• Freescale Vybrid F Series Executive Summary with Highlights

• ARM Cortex Overview

• Freescale Vybrid F Series Deep Dive
  • ARM Cortex-A5 500MHz + ARM Cortex-M4F 167MHz

• Freescale Vybrid F Series Enablement

• Freescale Vybrid Software
Freescale Vybrid Executive Summary
Freescale has the industry’s broadest range of solutions built on ARM® technology for automotive, industrial, consumer and networking applications.
Introducing the **Vybrid Controller Solutions**

**F Series**

**Rich Apps in Real Time**

**Integrated for the First Time**, an ARM® Cortex™-A5 MPU with a Cortex™-M4 microcontroller, sharing a large 1.5 MB on-chip SRAM, secure boot, anti-tamper and encryption engines, and a wide range of communication interfaces.

**Scalable System Performance**, ranging from a single highly-efficient ARM Cortex-A5 core to a dual-core Cortex-A5 + Cortex-M4 MPU – for simple industrial HMI, secure control, energy conversion, integrated connectivity and mobile battery-operated applications.

**Total System Solution**, including application notes, integrated development environment tools, Linux® OS and MQX™ RTOS, Tower System and a rich set of Freescale partner resources.
Vybrid Controller F Series Target Applications

- Industrial HMI
- Secure Control
- Energy Conversion
- Integrated Connectivity
- Mobile Battery Operation

**Industrial HMI**
- XGA or dual SVGA industrial HMI (2D graphics)
- Large or high-quality small appliance
- Portable patient monitor
- Industrial scanner or printer
- Simple vending machine with 2D LCD or segment display

**Secure Control**
- Energy grid protection, e.g. circuit breaker or monitor
- Infrastructure control, e.g. water treatment or gas pipeline
- Building control, e.g. elevator or automated door
- Kiosk with 2D display, e.g. gas pump

**Energy Conversion**
- Motor drive
- Industrial pump or fan
- Power inverter
- Appliance with motors or pumps
- Mobile patient care, e.g. infusion pump or respirator

**Integrated Connectivity**
- Wired and wireless communications protocols
- Energy management hub
- Networked HVAC

**Mobile Battery Operation**
- Industrial vehicle with control & HMI, e.g. tractor, train, ship, heavy equipment
- Service robot
1. If the application uses up to 1.5 MB of on-chip SRAM
   • Eliminates or reduces external DDR memory chips
   • Much lower latency than external DDR or Quad SPI

2. When the VF6xx on-chip ARM Cortex-M4 core replaces external MCU or FPGA
   • Reduces components, PCB area, and power consumption
   • ARM DS-5 tools eases programming of ARM Cortex-A5 and Cortex-M4 cores

3. When system security is important
   • On-chip encryption, secure boot, anti-tamper and anti-clone capability
   • Optional encryption for two 10/100 Ethernet MACs with L2 switch

4. When HMI, video or audio are needed
   • On-chip LCD controller with 2D composition engine and PEG GUI dev platform
   • VF6xx has an on-chip video ADC for direct analog camera input

5. When error-correcting code (ECC) is needed for reliability
   • 8-bit ECC on DDR3; ECC on 512 KB of SRAM, 32-bit ECC on NAND flash
VF6xx - ARM Cortex-A5 (500 MHz) + Cortex-M4 (167 MHz)
Dual SVGA LCD, Camera Interface with Video ADC, Stereo Audio, DDR, Secure Boot, Tamper Detect, Dual USB OTG w/HS PHY, Dual Ethernet, L2 Switch, Dual Quad-SPI, NAND Flash Controller

VF5xx - ARM Cortex-A5 (500 MHz)
SVGA LCD, Camera Interface, Stereo Audio, DDR, Secure Boot, Tamper Detect, Dual USB OTG w/HS PHY, Dual Ethernet, L2 Switch, Dual Quad-SPI, NAND Flash Controller

VF3xx – ARM Cortex-A5 (266 MHz)
WQVGA LCD, Audio, Secure Boot, Tamper Detect, USB OTG w/HS, PHY, Dual Ethernet, L2 Switch, Dual Quad-SPI, NAND Flash Controller

Rich Apps in Real Time
Freescale MQX RTOS

- Modular, expandable development platform for 8/16/32-bit MCUs/MPUs
- Rapid evaluation and prototyping
- Supports a range of MCU and peripheral plug-in boards
- Growing web community www.towergeeks.org

Linux OS

- Full-featured, scalable, optimized, proven RTOS
- Simplifies hardware management
- Streamlines software development
- Reduces development cost and time to market

ARM DS-5

- Timesys LinuxLink supports free BSP for Vybrid Tower System and selected partner boards
- BSP solution integrates latest Linux kernel, drivers, Freescale MQX and ARM DS-5
- Timesys offers expert professional services and custom development

Enables flexible prototyping application development

Comprehensive OS solutions for embedded control, display and connectivity

Eases development on heterogeneous cores
Emcraft Systems Vybird VF6 Starter Kit

- Low cost starter kit for the Freescale Vybird VF6

- Included in the kit:
  - Linux-ready Vybird VF6 System-On-Module (VF6 SOM)
  - Tower-compatible development baseboard (TWR-SOM-BSB) that can be used in USB-powered standalone mode or plugged into the Freescale Tower platform for connectivity with other Tower modules

- Emcraft provides a software distribution for the VF6 SOM:
  - Linux for the Cortex-A5 core
  - MQX for the Cortex-M4 core

Resources: [http://www.emcraft.com/som/vf6](http://www.emcraft.com/som/vf6)
Contact: Kent Meyer
Tel: 760-444-4165
E-mail: kent@emcraft.com
## IYTEC phyCORE-Vybrid System on Module

<table>
<thead>
<tr>
<th>Component</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU</strong></td>
<td>Freescale Vybrid VFxxx Dual Heterogeneous Core ARM® Cortex™-A5 @ 450 MHz (VF5xx, A5 only) ARM® Cortex™-M4 @ 167 MHz (VF6xx, A5+M4)</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>1 MB on-chip SRAM, 512+ MB DDR3, 256 MB+ NAND, 32 MB SPI-NOR, 32KB EEPROM</td>
</tr>
<tr>
<td><strong>Expansion</strong></td>
<td>2x SD/MMC</td>
</tr>
<tr>
<td><strong>Serial</strong></td>
<td>2x RS232, 4x UARTs, 2x CAN, 4 I2C, 4x SPI, 2x QSPI</td>
</tr>
<tr>
<td><strong>USB</strong></td>
<td>2x USB HS 2.0</td>
</tr>
<tr>
<td><strong>Network</strong></td>
<td>2x 10/100 Ethernet with L2 switch, IEEE 1588 PTP for Real-Time Ethernet</td>
</tr>
<tr>
<td><strong>Multimedia</strong></td>
<td>Video/Camera Interface Unit with optional OpenVG, Audio CODEC Audio (SAI, I2S, AC97, ESAI, SPDIF)</td>
</tr>
<tr>
<td><strong>Display</strong></td>
<td>Dual Display with support for color TFT up to SVGA. Resistive Touch Controller</td>
</tr>
<tr>
<td><strong>Mechanical Specifications</strong></td>
<td>41 x 51m</td>
</tr>
<tr>
<td><strong>Software</strong></td>
<td>Linux (Now), MQX (March 2013)</td>
</tr>
</tbody>
</table>

Kit Contents:

- SOM: PCM-052
- Carrier Board: PCM-952
- SD Card with software demo
- Cables, power supply, documentation
- 7” VGA LCD (optional)
- Bare PCB for prototyping (optional)

Tools/BSPs:

- Free Linux (kernel 3.3.9) BSP
- Free Freescale MQX™ BSP
- Free Timesys LinuxLink Pro subscription
- Free ARM Development Suite (DS-5™)
Complete, Compact CPU Module

- Vybrid VF5xx/VF6xx SoC, DDR3 RAM, NAND flash, Power Supply and Dual Ethernet
- Choice of form-factor: high-density connectors, SO-DIMM or surface-mount LGA
- Designed for environmentally demanding applications

Rich Applications AND Low Power

- ARM® Cortex™-A5 processor up to 500MHz
- Accelerated graphics for rich user interfaces
- Connectivity includes dual Ethernet PHY
- ARM® Cortex™-M4 core allows partitioning of I/O processing, enabling lower device power consumption

Rapid Design

- Production ready solution
- Development Kit provides quick prototyping and software development
- OS support includes Linux, MQX and .NET Micro Framework
Summary

Vybrid controllers deliver many cost saving features integrated with ARM Cortex technology for applications requiring secure real-time control and connectivity.

