Up to 20 MIPS

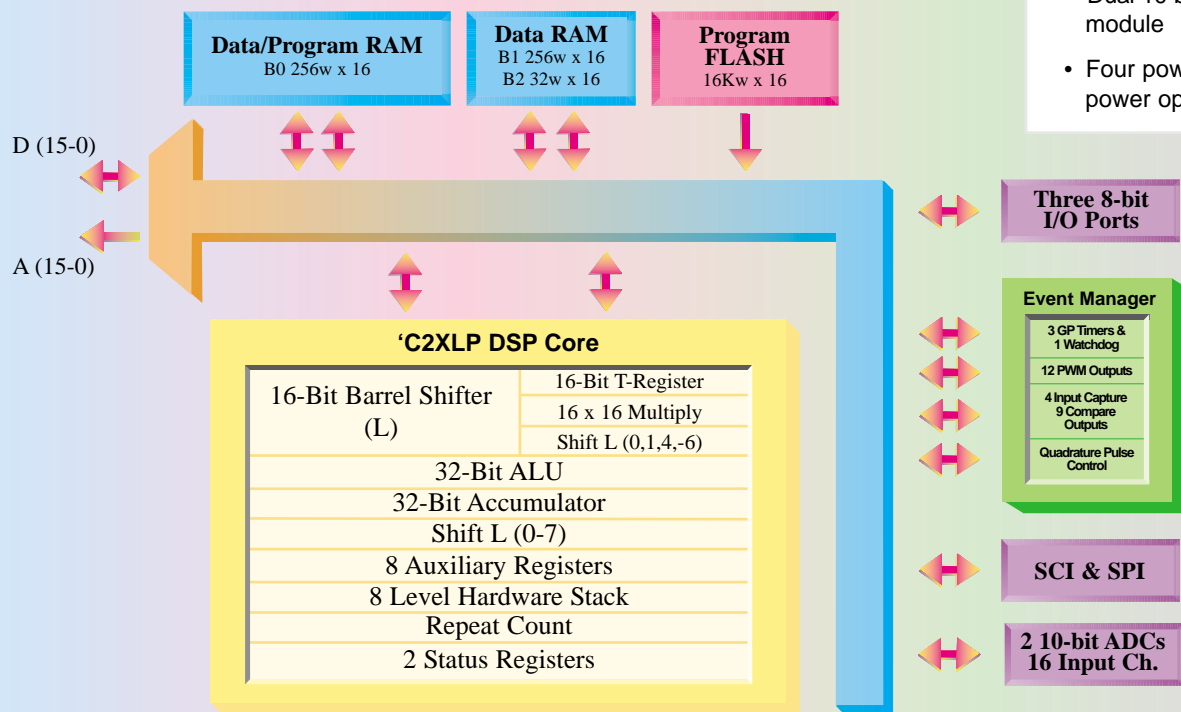*Product Bulletin*

SM/SMJ320F240 Military Digital Signal Processors

Key Features:

- 132-pin ceramic quad flatpack
- 50-ns instruction cycle time
- Military temp range: -55ºC to 125ºC
- Watchdog timer and 3 general purpose timers
- PWM Module with asynchronous, synchronous and vector modes
- 28 individually programmable, multiplexed I/O pins
- Processed to MIL-PRF-38535 (SMJ) or Military Temperature Range (SM)
- Dual 10-bit analog-to-digital conversion module
- Four power-down modes for low power operation

'F240 Block Diagram

Data/Program RAM
B0 256w x 16

Data RAM
B1 256w x 16
B2 32w x 16

Program
FLASH
16Kw x 16

D (15-0)

A (15-0)

'C2XLP DSP Core

16-Bit Barrel Shifter (L)	16-Bit T-Register
	16 x 16 Multiply
	Shift L (0,1,4,-6)
32-Bit ALU	
32-Bit Accumulator	
Shift L (0-7)	
8 Auxiliary Registers	
8 Level Hardware Stack	
Repeat Count	
2 Status Registers	

Three 8-bit
I/O Ports

Event Manager
- 3 GP Timers & 1 Watchdog
- 12 PWM Outputs
- 4 Input Capture 9 Compare Outputs
- Quadrature Pulse Control

SCI & SPI

2 10-bit ADCs
16 Input Ch.

Texas Instruments Digital Signal Processor (DSP) controllers are revolutionizing today's motor control applications in appliances, HVAC, industrial drives, automotive and consumer electronics. The SMJ320F240 DSP has brought the performance and flexibility of the TI family of DSP motor controllers to the military and industrial markets.

