>
<td>KV4x</td>
<td>M4 @ 150MHz</td>
<td>High Performance, small memories, integrates DSC ADC &amp; PWM IP for best in class performance.</td>
</tr>
<tr>
<td>KV5x</td>
<td>M4 @ 200MHz</td>
<td>Large memory blocks, integrates DSC ADC &amp; PWM IP for best in class performance.</td>
</tr>
<tr>
<td>KV6x</td>
<td>M4 @ 200MHz M0+ @ 75MHz</td>
<td>Dual core solution for multi-domain environment; M4 controlling Motor, M0+ for controlling house keeping &amp; safety tasks</td>
</tr>
<tr>
<td>KV7x</td>
<td>M4 @ 200MHz M4 @ 100MHz</td>
<td>Dual core solution for multi-domain environment; M4 controlling Motor, M4 for communications, controlling house keeping &amp; safety tasks</td>
</tr>
</tbody>
</table>
## KV1x Features and Benefits

<table>
<thead>
<tr>
<th>Features</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortex M0+ @ 75MHz</td>
<td>Fastest Cortex M0+ in the market enables PMSM motor control with a M0+ solution</td>
</tr>
<tr>
<td>Hardware Square Root &amp; Divide Hardblock</td>
<td>26% performance improvement running math intensive applications such as Sensorless FOC algorithms</td>
</tr>
<tr>
<td>Dual ADC Blocks @ 835nSec conversion time</td>
<td>Capture current &amp; voltage simultaneously for the most accurate result</td>
</tr>
<tr>
<td>4ch DMA</td>
<td>Further improvements in performance realized through increased CPU bandwidth-</td>
</tr>
<tr>
<td>6ch FlexTimer + 2x2ch FlexTimer</td>
<td>Motor control PWM generation with integrated PFC, or integrated speed sensor decoder (incremental decoder / hall sensor)</td>
</tr>
<tr>
<td>Integrated 6b DAC &amp; CMP</td>
<td>Reduce BOM costs with integrated components for over current over voltage fault detection</td>
</tr>
<tr>
<td>Peripheral Interconnection</td>
<td>ADC and CMP interconnected with PWM and PDB for real time hardware control.</td>
</tr>
<tr>
<td>Light weight peripheral and memory configuration</td>
<td>Enough performance for the majority of Motor Control applications, with the right amount of memory to fit complex motor control algorithms</td>
</tr>
<tr>
<td>Dual Watchdog</td>
<td>IEC60730 Compliant solution</td>
</tr>
</tbody>
</table>
DSC Series Update
**MC56F84xxx**

**Key Features:**

- **Core**
  - 56800EX Hawk V3 @ 100MHz supporting fractional arithmetic with 4 ACC, a pipeline depth of 8 cycles, separate program and data memory maps, nested looping, and a superfast interrupt far outpacing any competitive core on the market.

- **System**
  - Intermodule Cross-Bar directly connecting any input and/or output with flexibility for additional logic functions (AND/OR/XOR/NOR)
  - DMA controller for reduced core intervention when shifting data from peripherals
  - Memory resource protection unit to ease safety certification

- **Timers**
  - eFlexPWM – Freescale’s most advance timer for Digital Power Conversion with up to 24ch and 312pico-sec resolution, supported by 8 independent time bases, with half cycle reloads for increased flexibility and best in class performance
  - NanoEdge placer to implement fractional delays

- **Analog**
  - 2x12-bit high-speed ADCs each with 300ns conversion rates
  - 16 ch 16b SAR ADC that enables external sensors inputs and accurate system measurements
  - 4 analog comparators with integrated 6-bit DACs that can enable emergency shutdown of the PWMs
  - Integrated PGAs to increase the accuracy of ADC conversions on small voltages and currents

- **Others**
  - 5-volt tolerant I/O for cost-effective board design
  - Freescale FlexMemory for simplified data storage

**Packages**

48LQFP, 64LQFP, 80LQFP, 100LQFP

**Clocks**

- Phase Lock Loop
- Crystal OSC
- 8MHz OSC
- 32kHz OSC

**Communication Interfaces**

- 2x I2C/SMBus
- 3xUARTs
- 3xSPI
- FlexCAN

**Analog**

- 8ch HS 12-bit ADC w/PGA
- Band-Gap Ref
- 8ch HS 12-bit ADC w/PGA
- 12bit DAC
- 4 x Analog CMP with 6bit DAC
- 16ch 16-bit SAR ADC

**Timers**

- eFlexPWM 24ch
- NanoEdge Placer
- 16-bit Timer 8ch
- 2 x PITs
**MC56F827xx**

**Key Features:**

- **Core**
  - 56800EX Hawk V3 @ 50/100MHz supporting fractional arithmetic with 4 ACC, a pipeline depth of 8 cycles, separate program and data memory maps, nested looping, and a superfast interrupt far outpacing any competitive core on the market.

