Motor Control Overview

Next-Generation Embedded Motor Control from Texas Instruments

3Q 2004

INSIDE ▶

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Introduction to Motor Control Solutions

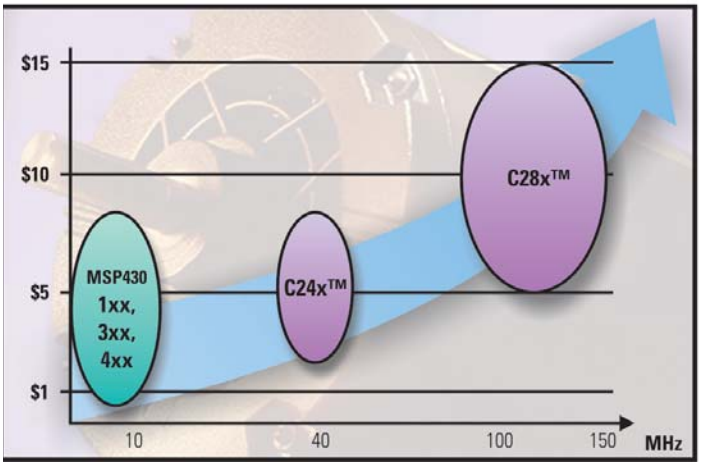
TI Solutions for Motor Control Applications

Today's competitive market demands motor control solutions that offer designers higher performance, greater functionality and efficiency and lower costs. As requirements have increased, traditional resources often lack the breadth of offerings, system expertise and knowledge that designers require for the next-generation motor control designs.

Texas Instruments (TI) offers customers a vast array of both analog and digital solutions for virtually any motor control applications. From power management and interface products to ultra-low-power microcontrollers and high-performance digital signal controllers, TI has the silicon expertise that combines systems expertise, hardware and software development tools and third-party support that's unmatched in the industry.

TI also offers the most comprehensive line of Analog-to-Digital and Digital-to-Analog solutions. And TI's leading interface products are highly robust and reliable even in the harshest environments and offer wide common-mode range fault tolerance and high ESD. The MSP430 line of ultra-low-power microcontrollers is ideal for applications that require 16-bit processing, low power consumption and precision measurement. Embedded controllers like TI's TMS320C2000™ digital signal controllers have emerged with the best combination of flexibility, efficiency and performance that makes them ideally suited for improving overall system capabilities and reducing system cost. As motor systems evolve with advanced features like sensorless AC induction vector control, "current-shaped" switched-reluctance control, and Permanent Magnet Synchronous (PMSM) servo field-oriented control, motor control designers benefit from easy-to-use hardware and software solutions that help get motor control designs to market faster with more customized features, better performance and lower cost.

Controller Solutions



The industry's most comprehensive hardware and software solutions

TI's extensive application-specific software covers almost any type of motor, including AC Induction (ACI), Brushless DC (BLDC), PMSM and Switched Reluctance (SR) taking into account single or three-phase and sensored or sensorless control techniques. By tapping into the TI digital motor control library (DMCLib) **(www.ti.com/ 2000dmclib)** you'll virtually eliminate the need for writing extensive code while quickly and efficiently adding the functionality that your latest motor control design requires. Our evaluation and development hardware tools will allow you to evaluate which controller works best for your specific requirements and start developing solutions quickly and easily.

Applications

- White goods/appliances
- Automotive
- Industrial drives/automation

TI offers a complete selection of motor control solutions including embedded digital signal controllers, microcontrollers, power management and interface solutions, development software and hardware as well as the industry's largest third party network.

Next-Generation Motor Control

Power, Integration, Flexibility

Digital signal controllers like TI's TMS320C2000™ controllers have emerged with the best combination of integration, flexibility, efficiency and performance that makes them ideally suited for improving overall system capabilities and reducing system cost. As motor systems evolve with advanced techniques like sensorless field-orientated control (FOC) or "current-shaped" switched-reluctance control, motor control designers benefit from reduced system costs, easier compliance with regulations on power consumption and reduced EMI radiation, and improved efficiency and reliability. The system-on-chip approach of TI's C2000™ controllers means high integration of peripherals and memory for low system costs through reduced component and space requirements.

What Customers Are Saying About TI Motor Control Solutions

Phil LeMay, manager of embedded designs, Segway LLC

"Since the Segway HT takes up no more space than an average person, space is an issue. The high level of performance and integration that TI's DSP controllers give us with on-board Flash and communication and control peripherals met our strict space requirements."

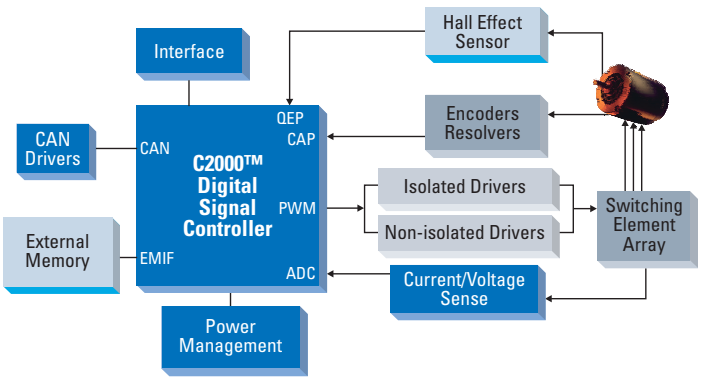
Don Urbano, Baldor Electric Company

"I just wanted to drop you a line to let TI know how happy I am with the IQ Math Library provided by TI. It has been a great help to me and has saved me a great deal of time with the math-intensive code in our Motor Control product that incorporates the TMS320C2812 DSP. I found IQ Math to be fast, accurate and easy-to-use."