The 'F24x platform provides the industry's highest level of on-chip integration and powerful computational ability which drives system costs down to unprecedented levels. This unique combination of processing power and control-specific peripherals allows designers to implement control systems with higher motor efficiency, quieter operation, lower energy consumption and greater reliability compared to traditional microcontroller solutions. Fewer external components are required which leads to reduced system cost. The SMJ320F240 features an on-chip Flash memory, a ceramic hermetic quad flatpack and a full military temperature range operation.

Optimized for Motor Control

Control-optimized 'F240 DSPs enable customers to design highly flexible and differentiated motor control systems. The 'F240 DSP is faster and more powerful than microcontrollers with the same level of peripheral integration. The 'F240 family provides up to 20 MIPS of DSP processing power with

SMJ320F240 Motor Control

Features:	Benefits:
Random PWM	• Reduces electrical and audible noise • Reduces mechanical resonance • Reduces size of EMI input filter
Sensorless Speed Control	• Replaces costly sensors with sophisti-cated rotor positioning and estimation routines
Variable Speed Control	• Eliminates mechanical gears/linkages • Improves system efficiency
PFC Control	• Eliminates external PFC controller • Reduces current spikes • Reduces board size
DC Link Ripple Compensation	• Reduces size and cost of dc link capacitors • Compensates for dc bus voltage ripple
Field-oriented Control	• Improves dynamic performance • Maximizes torque/amp operation • Reduces transient current spikes
Adaptive Control	• Compensates for changes in load and motor/system parameters

on-chip peripherals such as pulse-width modulation (PWM) channels, ultra-fast analog/digital converters, timers and Flash memory. Unlike classic 8- or 16-bit microcontrollers, TI's 'F240 DSP has the computational band-width to easily handle the sophisticated algorithms required for complex motor control functions, such as field oriented control (FOC) and random PWM generation. These control algorithms provide better dynamic performance while eliminating the need for expensive external components such as Hall-effect sensors and power factor correction (PFC) controllers. In addition, this processing power allows precise control of ac-induction, dc-brushless, switched-reluctance and step-per motors.

'F24x Flash Memory

The SMJF240 is the first DSP to offer the flexibility of single-cycle access to Flash memory on-chip at a price that is viable for military control systems. In a 16K-word configuration, the Flash module enables designers to store program code on-chip. This feature supports in-system reprogrammability and provides designers with a quick, easy way to adapt to changing standards and product upgrades with minimal development costs.

'C2000 DSP Core

The 16-bit 'C2000 core incorporates a static design and is manufactured in a sub-micron, triple-level-metal, full-complementary CMOS process for high performance, low power operation. The core was designed from the beginning to comprehend numerous complementary functions.

Performance at 20 MIPS allows the implementation of advanced algorithms and multi-tasking systems. A single-cycle instruction set enables complex mathematic functions to be calculated in real-time, and the Harvard architecture optimizes vector mathematics making it ideal for digital control system applications.

SMJ320F240 in CONTROL

'C2000 Memory Bus

The 'C2000 advanced Harvard architecture maximizes processing power by maintaining two separate memory bus structures, program and data, for full-speed execution. This multiple bus structure allows reading both data and instructions simultaneously. Instructions support data transfers between the two spaces. This architecture lets you store coefficients in program memory to be read in RAM thus eliminating the need for a separate coefficient ROM. This, coupled with a 4-deep pipeline, allows the SMJ320F240 to execute most instructions in a single cycle.

The 'C2000 dual-access RAM (DARAM) allows writes to and reads from the RAM in the same cycle without the address restrictions of SARAM. The dual-access RAM is configured in three blocks: block B0, block B1 and block B2. Block B0 is a 256-word block that can be configured as data or program memory. Block B1 is 256 words in data memory, and block B2 is 32 words in data memory. The ability of the DARAM to perform two accesses in one cycle, coupled with the parallel nature of the 'C2000 architecture, enables the 'C2000 devices to perform three concurrent memory accesses in any given machine cycle.

Event Manager

The 'F24x device's on-board event manager is key in giving designers a complete, high performance motor control solution. Functionally, it provides all PWM and I/O features to drive all motor types. Features include up to three up/down timers and up to nine comparators that, when coupled with flexible waveform generation logic, can create up to 12 PWM outputs. This design includes support for symmetrical (centered) and asymmetrical (non-centered) PWM generation capabilities and a space vector PWM state machine. The PWM's dead-band generation unit is included and helps protect associated power transistors.