- **System**
  - Intermodule Cross-Bar directly connecting any input and/or output with flexibility for additional logic functions (AND/OR/XOR/NOR)
  - DMA controller for reduced core intervention when shifting data from peripherals
  - Memory resource protection unit to ease safety certification

- **Timers**
  - eFlexPWM – Freescale’s most advance timer for Digital Power Conversion with up to 8ch and 312pico-sec resolution, supported by 4 independent time bases, with half cycle reloads for increased flexibility and best in class performance
  - NanoEdge placer to implement fractional delays

- **Analog**
  - 2x12-bit high-speed ADCs each with 800ns conversion rates
  - 4 analog comparators with integrated 6-bit DACs that can enable emergency shutdown of the PWMs
  - Integrated PGAs to increase the accuracy of ADC conversions on small voltages and currents

- **Power Consumption:**
  - Less than 0.4mA/Mhz at full speed run

**Others**

- 5-volt tolerant I/O for cost-effective board design

**Packages**

32QFN (5x5), 32LQFP, 48LQFP, 64LQFP
Motor Control Solutions Resource
Switched Reluctance Motor Control Solutions

**Advantages**
- Reliable electronics
- High starting torque
- Removal of position sensor

**Applications**
- Industrial machines
- Medical scanners
- Computers, office equipment
- Toys
- Food processors
- Vacuum cleaners
- Machine tools
- Large appliances

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**Application Notes**

**Digital Signal Controller**
- AN1912 - DSP56F80x 3-Phase SR Motor Control with Hall Sensors using DSP56F80x
- AN1932 - 3-Phase SR Sensorless Motor Control using DSP56F80x
- AN1937 - 3-Phase Switched Reluctance Motor Control with Encoder Using DSP56F80x

**Reference Design**
- DRM030 - 3-Phase SR Motor Sensorless Control Reference Design
- DRM031 - 3-Phase Switched Reluctance Motor Drive Control with Encoder Using 56F805
- DRM032 - 3-Phase SR Motor Control with Hall Sensors Reference Design
- DRM100 - Designer Reference Manual, Devices Supported: 56F801X

**Recommended Devices**
- **Digital Signal Controller**: MC56F80x, MC56F80xx, MC56F82xx, MC56F83xx
- **Analog/Mixed-Signal Power ICs**
- **Motor Driver**: MC33927, MC33937
BLDC Motor Control Solutions

Advantages
- Enables bi-directional operation with fast torque response
- Low noise, high efficiency
- Removes the position sensor
- Cost-effective control topology
- Speed and torque control

Applications
- Industrial control
- Large appliances
- HVAC
- Compressors
- Blowers
- Toys
- Pumps
- Health care equipment

Recommended Devices

8-bit MCU: 908MR, 908GB, 9S08QA, 9S08QD, 9S08SF, 9S08SH, 9S08AC, 9S08MP

Digital Signal Controller: MC56F80x, MC56F80xx, MC56F82xx, MC56F83xx

32-bit MCU: MCF51AC, MCF51AG, K10, K20, MCF521x, MCF523x, MPC56x, MPC560xP, MPC55xx, MCF5441x

Analog/Mixed-Signal Power ICs
Power Supply: MC34702, MC34717, MC33730, MC34923
Motor Driver: MC33927, MC33937, MC34923
Application Notes

8-bit
AN1627 - Low Cost High Efficiency Sensorless Drive for Brushless dc Motor Using MC68HC(7)05MC4
AN1702 - Brushless DC Motor Control Using the MC68HC705MC4
AN1858 - Sensorless Brushless dc Motor Using the MC68HC908MR32 Embedded Motion Control Development System
AN2355 - Sensorless BLDC Motor Control on MC68HC908MR32 Software Description
AN2687 - BLDC Fan Control using the MC68HC908QT2
AN2983 - LIN-Enabled BLDC Engine Fan
AN3832 - Sensorless BLDC Motor Control Using MC9S08AC16
AN4058 - BLDC Motor Control with Hall Effect Sensors Using the 9S08MP
AN4142 - MC9S08MP16 High Speed BLDC Sensorless Drive

Digital Signal Controller
AN1913 - 3-phase BLDC Motor Control with Sensorless Back-EMF ADC Zero Crossing Detection using DSP 56F80x
AN1914 - 3-Phase BLDC Motor Control with Sensorless Back EMF Zero Crossing Detection Using DSP56F80x
AN1915 - 3-Phase BLDC Motor Control with Quadrature Encoder using DSP56F80x
AN1916 - 3-Phase BLDC Motor Control with Hall Sensors Using 56800/E Digital Signal Controllers
AN1961 - 3-Phase BLDC Motor Control with Quadrature Encoder Using the 56F800/E

32-bit
AN2892 - 3-Phase BLDC Motor with Speed Closed Loop, driven by eTPU on MCF523x
AN2948 - Three 3-Phase BLDC Motors with Speed Closed Loop, driven by eTPU on MCF523x
AN2954 - BLDC Motor with Speed Closed Loop and DC-Bus Break Controller, driven by eTPU on MCF523x
AN2957 - BLDC Motor with Quadrature Encoder and Speed Closed Loop, Driven by eTPU on MCF523x
AN3005 - BLDC Motor with Quadrature Encoder and Speed Closed Loop, driven by eTPU on MPC5554
AN3006 - BLDC Motor with Hall Sensors and Speed Closed Loop, driven by eTPU on MPC5554
AN3007 - BLDC Motor with Speed Closed Loop and DC-Bus Break Controller, driven by eTPU on MPC5554
Permanent Magnet Synchronous Motor Control Solutions

