KINETIS V SERIES MCUS

3.3V HIGH SPEED, HIGH PERFORMANCE ARM-BASED MCUS

SECURITY AND CONNECTIVITY BU
SR. MCU FAE, STANLEY HUANG
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Agenda

- Kinetis V(KV) MCU Product Family, Block diagram & Key Features
- Motor Control Solutions
- Key Enablement Tools
Kinetis V series MCUs based on ARM® Cortex® cores
Target on Motor Control & Digital Power Conversion

Motor Control

- Sensored BLDC / PMSM
  - High Dynamic Control
- Sensored ACIM
- Sensorless FOC
  - PMSM/BLDC
  - High Dynamic Control
  - Low Dynamic Control
- Sensorless ACIM
- Multi-Motor Control

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
Motor Control Applications

- Fans
- Pumps
- Blenders
- Compressors
- HVAC
- Washers
- Driers
- Dishwashers
- Air Filters

- Power Tools
- Robotics
- Pick-and-place
- Conveyor Belts
- Factory Automation
- Winders
- CNC Machines
- 3-D Printers
- Servo Drives

- Multi-Motor Control
- Drones/UAV’s
- CPAP Pumps
MCU FAMILIES
New Levels of Performance, Reliability and Power Efficiency for Motor Control and Digital Power Conversion

- **KV1x MCU Family**
  - BLDC, entry-level PMSM
  - ARM® Cortex®-M0+
  - + Motor Control Software

- **KV3x MCU Family**
  - Mid-range PMSM, UPS power control
  - ARM® Cortex®-M4
  - + Multi Channel Timers
  - + DSP+ Floating Point Unit

- **KV4x MCU Family**
  - High-performance motors, UPS, solar and mid-range AC/DC control
  - ARM Cortex-M4

- **KV5x MCU Family**
  - High-performance single/multi motor systems with connectivity & security.
  - Advanced digital power conversion
  - ARM Cortex-M7

Feature Integration

- NXP IDE, RTOS, Software Libraries and Motor Control Development Tools
## Kinetis V Series: Performance and Feature Scalability

### Key Peripherals for Motor and Power Control Applications

<table>
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<tr>
<th>MCU Family</th>
<th>Core</th>
<th>Memory</th>
<th>Motor Control Timers</th>
<th>ADC</th>
<th>DAC</th>
<th>ACMP</th>
<th>Comms.</th>
<th>Packages</th>
</tr>
</thead>
<tbody>
<tr>
<td>KV5x</td>
<td>240MHz CM7 DSP + FPU</td>
<td>512kB-1MB Flash</td>
<td>2 x 8ch, 1x 2ch FlexTimer</td>
<td>4 x 12bit</td>
<td>1x 12-bit</td>
<td>4x ACMP with 6-bit DAC</td>
<td>Ethernet 3 x CAN</td>
<td>144 pin 100 pin</td>
</tr>
<tr>
<td>KV4x</td>
<td>168MHz CM4 DSP + FPU</td>
<td>64-256kB Flash</td>
<td>2 x 8ch, 1x 2ch FlexTimer</td>
<td>12ch eFlexPWM + Nano-Edge</td>
<td>2x 12bit</td>
<td>2x 12-bit</td>
<td>2x 6-bit DAC</td>
<td>2 x CAN</td>
</tr>
<tr>
<td>KV3x</td>
<td>100/120MHz CM4 DSP + FPU</td>
<td>64-512kB Flash</td>
<td>2 x 8ch, 2x 2ch FlexTimer</td>
<td>-</td>
<td>2x 16-bit</td>
<td>2x 6-bit DAC</td>
<td>-</td>
<td>100 pin 64 pin 48 pin 32 pin</td>
</tr>
<tr>
<td>KV1x</td>
<td>75MHz CM0+ H/W DIV &amp; SQT</td>
<td>16-128kB Flash</td>
<td>2x 6ch, 2x 2ch FlexTimer</td>
<td>-</td>
<td>2x 16-bit</td>
<td>2x 6-bit DAC</td>
<td>-</td>
<td>64 pin 48 pin 32 pin</td>
</tr>
</tbody>
</table>

### Scalable performance, timing and analog functionality based on application need
Kinetis V – MCU by Motor Type

KV1x: FOC ACIM
1 PMSM Motor
Low Dynamic PMSM FOC
1 or 2 BLDC Motors
BLDC Motors – FOC; Sensorless & Sensor’d