In addition, the event manager integrates up to four capture inputs, two of which can serve as direct inputs for optical-encoder quadrature pulses. In all, these features represent a state-of-the-art solution for flexible PWM
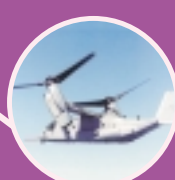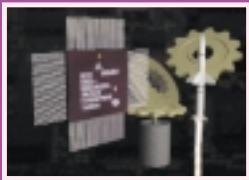
Digital Control Systems

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higher performance
motor control

generation and system control.

TI DSP Development Tools

TI and its third-party network have created a broad range of development tools that specifically support the requirements of motor-control designers that include:

• Code Generation Tools

• C Compiler—it accepts ANSI C source code and produces efficient 'C2000 assembly language code. It is able to perform a variety of optimizations to improve the density and efficiency of the compiled code.

• Assembly/Linker—it converts TMS320 assembly language source files into executable code. The assembly language tools include an archiver, hex conversion utility, cross-reference utility and an absolute lister.

Evaluation/Development Tool Kits

The Evaluation Module (EVM) is the easiest way to fully evaluate and begin developing code for embedded, real-time motor control systems. The 'F24x EVMs use industry leading devel-

opment tools, including TI's C Compiler and Code Composer, allowing designers to take their ideas from concept to production quickly and easily. Design flexibility is increased with on-board peripherals, such as 4-channel/12-bit DAC, additional external memory and multiple expansion ports.

Technosoft Motion Control (MCK) is an easy to use development board designed by Technosoft especially for motor control applications using the 'F240 DSP. The MCK is an EVM-like board that includes ready to run examples of speed control algorithms for ac and dc brushless motors in order to speed up the development process. The MCK offers the basic tools needed to quickly evaluate, develop and implement motor control algorithms. It also offers additional functionality with an on-board three phase inverter and a Permanent Magnet Synchronous brush-

less motor.

Debuggers/Emulators

The Code Composer Simulator is an inexpensive software program that uses the host processor and memory to perform assembly instruction and C-level simulation of the 'C2xLP core and non-real time debug without the hardware in place. Useful features include the ability to simulate external interrupts and I/O transfers and to monitor opcode and addresses at each phase of the pipeline.

Code Composer is the DSP industry's first fully integrated development environment (IDE) with DSP-specific functionality. With its familiar MD-Visual C++ like environment, Code Composer enables designers to edit, build and debug, profile and to manage projects from a single unified environment to help you get started quickly. Other unique features include graphical signal analysis, injection/extraction of data signals via file I/O, multi-processor debugging, automated testing and customization via the C-interpretive scripting language. Code composer is compatible with TI's XDS510 Emulators, code generation tools and third-party development boards.

SMJ320F240 TYPICAL APPLICATION
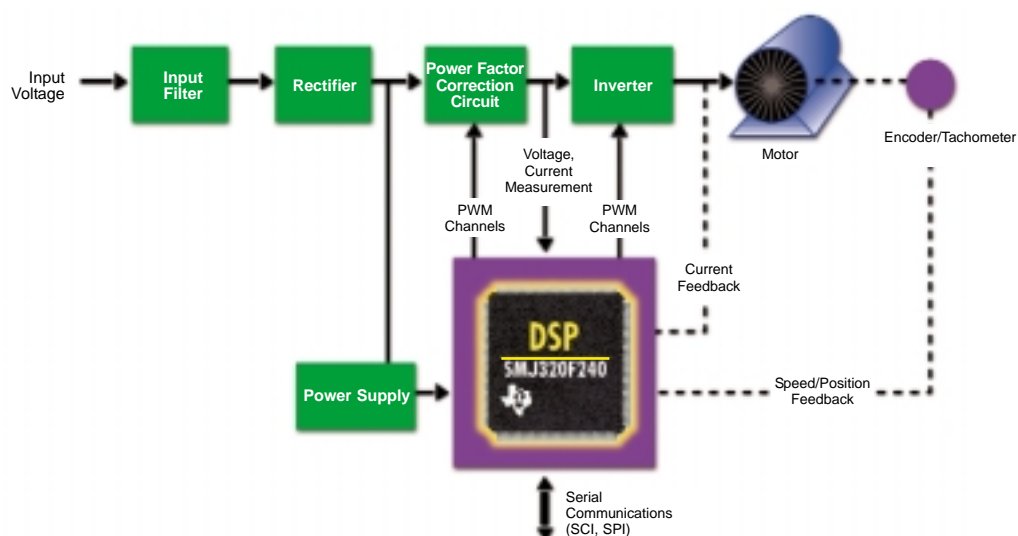
With a high level of peripheral integration and powerful computational abilities, the SMJ320F240 becomes the center of many different control applications.

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