- Advantages
  - Low-noise operation
  - High drive efficiency
  - High-precision speed/torque control
  - Suitable for drives with high dynamic requirements
  - Removal of speed sensor

- Applications
  - Robotics
  - Elevators
  - Servo drivers
  - Traction systems
  - Industrial motion control
  - Automotive
  - Appliances
  - HVAC
  - Compressors
  - Blowers

Reference Design

8-bit
DRM036 - Sine Voltage Powered 3-Phase Permanent Magnet Synchronous Motor with Hall Sensors

Digital Signal Controller
DRM018 - 3-Phase PM Synchronous Motor Torque Vector Control Using 56F805
DRM029 - 3-Phase PM Synchronous Motor Control with Quadrature Encoder Using 56F805
DRM037 - 3-Phase PMSM Vector Control
DRM077 - Design of PMSM and BLDC Sensorless Motor Control using the 56F8013 Device
DRM099 - Sensorless PMSM Vector Control with a Sliding Mode Observer for Compressors Using MC56F8013
DRM102 - PMSM Vector Control with Single-Shunt Current-Sensing Using MC56F8013/23
DRM110 - Sensorless PMSM Control for an H-Axis Washing Machine

32-bit
DRM105 - 3-phase PMSM Vector Control using Quadrature Encoder on MCF51AC256
DRM109 - Sensorless PMSM Vector Control on MCF51AC256

Recommended Devices

Digital Signal Controller: MC56F80x, MC56F80xx, MC56F82xx, MC56F83xx

32-bit MCU: MCF51AC, MCF51AG, K10, K20, K30, K40, K60, MCF521x, MCF523x, MPC56x, MPC560xP, MPC55xx, MCF5441x

Analog/Mixed-Signal Power ICs
Power Supply: MC34702, MC34717, MC33730, MC34923
Motor Driver: MC33927, MC33937, MC34923
Permanent Magnet Synchronous Motor Control Solutions (cont’d)

<table>
<thead>
<tr>
<th>Application Notes</th>
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<tbody>
<tr>
<td><strong>8-bit</strong></td>
</tr>
<tr>
<td>AN2357 - Sine Voltage Powered 3-Phase Permanent Magnet Motor with Hall Sensor</td>
</tr>
<tr>
<td><strong>Digital Signal Controller</strong></td>
</tr>
<tr>
<td>AN1917 - 3-Phase PM Synchronous Motor Control with Quadrature Encoder Using DSP56F80x</td>
</tr>
<tr>
<td>AN1931 - 3-Phase PM Synchronous Motor Vector Control</td>
</tr>
<tr>
<td>AN1999 - 56F8300 Hybrid Controller Used in Control of Electro-Mechanical Brake</td>
</tr>
<tr>
<td>AN3301 - Design of a PMSM Servo System using the 56F8357 Device</td>
</tr>
<tr>
<td><strong>32-bit</strong></td>
</tr>
<tr>
<td>AN2972 - Using the PMSM Vector Control eTPU Function</td>
</tr>
<tr>
<td>AN3002 - Permanent Magnet Synchronous Motor Vector Control, Driven by eTPU on MCF523x</td>
</tr>
<tr>
<td>AN3206 - Permanent Magnet Synchronous Motor Vector Control, Driven by eTPU on MPC5500</td>
</tr>
<tr>
<td>AN3729 - Using FlexTimer in ACIM/PMSM Motor Control Applications</td>
</tr>
</tbody>
</table>
Sensorless PMSM Motor Control Using MC56F80xx

- MC56F80xx digital signal controller
- 3-phase AC/BLDC high voltage power stage board
- 1-phase line input 110/230VAC @ 50/60Hz
- Appliance PM motor
- Initial rotor position detection
- Full torque at motor start-up
- Field weakening
- Application based on C-callable library functions (GFLIB, GDFLIB, MCLIB, ACLIB)
- Current control loop execution time: 55us
- Speed control loop with field weakening execution time : 17us
- Flash: ~ 6KB, RAM ~ 1.5KB
- Reference design manual
PMSM Sensorless Drive for Dishwasher Pump

- **Target Devices/Platforms:**
  - MC56F8006
  - Motor Control Applications
  - PM Synchronous Motor
  - Sensorless Control
  - Motor Control S/W Library

- **Applications Usage:**
  - Appliance (dishwasher pump, dryer drive)
  - Industrial (pumps, compressors, fans, HVAC)
  - Industrial Drives

- **Application Features:**
  - Sensorless control of Permanent Magnet Synchronous motor using Back-EMF Observer
  - One board solution - processor and power electronic on one board
  - Supply Voltage (110-230Vac +10%-15%)/50-60Hz
  - Output power approximately 200W for 230Vac input
  - Rotor speed - one direction, up to 3500rpm
  - Rotor alignment method will be used
  - Over-current protection and Over-voltage protection
  - Power module over-temperature protection
  - RS232 communication with PC
  - Header with GPIO for external start/stop switch
  - Header for encoder for development purposes
Refrigerator Compressor Control Solution

Over-/Under-voltage protection
Over-current protection
85%~110% of rated mains voltage startup
Easy to debug and demonstrate using FreeMASTER
Refrigerator Compressor Control Solution (Cont.)