 Vybrid offers development platforms, tools and expert partners to go from concept to market faster and easier.

Drive rugged industrial solutions with long life and reliability through a portfolio of products that optimize applications processing and real-time control features.

With these devices, Freescale takes a commanding lead in creating the industry’s most comprehensive portfolio built on the ARM architecture.

Rich Apps in Real Time
ARM Overview
The ARM Cortex™ Processor Family

**Cortex™-A**
- servers
- set top boxes
- netbooks
- mobile applications

**Cortex™-R**
- disk drives
- digital cameras
- mobile baseband

**Cortex™-M**
- appliances
- motors
- audio
<table>
<thead>
<tr>
<th></th>
<th>ARM9</th>
<th>ARM11</th>
<th>Cortex-A5</th>
<th>Cortex-A8</th>
<th>Cortex-A9</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Architecture</strong></td>
<td>ARMV5</td>
<td>ARMV6</td>
<td>ARMv7 + MP</td>
<td>ARMv7</td>
<td>ARMv7 + MP</td>
</tr>
<tr>
<td><strong>Multi-Core Capable</strong></td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td><strong>Pipeline and Machine</strong></td>
<td>5-stage</td>
<td>8-stage</td>
<td>8-stage, Single issue, In-Order</td>
<td>13-stage, Dual Issue, in-order</td>
<td>8-Stage, Dual issue, Out of Order</td>
</tr>
<tr>
<td><strong>Frequency Range (40nm)</strong></td>
<td>366MHz</td>
<td>483MHz</td>
<td>300-950+MHz</td>
<td>600-2000 MHz</td>
<td>600-1900+ MHz</td>
</tr>
<tr>
<td><strong>Power Efficiency (DMIPS/mW)</strong></td>
<td>4.5</td>
<td>3.9</td>
<td>14.4</td>
<td>4</td>
<td>8</td>
</tr>
<tr>
<td><strong>DMIPS/MHz</strong></td>
<td>1.1</td>
<td>1.26</td>
<td>1.6 per CPU</td>
<td>2.0</td>
<td>2.5 per CPU</td>
</tr>
</tbody>
</table>
Forget traditional 8/16/32-bit classifications

- Seamless architecture across all applications
- Every product optimized for ease of use

Cortex-M0

“8/16-bit” applications

Cortex-M3

“16/32-bit” applications

Cortex-M4

“32-bit/DSC” applications

Binary and Tool Compatibility
SIMD extensions perform multiple operations in one cycle

\[ \text{Sum} = \text{Sum} + (A \times C) + (B \times D) \]

SIMD techniques operate with packed data

- 32-bit
- 64-bit
Freescale Vybrid F Series
# Vybrid F Series Feature Summary

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<th>Common Platform, Analog and Digital</th>
<th>Features Options</th>
<th>Tools</th>
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<tr>
<td>I²C</td>
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<tr>
<td>CRC</td>
<td></td>
<td></td>
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<tr>
<td>Programmable Delay Block</td>
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<tr>
<td>Flash Controller</td>
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<tr>
<td>USARTS</td>
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<tr>
<td>Low Voltage, Low Power</td>
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</tr>
<tr>
<td>Multiple Operating Modes, Clock Gating (1.71 to 3.6V)</td>
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<tr>
<td>ESAI</td>
<td></td>
<td></td>
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<tr>
<td>12-bit ADC</td>
<td>DDR</td>
<td>Bundled IDE</td>
</tr>
<tr>
<td>12-bit DAC</td>
<td>Camera Interface</td>
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<tr>
<td>Secure JTAG</td>
<td>Video ADC</td>
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</tr>
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<td>Secure Fuses</td>
<td>USB Host w/PHY</td>
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<td>Timers</td>
<td>USB OTG w/PHY</td>
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<tr>
<td>Secure RAM</td>
<td>Segment LCD</td>
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<tr>
<td>eSDHC</td>
<td>TFT LCD (w/ touch screen)</td>
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<tr>
<td>UARTS</td>
<td>Ethernet Controller</td>
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<tr>
<td>DMA</td>
<td>L2 Switch</td>
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<tr>
<td>SRAM</td>
<td>Security (HAB, Tamper Det)</td>
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<tr>
<td></td>
<td>External Bus</td>
<td></td>
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<tr>
<td>FAMILY</td>
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<td><strong>VF6xx</strong> [Heterogeneous Dual Core]</td>
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<td>Cortex A5 up to 500 MHz</td>
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<td></td>
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<tr>
<td>Cortex M4 up to 167 MHz</td>
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<td></td>
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<tr>
<td>Up to 1.5 MB SRAM</td>
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<td></td>
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<tr>
<td>364-pin MAPBGA</td>
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<tr>
<td><strong>VF5xx</strong></td>
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<tr>
<td>364-pin MAPBGA</td>
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<td><strong>VF3xx</strong></td>
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<tr>
<td>Cortex A5 up to 266 MHz</td>
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<tr>
<td>Up to 1.5 MB SRAM</td>
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<tr>
<td>176-pin LQFP</td>
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## Vybrid F Series Feature Options (part 2)

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<th>Family</th>
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<th>Camera Interface</th>
<th>Video ADC</th>
<th>USB Host w/PHY</th>
<th>USB OTG w/PHY</th>
<th>Segment LCD (w/ touch screen)</th>
<th>Ethernet Controller</th>
<th>L2 Switch</th>
<th>Security (HAB, Tamper Det)</th>
<th>External Bus</th>
</tr>
</thead>
</table>
| **VF6xx [Heterogeneous Dual Core]**  
Cortex A5 up to 500 MHz  
Cortex M4 up to 167 MHz  
Up to 1.5MB SRAM  
364-pin MAPBGA          | Y   | Y                | Y         | 2              | Y             | 2                           | 2                   | Y         | Y                          | Y            |
| **VF5xx**  
Cortex A5 up to 500 MHz  
Up to 1.5 MB SRAM  
364-pin MAPBGA          | Y   | Y                | 2         | Y              | 2             | 2                           | Y                   | Y         | Y                          | Y            |
| **VF3xx**  
Cortex A5 up to 266 MHz  
Up to 1.5 MB SRAM  
176-pin LQFP            |     |                   |           | 1              | Y             | Y                           | 1                   | 2         | Y                          | Y            |
### Core
Up to 266 MHz ARM Cortex-A5 with TrustZone

### Memory
- 32 KB I and D L1 Cache
- 1.5 MB SRAM (ECC support on 512KB)
- NAND flash controller with 32-bit ECC
- Dual Quad SPI Interface

### Analog
- 2 x 12-bit ADC (12-ch), 2 x 12-bit DAC

### Communication
- 4 x UART, 2 x CAN, 3 X SPI, 2 X I2C
- 2 x 10/100 Ethernet MAC with IEEE 1588 and L2 Switch
- USB2.0 OTG with PHY

### Audio
- 3 x SAI for full-duplex serial interfaces like I2S, AC97 Enhanced serial audio interface (ESAI)

### Display and Video
- TFT LCD up to WVGA
- Segment LCD
- Video Interface unit with parallel camera interface

### Security (optional)
- Tamper detect, high assurance boot
- Cryptographic accelerators
- True Random Number Generator (RNG)