KV3x: Power Control: UPS, SMPS, Photo Voltaic
FOC ACIM
Up to 2 x PMSM Motors
High Dynamic PMSM FOC
Up to 4 x BLDC Motors
BLDC Motors – FOC; Sensorless & Sensor’d

KV4x: Up to 2 x FOC ACIM
Up to 4 x PMSM Motors

KV5x: Up to 8 x BLDC Motors

Industrial Real Time Control
Kinetis V Series KV1x: Block Diagram

Core/System
- 75MHz Cortex-M0+ with Hardware Divide & Square Root
  - 4ch DMA

Memory
- 16/32/64/128KB Flash
- 8/16KB SRAM
- Option with FAC (Flash access control)

Communications
- Multiple serial ports + 1 FlexCAN*

Analog
- 2 x 8ch 16-bit ADC
  - 1.2Msps in 12-bit mode (835ns)
- 1 x 12-bit DAC
- 2 x ACMP with 6-bit DAC

Timers
- Up to 2x6ch FlexTimer (PWM) *
- Up to 4x2ch FlexTimer (PWM/Quad Dec.)
- Low Power Timer

Other
- 32-bit CRC
- Up to 54 GPIO
- 1.71V-3.6V; -40 to 105°C

Packages
- 32QFN, *32LQFP, 48LQFP, 64LQFP
  * Package Your Way

Availability: Mass Production
Cortex M7—Replacement for MCU+DSP

**Trends:**
- Convergence of MCU+DSP to DSC for cost reduction
- Increased processing demands
- Increasing consumer expectation of quality in portable devices

**Example applications:**
- Multi-channel audio
- Dolby Digital in consumer devices
- Advanced Motor Control
- Factory Automation
- Automotive
- Image processing

**CM7 Advantage:**
- High performance core with fast DSP
- Compatibility with existing Cortex-M4 designs
- Flexible memory system
## Kinetis V Series KV3x: Block Diagram

### Core/System
- Cortex-M4 @ 100/120MHz with FPU
- 4 or 16ch DMA

### Memory
- 64/128/256/512KB Flash,
- 16/24/48/96KB SRAM
- FlexBus (512KB version only)
- Bootloader

### Communications
- Multiple serial ports

### Analog
- 2 x 16-bit ADC: 1.2Msps in 12-bit mode
- Up to 2 x 12-bit DAC
- 2 x ACMP with 6-bit DAC

### Timers
- Up to 2x8ch FTM (PWM)
- 2x2ch FTM (PWM/Quad Dec.)
- Programmable Delay Block
- Low Power Timer

### Other
- Up to 70 I/Os
- 6 high-drive I/Os (20mA) – SPI/I2C
- 1.71V-3.6V; -40 to 105°C

### Packages
- 32QFN, *48LQFP, 64/100LQFP
- *Alternative, non committed package

### Security and Integrity
- Cyclic Redundancy Check
- Internal & External Watchdogs
- Flash Access Controller

### Analog
- 2 x 16-bit ADC
- 2 x ACMP w/ 6b DAC
- Up to 2 x 12-bit DAC
- V Ref

### Timers
- FlexTimers
- Programmable Delay Block
- Low Power Timer
- Periodic Interrupt Timer

### Communication Interfaces
- 2 x I²C
- 4 x UARTs
- 2 x DSPI

### Clocks
- Phase-Locked Loop
- Frequency-Locked Loop
- Low/High Frequency Oscillators
- Internal Reference Clocks

### Other Interfaces
- Debug Interfaces
- DSP
- Interrupt Controller
- FPU

### Availability: Production Now

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*Optional*
### Kinetis V Series KV4x: Block Diagram

#### Core/System
- 168MHz Cortex-M4, FPU

#### Memory
- 64/128/256KB Flash @ 128bits wide w/ 128Byte cache
- 16/24/32KB SRAM
- Bootloader

#### Communications
- Multiple serial ports
- Up to 2 x CAN

#### Analog
- 2 x 8ch 12-bit ADC
  - Sampling at up to 4.1MS/s
  - PGA x1, x2, x4
- 12-bit DAC
- 4 x ACMP with 6-bit DAC

#### Timers
- Up to 12ch eFlexPWM
  - Up to 312ps PWM and PFM Resolution
- 2x8ch + 1x2ch FlexTimer (PWM)
- Quadrature Encoder
- 2 x Programmable Delay Blocks