1. Advanced Sensor-less Field Oriented Control.
2. Safe and Convenient Development Platform
3. Reliable Startup Performance.
4. Patented Flux-weakening Algorithm.
5. Compressor Vibration Elimination.
Design HW Blocks for 3-in-1

- Interleaved PFC
- Control
- Feedback
- dc bus
- 3Ph. Inverter Motor 1
- Control
- Feedback
- 3Ph. Inverter Motor 2
- Control
- Feedback
- PMSM
- Fan
- Interleaved PFC Control
- Sensorless FOC Control Motor 1
- Sensorless FOC Control Motor 2
- Application S/W
- MC56F84xx
- Application Control
- AC Line
- Compressor
H/W Kits - 3-in-1 High Voltage Power Stage

• **Usage:**
  - Two 3-phase motors + PFC
  - AirCon type of applications

• **Power Board Features:**
  - Input Voltage 115-230Vac, 50/60Hz
  - Output Power 2kW for 230Vac input
  - Two Drives up to 1500W and up to 500W
  - 3-phase IGBT module (Fairchild) 2 pcs
  - Current and voltage sensing
  - Galvanic isolated SCI / USB interface
  - Encoder / Hall Sensor and tacho interface
  - DC-Brake
  - PFC
  - PCI Daughter Card using Nevis(56F84xxx)
Typical Requirements of 3-in-1

- **Motor 1 & 2**
  - 2x 6-channel PWM modules
  - Parallel sampling 9-channel ADC
  - 2x dc bus current fault to PWM modules

- **PFC**
  - 2-channel high-precision PWM
  - 2-channel ADC with DMA
  - Timer
  - PDB
  - PFC current and dc bus over-voltage fault (comparators)

- **Application**
  - 3-channel ADC for temperature measurement
  - UART with DMA for communication

- **Inter-peripheral cross-bar unit** – signals interconnection
MC56F84xxx Application for 3-in-1

- **Motor 1**
  - 6-ch. High-Res PWM
  - 4-ch. HS ADC (currents)
  - Cross Bar (PWM to ADC)

- **Motor 2**
  - 6-ch. PWM
  - 4-ch. HS ADC (currents)
  - Cross Bar (PWM to ADC)

- **PFC**
  - 2-ch. High-Res PWM
  - 3-ch. SAR ADC (Vin, Ipfc, Vdcb)
  - 2x CMP (faults)
  - 2x DMA (ADC read and config)
  - Cross Bar (TMR to PDB to ADC)
  - Cross Bar (CMP to PWM fault)
  - 1x Timer
  - 1x PDB

- **Application**
  - 1x UART
  - 1x DMA (UART Tx)
  - 3-ch. HS ADC (temperature)
Application demo of 3-in-1
System Application Development

- **Target Devices/Platforms:**
  - Dual sensorless PMSM FOC plus interleaved PFC converter
  - MC56F84789

- **Applications Usage:**
  - Air-conditioner outdoor unit

- **Application Features:**
  - High performance, low cost all DC VF air-conditioner outdoor unit control system
  - Three control objectives (interleaved single-phase PFC converter, blower and compressor) with one MC56F84789 device
  - Input voltage range of 85 – 265VAC/40 – 70Hz
  - Compressor driver inverter – 1500W, blower driver inverter – 500W
  - Single-phase two channels interleaved PFC converter compatible with global mains input
  - Sensorless FOC algorithm for both compressor and blower
  - Anti-typhoon startup for blower, and load torque compensation control for compressor to reduce system vibration and noise
  - DC bus brake resistor with an independent comparator Over-/under-voltage, over-current protection and lock of rotor detection
  - PCI Express processor board
  - Isolated communication
  - FreeMASTER software control interface and monitor
Tower Based Dual PMSM with Encoder using Kinetis K Series 100MHz
Three-Phase AC Induction Motor Control Solutions

- **Advantages**
  - Enables bi-directional operation with fast torque response
  - Very high-precision speed/torque control
  - Suitable for drives with high dynamic requirements
  - High efficiency
  - Removal of position sensor

- **Applications**
  - Large appliances
  - HVAC
  - Blowers, fans
  - Pumps
  - Lifts, cranes, elevators
  - Conveyors
  - Frequency inverters
  - Industrial controls
  - Industrial compressors
  - Treadmills
  - Industrial compressors
  - Universal inverters
  - Construction machinery

**Recommended Devices**

- **8-bit MCU:** 908MR, 9S08GB, 9S08QD, 9S08SH, 9S08AC, 9S08MP
- **Digital Signal Controller:** MC56F80x, MC56F80xx, MC56F82xx, MC56F83xx, MC56F84xx
- **32-bit MCU:** MCF51AC, MCF51AG, K10, K20, K30, K40, K60, MCF521x, MCF523x, MPC56x, MCF5441x
- **Analog/Mixed-Signal Power ICs**
  - **Power Supply:** MC34702, MC34717, MC33730, MC34923
  - **Motor Driver:** MC33927, MC33937, MC34923
## Three-Phase AC Induction Motor Control Solutions (cont’d)

### Application Notes

#### 8-bit
- AN1664 - Low Cost 3-Phase ac Motor Control System Based on MC68HC908MR24
- AN1857 - A 3-Phase ac Induction Motor Control System Based on the MC68HC908MR32
- AN2154 - Low-Cost, 3-Phase, AC Motor Control System with Power Factor Correction Based on MC68HC908MR32