### Power Management and Package
- Internal regulator (PMIC)
- 176-pin LQFP
- Industrial Qualification (-40 to +85C)

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<thead>
<tr>
<th>Debug and Trace</th>
<th>System</th>
<th>Core</th>
<th>Analog</th>
</tr>
</thead>
<tbody>
<tr>
<td>JTAG</td>
<td>AMBA NIC</td>
<td>ARM Cortex™-A5 Up to 266 MHz</td>
<td></td>
</tr>
<tr>
<td>Trace</td>
<td>Internal and External Watchdog</td>
<td>DP-FPU</td>
<td></td>
</tr>
<tr>
<td>Timers</td>
<td>Interrupt Router</td>
<td>NEON</td>
<td></td>
</tr>
<tr>
<td>Flex Timer (8-ch)</td>
<td>DMA Up to 64-ch</td>
<td>L1 I/D-Cache</td>
<td></td>
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<tr>
<td>Flex Timer (2-ch)</td>
<td>Power Management Regulators</td>
<td>Trace / Debug</td>
<td></td>
</tr>
<tr>
<td>Flex Timer (2-ch)</td>
<td>Memory Protection Unit</td>
<td>GIC</td>
<td></td>
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<tr>
<td>IEEE 1588 Timers</td>
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<td></td>
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<tr>
<td>Periodic Interrupt</td>
<td></td>
<td></td>
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<tr>
<td>Low Power Timers</td>
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<table>
<thead>
<tr>
<th>Memory</th>
<th>Display &amp; Video</th>
<th>Security (Optional)</th>
<th>Communications</th>
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<tbody>
<tr>
<td>Boot ROM</td>
<td>TFT LCD</td>
<td>Cryptography Module</td>
<td></td>
</tr>
<tr>
<td>1.5 MB SRAM</td>
<td>Segment LCD</td>
<td>Tamper Detect</td>
<td></td>
</tr>
<tr>
<td>Memory Interfaces</td>
<td>Digital Video Camera Interface</td>
<td>Secure RTC</td>
<td></td>
</tr>
<tr>
<td>NAND Flash Controller</td>
<td></td>
<td>Secure RTIC</td>
<td></td>
</tr>
<tr>
<td>2 x Quad SPI with XIP</td>
<td></td>
<td>Secure RAM</td>
<td></td>
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<tr>
<td>External Bus Interface</td>
<td></td>
<td>Secure Fuses</td>
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<td></td>
<td></td>
<td>Secure WDOG</td>
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<td>Secure JTAG</td>
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<tr>
<td>Audio</td>
<td></td>
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</tr>
<tr>
<td>ASRC</td>
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<tr>
<td>3 x SAI</td>
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<tbody>
<tr>
<td>Clock Monitors</td>
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<tr>
<td>Internal Reference Clocks</td>
</tr>
<tr>
<td>Low / High Frequency Osc.</td>
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<table>
<thead>
<tr>
<th>Analogs</th>
</tr>
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<tbody>
<tr>
<td>2 x 12-bit ADC</td>
</tr>
<tr>
<td>2 x 12-bit DAC</td>
</tr>
<tr>
<td>PLL</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Communications</th>
</tr>
</thead>
<tbody>
<tr>
<td>4 x UART</td>
</tr>
<tr>
<td>3 x SPI</td>
</tr>
<tr>
<td>2 x Ethernet (10/100) With IEEE 1588</td>
</tr>
<tr>
<td>L2 Switch</td>
</tr>
<tr>
<td>1 x USB OTG + PHY</td>
</tr>
<tr>
<td>1 x Secure Digital I/O</td>
</tr>
<tr>
<td>Up to 115 GPIO (with Interrupt)</td>
</tr>
</tbody>
</table>
**Core**
Up to 500MHz ARM™ Cortex-A5 with TrustZone

**Memory**
32KB I and D L1 Cache
1.5MB SRAM with no L2 Cache, or,
1MB SRAM with 512KB of L2 Cache (Optional)
ECC support on 512KB SRAM
LPDDR2/DDR3 DRAM controller (8/16-bit ECC)
NAND Flash Controller with 32-bit ECC
Dual Quad SPI Interface

**Analog**
2 x 12-bit ADC(16-Ch), 2 x 12-bit DAC

**Communication**
6 x UART, 2 x CAN, 4 x SPI, 4 x I2C
2 x 10/100 Ethernet MAC with IEEE 1588 and L2 Switch
Dual USB2.0 HOST and OTG with PHY

**Audio**
4 x SAI for full-duplex serial interfaces like I2S, AC97
ESAI – Enhanced Serial Audio Interface
SPDIF

**Display and Video**
Dual TFT LCD up to SVGA resolution
Video Interface unit with parallel camera interface

**Security (optional)**
Secure boot and tamper detection
Cryptographic accelerators
True Random Number Generator (RNG)

**Power Management and Package**
Internal regulator (PMIC)
17x17 0.8mm pitch 364-pin MAPBGA
Industrial Qualification (-40 to 85C)

---

**Debug and Trace**
- JTAG
- Trace

**Timers**
- Flex Timer (8-ch)
- Flex Timer (2-ch)
- Flex Timer (2-ch)
- Flex Timer (8-ch)
- IEEE 1588 Timers
- Periodic Interrupt
- Low Power Interrupts

**Memory**
- Boot ROM
- Up to 1.5 MB SRAM

**Display & Video**
- TFT LCD
- Digital Video Camera Interface

**Memory Interfaces**
- DRAM Controller (LPDDR2 / DDR3)
- NAND Flash Controller
- 2 x Quad SPI with XIP
- External Bus Interface

**Security (Optional)**
- Cryptography Module
- Tamper Detect
- Secure RTC
- Secure RTIC
- Secure RAM
- Secure Fuses
- Secure WDOG
- Secure JTAG

**Audio**
- ASRC
- 4 x SAI
- ESI
- SPDIF

**Communication**
- 6 x UART
- 4 x I2C
- 2 x Ethernet (10/100) With IEEE 1588
- L2 Switch
- 2 x USB OTG + PHY
- 2 x Secure Digital I/O
- Up to 135 GPIO (with Interrupt)
Cores
Up to 500MHz ARM™ Cortex-A5 with TrustZone
Up to 167MHz ARM™ Cortex-M4

Memory
32KB I and D L1 Cache for A5, 16KB I and D for M4
1.5MB SRAM with no L2 Cache, or
1MB SRAM with 512KB of L2 Cache (Optional)
ECC support on 512KB SRAM
64KB TCM for M4
LPDDR2/DDR3 DRAM controller (8-bit ECC)
NAND Flash Controller (32-bit ECC)
Dual Quad SPI Interface

Analog
2 x 12-bit ADC (16-Ch), 2 x 12-bit DAC

Communication
6 x UART, 2 x CAN, 4 x SPI, 4 x I2C
2 x 10/100 Ethernet MAC with IEEE1588 and L2 Switch
Dual USB2.0 HOST and OTG with PHY

Audio
4 x SAI for full-duplex serial interfaces like I2S, AC97
ESAI – Enhanced Serial Audio Interface
SPDIF

Display and Video
Dual TFT LCD up to SVGA resolution
Digital and Analog Video Camera Interface

Security (Optional)
Secure boot and tamper detection
Cryptographic accelerators
True Random Number Generator (RNG)

Power Management and Package
Internal regulator (PMIC)
17x17 0.8mm pitch 364-pin MAPBGA
Industrial Qualification (-40 to +85C)

Changes from previous family
# Hybrid Controller F Series Key Feature Details

<table>
<thead>
<tr>
<th>Feature</th>
<th>VF3xx - LQFP176</th>
<th>VF5xx, VF6xx - BGA364, 17 x 17, 0.8mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>266 MHz ARM Cortex-A5</td>
<td>400 – 500 MHz ARM Cortex-A5 (628 DMIPS) and optional 166 MHz Cortex-M4 (208 DMIPS)</td>
</tr>
<tr>
<td>On-chip SRAM</td>
<td>1.5 MB (512 KB with ECC)</td>
<td>1.5 MB (512 KB with ECC), or 1MB + 512K L2 cache</td>
</tr>
<tr>
<td>Serial Flash interface</td>
<td>Dual DDR QuadSPI</td>
<td>Dual DDR QuadSPI</td>
</tr>
<tr>
<td>NAND Flash Controller</td>
<td>Yes (8-bit) up to 32-bit HW ECC</td>
<td>Yes (16-bit) up to 32-bit HW ECC</td>
</tr>
<tr>
<td>External FlexBus interface</td>
<td>Yes (addr / data mux’d)</td>
<td>Yes, (addr / data mux’d plus 8-bit dedicated data)</td>
</tr>
<tr>
<td>DRAM interface</td>
<td>No</td>
<td>16-bit LPDDR2/DDR3 , 400 MHz, 8/16-bit ECC</td>
</tr>
<tr>
<td>Display interface</td>
<td>WQVGA with 24-bit RGB and 40x4 Segmented LCD</td>
<td>1x TFT (up to XGA), OR 2x TFT up to SVGA</td>
</tr>
<tr>
<td>Video ADC / Camera input</td>
<td>1x Composite 24-bit parallel digital</td>
<td>2x Composite 24-bit parallel digital or analog</td>
</tr>
<tr>
<td>10/100 Enet w/ IEEE 1588</td>
<td>2 with L2 switch</td>
<td>2 with L2 switch</td>
</tr>
<tr>
<td>Analog</td>
<td>2 x 12-bit ADC (12-ch), 2 x 12-bit DAC</td>
<td>2 x 12-bit ADC (12-ch), 2 x 12-bit DAC</td>
</tr>
<tr>
<td>USB</td>
<td>1x USB OTG HS with PHY</td>
<td>2x USB OTG HS with PHY</td>
</tr>
<tr>
<td>Audio interface</td>
<td>SAI x3 (i2s x3), ESAI x1 (2 Tx, 4 Tx or Rx)</td>
<td>SAI x4 (i2s x4), ESAI x1 (2 Tx, 4 Tx or Rx)</td>
</tr>
<tr>
<td>UART, DSPI, I2C</td>
<td>4, 3, 2</td>
<td>6, 4, 4</td>
</tr>
<tr>
<td>SD/MMC interface</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>CAN</td>
<td>2x FlexCAN</td>
<td>2x FlexCAN</td>
</tr>
<tr>
<td>GPIO</td>
<td>Up to 115</td>
<td>Up to 135</td>
</tr>
</tbody>
</table>
### Hybrid Controller F Series Part Numbering (April 2013)