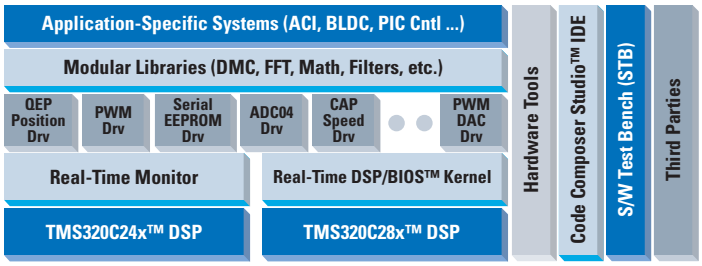
Rachael Karisny, senior marketing engineer, Rockwell Automation

"We needed a processor that could handle this complex task and algorithm, as well as meet our strict size restrictions. The LF2401A was the only embedded processor that met these requirements along with the price, service and support that we needed."

Motor Control Block Diagram



Software Block Diagram



Performance Through Software

C2000 controllers are able to perform complex and intensive algorithms with ultra-fast interrupt response times and single-cycle read, modify and write. This allows TI's controllers to monitor and control the most simple to the most complex functions in software for design with higher torque, torque at zero revolutions per minute (rpm) and lower torque ripples.

TI offers flexibility and ease of use with hardware and software solutions that help get motor control designs to market faster with more customized features, better performance and lower cost. With application-specific algorithms and the DMC Library **(www.ti.com/2000dmclib)**, for example, you'll virtually eliminate the need for writing extensive code while quickly and efficiently adding the functionality that your latest motor control design requires. Hardware development boards and evaluation modules will allow you to examine characteristics of the digital signal controller and determine which devices best fit your application requirements. TI's extensive third parties offer additional hardware, software and consulting services for virtually all motor control applications and design stages.

From Sub $2 to 150 MIPS, DSP-Based Controllers for Your Application

TMS320C2000™ CONTROLLER PLATFORM DEVICE GENERATIONS

DSP Generation	DSP Type	Features
TMS320C24x™ DSP	16-bit data fixed-point	SCI, SPI, CAN, 10-bit A/D, event manager (PWM, QEP, CAP, timers), watchdog timers, on-chip Flash memory, 20–40 MIPS
TMS320C28x™ DSP	32-bit data fixed-point	SCI, SPI, CAN, 12-bit A/D, event manager (PWM, QEP, CAP, timers), McBSP, watchdog timers, on-chip Flash memory, up to 150 MIPS

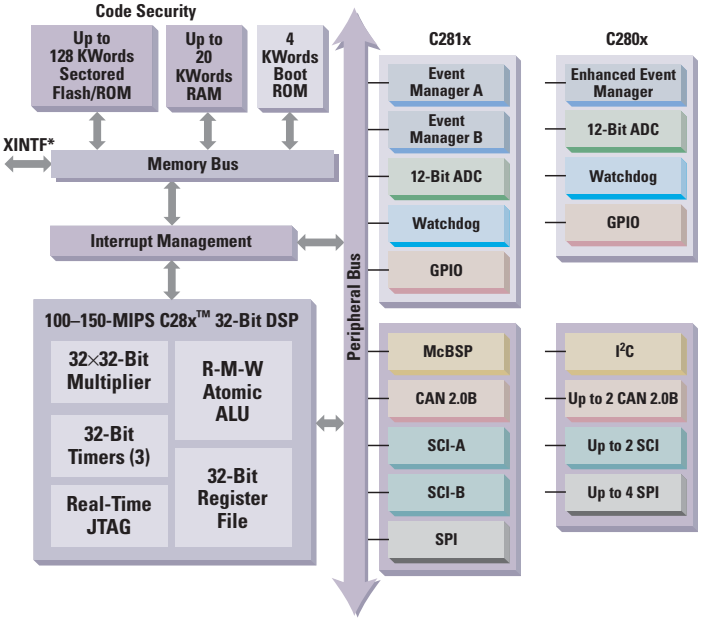
Based on TI's leading digital signal processing technology, TI's C2000™ controllers are driving the digital revolution of motor control by providing the industry's highest-performing and most code-efficient digital signal controllers. C2000 controllers set the standard for performance and MCU peripheral integration by offering a unique combination of standard on-chip peripherals such as communication interfaces and ultra-fast A/D converters as well as motor-specific peripherals such as PWM generation and QEP/CAP modules.

The TMS320F2810, TMS320F2811 and TMS320F2812 controllers are the industry's first 32-bit controllers with on-board Flash memory and performance up to 150 MIPS. The TMS320C28x™ core is the world's highest-performance DSP core optimized for digital motor control applications.

The C28x™ core has the computational bandwidth to handle numerous sophisticated control algorithms in real-time, such as sensorless field oriented control, motion profiling, and power factor correction. The C28x core is also the industry's most C/C++ code efficient core and is fully code compatible with current devices in the C2000 digital signal controller platform.