#### Digital Signal Controller
- AN1910 - 3-Phase AC Motor Control with V/Hz Speed Closed Loop Using the DSP56F80X
- AN1911 - 3-Phase AC Motor Control with V/Hz Speed Open Loop Using DSP56F80X
- AN1918 - Indirect Power Factor Correction for 3-Phase AC Motor Control with V/Hz Speed Open Loop Application Using DSP56F80x
- AN1930 - 3-Phase AC Induction Motor Vector Control Using DSP56F80x
- AN1958 - 3-Phase AC Motor Control with V/Hz Speed Closed Loop Using the 56F800/E
- AN3234 - Washing Machine Three-Phase AC Induction Motor Drive
- AN3476 - Washing Machine Three-Phase AC-Induction Direct Vector Control

#### 32-bit
- AN1524 - AC Motor Drive Using Integrated Power Stage
- AN1310 - Using the MC68332 Microcontroller of AC Induction Motor Control
- AN2971 - Using the ACIM Volts per Hertz (ACIM/VHZ) eTPU Function
- AN2973 - Using the ACIM Vector Control eTPU Function
- AN2968 - Using the AC Motor Control eTPU Function Set (set4)
- AN2969 - Using the AC Motor Control PWM eTPU Functions
- AN3000 - AC Induction Motor Volts per Hertz Control, Driven by eTPU on MCF523x
- AN3001 - AC Induction Motor Vector Control, Driven by eTPU on MPC5500
- AN3205 - AC Induction Motor Volts per Hertz Control with Speed Closed Loop, Driven by eTPU on MPC5500
- AN3729 - Using FlexTimer in ACIM/PMSM Motor Control Applications

### Reference Design

#### 8-bit
- DRM019 - 3-Phase AC Induction Motor Drive with Dead Time Distortion Correction Using the MC68HC908MR32
- DRM020 - 3-Phase AC Induction Motor Drive with Tachogenerator Using MC68HD908MR32
- DRM115 - 3-Phase AC Induction Motor Control with PFC Using MC9S08MP16

#### Digital Signal Controller
- DRM021 - 3-Phase ACIM Volt per Hertz Control Using 56F80x
- DRM023 - 3-Phase AC Induction Motor Vector Control Using 56F805
- DRM075 - Design of an ACIM Vector Control Drive using the 56F8013 Device
- DRM092 - 3-Phase AC Induction Vector Control Drive with Single Shunt Current Sensing

#### 32-bit
- DRM006 - General-Purpose 3-Phase AC Industrial Motor Controller Designer Reference Manual
3ph. ACIM Vector Control Demo

- **Target Devices/Platforms:**
  - Digital Signal Controller
  - MC56F8013
  - MC56F8023
  - Motor Control Applications
  - AC Induction Motor
  - Washing Machine

- **Applications Usage:**
  - Horizontal/vertical washing machine applications
  - High voltage three phase AC induction motors
  - Consumer/industrial market applications

- **Application Features:**
  - Three-Phase AC Induction Drive for Washing Machine
  - Target MC56F8013/23
  - Direct vector control algorithm
  - Speed range 0 - 20000 rpm (motor speed), 0 - 2000 rpm (drum speed)
  - Reconstruction of three-phase currents from DC-bus shunt resistor
  - Cost-efficient tachogenerator on motor shaft for speed sensing
  - Non-recuperative braking and deceleration control
  - Independently control motor torque and flux
  - Over-current, over-voltage and under-voltage protection
  - Washer algorithms implementation:
    - Out-of-balance detection for spin dry
    - Tumble - wash
    - Spin – dry
    - Serial RS232 control interface
ACIM Scalar Control with PFC

- **Target Devices/Platforms:**
  - MC9S08MP16
  - MC9S08JS16
  - Motor Control Applications
  - AC Induction Motor
  - V/Hz Control
  - Embedded Control Library

- **Applications Usage:**
  - Washing machines
  - Compressors
  - Air conditioning units
  - Fans
  - Industrial drives
  - Appliances

- **Application Features:**
  - Three-phase ACIM V/Hz control using tacho generator as a rotary transducer
    - Controlled acceleration and deceleration
    - Speed in the range of 0 to 2400 rpm for 4-pole motor
    - The drive can run clockwise or counterclockwise.
    - Speed is sensed by a tachometer/generator.
    - PWM frequency is 16 kHz.
    - Operation in FreeMASTER or demo operating mode
    - Overvoltage and overcurrent protection
  - Power Factor Correction (PFC)
    - Automatic input voltage detection 110 V/60 Hz and 230 V/50 Hz
    - dc-bus voltage regulation: 390VDC, 5% ripple for Pout = 300W
    - Overvoltage protection
    - Power factor: > 0.94 @ 230VAC
  - Freescale MC9S08MP16 microcontroller
  - Three-phase high voltage (230/115 V) power board
S12 MagniV
Solutions for Motor Control
Sub Agenda

• Technology Overview
  - System in Package
  - LL18UHV
• S12ZVM (Carcassonne) Overview
• Product benefits
Automotive Market Trends – Motor Control