<table>
<thead>
<tr>
<th>Production Part Number*</th>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MVF30NN151CKU26</td>
<td>LQFP-EP 176 24<em>24</em>1.6</td>
<td>A5-266, No Security, 176LQFP</td>
</tr>
<tr>
<td>MVF30NS151CKU26</td>
<td>LQFP-EP 176 24<em>24</em>1.6</td>
<td>A5-266, Security, 176LQFP</td>
</tr>
<tr>
<td>MVF50NN151CMK40</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-400, No Security, 364BGA</td>
</tr>
<tr>
<td>MVF50NS151CMK40</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-400, Security, 364BGA</td>
</tr>
<tr>
<td>MVF50NN151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, No Security, 364BGA</td>
</tr>
<tr>
<td>MVF50NS151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, Security, 364BGA</td>
</tr>
<tr>
<td>MVF51NN151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, L2 Cache, No Security, 364BGA</td>
</tr>
<tr>
<td>MVF51NS151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, L2 Cache, Security, 364BGA</td>
</tr>
<tr>
<td>MVF60NN151CMK40</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-400, M4, No Security, 364BGA</td>
</tr>
<tr>
<td>MVF60NS151CMK40</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-400, M4, Security, 364BGA</td>
</tr>
<tr>
<td>MVF60NN151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, M4, No Security, 364BGA</td>
</tr>
<tr>
<td>MVF60NS151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, M4, Security, 364BGA</td>
</tr>
<tr>
<td>MVF61NN151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, M4, L2 Cache, No Security, 364BGA</td>
</tr>
<tr>
<td>MVF61NS151CMK50</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-500, M4, L2 Cache, Security, 364BGA</td>
</tr>
<tr>
<td>MVF62NN151CMK40</td>
<td>MAP 364 17<em>17</em>1.5 P0.8</td>
<td>A5-400, M4 Primary, No Security, 364BGA</td>
</tr>
</tbody>
</table>

**Tower Systems:**

- **$199 TWR-VF65GS10 Tower System Module**
- **$269 TWR-VF65GS10-KIT (Includes TWR-SER, TWR-ELEV)**
- **$399 TWR-VF65GS10-PRO (Includes TWR-SER2, TWR-LCD-RGB, TWR-ELEV)**
- **$1500 TWR-VF65GS10-DS5 (Includes TWR-SER2, TWR-LCD-RGB, TWR-ELEV+ DS5 License)**

[Freescale Buy Direct]
Vybrid Differentiator: Connectivity

**Real-time Ethernet**
- Dual 10/100 Ethernet with IEEE® 1588 time stamping
- 2-port Ethernet L2 switch
- EtherNet/IP CIP Sync
  - Device Level Ring (DLR) (to be confirmed)
- PROFINET RT
  - Not PROFINET IRT
- EtherCAT master
  - EtherCAT slave needs ASIC
- Modbus TCP
- BACnet
- POWERLINK (to be confirmed)

**Wireless**
- Connect wireless transceivers through SPI interface and run protocol from large on-chip SRAM
  - ZigBee®
  - Wi-Fi®
  - Wireless M-Bus
  - Z-Wave
  - And others

**Fieldbus Protocols**
- Modbus RTU (RS485)
- CANopen (CAN)
- DeviceNet (CAN)
- IO-Link (UART)
## Hybrid Power Modes

<table>
<thead>
<tr>
<th>Modes</th>
<th>General Description</th>
<th>Current Consumption (mA)</th>
<th>Normal Recovery Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN</td>
<td>All functionality is available</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>WAIT</td>
<td>CA5 and CM4 cores Halted</td>
<td></td>
<td>Interrupt</td>
</tr>
<tr>
<td>LPRUN</td>
<td>24 MHz operation, PLL bypass</td>
<td></td>
<td>Interrupt</td>
</tr>
<tr>
<td>ULPRUN</td>
<td>32 kHz/128 kHz operation, PLL Off</td>
<td></td>
<td>Interrupt</td>
</tr>
<tr>
<td>STOP</td>
<td>Lowest power mode with all power retained, RAM retention and LVD protection</td>
<td>5-6 mA</td>
<td>Interrupt</td>
</tr>
<tr>
<td>LPSTOP3</td>
<td>64K RAM retention. I/O states held. ADCs/DACs optionally power-gated. RTC functional. Wakeup from interrupts</td>
<td>80-100uA</td>
<td>Wakeup/Reset</td>
</tr>
<tr>
<td>LPSTOP2</td>
<td>16K RAM retention. I/O states held. ADCs/DACs optionally power-gated. RTC functional. Wakeup from interrupt</td>
<td>40-45 uA</td>
<td>Wakeup/Reset</td>
</tr>
<tr>
<td>LPSTOP1</td>
<td>I/O states held. ADCs/DACs optionally power gated. RTC functional. Wakeup from interrupts</td>
<td>35-40 uA</td>
<td>Wakeup/Reset</td>
</tr>
<tr>
<td>Battery Backup</td>
<td>All supplies OFF, SRTC, 32kXOSC ON, tampers and monitors ON.</td>
<td>8uA</td>
<td>POR</td>
</tr>
</tbody>
</table>
## Hybrid Power Modes

### Typical Power Modes in an embedded system

<table>
<thead>
<tr>
<th>Mode</th>
<th>Recovery Time</th>
<th>(\text{“Typical” Idd Range} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Run</td>
<td>-</td>
<td>(&lt; 320, \mu\text{A/MHz})</td>
</tr>
<tr>
<td>Wait</td>
<td>30 , \mu\text{s}</td>
<td>80-25 , \text{mA}</td>
</tr>
<tr>
<td>Stop</td>
<td>300 , \mu\text{s}</td>
<td>8-10 , \text{mA}</td>
</tr>
<tr>
<td>DeepSleep</td>
<td>N/A</td>
<td>7-8 , \text{uA}</td>
</tr>
</tbody>
</table>

### Vybrid Extended Power Modes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Recovery Time</th>
<th>(\text{“Typical” Idd Range} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>RUN</td>
<td>-</td>
<td>(&lt; 320, \mu\text{A/MHz})</td>
</tr>
<tr>
<td>LPRUN</td>
<td>-</td>
<td>20-25 , \text{mA}</td>
</tr>
<tr>
<td>ULPRUN</td>
<td>-</td>
<td>8-10 , \text{mA}</td>
</tr>
<tr>
<td>LPSTOP3</td>
<td>300 , \mu\text{s}</td>
<td>80-100 , \text{uA}</td>
</tr>
<tr>
<td>LPSTOP2</td>
<td>300 , \mu\text{s}</td>
<td>40-45 , \text{uA}</td>
</tr>
<tr>
<td>LPSTOP1</td>
<td>300 , \mu\text{s}</td>
<td>35-40 , \text{uA}</td>
</tr>
<tr>
<td>VBAT</td>
<td>N/A</td>
<td>7-8 , \text{uA}</td>
</tr>
</tbody>
</table>