#### Other
- 32-bit CRC
- Inter-Peripheral Crossbar with AND/OR interface
- Up to 56 I/Os
- 1.71V-3.6V; -40 to 105°C

#### Packages
- *48LQFP, 64 LQFP & 100LQFP
- *Alternative, non committed package

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### Security and Integrity

- 2 x 12-bit ADC w/PGA
- 4 x ACMP
- 1 x 12-bit DAC
- V Ref
- Cyclic Redundancy Check
- Internal & External Watchdogs
- Flash Access Controller

### Analog

- 2 x 12-bit ADC w/PGA
- 4 x ACMP
- 1 x 12-bit DAC
- V Ref

### Timers

- 12ch eFlexPWM
- FlexTimers
- Programmable Delay Block
- Periodic Interrupt Timers
- Low-Power Timer
- Quad Encoder/Decoder

### Communication Interfaces

- 1x I²C
- 2x CAN
- 2x UARTs
- 1x SPI

### Clocks

- Phase & Frequency-Locked Loop
- Internal Reference Clocks
- Low/High Frequency Oscillators

### Availability

Availability: Production Now
Kinetis KV5x MCU Family

**Key Features:**

**Core/System**
- Upto 220MHz Cortex-M7 with FPU and 32ch DMA
- 16KB Instruction Cache / 8KB Data Cache

**Memory**
- 512KB/1MB Flash, 256bits wide, 128 Bytes cache
- 128/256KB SRAM
- Boot Flash

**Communications**
- Multiple serial ports
- 3 x FlexCAN

**Analog**
- 4 x 8ch 12-bit ADC
  - 5MspS Sample Time
- 1 x 16-bit SAR ADC
- 1 x12-bit DAC
- 4 x ACMP w/ 6b DAC

**Timers**
- 1 x 12ch eFlexPWM
  - 312ps PWM and PFM Resolution
- 1 x 12ch eFlexPWM
- 2x8ch FlexTimer (PWM)
- 2x2ch FlexTimer (PWM)
- Quadrature Encoder
- 2 x Programmable Delay Blocks
- Low-Power Timer

**Others**
- MMCAU & RNG
- 32-bit CRC
- Inter-module Crossbar Switch with AOI
- Memory Protection Unit
- 1.71V-3.6V; -40 to 105°C

**Packages**
- 100LQFP, 144LQFP, 144MAPBGA
- V Temp (105°C) : 220MHz

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**Security and Integrity**
- Cyclic Redundancy Check (CRC)
- MMCAU
- RNG

**Analog**
- 4 x12-bit SAR ADC
- 4 x ACMP
- 1 x12-bit DAC
- 1 x16-bit SAR ADC

**Timers**
- 2x12ch eFlexPWM
- 2x8ch FlexTimer
- 2x2ch FlexTimer
- 2x PDB
- PIT
- Quad Encoder

**Communication Interfaces**
- 2xI²C
- 3x CAN
- 6xUARTs
- 3xSPI
- IEEE 1588 Ethernet MAC

**Clocks**
- Phase & Frequency-Locked Loop
- Low/High Frequency Oscillators
- Internal Reference Clocks
Key Features
Cortex-M0+: What’s the “+” standing for?

- **Extended system-level capabilities**
  - Single-cycle fast I/O access port facilitates bit-banging and software protocol emulation, keeping an 8-bit ‘look and feel’
  - Up to 50% faster than normal I/O
  - Rapid GPIO controller (FGPIO) have SET/CLEAR/TOGGLE control for all pins in zero wait states
  - Fast application response by **Bit Manipulation Engine** (BME)
Bit Manipulation Engine (BME)

- The BME provides hardware support for atomic read-modify-write memory operations to the peripheral address space in Cortex-M0+.
  
  - Decorated Stores
    - AND, OR, XOR and Bit field insert (BFI)
  
  - Decorated Loads
    - Load and clear one bit (LAC1), Load and Set one bit (LAS1), Unsigned bit field extract (UBFX)
Bit Manipulation Engine (BME)

- Cortex-M0/M0+ does NOT support bit manipulation at all.
- NXP created bit manipulation (AND, OR, XOR and Bit field insert (BFI)) support.
- Platform hardware support for uninterruptible atomic read-modify-write memory operations to the peripheral address space in Cortex-M0+ based microcontrollers.
- Reduced overall code size and improved bits operation speed as well system response speed.
Memory-Mapped Divide and Square Root (MMDVSQ)

- ARM’s Cortex-M0+ core does NOT support integer divide & square root instructions. Requires software emulation via a software library function.

