Digital AC Drive Control
Freescale solutions for industrial AC drives

Industrial AC drives are used to drive a wide variety of asynchronous or synchronous AC motors. The AC induction motor is a popular choice for industrial automation and OEM machinery applications. Industrial automation covers a wide range of applications including pumps, fans, HVAC, centrifuges, elevators, escalators, test stands, packaging, smart material working and smart baggage handling.

AC drives use different control techniques depending upon the final application. The most common is open loop V/Hz, which is used for low dynamic applications like fans or pumps. High dynamic applications use field oriented control (FOC), which allows for precise motor control under a variety of conditions. Many AC drives are equipped with auto detection of the motor parameters, allowing for sensorless drive operation.

AC drives are available in a wide range of output power, from 250 W (DIN rail mounted) up to several megawatts. Very high-power AC drives usually connect multiple lower power AC drives in parallel.

Beyond AC motor control, industrial drives are equipped with many additional features. Typical features of AC drives include implementation of a programmable logic controller (PLC) as well as on-board or expansion I/O ports. These I/O ports can be used to apply switches, relays and other sensors to the application. The PLC can speed target application development and eliminate complicated wired schemas. Another important feature of AC drives is communication support.

Industrial drives use many types of communication interfaces, including PROFI bus, MODBUS, CANopen, DeviceNet and EtherNet IP.

Application Requirements

MCU requirements for AC drives differ with complexity of the AC drive and position of the isolation barrier. Low-power drives often use dual MCU topology where the MCU on the non-isolated side is responsible for motor control and the isolated MCU handles user interface and I/O signals. This topology is shown in figure 1.

A DSC is often used as a primary controller. The Freescale MC56F80xx, MC56F82xxx, MCF56F84xxx family is well suited for digital motor control, combining the DSP’s calculation capability with the MCU’s controller features on a single chip. These hybrid controllers offer many dedicated peripherals such as pulse width modulation (PWM) modules, analog-to-digital converters (ADC), timers, communication peripherals (SCI, SPI, I²C), and on-board flash and RAM.

Selection of a secondary controller depends on the complexity of the user interface and the amount of I/O signals. A general-purpose MCU is often suitable for simple user interfaces, while an MCU with LCD or VGA controller is often preferred for more advanced applications. Kinetis L and K series MCUs are ideal for these advanced user interface applications.

Kinetis K Series

When AC drives use a single MCU topology, the MCU is located on the non-isolated side, while all I/Os and communication and user interfaces employ galvanic isolation. The Kinetis K series is ideal for AC drives implementing a programmable logic controller, operating system and a wide range of communication interfaces.

Kinetis MCUs are the most scalable low power, mixed-signal ARM®
Cortex™-M4 core-based solutions in the industry. The portfolio consists of seven MCU families with over 200 pin-, peripheral- and software-compatible devices (see figure 2). Each family offers excellent performance, memory and feature scalability with common peripherals, memory maps and packages, providing easy migration both within and between families.

The most suitable family for advanced AC drives is the Kinetis K70 series, with a powerful ARM Cortex-M4 core running at 120/150 MHz. Peripherals include an integrated graphics LCD controller, IEEE® 1588 Ethernet MAC, Full- and High-Speed USB 2.0 On-The-Go with device charger detect capability, hardware encryption and tamper detection capabilities. The K70 is available with 512 KB or 1 MB of flash in 256-pin MBGA packages. Each MCU includes a rich suite of analog, communication, timing and control peripherals, as well as a single precision floating point unit and NAND flash controller. 256-pin versions include an on-chip DRAM controller for system expansion. The K70 also includes peripherals for motor control such as up to four FlexTimers with two or eight PWM outputs, up to four ADC and programmable delay blocks for FTM to ADC synchronization. This set of peripherals allows for the design of powerful and complex AC drives.

### Vybrid Controller Series

For more advanced AC drives, which run operating systems such as Linux®, there are devices from the Vybrid series suitable for such high demands, particularly those in the VF6xx family. The VF6xx family features a heterogeneous dual-core solution that combines ARM Cortex™-A5 and Cortex-M4 cores. The family also features dual USB 2.0 OTG controllers with integrated PHY, dual 10/100 Ethernet controllers with L2 switch, 1.5 MB of on-chip SRAM and a rich suite of communication, connectivity and human-machine interfaces, multiple serial interfaces including UARTs with support for ISO7816 SIM/smart cards, SPI and I²C and dual CAN modules. VF6xx devices can interface to a variety of external peripherals and memories for system expansion and data storage.

These devices allow an application to be split into two parts. The ARM Cortex-M4 core is responsible for real-time control of motor drives, including PLC, while the ARM Cortex-A5 core can run operating systems responsible for rich multimedia.

For more information, visit freescale.com/Kinetis or freescale.com/dsc.

### Figure 2: Kinetis MCU Portfolio

<table>
<thead>
<tr>
<th>Family</th>
<th>Program Flash</th>
<th>Packages</th>
<th>Features</th>
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<tbody>
<tr>
<td>K70 Family</td>
<td>512 KB–1 MB</td>
<td>196–256-pin</td>
<td>Low power, mixed signal, USB, Ethernet, encryption and tamper detect, DDR, graphic LCD</td>
</tr>
<tr>
<td>K6x Family</td>
<td>256 KB–1 MB</td>
<td>100–256-pin</td>
<td>Low power, mixed signal, USB, Ethernet, encryption and tamper detect, DDR</td>
</tr>
<tr>
<td>K50 Family</td>
<td>128–512 KB</td>
<td>64–144-pin</td>
<td>Low power, mixed signal, USB, segment LCD, Ethernet, encryption and tamper detect, operational transimpedance amplifiers</td>
</tr>
<tr>
<td>K40 Family</td>
<td>64–512 KB</td>
<td>64–144-pin</td>
<td>Low power, mixed signal, USB, segment LCD</td>
</tr>
<tr>
<td>K30 Family</td>
<td>64–512 KB</td>
<td>64–144-pin</td>
<td>Low power, mixed signal, segment LCD</td>
</tr>
<tr>
<td>K20 Family</td>
<td>32 KB–1 MB</td>
<td>32–144-pin</td>
<td>Low power, mixed signal, USB</td>
</tr>
<tr>
<td>K10 Family</td>
<td>32 KB–1 MB</td>
<td>32–144-pin</td>
<td>Low power, mixed signal</td>
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How to Reach Us:

Home Page:
freescale.com

Motor Control
Portfolio Information:
freescale.com/motorcontrol

e-mail:
support@freescale.com

USA/Europe or Locations Not Listed:
Freescale Semiconductor
Technical Information Center, CH370
1300 N. Alma School Road
Chandler, Arizona 85224
1-800-521-6274
480-768-2130
support@freescale.com

Europe, Middle East, and Africa:
Freescale Halbleiter Deutschland GmbH
Technical Information Center
Schatzbogen 7
81829 Muenchen, Germany
+49 89 92103 559 (German)
+33 1 69 35 48 48 (French)
support@freescale.com

Japan:
Freescale Semiconductor Japan Ltd.
Headquarters
ARCO Tower 15F
1-8-1, Shimo-Meguro, Meguro-ku,
Tokyo 153-0064, Japan
0120 191014
+81 3 5437 9125
support.japan@freescale.com

Asia/Pacific:
Freescale Semiconductor Hong Kong Ltd.
Technical Information Center
2 Dai King Street
Tai Po Industrial Estate,
Tai Po, N.T., Hong Kong
+800 2666 8080
support.asia@freescale.com

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