### Power Gate modes with Wakeup capability

- Enables complete shut-down of core logic, including WKUP, further reducing leakage currents in all low power modes
- Supports 16 external input pins and 8 internal modules as wakeup sources
- Wakeup inputs are activated in LPSTOP modes
2D Advanced Composition Engine (2D-ACE)
• Resolutions supporting up to XGA (1024x768)
• Supports full RGB888 for TFT display
• Alpha-blending, Gamma Correction and Temporal dithering
• Support for up to 64 layers, 6 blended
• Impressive 2D graphics acceleration

Audio Subsystem – SAI, ESAI, ASRC and SPDIF

Video Interface (VIU)
• Supports QVGA to XGA
• 8/10 bit ITU656 video
• Up to 24 bits digital RGB
• Video up-scaling and down-scaling
• Brightness and contrast adjustment
• YUV to RGB888 or RGB565 conversion
• De-interlace function

Integrated Video ADC (VF6xx only)
• Supports direct analog Video input (NTSC/PAL)
• Up to 4 Video Inputs
splay Controller (2D-ACE) with Composition Engine

 Vybrid 2D-ACE support

- Color conv pre blend. RLE exp. 32bpp
- Animate. Alpha, Pos, Obj ...
- Blend Color key 6 planes
- Dither. Gamma corr CRC check

- Pipelined operation up to 90 MHz pixel clock
- Memory size optimized
- Per object animation frame rate
## Hybrid Controller 2D-ACE Color conversion

<table>
<thead>
<tr>
<th>Object color format</th>
<th>Notes</th>
</tr>
</thead>
</table>
| **Indexed** (RGBA8888 CLUT) | • **YUV4:2:2** (YCbCr422)  
  .. Programmable coefficient  
• **RLE**  
  .. 8,16,32bpp expansion  
• **A4, A8**  
  .. Pre blend with fore and back color  
• **LO4, LO8**  
  .. Luminance offset, pre-blend alpha  
• **APAL88**  
  .. Indexed 8bpp + 8bpp alpha  |
| **Direct** |  |
| **Special** |  |
| **RGB8888** |  |
| **ARGB8888** |  |
| **YUV4:2:2** |  |
| **A4, A8** |  |
| **LO4, LO8** |  |
| **RLE** |  |
Size, ex. Pop up
Position, ex. Fly in out
Alpha, ex. Fade in / out
Color, ex. Text/icon state
Color Key, ex. Dynamic reveal hide
CLUT, ex. Segment pixel group color, hide, reveal
Image, ex. Image sequence animation
Vertical Scroll, ex. List scroll
• Dual QuadSPI architecture supports:
  • 2 external Serial Flashes per QuadSPI module
  • Up to 104 MHz SDR and Up to 80 MHz DDR Serial Flash
  • Programmable Sequence Engine for compatibility to any Serial flash
  • XIP (Execute-In-Place)
  • Supports up to 4 chip selects

• QuadSPI can control 2 x 4-bit serial flashes:
  – Individual Flash mode
  – Parallel mode enabling ‘octal flash’ with data recombination internally in QuadSPI – READING ONLY

• Up to 80 MHz clock (160 MByte/sec peak bandwidth)

• Flexible Receive (RX) Buffering Scheme:
  – Sub-buffers allocated to specific masters.
  – Master prioritisation
  – Pre-fetch capability
  – Suspend & resume for lower priority masters
Hybrid Differentiator: Security

- **Hardware security accelerators**
  - Secure boot
  - Cryptographic accelerators
  - Tamper detection

- **Hardware-supported security features:**
  - Secure High Assurance Boot
  - AES, DES/3DES, SHA-1, SHA-224, SHA-256
  - Run-time Integrity Checker and Security Controller (incl. Secure RAM and Security Monitor)
  - Random Number Generator (NIST SP 800-90)
  - Secure JTAG Controller (with electrical fuses)
  - Secure real-time clock
  - Universal Unique ID
  - Tamper Detection
  - ARM TrustZone
**Vybrid DDR3 Interface Overview**

- Vybrid DDR3 supports up to 400MHz operation (800MT)

- Single 16-bit DDR3 memory chip placed externally.
  - Up to 16Gbit (2GB)

  - 2 Data Lanes
    - Lane 0: D0-D7, DQM0, DQS0/DQS0_B
    - Lane 1: D8-D15, DQM1, DQS1/DQS1_B

  - Address + Command + Control Signals
    - A0-A15
    - BA0-BA2, RAS, CAS, WE
    - CS, ODT, CKE
    - CLK/CLK_B

![Diagram of Vybrid DDR3 Interface](image)
At 400MHz, the DDR3 interface is one of the fastest and most critical interfaces for chip routing on Vybrid.
  - Data is latched on both the rising AND falling edges.

Simple ‘connect-the-dots’ does not work.
  - At these speeds the traces are considered transmission lines.

We must incorporate PCB controlled impedances.

We must simulate the design.
• General Rule for Vybird DDR3:
  – All DDR3 Single Ended Traces = 50Ω
  – All DDR3 Differential Signals = 100Ω
  – These are not resistors.
  – These are “characteristic impedances” of transmission lines.
    • mostly to do with the capacitance and inductance per unit length of the trace.
      – Has negligible effect at low frequencies.
      – Extremely important at high frequencies.
Vybrid Controller F Series Use-Cases
**Industrial Control with Display**

**ARM Cortex-A5**
- High Level OS i.e. Linux
- Human machine interfaces
  - Display, camera, keypad
- Connectivity
  - Ethernet, WiFi, USB
- Security
  - TrustZone, secure boot, encryption

**ARM Cortex-M4**
- Real-Time OS i.e. MQX
  - Power management
  - Control of I/O peripherals
  - ADC/PWM for motor control
  - Audio control for Alarm & information

---

**Motor Control**  
**Audio Out**  
**DAC**  
**ADC**  
**Q SPI**  
**DDR**  
**NAND**  
**EBUS**  
**ADC**  
**PWM FlexTimer**  
**DAC**  
**Crypto**  
**Real Time Integrity**  
**SNVS**  
**Tamper Detection**  
**Secure Fuse**  
**HAB**  
**Secure JTAG**  
**ENET**  
**SDIO**  
**Ethernet**  
**USB Host**  
**USB OTG**  
**USB**  
**GPIO**  
**Tamper Detection**  
**Wi-Fi**  
**LAN**  
**USB**  
**Keypad**  
**Trigger**  
**Audio CODEC**  
**Audio In**  
**Touch Screen**
Single-chip Real-time Ethernet Protocols

ARM Cortex-A5
- Manage system load and everything except Ethernet

ARM Cortex-M4
- Exclusively manage real-time protocols like PROFINET, EtherCAT, etc.
• The ARM Cortex-M4 includes a suite of signal processing extensions (DSP capabilities) that can be used to accelerate audio/video encode and decode.

• Data processing (i.e. Audio decoding) is offloaded to the Cortex-M4 while the Cortex-A5 sleeps (in RUN mode) to optimize system power consumption.

• Similar to “Audio decoding”, Cortex-M4 can be used for any DSP processing acting like a co-processor.

• Independent frequency control on both cores allow better control on performance and power management.
Overview of MCC

• Multi-Core Communication
• Communication layer between MQX and Linux
• Lightweight, fast
  – API calls are simple send / receive between endpoints
  – Endpoints are [core, node, port] triplets
    • Sort of IP host, address, port – but not really.
    • Core is fixed (A5=0, M4=1)
    • Linux can have multiple nodes, MQX only 1
    • Each can have multiple endpoints, arbitrary numbering
  – Uses shared SRAM and interrupts
  – Received data can be passed by pointer or copied
  – Variable timeouts

• Configurable:
  – Buffer sizes
  – # of buffers
  – Max # of endpoints
Portable Hospital Monitor Example with Asymmetrical-Multiprocessing Architecture

- Importance of HMI in medical is becoming more important, however FDA approval is lengthy even for minor changes to the product.
- With a single-chip, dual-core device, medical customers can segment the main application code into:
  a) Non-critical sections and
  b) Critical sections
- Changes to critical sections can require FDA approval. Approval process can be minimized for changes to non-critical section, i.e. integrating a new communication interface.
- Cortex-M4 core is ideally suited to handle real-time functions of patient critical health parameters, while the Cortex-A5 is ideal for applications such as processing of the HMI.
Freescale Vybrid F Series Enablement
Hybrid Controller F Series Enablement on Tower System