- KVxx MCU includes a lightweight, memory-mapped divide & square root coprocessor (MMDVSQ)
  - Supports 32/32 signed and unsigned divide (or remainder) calculations
  - Supports 32-bit unsigned square root calculations

- MMDVSQ noticeably reduce the fast control loop execution time. Additionally, each iteration of the fast control loop includes 3 integer divisions and 1 SQRT calculation.

### Memory-Mapped Programming Model

Four 32-bit data registers

- **DEND** = dividend
- **DSOR** = divisor
- **RCND** = radicand
- **RES** = result

+ **CSR** = control/status
Analog-to-Digital Converter (ADC)

- Successive Approximation (SAR) ADC.

- High sampling rate and high resolution than competitors.

- Additionally, We have:
  - Hardware averaging by 1, 4, 8, 16, or 32. (Set AVGS bits)
  - Self-calibration mode
  - Automatic Compare Function (less-than, greater-than or equal-to, within range, or out-of-range)
  - Triggering synchronization w/DAC
  - Internal temperature sensor
  - DMA trigger
ADC Self-calibration Mode

- One-time calibration **must** be done to generate the offset and gain compensation values in the start.

- These values are automatically subtracted (offset, ADCOFS registers) and multiplied (gain) during the conversion sequence to compensate for internal errors.
ADC Compare Modes

- Inside and Outside range capabilities allow applications to do comparator functions without the need for added hardware.
- Continuous conversions can be used so that the ADC will not interrupt until the compare condition is met.

<table>
<thead>
<tr>
<th>ADC1R</th>
<th>ADC2R</th>
<th>ADCCV1 relative to ADCCV2</th>
<th>Function</th>
<th>Compare Mode Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 0</td>
<td>-</td>
<td>Less than threshold</td>
<td></td>
<td>Compare true if the result is less than the ADCCV1 registers.</td>
</tr>
<tr>
<td>1 0</td>
<td>-</td>
<td>Greater than or equal to threshold</td>
<td></td>
<td>Compare true if the result is greater than or equal to ADCCV1 registers.</td>
</tr>
<tr>
<td>0 1</td>
<td>Less than or equal</td>
<td>Outside range, not inclusive</td>
<td></td>
<td>Compare true if the result is less than ADCCV1 or the result is Greater than ADCCV2</td>
</tr>
<tr>
<td>0 1</td>
<td>Greater than</td>
<td>Inside range, not inclusive</td>
<td></td>
<td>Compare true if the result is less than ADCCV1 and the result is Greater than ADCCV2</td>
</tr>
<tr>
<td>1 1</td>
<td>Less Than or equal</td>
<td>Inside range, inclusive</td>
<td></td>
<td>Compare true if the result is less than or equal to ADCCV1 and the result is Greater than or equal to ADCCV2</td>
</tr>
<tr>
<td>1 1</td>
<td>Greater than</td>
<td>Outside range, inclusive</td>
<td></td>
<td>Compare true if the result is Greater than or equal to ADCCV1 or the result is less than or equal to ADCCV2</td>
</tr>
</tbody>
</table>

Less than Threshold

Greater than or Equal to Threshold

Outside Range

Inside Range

Outside Range Lower Limit

Outside Range Upper Limit

ADCCV1

ADCCV2
FlexTimer is used to generate different PWM modes. Such as edge/center align PWM, dead time insert, Trig ADC…

We also use to Measure Speed/Position.

- The FlexTimer can be used for Speed/Position Measurement
- Quadrature Mode
  - The FTM is capable to decode signals from quadrature encoder
  - There are input filters for both A and B inputs
• Pulse width modulation (PWM) is a basic technique for average control of voltage/current in many applications like motor control, switched mode power supplies, lighting, wireless charging, audio amplifiers, and many others.

• This technique represents efficient method to convert one level of voltage/current to another level.

Figure 2. Impact of PWM resolution on output signal
Figure 3. Fractional delay block in eFlexPWM module

Figure 4. Operating principle of fractional delay block
U.S. Patent # 7288977: High resolution pulse width modulator

ie. Original PWM 16bit resolution + 5bits in the output stage, to become 21bit resolution

- Nanoedge and PWM dithering is best for digital power.
Enhanced Direct Memory Access (eDMA)

eDMA controller:
A 2\textsuperscript{nd}-generation DMA performing complex data transfers.