• **Reduction of power consumption** critical for creating “greener” vehicles
  - Reduce weight for **cables & motors**
  - **Smarter** control techniques

• **Higher reliability**
  - Brushless DC motors for high duty applications
  - High temperature >125C

• Increase convenience and comfort
  - Find **space** for new features
  - Make them **affordable** to user
**What’s S12 MagniV?**

**SiP = System in Package**

**Semi-Discrete Solution**
- Standard MCU
- Application Specific Analog IC (ASIC)

**Multi-die SiP**
- Single package
- Die-to-die bonding

**Monolithic SiP**
- MCU and Analog on the same die

---

**SiP** = System in Package

**Multi-die SiP**

**Monolithic SiP**
15 Years of System in Package (SiP) Experience

- **908E622/1**
  - 8-bit HC08 + SMOS5 Mirror Driver

- **908E624**
  - 8-bit HC08 + SMOS5 Relay Driver

- **908E626**
  - HC08 + SMOS5 AFS Stepper Driver

- **908E630**
  - 8-bit HC08 (SOG) + SMOS8 Relay Driver

- **912F634**
  - 16-bit S12I32 + SMOS8 Relay & Switch Driver

- **HC05PV8**
  - 8-bit HC05 Hyper-integrated Relay Driver

- **Troll - MUX3**
  - 8-bit HC05 Hyper-integrated Climate Stepper Driver

- **908E624**
  - 8-bit HC08 + SMOS5 Relay Driver

- **908E630**
  - 8-bit HC08 (SOG) + SMOS8 Relay Driver

- **912F634**
  - 16-bit S12I32 + SMOS8 Relay & Switch Driver

- **S12VR64**
  - First S12 MagniV product

- **S12ZVM**
  - S12ZVH

- **LL18UHV technology**
  - Monolithic SiP

- **S12Z Core**
  - Architecture Repartitioning

- **S12 Core (0.25um)**
  - Architecture Repartitioning

- **HC05 Microcontroller with EEPROM (IDR60% -1.2um)**

- **SiP Architecture**
  - HC08 Microcontroller with flash (0.5um)

- **SMOS8 (0.25um)**
  - QFN Package

- **SMOS5 (0.8um)**

- **54ld SOIC Package**

- **Monolithic Architecture**
  - HC05 Microcontroller with EEPROM (IDR60% -1.2um)

- **Mechatronics Package**

- **Start of SiP R&D**

- **1st Gen**

- **2nd Gen**

- **3rd Gen**

- **4th Gen**
LL18UHV Technology Summary

Digital Logic
S12, PWMs, Timers, SRAM, SPI, SCI, GPIO, Watchdogs, etc.

High-Voltage Analog
Low Side & High Side Drivers, Voltage Regulator LIN/CAN Phy. etc.

Non-Volatile Memory
Flash, EEPROM

Existing
Low Leakage 180nm CMOS+NVM

40V UHV Devices
S12 MagniV Roadmap

Motor Control
- S12VRxx (Tomar): 2 LS for relay based DC motor control

Instrument Cluster
- Multi-PHY companion chip

Lighting
- LIN enabled

General Purpose
- CAN enabled

2012
- 2Q 3Q 4Q

2013
- 3Q 4Q 1Q

2014
- 1Q

2015
- 1Q

Check Freescale sales representatives for detail. (NDA required.)
S12ZVM Concept

Full Discrete

- VREG (8pin)
- CAN or LIN phy (8pin)
- Op-amps

MCU or DSC (48pin)

Gate Driver (48pin)

- ~50 pins less at assembly
- 4 to 6 cm² PCB space savings

Semi Integrated

- MCU or DSC (48pin)
- ASIC (GDU+VREG+LIN+Op-amps) (48pin)

- ~30 pins less at assembly
- 2 to 3 cm² PCB space savings

4cm ~1 ½ in.

~30 pins less at assembly
2 to 3 cm² PCB space savings
S12ZVM Family

Multiple options to support different interface and motor types

- LIN bus based applications
- CAN bus based applications
- PWM input based applications

BLDC / PMSM Motors

DC Motors
S12ZVM Family – LIN Options

- Integrated LIN physical layer
- 32KB, 64KB or 128KB embedded flash
- AEC Grade 0 option Ta=150°C

S12ZVM Family

Digital Components
5V Analogue Components
MCU Core and Memories
High-Voltage Components
S12ZVM Family – CAN Options

- 5V regulator controller to support an external CAN transceiver
- 64KB or 128KB embedded flash
- AEC Grade 0 option Ta=150°C

S12ZVMC128/64
S12ZVM Family – PWM Option

- No MSCAN controller
- No LIN physical layer
- 32KB embedded flash only
- AEC Grade 0 option Ta=150C

S12ZVM32
Carcassonne – S12ZVML128

- **Target applications:**
  - BLDC motor control
  - DC motor control

- **Key Features:**
  - S12Z CPU @ 50MHz bus speed
  - Embedded VREG
  - LIN phy, LIN2.1 compliant
  - Embedded GDU for 3ph BLDC
  - Embedded EE
  - 1x MSCAN controller
  - 2xSCI, 1xSPI
  - Dual 12bit ADC, synch with PWM
  - 20mA/5V EVDD sensor supply pin
  - 2x Op-amp for current sense (each needs 3 pins mux’d with ADC inputs)
  - 64LQFP-EP 10x10/0.5mm
# S12ZVM Family Feature Set Summary