**Hardware Platform**

**Tower System**
- Modular, expandable development platform for 8/16/32-bit MCUs/MPUs
- Rapid evaluation and prototyping
- Supports a range of MCU and peripheral plug-in boards
- Growing web community [www.towergeeks.org](http://www.towergeeks.org)

**Complimentary Operating Systems**

**Freescale MQX RTOS**
- Full-featured, scalable, optimized, proven RTOS
- Simplifies hardware management
- Streamlines software development
- Reduces development cost and time to market

**Linux OS**
- Timesys LinuxLink supports free BSP for Vybrid Tower System and selected partner boards
- BSP solution integrates latest Linux kernel, drivers, Freescale MQX and ARM DS-5
- Timesys offers expert professional services and custom development

**Software**

**ARM DS-5**
- Developed and maintained by ARM for Freescale Vybrid
- Powerful compiler for both ARM Cortex™-A5 and Cortex™-M4 cores
- Debugger with MQX support for both core types in one IDE
- Streamline™ Performance Analyzer

Enables flexible prototyping application development

Comprehensive OS solutions for embedded control, display and connectivity

Eases development on heterogeneous cores
Freescale Vybrid F Series Hardware
DS-5 Toolkits for Freescale Vybrid Controllers

- Integrated solution, developed and maintained by ARM for Freescale Vybrid
  - End-to-end development, from SoC bring-up to application debug
- Powerful ARM Compiler for both ARM Cortex™-A5 and Cortex™-M4
  - Optimized code size and performance
- Intuitive DS-5 Debugger with Linux/MQX support
  - Full debug for both core types in one IDE
  - Flexible graphical user interface
  - DSTREAM probe with 4GB trace buffer
  - Supports CMSIS-DAP Debug Probe on Vybrid Tower System modules/kits
- Streamline™ Performance Analyzer
  - System-wide analysis of Linux and Android systems
  - Timeline and profiling reports

From board bring up, through firmware development and application optimization, Development Studio 5 is the right tool for Freescale Vybrid controller development.
## i-5 Connection to Tower System

<table>
<thead>
<tr>
<th>Connection</th>
<th>Connects to</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>USB</td>
<td>On-board debug MCU via CMSIS-DAP I/F</td>
<td>JTAG debug and ETB trace of code running on Cortex-A5 and Cortex-M4</td>
</tr>
<tr>
<td>TCP/IP (*)</td>
<td>Vybrid chipset</td>
<td>Linux application debug via gdbserver</td>
</tr>
<tr>
<td>TCP/IP (*)</td>
<td>Vybrid chipset</td>
<td>Linux system analysis with Streamline</td>
</tr>
</tbody>
</table>

(*) Both Linux application debug and Streamline require a TCP/IP connection to the target. In Linux, the TCP/IP connection is normally implemented on Ethernet, but USB could be an alternative.

It is recommended that the Tower System provides both USB (for bare metal debug over CMSIS-DAP) and Ethernet (for application debug) connections.
Emcraft Systems Vybrid VF6 Starter Kit

• Low cost starter kit for the Freescale Vybrid VF6

• Included in the kit:
  – Linux-ready Vybrid VF6 System-On-Module (VF6 SOM)
  – Tower-compatible development baseboard (TWR-SOM-BSB) that can be used in USB-powered standalone mode or plugged into the Freescale Tower platform for connectivity with other Tower modules

• Emcraft provides a software distribution for the VF6 SOM:
  – Linux for the Cortex-A5 core
  – MQX for the Cortex-M4 core

Resources:  http://www.emcraft.com/som/vf6
Contact:     Kent Meyer
Tel:         760-444-4165
E-mail:      kent@emcraft.com

**PHYTEC Vybrid Kit** - $195.00
- SOM, Carrier Board, Cables
- Linux and MQX BSP
- Free LinuxLink Pro Subscription
- ARM DS-5 Development Suite Eval
- Free kit support

---

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CPU</strong></td>
<td>Freescale Vybrid VFxxx Dual Heterogeneous Core ARM® Cortex™-A5 @ 450 MHz (VF5xx, A5 only) ARM® Cortex™-M4 @ 167 MHz (VF6xx, A5+M4)</td>
</tr>
<tr>
<td><strong>Memory</strong></td>
<td>1 MB on-chip SRAM, 512+ MB DDR3, 256 MB+ NAND, 32 MB SPI-NOR, 32KB EEPROM</td>
</tr>
<tr>
<td><strong>Expansion</strong></td>
<td>2x SD/MMC</td>
</tr>
<tr>
<td><strong>Serial</strong></td>
<td>2x RS232, 4x UARTs, 2x CAN, 4 I2C, 4x SPI, 2x QSPI</td>
</tr>
<tr>
<td><strong>USB</strong></td>
<td>2x USB HS 2.0</td>
</tr>
<tr>
<td><strong>Network</strong></td>
<td>2x 10/100 Ethernet with L2 switch, IEEE 1588 PTP for Real-Time Ethernet</td>
</tr>
<tr>
<td><strong>Multimedia</strong></td>
<td>Video/Camera Interface Unit, Audio CODEC Audio (SAI, I2S, AC97, ESAI, SPDIF)</td>
</tr>
<tr>
<td><strong>Display</strong></td>
<td>Dual Display with support for color TFT up to SVGA, Resistive Touch Controller</td>
</tr>
<tr>
<td><strong>Temperature</strong></td>
<td>-40° to +85° C</td>
</tr>
<tr>
<td><strong>Power Consumption</strong></td>
<td>1.5 W (typical)</td>
</tr>
<tr>
<td><strong>Software Enablement</strong></td>
<td>Richly featured Linux and MQX software BSP support</td>
</tr>
<tr>
<td><strong>Form Factor</strong></td>
<td>41 x 51mm</td>
</tr>
</tbody>
</table>

**Contact PHYTEC Sales:**
Americas/Asia: Brad Dodson | bdodson@phytec.com | 800.278.9913 | 206.780.9047
EMEA: Ralf Orschau | r.orschau@phytec.de | +49 (0) 6131 9221 32

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**PHYTEC**
Intelligent Systems

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**Five Years Out**

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53
### IYTEC phyCORE-Vybrid System on Module

<table>
<thead>
<tr>
<th>CPU</th>
<th>Freescale Vybrid VFxxx Dual Heterogeneous Core ARM® Cortex™-A5 @ 450 MHz (VF5xx, A5 only) ARM® Cortex™-M4 @ 167 MHz (VF6xx, A5+M4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Memory</td>
<td>1 MB on-chip SRAM, 512+ MB DDR3, 256 MB+ NAND, 32 MB SPI-NOR, 32KB EEPROM</td>
</tr>
<tr>
<td>Expansion</td>
<td>2x SD/MMC</td>
</tr>
<tr>
<td>Serial</td>
<td>2x RS232, 4x UARTs, 2x CAN, 4 I2C, 4x SPI, 2x QSPI</td>
</tr>
<tr>
<td>USB</td>
<td>2x USB HS 2.0</td>
</tr>
<tr>
<td>Network</td>
<td>2x 10/100 Ethernet with L2 switch, IEEE 1588 PTP for Real-Time Ethernet</td>
</tr>
<tr>
<td>Multimedia</td>
<td>Video/Camera Interface Unit with optional OpenVG, Audio CODEC Audio (SAI, I2S, AC97, ESAI, SPDIF)</td>
</tr>
<tr>
<td>Display</td>
<td>Dual Display with support for color TFT up to SVGA. Resistive Touch Controller</td>
</tr>
<tr>
<td>Mechanical Specifications</td>
<td>41 x 51m</td>
</tr>
<tr>
<td>Software</td>
<td>Linux (Now), MQX (March 2013)</td>
</tr>
</tbody>
</table>

Kit Contents:

- SOM: PCM-052
- Carrier Board: PCM-952
- SD Card with software demo
- Cables, power supply, documentation
- 7” VGA LCD (optional)
- Bare PCB for prototyping (optional)

Tools/BSPs:

- Free Linux (kernel 3.3.9) BSP
- Free Freescale MQX™ BSP
- Free Timesys LinuxLink Pro subscription
- Free ARM Development Suite (DS-5™)
Software (RTOS, OS)
Freescale Bundled MQX RTOS