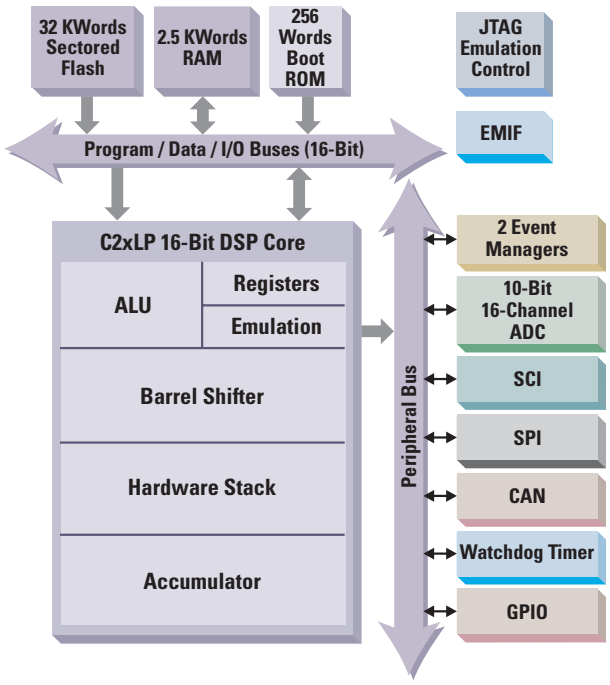
The TMS320C24x generation offers the lowest cost and smallest optimized controllers available and is designed for applications that demand high integration due to space restrictions or cost sensitivity like consumer appliances. They offer 20 to 40 MIPS of DSP performance along with MCU control and ease-of-use with integrated Flash memory and are ideal for implementing sophisticated control algorithms that allows designers to choose smaller, more efficient motors while at the same time providing their customers with quieter, higher performance and energy-efficient systems.

TMS320C28x Digital Signal Controller Diagram



The C28x controllers are the industry's first 32-bit control-based DSPs with onboard reprogrammable Flash, factory programmed ROM, or cost effective RAM-only memory options and performance from 100 to 150 MIPS.

TMS320LF2407A Digital Signal Controller Block Diagram



For high-performance industrial applications, the Flash-based LF2407A Controller includes peripherals such as a Controller Area Network (CAN) module to enable communications in harsh and noisy environments.

Software and Hardware Tools for Fast and Easy Development

TI offers a full range of hardware development tools designed to help you get designing your system quickly and efficiently. These include:

eZdsp™ DSP Starter Kit

DM1500 Motor Controller

Features

- Compatible with LF2407 and F2812 eZdsp Starter Kits*
- Optically isolated digital I/O
- Rated bus voltages of +350 VDC
- Rated current is 5 A continuous, 10 A peak
- Compatible with ACI, BLDC and SR motors

Includes

- DMC1500 circuit board and base
- Technical reference with schematics from Spectrum Digital

**Customers must purchase eZdsp kit separately*

DMC550 Motor Controller

Features

- Compatible with LF2407 and F2812 eZdsp Starter Kits
- 2.5-Amp drive at +24-VDC bus
- Compatible with BLDC motor

Includes

- Technical reference with schematics from Spectrum Digital

MOTOR-SPECIFIC SOFTWARE SOLUTIONS

http://www.ti.com/c2000appsw

System	Motor Type	Sensored	Sensorless	Description	C24x™ DSP	C28x™ DSP
ACI1-1	1 ph AC Induction	•		Tacho I/P, VHz / SinePWM/ Closed Loop (CL) Speed PID	•	
ACI3-1	3 ph AC Induction	•		Tacho I/P, VHz / SinePWM / CL Speed PID	•	•
ACI3-2	3 ph AC Induction		•	MRAS (speed estimator), VHz / SinePWM / CL Speed PID	•	•
ACI3-3	3 ph AC Induction	•		Tacho I/P FOC / SinePWM / CL Current PID for D, Q / CL Speed PID	•	•
ACI3-4	3 ph AC Induction		•	Direct Flux Estimator + Speed Estimator FOC / SinePWM / CL Current PID for D, Q / CL Speed PID	•	•
PMSM3-1	3 ph Permanent Magnet Synch	•		QEP FOC / SinePWM / CL Current PID for D, Q / CL Speed PID	•	•
PMSM3-2	3 ph Permanent Magnet Synch		•	SMO (Sliding Mode Observer) Position Estimator FOC / SinePWM / CL Current PID for D, Q / CL Speed PID	•	•
PMSM3-3	3 ph Permanent Magnet Synch	•		Resolver / FOC / CL Current PID for D, Q / CL Speed PID		•
PMSM3-4	3 ph Permanent Magnet Synch	•		QEP / FOC / Position Control		•
BLDC3-1	3 ph Trapezoidal Brushless DC	•		3 Hall Effect I/P Trapezoidal / CL Loop Current PID / CL Speed PID	•	•
BLDC3-2	3 ph Trapezoidal Brushless DC		•	BEMF / Zero Crossing Detection Trapezoidal / CL Loop Current PID / CL Speed PID	•	•
DCMOTOR	Brushed DC	•		Speed & Position / QEP without Index		•

Motor-specific software downloads available today, free of charge, that allow designers to develop solutions for sensored and sensorless control systems.