<table>
<thead>
<tr>
<th>Flash /RAM Size</th>
<th>128 / 8 KB</th>
<th>64 / 4 KB</th>
<th>32 / 2 KB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connectivity</td>
<td>LIN</td>
<td>CAN</td>
<td>LIN</td>
</tr>
<tr>
<td>Product Name</td>
<td>S12ZVML128</td>
<td>S12ZVMC128</td>
<td>S12ZVML64</td>
</tr>
<tr>
<td>Pin count</td>
<td>64</td>
<td>64</td>
<td>64</td>
</tr>
<tr>
<td>EEPROM (bytes)</td>
<td>512</td>
<td>512</td>
<td>512</td>
</tr>
<tr>
<td>LIN PHY</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>2nd VREG</td>
<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>PWM channels</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>ADC (ext. channels)</td>
<td>4 + 5</td>
<td>4 + 5</td>
<td>4 + 5</td>
</tr>
<tr>
<td>MSCAN</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>SCI</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>SPI</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>TIM (IC/OC channels)</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

**Important note:** the 48LQFP-EP option initially planned as a smaller footprint option for DC motors was cancelled on 29Nov12. Packaging validation showed a reliability risk for bonding the die to the exposed pad due to relative sizes and leadframe structures. Customers interested in the 48LQFP-EP should be redirected to the 64LQFP-EP option which doesn’t exhibit that risk due to a different mechanical design.
High-Temperature Option

<table>
<thead>
<tr>
<th></th>
<th>M-Temp</th>
<th>W-Temp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Ambient Temperature (Ta)</td>
<td>125C</td>
<td>150C</td>
</tr>
<tr>
<td>Max Junction Temperature (Tj)</td>
<td>150C</td>
<td>175C</td>
</tr>
<tr>
<td>Max CPU speed</td>
<td>50MHz</td>
<td>40MHz</td>
</tr>
<tr>
<td>Price adder vs V-Temp (Ta=-40/+105C)</td>
<td>5%</td>
<td>15%</td>
</tr>
<tr>
<td>AEC Qual</td>
<td>Grade 1</td>
<td>Grade 0</td>
</tr>
</tbody>
</table>

Other considerations for HT option:

- Datasheet pending characterization. Potential de-rating of parameters:
  - IRC accuracy for LIN operation >1,3%
  - NVM write/erase performance/timing
- Embedded temp sensor can be used to adapt control strategies
The pinout represents functionality. The physical pins location is not correct nor does it reflect pin multiplexing.
## Operating Voltage Ranges

### Without Boost

<table>
<thead>
<tr>
<th>Vsup</th>
<th>MCU</th>
<th>GDU</th>
</tr>
</thead>
<tbody>
<tr>
<td>20V...40V</td>
<td>Full</td>
<td>Disabled</td>
</tr>
<tr>
<td>7V...20V</td>
<td>Full</td>
<td>Enabled</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Vgs &gt; Vsup – 2*Vbe (5V min)</td>
</tr>
<tr>
<td>6V .. 7V</td>
<td>Full</td>
<td>Disabled</td>
</tr>
<tr>
<td>3.5V .. 6V</td>
<td>Full</td>
<td>Disabled</td>
</tr>
<tr>
<td>&lt;3.5V</td>
<td>Reset</td>
<td>Disabled</td>
</tr>
</tbody>
</table>

### With Boost

<table>
<thead>
<tr>
<th>Vsup</th>
<th>MCU</th>
<th>GDU</th>
</tr>
</thead>
<tbody>
<tr>
<td>20V...40V</td>
<td>Full</td>
<td>Disabled</td>
</tr>
<tr>
<td>9.5V...20V</td>
<td>Full</td>
<td>Boost OFF for Vsup &gt; 11V Vgs = 9.6V</td>
</tr>
<tr>
<td>6V .. 9.5V</td>
<td>Full</td>
<td>Boost ON Vgs &gt;9V</td>
</tr>
<tr>
<td>3.5V .. 6V</td>
<td>Full</td>
<td>Boost ON Vgs &gt;9V</td>
</tr>
<tr>
<td>&lt;3.5V</td>
<td>Reset</td>
<td>Disabled</td>
</tr>
</tbody>
</table>
The pinout represents functionality. The physical pins location is not correct, and also does not reflect pin multiplexing.
SMTA (Surface Mount Technology Association):
As of 2004, typical NMACPCs (Non-Material Assembly Cost Per Component) range from $0.04 to $0.15 per component assembled and NMACPI/O (Non-Material Assembly Cost Per Input/Output) range from $0.005 to $0.02 per I/O assembled.