- **Free Scalable, fully-featured and proven RTOS with 32-bit MCUs**
  - Full-featured and powerful
    - BSPs incorporate tightly integrated RTOS, Middleware (USB, TCP/IP stacks), file system, and I/O drivers
    - Designed for speed and size efficiency
  - Market proven
    - Available on Freescale processors for > 15 years
    - Used in millions of products including Medical and Heavy Industrial applications
  - Simple and scalable
    - As small as ~10KB for smallest implementation, or scale up to support sophisticated networking and threading
    - Intuitive API & modular architecture enables straightforward fine-tuning of features
    - Production source code provided
  - Similar to other “pay-for” software OS

Software integration headache

Integrated MQX Solution

$95K of free Software

Integrated MQX Solution

- CodeWarrior Development Environment
- CodeWarrior Processor Expert™
- Third Party: IAR
- Open Source BDM Third Party: Emulator/Probe

- Demo Code
- Applications
- Customized Applications
- Application Tasks and Industry Specific Libraries
- Ethernet (RTCS)
- File System
- Core Services MQX RTOS
- Third Party: IAR
- Third Party and Freescale
- Discrete Driver, Third Party and Freescale
- BDM/JTAG
- Microcontroller
- Hardware

Intelligent Systems

Five Years Out
MQX: What’s free and what’s add-on?

Free Components

- RTOS (Full priority-based, pre-emptive scheduler)
- Real-time TCP/IP Communication Suite (RTCS) - TCP/IP, FTP, Telnet, DHCP, SNMP etc..
- USB Host – PHDC (medical) ,HID, MASS, HUB, CDC,
- USB Device - HID, MASS, CDC, PHDC
- MS-DOS File System (MFS)
- BSP I/O Driver: CAN, UART etc…
- Basic HTTP Web server
- Benchmarking Tool
- Base Support: Freescale TIC, FAE, AE
- Compatible Freescale embedded GUI Library

Add-on Components

- IAR & CW: MQX Task Aware Debugging integrated within tools
- Freescale - Level 2 Support
- Bluetooth
- RTA & IXXAT: Industrial Protocols - 1588, CANopen etc.
- Freescale Low Cost NanoSSL™ and NanoSSH™
- Swell & Segger: Graphic Libraries
- Free Freescale EGUI
• The MQX 4.0 IP stack RTCS will be extended with IP V6 core protocol support. The stack will be capable of IP V4, IP V6 or both.
  – IP V6 core protocols
    • IP V6 (RFC 2460)
    • ICMP V6 (RFC 4443)
    • Neighbor Discovery (RFC 4861)
    • TCP/UDP on top of IP V4 and/or IP
  – Example Applications
    • HTTP Server
    • HVAC
  – Tested to be compliance IP V6 ready silver logo certification

• IP V6 Ready Gold logo certification in 2013!

* Add On Features
Embedded Linux Reference Model

**Target**

- **Application** (e.g. Base Station Control)
  - App Features
- **Application 1**
- **Application 2**
- **Third-Party Application**

**Middleware and Application Services**

- Networking
- UI
- Networking
- Security
- Reliability
- Reliability

**Linux kernel**

- Driver
- Driver
- Driver
- Driver
- more

**Bootloader**

- Driver
- Driver
- Driver
- Driver
- more

**Board**

- SOC
- LCD
- HW accel.
- SD
- USB
- more

**Virtualization**

---

**Host**

**Development Tools**

- Cross-Development Environment (SDK)
- IDE
  - Application Debugging
- Build System (e.g. Factory)
- RFS, Kernel, App
- Collaborative Development
- Profiling
- Tracing
- System Management

- KGDB/ printk Debugging
- JTAG
- SMP support, RT enhancements

- Target Images
- Binaries Deployment
- Target Management
nesys LinuxLink: FREE Supported, Commercial Linux for Freescale Vybird F Series

• Absolutely free professional tools for Vybird developers
• Build a complete, customized embedded Linux BSP in minutes with LinuxLink
  – Latest kernels and drivers, full support for Freescale MQX
  – More than 1400 user space packages
  – Support for popular boards such as Tower series from Freescale and phyCORE from PHYTEC
  – Continually updated repository of tutorials, documentation, and demos (with source)
• TimeStorm plug-ins tightly integrate unique features into ARM DS-5 development environment
  – "LinuxLink SDK-aware" plus GCC toolchain and GDB support
  – Full support for ARM gator daemon, DSTREAM and probes
  – Seamless Qt Creator integration for Qt HMI development
• Unmetered support available via email
• Optional access to Timesys premium support packages, hands-on Linux training and full services offerings
Windows Embedded Family

- Windows Embedded Compact
  - Portable Media
  - Consumer
  - Thin Client
- Windows Embedded Standard
  - Entertainment
  - Medical
- Windows Embedded Server
  - Dedicated Servers
- Windows Embedded Enterprise
  - Personal Navigation
  - Industrial
  - Thin Client

Windows NAV
Intelligent Systems

Five Years Out
Software (Tools)
About Timesys: Proven Linux Pedigree

More than 1000 projects, 200+ customers
First to develop and deliver an award-winning, automated, intelligent, embedded Linux build system (LinuxLink 3.0)

Support for 8 architectures, 100+ processors & SoCs
Customers targeting industrial automation, mil/aero, medical, telecom, consumer electronics, and automotive segments

Support for multi-core environments
Embedded Linux Made Easy with LinuxLink

- Build Your Custom BSP
- Build & Debug Your Custom Applications
- Deploy to Your Custom Hardware
LinuxLink cloud development allows customers to rapidly deploy pre-built or custom BSP/SDKs for Tower or other hardware platforms.
Timeline: The Big Picture

Find hotspots, system glitches, critical conditions at a glance

Select from 40+ CPU counters, OS level and custom metrics

Select one or more processes to visualize their instant load on CPU

Accumulate counters, measure time and find instant hotspots

Combined task switch trace and sampled profile for all threads
DSTREAM Debug & Trace Unit

- High performance memory download and trace collection
  - USB 2.0 and Ethernet 10/100base-T interfaces
  - Probe for JTAG, CoreSight, TI and MIPI connectors
  - Fast memory download algorithms
  - Very large memory buffer for long-term trace capture

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>JTAG speed</td>
<td>60 MHz</td>
</tr>
<tr>
<td>Download speed</td>
<td>2.5 MB/s</td>
</tr>
<tr>
<td>Trace buffer</td>
<td>4GB</td>
</tr>
<tr>
<td>Trace speed</td>
<td>600 Mbps/pin (16-bit)</td>
</tr>
</tbody>
</table>
Win the Race to Market
With a Proven RTOS and the Fastest Debug Probes

SEGGER knows embedded software and development tools, because we use them in the development of our own industry leading products. Our J-Link debug probe product line, which now boasts the fastest download speeds available (3.0 MB/s), makes use of SEGGER’s RTOS, File System, USB Stack, and TCP/IP Stack. We understand the needs and time-lines of the modern embedded developer and mold our products around them with unparalleled performance and reliability.

Call us now and start your project today! +49.2103.2878.0 1.617.874.1255
• World-leading supplier of embedded tools
• Founded in 1983
• 150+ employees
• Headquartered in Uppsala, Sweden
• 11 sales and support offices worldwide providing local technical support

98% recurring customers

82 Enterprise agreements

65% companies with more than one EW product
Why do customers choose IAR Systems?

Our customers need:

- Standardization – one IDE for everything
- Quality products and ease of use
- Performance in code size and speed
- Power-efficient applications
- Flexibility in the choice of processor
- Short time to market & reusable code
- Technical support
- Cost control

“We’ve found that IAR Embedded Workbench compilers code intelligently in terms of code size and speed. IAR Embedded Workbench delivers quality code and an excellent debugging environment.”
Stephan Knecht, CEO at Bones Inc.