TMS320C2000™ DEVELOPMENT TOOLS

Development Tool http://www.ti.com/mcdevboards	Part Number	Includes	Price[1]
LF2401A eZdsp	TMDSEZD2401 / TMDSEZD2401-0E	Code Composer Studio™ v2.21 DSK version	$295
LF2407A EVM Development Bundle	TMDS3P70106A / TMDS3P70106AE	Code Composer Studio (CCStudio) v2.2, XDS510PP+	$1,995
LF2407 eZdsp	TMDSEZD2407 / TMDSEZD2407-0E	CCStudio v2.21 DSK version	$295
F2812 eZdsp	TMDSEZD2812 / TMDXEZD2812-0E	CCStudio v2.12 DSK version	$295
F2812 eZdsp (DSP in Socket)	TMDSEZS2812 / TMDXEZS2812-0E	CCStudio v2.12 DSK version	$449
R2812 eZdsp Starter Kit	TMDXEZR2812 / TMDXEZR2812-OE	CCStudio, USB cable, 256-Kbit socket EEPROM	$495
DMC1500	Spectrum Digital 701228/9	Driver platform for AC induction/DC brushless, switch reluctance motors	$1,500
DMC550	Spectrum Digital 701230	Driver platform for DC brushless motors	$495
F2812 Development Bundle with XDS510PP+ Emulator	TMDSEVP2812 / TMDXEVP2812-0E	F2812 eZdsp (DSP in socket), CCStudio v2.2, XDS510PP+	$1,995
F2812 Development Bundle with USB Emulator	TMDSEVU2812 / TMDXEVU2812-0E	F2812 eZdsp (DSP in socket), CCStudio v2.2, XDS510™ USB Emulator	$2,295

[1] *Price per unit in U.S. dollars*

Third-Party Network Highlights

Application-specific software and hardware is available from TI and TI's Third-Party Network companies to help digital control developers more easily evaluate and design products integrating either TMS320C24x™ or TMS320C28x™ Controllers.

MOTOR CONTROL THIRD PARTIES

Third Party http://www.ti.com/3rdparty	Category	Products
Softronics	Hardware Development Boards & Emulators	Emulators, Target Boards, Flash*Pack
Spectrum Digital	Hardware Development Boards & Emulators	Emulators, Evaluation modules, Development boards
Technosoft	Hardware Development Boards & Algorithms	Digital Motor Control Developer, Development Kits
International Rectifier	Hardware Development Boards	iNTERO Development System
NFO Control AB	Hardware Development Boards	Hardware and Software Design Services
Hyperception	Graphical Development Environment	RIDE, VAB®
MathWorks	Graphical Development Environment	MATLAB®, SIMULINK®, Developer's Kit
Visual Solutions	Graphical Development Environment	VisSim™ - TI C2000™ DSP Rapid Prototyper
ML Electronics	Engineering Services	Hardware and Software Design Services
Aria Controls	Engineering Services	Hardware and Software Design Services
Wiley Electronics	Engineering Services	Motor Control Software Libraries, Control Boards
d3 Engineering	Engineering Services	Hardware and Software Design Services, Kruse Control
Port GmbH	CAN Drivers	ANSI-C CANopen Driver Package
Schmidhauser AG	CAN Drivers	Dynamic Transverse Controller, ACS Servo Controller
Vector CANtech	CAN Drivers	Automotive OEM packages
ETAS	Operating System	OSEK-compliant
Pumpkin	Operating System	Salvo
Windmill Innovations	Ethernet and Development Boards	TCP/IP Stack
National Instruments	Graphical Development Environment	LabVIEW
Data I/O	Flash Programming	Device Programmers
BP Microsystems	Flash Programming	Device Programmers

Application Notes

TI has an extensive list of application-specific notes that are designed to help you in your development and implementation of embedded control solutions. Motor types covered include:

- AC induction
- Brushless DC
- Permanent magnet synchronous
- Single and three phase

For a complete listing of application notes, visit **www.ti.com/mcappnotes**

MSP430 Ultra-Low-Power MCUs

Microcontrollers Overview

The MSP430 family of ultra-low-power, 16-bit RISC, mixed-signal processors from TI provides the ultimate System-on-Chip (SoC) solution for battery-powered measurement. A flexible clock system switches from ultra-low-power standby to high-performance signal processing in less than 6 µs. Embedded emulation reduces design cycle time. For low-power applications where both analog and digital signal processing are required, the MSP430 line provides a range of exceptional cost/performance options.

Ultra-Low-Power Flash MCUs

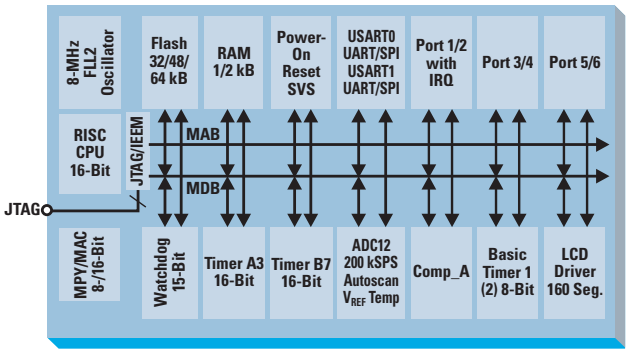
MSP430F449

With the highest level of analog integration and the industry's lowest power consumption, the MSP430F43x/F44x parts provide complete systems on a chip (SoC). The easy-to-use MSP-FET430P440 Flash emulation tool is available for U.S. $99.