The DMA hardware includes:
• Source- and destination-address calculations
• Data-movement operations
• Local memory, transfer-control descriptor (TCD), containing transfer control descriptors for each DMA channels
eDMA system block diagram
eDMA interconnect diagram

- UARTs
- SPIs
- \(\text{l}^2\text{Cs}\)
- SPIs
- FTMs
- ADCs
- HSCMPs
- DACs
- PDB
- GPIOs
- DMA Mux
- DMA Mux

16 DMA Requests

- clock
- DMA CH0 int
- DMA CH1 int
- DMA CH3 int
- error int

SIM
MCG

NVIC
# DMA: Nested Loop Example

<table>
<thead>
<tr>
<th></th>
<th>NBYTES</th>
<th>Minor Loop</th>
<th>Major Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA Request -&gt;</td>
<td>4</td>
<td>CITER = 3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA Request -&gt;</td>
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<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DMA Request -&gt;</td>
<td>4</td>
<td>CITER = 1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DMA Channel Linking

ADC COCO

Source (ADC Rn) --- DMA 0 transfers --- Destination (RAM)

Source (RAM) --- DMA 1 transfers --- Destination (ADC SC1)

Automatic scan for 16-bit SAR ADC
## DMA: Minor Loop Channel Linking Example

<table>
<thead>
<tr>
<th>NBYTES</th>
<th>Minor Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA Request Ch1→</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CITER = 3</td>
</tr>
<tr>
<td>3</td>
<td>Major Loop</td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DMA Request Ch1→</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CITER = 2</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DMA Request Ch1→</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CITER = 1</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

### DMA Request Ch2→
- DMA Request Ch2→
- DMA Request Ch2→
- DMA Request Ch2→
DMA: Major Loop Channel Linking Example

<table>
<thead>
<tr>
<th>NBYTES</th>
<th>Minor Loop</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMA Request Ch1-&gt;</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CITER = 3</td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DMA Request Ch1-&gt;</td>
<td>CITER = 2</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DMA Request Ch1-&gt;</td>
<td>CITER = 1</td>
</tr>
<tr>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>DMA Request Ch2-&gt;</td>
<td></td>
</tr>
</tbody>
</table>
V.D.E. Approved IEC60730 Class B safety s/w routines from Freescale

"All pieces have been certified by VDE to help accelerate manufacturer development of Automatic Control"
KV MOTOR DEMONSTRATIONS
Kinetis V Series: KV5x Quadcopter Demo
New FSL ESC Module (KV5x MCU & GD3000 Motor Driver IC)

- **1x KV5x MCU** driving all 4 motors using 6-step BLDC open loop control algorithm
  Replaces **4x 8-bit MCUs!!**
- KV4x (Cortex-M4) design also available
- **4x MC34GD3000 motor pre-drivers** - existing MC34937A in 56QFN, 8x8mm
  Replaces **24 transistors!!**
- KV5x ESC design could be expanded to include
  - FOC algorithm…for quieter motor operation e.g. filming applications
  - ‘NAZA’ Flight Stability Controller using FSL GYRO
AN4935-- PMSM Sensorless FOC for a Fan Using the Kinetis KV10
By leveraging Kinetis MCUs(KV10), the Haiku® with SenseME™ ceiling fan is able to detect changes in a room’s temperature, humidity and occupancy and automatically adjusts speed, LED lighting to meet them.
MOTOR CONTROL ENABLEMENT HARDWARE
Low Cost Reference Platforms: Hardware + Software
BLDC & PMSM

Complete Reference Design

FRDM-KV31F
FRDM-KV10Z

FRDM-MC-LVPMSM:
- PMSM (Sinusoidal) control
- 24V, 5Amp, 120W

FRDM-MC-LVBLDC:
- BLDC (Trapezoidal) control
- 12V, 5Amp, 60W

FRDM-MC-LVMTR:
- 4000RPM, 90W

Or Your Motor
Tower Reference Platform: Hardware + Software

BLDC & PMSM

TWR Reference Design

TWR-KV11Z75M
TWR-KV31F120M
TWR-KV46F150M
TWR-KV58F220M

TWR-ELEV

TWR-MC-LV3PH
- PMSM (Sinusoidal) &
- BLDC (Trapezoidal) control
- Includes Linix 4000RPM Motor
High Voltage Reference Platform: Hardware + Software
ACIM, BLDC & PMSM