“For several years we have been working successfully with IAR Systems. Their tools give us the flexibility and performance we need to realize even our most ambitious product developments.”
Ralf Westerheide, Group Manager of Software Development at Miele & Cie

“The tool from IAR Systems turned out to be extremely easy to use. I think everybody on the team pretty much liked it. It’s very intuitive.”
Roger Lambert, Design Engineer at GE Sensing

“With the complexity of our software and the cost requirement, code size is a major issue. The IAR Systems solution does an excellent job with code density.”
Brooks Barrett, Software Engineer at Ember
R Support for Vybrid multicore platform

• The Embedded Workbench for ARM supports all ARM cores from all semiconductor vendors
• Vybrid is Freescale’s dual core ARM Cortex-A5/M4 architecture
  – A single EWARM Workspace can have two projects, one to target each core
  – EWARM can debug both cores with a single hardware debugger
  – Two instances of EWARM can access the same hardware debugger, each instance accessing one of the two cores
Altia's Mission

• Get the best user interface
• from the artist’s imagination
• to the lowest cost hardware
• in the shortest time.
• Reduced engineering time (average 50%)

• From low end processors to high end systems

• Portability across multiple hardware platforms

• Works with any operating system – or no operating system at all

• Custom GUI development

• Complete, efficient C source code
• Freescale acquired key assets of Swell Software on August 18, 2010, an industry leader in GUI software tools

• Swell Software provides **Graphical User Interface (GUI) Solutions for Embedded Devices.** The PEG family of tools are designed to meet widely varying power, performance and memory requirements. Helping our customers:
  • Reduce product development risk
  • Lower in-house development costs
  • Accelerate time to market

• PEG Software accelerates GUI design for embedded devices by allowing developers to create prototypes on a Windows or Linux-based PC by providing a complete visual layout and design tool to enable GUI design to take place in parallel to the embedded software/hardware development.

• The PEG WindowBuilder™ automatically generates C++ source code that is ready to be compiled and linked into any application, further accelerating the deployment of the final product.
Software Support (3rd Party)
50+ engineering team - experts in system integration on complex embedded devices

Consumer
Automotive
Industrial
Medical

Subsidiary of a 600 employees company specialized in complete turnkey development for Embedded markets

Long track record with competitive operating systems using architectures from our main board manufacturer and semiconductor vendor partners
### Evaluation

*Incremental training offer adapted to each step of the development cycle*
- Trainings
- Workshops
- Benchmarking
- Feasibility Study / Proof of Concept

### Architecture

*Reliable solutions securing robust architecture*
- System Architecture Consulting
- Design Review
- Reference BSPs with Maintenance and Support

### Design

*Complete set of services to ensure best time to market*
- Support Contracts
- Turnkey HW+SW designs
- Firmware Expertise
- Application Development

---

MAKE THE CHOICE THAT FITS BEST FOR YOU

- with development kits offered for FREE at the end of each session
- delivered onsite by one of our expert in the field requested for the training

Secure your software and hardware design by collaborating with our engineers

Insure reliability and robustness of your device thanks to our partnerships with best worldwide SVs for reference BSPs

Be flexible and optimize time-to-market of your next product with our services from support contract to complete turnkey design
Adeneo Embedded Program Management

Core competencies for 32-bit embedded devices development make our engineers for each stages of your project:

**Application Development**
- Multimedia
- Custom GUI
  - Silverlight
  - .NET Compact Framework
- Real-time
- Data management
- Geo-localisation GPS
- Middleware
- Custom shells / Firmware update

**Firmware Expertise**
- Edition/Customization of reference BSPs for many Silicon Vendors architecture or off-the-shelf boards (SOC, SOM)
- OS optimization
  - power management
  - boot duration
  - real-time performances
  - ...

**Hardware Development**
- Team of 100+ HW design engineers from AdetelGroup close working with Adeneo Embedded
- Full turnkey development including both hardware and software design
- Collaboration with SVs both on the HW side and the OS system integration
nesys LinuxLink: FREE Supported, Commercial Linux for Freescale Vybird F Series

• Absolutely free professional tools for Vybird developers
• Build a complete, customized embedded Linux BSP in minutes with LinuxLink
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  – Seamless Qt Creator integration for Qt HMI development
• Unmetered support available via email
• Optional access to Timesys premium support packages, hands-on Linux training and full services offerings
Supplemental Material: 2D-ACE and TCON
What is the « standard » way for graphics?
What is the «standard» way for graphics?

• It consumes a lot of RAM!
• For a WVGA screen:
  – $800 \times 480 \times 24\text{bpp} \times 2 = 2\text{MB}$ without scratch pad memory

• It consumes a lot of memory bandwidth
The 2D-ACE is an advanced graphics compositing and blending engine that directly drives an external TFT LCD

- Allows full flexibility of TFT display sizes
- Fetches bit-mapped “sprites” from on- or off-chip memory using DMA
- Creates final panel contents by compositing and blending these graphics
- Has support for a cursor separate from the “sprite” graphics
- Supports multiple source graphic formats in RGB and YUV format and with and without alpha and run length encoding
  - 16bpp RGB565, RGB1555, RGB4444, 24bpp RGB888 and 32bpp ARGB8888
  - Indexed colors with variable bit depths from 1 bit per pixel (bpp) to 8bpp and APAL8
  - YUV format - YCbCr422
- Adjusts the gamma of the graphics to match the TFT in use and dithers pixel colors on panels with less than 24-bit color
- Displays a test signal to allow calibration of panel and system test
• The 2D-ACE combines layers or “sprites” to create the final content
  – There are up to 66 different sources of content possible
    • 64 programmable layers that contain source graphics
    • A cursor layer
    • 1 layer as a default color for the background
  – Layers are in a fixed priority to each other
  – For each pixel position
    • the 2D-ACE fetches a pixel from the topmost layer placed there AND
    • a pixel from the next layer in the priority
    • and pixels from up to four further layers (dependent on user configuration)
  – If indexed colors are used these are converted to 32bpp before processing
  – The fetched pixels are then blended to give the display content for that position.
    • The blending attributes are determined per layer and the lowest priority pixel’s blending attributes are ignore
  – Each resulting pixel can be gamma corrected
  – The output format is 8 bits per channel(24bpp)
What is a layer?

- A layer is the mechanism by which graphics are displayed on the panel.
- The 2D-ACE has a set of 9 registers to configure each layer.
- The layer registers configure:
  - Height & width of layer (pixels)
  - Signed position on panel (x,y)
  - Pointer to graphic (32-bit)
  - Graphic coding (bpp) & CLUT, blending type, tile & safety
  - Chroma limits (max & min)
  - Tile size
  - Transparency mode colors
Creating the image on the panel
Creating the image on the panel – sky

Layer 20:
16x480
(0,0)
YCbCr
Alpha:100%
Serial flash
Creating the image on the panel – sky

Layer 20:
800x480
(0,0)
YCbCr
Alpha: 100%
Tile size: 16x480
Serial flash
Creating the image on the panel - city

Layer 12:
800x430
(0,50)
8BPP
Alpha:100%
Simple chroma
DRAM
Creating the image on the panel - flag

Layer 10:
52x34
(350,70)
4BPP
Alpha: 100%
SRAM
Creating the image on the panel – car & gas

Layer 8:
60x60
(100,350)
8BPP
Alpha:100%
Simple Chroma
Serial flash

Layer 9:
60x60
(80,348)
8BPP
Alpha:100%
Simple Chroma
SRAM
Layer 6:
40x40
(5,120)
4BPP
Alpha: 100%
Simple Chroma
Serial flash
Creating the image on the panel
Creating the image on the panel
• At each pixel position up to six layers may be blended
  – User can globally configure the 2D-ACE to blend 2, 3, 4, 5 or 6 layers
• The blend stack determines how each pixel is blended
  – Layers below the lowest priority pixel are not visible
  – The blending settings for the lowest priority pixel are ignored
Configuring the 2D-ACE Timing

- The 2D-ACE has a choice of clock sources to optimize the configuration options
- Configure the 2D-ACE panel timing settings to match the provided by the panel manufacturer
  - The 2D-ACE provides registers to configure these relationships in a “panel friendly” manner
- The pixel clock is specified by the panel manufacturer
  - Value is specified to allow the panel to be refreshed at 50 – 60Hz
- The 2D-ACE clock can be calculated from the pixel clock value and the depth of the blend required
TFT Timing Example

H Pulse width

H Back Porch

H Front Porch

V Pulse width

V Back Porch

V Front Porch

Sharp LQ043T1DG02
• 2D-ACE has highly configurable timing for the interface signals, but the TCON adds even more flexibility

• Timing generation unit supporting 12 timing signal channels (4 comparators, 6 pulse generators, 1 toggle generator, and a signal mixer)

• Supports remapping of color channels
Arrow Electronics – Five Years Out

Guiding Innovation Forward
Questions