Key Features

- Ultra-low-power Flash MCU with high-performance 200-kSPS, 12-bit ADC and LCD driver on one chip
- Power consumption of <1 µA in standby mode extends battery life
- Modern 16-bit RISC CPU enables new applications at a fraction of the code size
- In-system programmable Flash permits last-minute code changes, field upgrades and data logging to Flash

Get samples, datasheets, EVMs and application reports at:
www.ti.com/sc/device/msp430f449



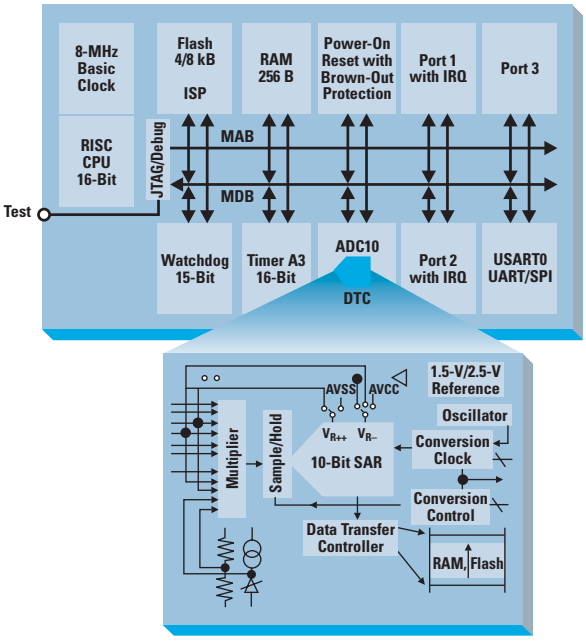
MSP430F449—TI's mixed-signal Flash MCU delivers the world's lowest power SoC solution for embedded display applications.

MSP430F169

Experience the ultimate signal-chain-on-chip (SCoC) solution for low-power applications. As the industry's first ultra-low-power MCU-based SCoC, the MSP430F169 combines an 8-channel 200-ksps 12-bit ADC, two 12-bit DACs and a programmable direct memory access (DMA) controller, and is ideal for power-, space-, and cost-sensitive applications. The device also includes 60-kB Flash, 2-kB RAM, a watchdog timer, a comparator, 10 channels of pulse width modulation, two universal synchronous asynchronous receive transmits (USARTs), an I^2C interface, a 16-bit hardware multiplier and a supply voltage supervisor (SVS). The MSP-FET430P140 Flash emulation tool offers a completely integrated development environment for only U.S. $99.

Key Features

- Ultra-low power consumption: 280-µA active mode, 1.6-µA standby mode at 2.2 V (typ)
- 16-bit RISC architecture enables new applications at a fraction of the code size
- In-system programmable Flash permits last-minute code changes, field upgrades and data logging to Flash
- High-performance integrated analog and digital peripherals reduce system cost and speed time-to-market



MSP430F169—The industry's first complete MCU-based SCoC.

Get samples, datasheets, EVMs and app reports at:
www.ti.com/sc/device/msp430f169

MSP-FET430 Flash Emulation Tool

- JTAG-based real-time in-system emulation
- Target board, interface box, cable and samples
- CD-ROM includes Kickstart IDE, assembler, linker, simulator and 2-KB C-compiler
- **Prices start at U.S. $49.**

MSP430 ULTRA-LOW-POWER MICROCONTROLLERS

Device[1]	Program	SRAM	I/O	LCD Seg	Watch-dog 16-Bit	Timer_A 16-Bit No. of C/C[2]	Timer_B 16-Bit No. of C/C[2]	USART	I^2C	SVS	Brown-Out Reset	MPY	Comp_A	ADC	Additional Analog	Pins/Packages	Price[3]
Flash/ROM-Based F1xx Family V_{CC} 1.8 to 3.6 V																	
MSP430F1101A	1 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	0.99
MSP430C1101	1 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	0.60
MSP430F1111A	2 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.35
MSP430C1111	2 KB	128	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.10
MSP430F1121A	4 KB	256	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.70
MSP430C1121	4 KB	256	14	—	✔	3	—	—	—	—	—	—	✔	slope	—	20 DGV, DW, PW, 24 RGE	1.35
MSP430F1122	4 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW, 32 RHB	2.00
MSP430C1122	4 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW	1.50
MSP430F1132	8 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW, 32 RHB	2.25
MSP430C1132	8 KB	256	14	—	✔	3	—	—	—	—	✔	—	—	5-ch ADC10	—	20 DW, PW	1.70
MSP430F122	4 KB	256	22	—	✔	3	—	1	—	—	—	—	✔	slope	—	28 DW,PW, 32 RHB	2.15
MSP430F123	8 KB	256	22	—	✔	3	—	1	—	—	—	—	✔	slope	—	28 DW,PW, 32 RHB	2.30
MSP430F1222	4 KB	256	22	—	✔	3	—	1	—	—	✔	—	—	8-ch ADC10	—	28 DW, PW, 32 RHB	2.40
MSP430F1232	8 KB	256	22	—	✔	3	—	1	—	—	✔	—	—	8-ch ADC10	—	28 DW,PW, 32 RHB	2.50
MSP430F133	8 KB	256	48	—	✔	3	3	1	—	—	—	—	✔	8-ch ADC12	—	64 PM, RTD, PAG	3.00
MSP430C1331	8 KB	256	48	—	✔	3	3	1	—	—	—	—	✔	slope	—	64 PM, RTD	2.00
MSP430F135	16 KB	512	48	—	✔	3	3	1	—	—	—	—	✔	8-ch ADC12	—	64 PM, RTD, PAG	3.60
MSP430C1351	16 KB	512	48	—	✔	3	3	1	—	—	—	—	✔	slope	—	64 PM, RTD	2.30
MSP430F147	32 KB	1024	48	—	✔	3	7	2	—	—	—	✔	✔	8-ch ADC12	—	64 PM, RTD, PAG	5.05
MSP430F1471	32 KB	1024	48	—	✔	3	7	2	—	—	—	✔	✔	slope	—	64 PM, RTD	4.60
MSP430F148	48 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	8-ch ADC12	—	64 PM, RTD, PAG	5.75
MSP430F1481	48 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	slope	—	64 PM, RTD	5.30
MSP430F149	60 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	8-ch ADC12	—	64 PM, RTD, PAG	6.05
MSP430F1491	60 KB	2048	48	—	✔	3	7	2	—	—	—	✔	✔	slope	—	64 PM, RTD	5.60
MSP430F155	16 KB	512	48	—	✔	3	3	1	✔	✔	✔	—	✔	8-ch ADC12	(2) DAC12	64 PM	4.95
MSP430F156	24 KB	1024	48	—	✔	3	3	1	✔	✔	✔	—	✔	8-ch ADC12	(2) DAC12	64 PM	5.35
MSP430F157	32 KB	1024	48	—	✔	3	3	1	✔	✔	✔	—	✔	8-ch ADC12	(2) DAC12	64 PM	5.85
MSP430F167	32 KB	1024	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	6.75
MSP430F168	48 KB	2048	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	7.45
MSP430F169	60 KB	2048	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	7.95
MSP430F1610	32 KB	5120	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	8.25
MSP430F1611	48 KB	10240	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	8.65
MSP430F1612	55 KB	5120	48	—	✔	3	7	2	✔	✔	✔	✔	✔	8-ch ADC12	(2) DAC12	64 PM	8.95
Flash/ROM-Based F4xx Family With LCD Driver V_{CC} 1.8 to 3.6 V																	
MSP430F412	4 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	2.60
MSP430C412	4 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	1.90
MSP430F413	8 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	2.95
MSP430C413	8 KB	256	48	96	✔	3	—	—	—	✔	✔	—	✔	slope	—	64 PM, RTD	2.10
MSP430F423	8 KB	256	14	128	✔	3	—	1	—	✔	✔	—	—	(3) SD16	—	64 PM	4.50
MSP430F425	16 KB	512	14	128	✔	3	—	1	—	✔	✔	—	—	(3) SD16	—	64 PM	4.95
MSP430F427	32 KB	1024	14	128	✔	3	—	1	—	✔	✔	—	—	(3) SD16	—	64 PM	5.40
MSP430F435	16 KB	512	48	128/160	✔	3	3	1	—	✔	✔	—	✔	8-ch ADC12	—	80 PN, 100 PZ	4.45
MSP430F436	24 KB	1024	48	128/160	✔	3	3	1	—	✔	✔	—	✔	8-ch ADC12	—	80 PN, 100 PZ	4.70
MSP430F437	32 KB	1024	48	128/160	✔	3	3	1	—	✔	✔	—	✔	8-ch ADC12	—	80 PN, 100 PZ	4.90
MSP430F447	32 KB	1024	48	160	✔	3	7	2	—	✔	✔	✔	✔	8-ch ADC12	—	100 PZ	5.75
MSP430F448	48 KB	2048	48	160	✔	3	7	2	—	✔	✔	✔	✔	8-ch ADC12	—	100 PZ	6.50
MSP430F449	60 KB	2048	48	160	✔	3	7	2	—	✔	✔	✔	✔	8-ch ADC12	—	100 PZ	7.05