HVP-MC3PH
- includes HVP-KV46F150M card
- 85/230 volt,
- 1KW 3-ph motor control inverter w/ PFC circuitry

Controller Card
- HVP-KV10Z32
- HVP-KV11Z75M
- HVP-KV31F120M
- HVP-KV58F

Your HV motor
Block Diagram
### S/w Enablement Guide

<table>
<thead>
<tr>
<th>Software</th>
<th>Description</th>
<th>Cost</th>
<th>Supported Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>MCAT</strong> (Motor Control Application Tuner)</td>
<td>GUI based FreeMASTER plug-in tool that provides real-time monitoring, tuning and updating of motor control system parameters. Provided as a plug-in for the FreeMASTER tool. Designed to work with FSL Ref. Design s/w.</td>
<td><strong>Cost: free of charge</strong></td>
<td>KV1x, KV3x, KV4x, KV5x</td>
</tr>
<tr>
<td><strong>FreeMASTER</strong></td>
<td>Complimentary GUI based run-time debug monitor and data visualization tool. Replaces debugger in situations when the core can not be simply stopped, ideal for motor control and power conversion application development.</td>
<td><strong>Cost: free of charge</strong></td>
<td>KV1x, KV3x, KV4x, KV5x</td>
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<tr>
<td><strong>Motor Control Toolbox</strong></td>
<td>MATLAB™/Simulink™ modelling environment motor control plug-in tool for automatic code generation. Supports multiple compilers. FreeMASTER compatible.</td>
<td>Cost: $8K license cost</td>
<td>KV1x, KV3x, KV4x, KV5x</td>
</tr>
<tr>
<td><strong>POWERSIM Motor Control Design Suite</strong></td>
<td>Low cost Simulation software specifically designed for power electronics and motor drives.</td>
<td>Cost: $700 (1st license)</td>
<td>KV3x (Now), Others to follow</td>
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## Motor Control Reference Solutions

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<td>Appliances</td>
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<td>TWR HVP</td>
<td>IoT Motor Control</td>
<td>Now – Contact Marketing</td>
<td>NA</td>
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</table>

Our reference designs are easily accessible via: [nxp.com/nxpdesigns](http://nxp.com/nxpdesigns)
Motor Control needs a PhD!

Too Hard to Tune! - I can never get the right level of performance
Too Hard to Debug! - When I have a problem its difficult to resolve
Takes Too Long! - PID tuning takes months to get right
Needs Special Expertise! - Need a motor control expert

Even after I have done all that, it Still Doesn’t Work Right!

Motor Control is difficult!!
Kinetis Motor Suite (KMS) Graphical User Interface
Spin a motor just in 5 Steps!!

1) Enter your motor's basic information

The default values in the fields below are for the reference motor for this development platform. Overwrite the default values using values found on your motor's nameplate or datasheet.

- Motor Name: Linx 45ZWN24-40
- Rated Speed: 4000 [RPM]
- Rated Current: 2.3 [A rms]
- Rated Voltage (DC): 24 [V]
- Pole Pairs: 2

Click to Update Values
NEW Application Notes & Design Reference Manuals

- DRM144-- Three-Phase BLDC Sensorless Motor Control
- DRM148-- Sensorless PMSM Field-Oriented Motor Control
- AN4911-- 3-Phase PMSM Sensorless FOC Using the MKV31F
- AN4862-- 3-Phase BLDC Sensorless Control Using the MKV10x
- AN4870-- Tuning 3-Phase BLDC Motor Sensorless Control Application Using the MKV10x
- AN5049-- Three-Phase PMSM Sensorless FOC Using the MKV10Z32 with Automated Motor Parameters Identification
- AN4935-- PMSM Sensorless FOC for a Fan Using the Kinetis KV10
- AN4986-- Automated PMSM Parameter Identification
- AN4912-- Tuning 3-Phase PMSM Sensorless Control Application Using MCAT Tool
- AN4680-- PMSM Electrical Parameters Measurement
- AN4642-- Motor Control Application Tuning (MCAT) Tool for 3-Phase PMSM
- KVQRUG-- Kinetis V Series Peripheral Module Quick Reference