FSL assumption is $0.01 savings per pin in average for:
- Assembly (pick&place and soldering)
- Testing
Enablement Tools for Motor Control
Freescale Embedded Software Libraries

**Deliverables:**

- **General Function Library (GFLIB)** contains math, trigonometric, look-up table and control functions. These software modules are basic building blocks.
- **Motor Control Library (MCLIB)** contains vector modulation, transformation and specific motor related functions to build digitally controlled motor drives.
- **General Digital Filter Library (GDFLIB)** contains filter functions for signal conditioning.
- **Advanced Control Library (ACLIB)** will contain functions to enable building the variable speed AC motor drive systems with field oriented control techniques without position or speed transducer *(Available for Cortex M4).*

<table>
<thead>
<tr>
<th>GFLIB - General Function Library</th>
<th>GMCLIB - Motor Control Library</th>
<th>GDFLIB - Digital Filter Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sine, cosine, tangent</td>
<td>Clark, inverse clark</td>
<td>1(^{\text{st}}) and 2(^{\text{nd}}) order IIR filter</td>
</tr>
<tr>
<td>Square root</td>
<td>Park, inverse park</td>
<td>Moving average filter</td>
</tr>
<tr>
<td>Ramp</td>
<td>Vector limitation</td>
<td></td>
</tr>
<tr>
<td>Limitation on input signal</td>
<td>DC bus voltage ripple elimination</td>
<td></td>
</tr>
<tr>
<td>Proportional-Integral (PI) controller of parallel form</td>
<td>Stadard space vector modulation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>PM motor decoupling</td>
<td></td>
</tr>
</tbody>
</table>

Freescale Embedded Software Libraries

Target Devices/Platforms:
- Digital Signal Controllers
- Kinetis K Series
- ColdFire MCF51xx
- Qoriva MPC560xP
- PX Series (Power Architecture)

Range of Applications:
- Digital Control Systems
- Motor Control (BLDC, PMSM, AC)

Highlights/Description:
- Software modules implemented in assembly
- Optimized for speed
- C-callable interface
- Easy to use
- Fully documented

Deliverables:
- **General Function Library (GFLIB)** contains math, trigonometric, look-up table and control functions. These software modules are basic building blocks.
- **Motor Control Library (MCLIB)** contains vector modulation, transformation and specific motor related functions to build digitally controlled motor drives.
- **General Digital Filter Library (GDFLIB)** contains filter functions for signal conditioning.
- **Advanced Control Library (ACLIB)** will contain functions to enable building the variable speed AC motor drive systems with field oriented control techniques without position or speed transducer (will be available soon).
What is **FREEMASTER**

- Real-time Monitor
- Graphical Control Panel
- Demonstration Platform & Selling Tool
as a Real-time Monitor

• **Highlights:**
  - FreeMASTER helps developers to debug or tune their applications
  - Replaces debugger in situations when the processor core can not be simply stopped (e.g. motor control)
  - Recorder may be used to visualize transitions in near 10-us resolution
• **Using FreeMASTER as a Graphical Control Panel**
  - Variable Watch pane enables direct setting of the variable value
  - Sending Application Commands from the application GUI
  - Time-table stimulation of the variable value
  - HTML Pages and Forms
    - JScript or VBScript
    - Push buttons
    - Images, indicators
    - Sounds, videos
    - Sliders, gauges and other 3rd party ActiveX controls

• **Scripting in FreeMASTER**
  - HTML pages are displayed directly in the FreeMASTER window
  - HTML may contain scripts and ActiveX objects
    - FreeMASTER itself implements an invisible ActiveX object
    - Script accesses the FreeMASTER functionality through this object
      - Variable access
      - Stimulator access
      - Application Commands
      - Recorder Data
  - HTML may host whole applications, for example Excel
    - Excel Visual Basic macros may access FreeMASTER as well
Motor Control

Your essential source for motor control applications

Motors provide motion. Whether rotational or linear, motors move people and machines, impacting every aspect of our daily lives. Electric motors are clean and relatively efficient for the tasks they perform when compared to pneumatic or hydraulic alternatives. Freescale's strong portfolio of cutting-edge motor control technologies, tools and expert support enables a wide variety of cost-effective and energy-efficient motor control applications.

Motor Control Applications

- 1-Phase AC Induction Motor
- 3-Phase AC Induction Motor
- brushed DC Motor
- Brushless DC (BLDC) Motor
- Permanent Magnet Synchronous Motor
- Stepper Motor
- Switched Reluctance Motor
- Universal Motor

Design Resources

- Getting Started
  - Product Longevity
  - Training
- Software and Tools
- Design Partners

Application Summary

Pages for each motor type

Training & Events

- On-Demand Webcast
- Motor control trends with Freescale Technology
- On-Demand Training
  - Motor Control Roadmap
  - Motor Types Tutorial
  - Motor Control Trends
  - PMSM Sensorless Drive Using 16-bit DSPs
  - Getting Started with DSCs for Motor Control and Energy Conversion
  - Brushless DC Motor Deep Dive Using Freescale Technology
- Events
  - Freescale Technology Forum

Featured Videos

- PMSM Sensorless Pump Control
  (Video - 5:52) Sensorless sinusoidal speed control of PMSM for dishwasher pump featuring the Freescale MC56F3006
- PMSM Sensorless Motor Drive
  (Video - 7:41) Sensorless sinusoidal speed control of PMSM in whole speed range featuring the Freescale MC56F30xx in detail

Featured Software

- FreeMASTER
  Real-time control and debugging tool for 8-, 16- and 32-bit MCUs
- Freescale Embedded Software Libraries

Featured Reference Designs

- 3-Phase Sensorless BLDC Motor Control Using MC9S08MP16