[1] C = ROM, F = Flash [2] C/C = Capture/Compares [3] Suggested resale price in U.S. dollars in quantities of 1,000. *All devices support industrial temperature range.*

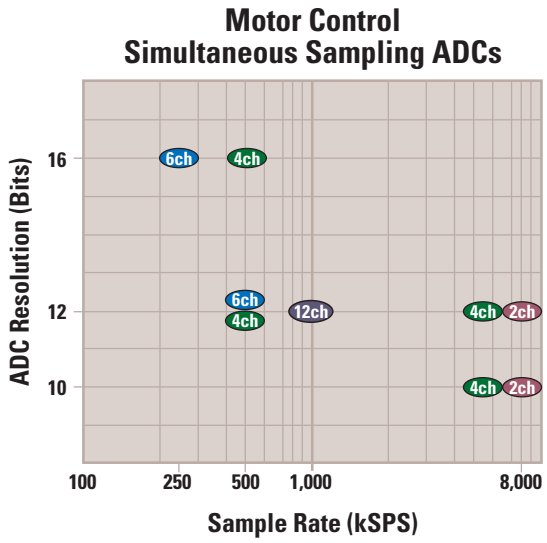
The Flash Emulation Tool (FET) supports complete in-system development and is available for all MSP430F1xx and MSP430F4xx Flash devices. Programming, assembler/C-source level debug, single stepping, multiple hardware breakpoints, full-speed operation and peripheral access are all fully supported in-system using JTAG.

Visit **www.ti.com/msp430** for more information.

Data Converters for Motor Control Applications

Texas Instruments' Burr-Brown product line offers the most comprehensive line of Analog-to-Digital Converter (ADC) and Digital-to-Analog Converter (DAC) solutions to drive the revolution of digital motor control. The latest generation of simultaneous sampling ADCs from TI establishes a higher industrial standard by offering precision, speed and integration for motor control applications. Two, four or six simultaneous sampling, fully differential channel devices enable sampling of incoming signals from 250 kSPS up to 8 MSPS and with resolution from 10 to 16 bits.

The VECANA01, a complete analog front end solution designed by Burr-Brown ten years ago, set the standard for performance and peripheral integration by offering a unique combination of on-chip peripherals such as multiplexers, sample and hold amplifiers, programmable gain amplifiers, sign comparators, window comparators, as well as DAC and ADCs.

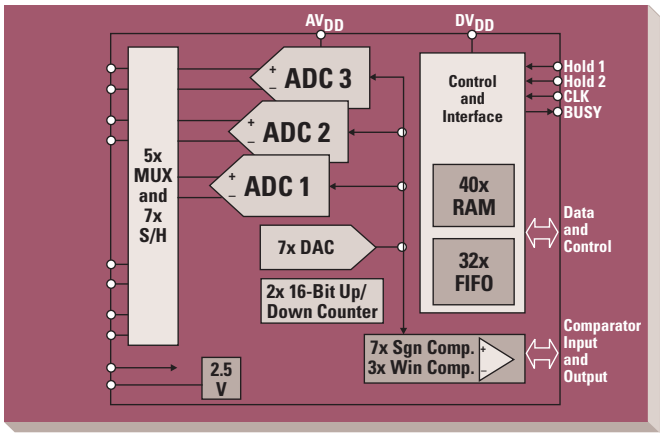


The new ADS7869 advances the performance of the VECANA01 by integrating three 12-bit, 1-MSPS ADCs, with additional functionality of 12 fully differential input channels and two 16-bit up/down counters designed specifically for motor control applications.

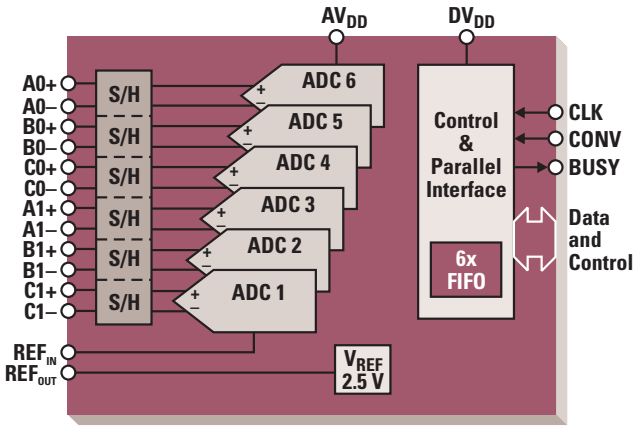
The ADS8364 is the industry's first 16-bit ADC that combines six independent ADCs on board, allowing simultaneous sampling of six fully differential analog signals at 250 kSPS. The ADS8364 features four times higher resolution and three times higher speed than the closest competitor. This functionality is also available in the 12-bit, 500-kSPS ADS7864.

The ADS8361 combines two advanced 16-bit ADCs on a single chip to provide simultaneous sampling of two fully differential analog signals at 500 kSPS. It is pin-for-pin and functionally compatible with the 12-bit, 500-kSPS ADS7861, allowing the same design for general-purpose and high-performance applications. The ADS8364 and ADS8361 feature digital interfaces which are DSP compatible and can accept voltage from 2.7 V up to 5.5 V, supporting different standards and control circuits.

ADS7869 Block Diagram



ADS8364 Block Diagram



Software and Hardware Tools for Fast and Easy Development

TI offers a full range of complete hardware and software development tools to help you design your signal chain quickly and efficiently. These tools include Data Converter Evaluation Modules (EVMs) which simplify prototyping of your signal chain and speed code development. The Data Converter EVMs are designed to interface to DSP development kits, either directly or through an interface board, allowing rapid prototyping of advanced data converter and DSP system designs. Many of these EVMs can also be directly connected to an MSP430-based development platform from Softbaugh, Inc. (HPA449).

DATA CONVERTERS FOR MOTOR CONTROL

Device Name	Resolution (Bits)	Sample Rate (kSPS)	Supply (V)	Data-Bus Interface	Analog Inputs	Power (max) (mW)	Vref (Int/Ext)	DNL (max) (±LSB)	INL (max) (±LSB)	Package	Data Converter Plug-In
ADS1202	1 (16)	10,000	5	Serial	1	37	Int	1	12	TSSOP-8	+
THS10064	10	6,000	3/5	Parallel	4	216	Int	1	1	TSSOP-32	+
THS1007	10	6,000	3/5	Parallel	4	216	Int	1	1	TSSOP-32	+
THS10082	10	8,000	3/5	Parallel	2	216	Int	1	1	TSSOP-32	+
THS1009	10	8,000	3/5	Parallel	2	216	Int	1	1	TSSOP-32	+
ADS7861	12	500	5	Serial	4	40	Int	1	1	SSOP-24	+
ADS7862	12	500	5	Parallel	4	40	Int	1	1	TQFP-32	+
ADS7864	12	500	5	Parallel	6	50	Int	1	1	TQFP-48	+
ADS7869	12	1,000	3/5	Parallel/Serial	12	250	Int	2	2	TQFP-100	+
THS1206	12	6,000	3/5	Parallel	4	216	Int	1	1.5	TSSOP-32	+
THS1207	12	6,000	3/5	Parallel	4	216	Int	1	1.5	TSSOP-32	+
THS12082	12	8,000	3/5	Parallel	2	216	Int	1	1.5	TSSOP-32	+
THS1209	12	8,000	3/5	Parallel	2	216	Int	1	1.5	TSSOP-32	+
ADS8364	16	250	3/5	Parallel	6	470	Int	2	8	TQFP-64	+
ADS8361	16	500	3/5	Serial	4	200	Int	2	8	SSOP-24	+

+ Motor control analog-to-digital converters supported with new version 3.30 of the free data converter plug-in (DCP) for Code Composer Studio™ IDE.
For a complete listing, visit www.ti.com/dataconverter.

DATA CONVERTER EVMs

Tool Name	Part Number	Price
ADS1202 Evaluation Module	ADS1202EVM	$49.00
THS10064 Evaluation Module	THS10064EVM	$99.00
THS1007 Evaluation Module	THS1007EVM	$99.00
THS10082 Evaluation Module	THS10082EVM	$99.00
THS1009 Evaluation Module	THS1009EVM	$99.00
ADS7861 Evaluation Module	ADS7861EVM	$49.00
THS1206 Evaluation Module	THS1206EVM	$99.00
THS1207 Evaluation Module	THS1207EVM	$99.00
THS12082 Evaluation Module	THS12082EVM	$99.00
THS1209 Evaluation Module	THS1209EVM	$99.00
ADS8364 Evaluation Module	ADS8364EVM	$149.00
ADS8361 Evaluation Module	ADS8361EVM	$49.00

Code Composer Studio™ IDE Plug-In

The free data converter plug-in (DCP) for Code Composer Studio IDE provides software support for interfacing TI's data converter with TI's TMS320C28x™, TMS320C24x™, TMS320C54x™, TMS320C55x™, TMS320C62x™, TMS320C67x™ and TMS320C64x™ DSP generations.

The data converter plug-in from TI is an example of the benefits developers can realize from the eXpressDSP™ open software driver architecture. This tool allows you to effortlessly configure and start your data converter from within the integrated development environment (IDE) of the DSP. The plug-in automatically generates C code with the data structures, configuration parameters and interface functions for TI's data converters.

Motor Control Analog-to-Digital Converters

APPLICATION NOTES

Part	Application Note	Number
ADS1202	Choosing an Optocoupler for the ADS1202 Operating in Mode 1	SBAA088
ADS1202	Interfacing the ADS1202 Modulator With a Pulse Transformer in Galvanically Isolated Systems	SBAA096
ADS1202	Combining the ADS1202 with an FPGA Digital Filter for Current Measurement in Motor Control Applications	SBAA094
ADS786x	Using a SAR Analog-to-Digital Converter for Current Measurement in Motor Control Applications	SBAA081
ADS8361	Interfacing the ADS8361 to the TMS320F2812 DSP	SLAA167
ADS8361	Interfacing the ADS8361 to the TMS320VC5416 DSP	SLAA162
ADS8361	Interfacing the ADS8361 to the TMS320C6711 DSP	SLAA164
ADS8364	Software Control of the ADS8364	SLAA155
ADS8364	Interfacing the ADS8364 to the TMS320F2812 DSP	SLAA163
ADS8364	Interfacing the ADS8364 ADC to the MSP430F149	SLAA150
THS10064	Resetting Non-FIFO Variations of the 10-Bit THS10064	SLAA144
THS100x	Reading the Configuration Registers of the 10-Bit THS10064, THS1007, THS10082, and THS1009	SLAA143
THS1206	Designing With the THS1206 High-Speed Data Converter	SLAA094
THS1206	Resetting Non-FIFO Variations of the 12-Bit THS1206	SLAA145

Interface

Interface Overview

The interface devices used in industrial applications to transmit data throughout the network, or portion of the system through the bus line, need to be robust and reliable to perform in these typical harsh environments. Wide common-mode range, fault tolerance, and high ESD are a few of the features highly desirable in these applications.

CAN (ISO11898)

Controller Area Network (CAN) is a serial bus system especially suited for networking "intelligent" devices as well as sensors and actuators within a system or subsystem. CAN comes from the standard of ISO11898. One of the outstanding features of the CAN protocol is its high transmission reliability, which has the ability to diagnose and repair data errors. The CAN controller registers a station error and evaluates it statistically in order to take appropriate measures. The maximum transmission rate of CAN is specified as 1 Mbps. This value applies to networks up to 40 m. For longer distances the data rate must be reduced. See **interface.ti.com** for more information.

RS-232

The UART is a key component of a PC serial communications port that handles asynchronous communications. See **interface.ti.com** for more information.

RS-485 (TIA/EIA-485)

Interface circuits employing RS-485 drivers, receivers or transceivers are used in practically any application requiring an economical, rugged interconnection between two or more computing devices. The low-noise coupling of balanced signaling with twisted-pair cabling and the –7-V to 12-V common-mode voltage range of RS-485 allow data exchange at data signaling rates up to 50 Mbps, or distances of several kilometers at lower rates. The receivers are capable of detecting a differential input signal as low as 200 mV. Although the standard specifies up to 32 nodes to be connected, there are devices with increased input impedance and reduced unit load (UL) specifications, which can increase the number of nodes allowed. See **interface.ti.com** for more information.

3.3-V CAN Transceiver

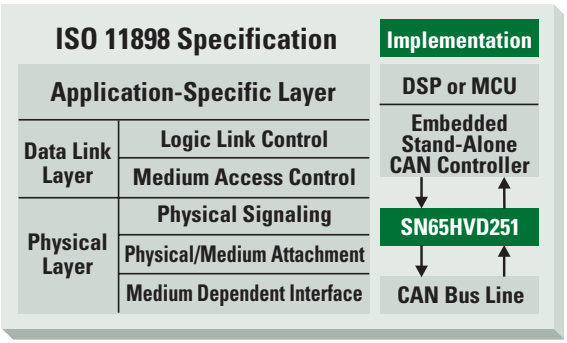
SN65HVD230/SN65HVD231/SN65HVD232

Get samples, datasheets and app reports at:

www.ti.com/sc/device/partnumber

Replace partnumber in URL with SN65HVD230, SN65HVD231 or SN65HV232

The SN65HVD230/1/2 transceivers implement the ISO11898 standard specification for the CAN bus architecture. Designed for operation in especially-harsh environments, the devices feature cross-wire protection, loss-of-ground and overvoltage protection, overtemperature protection, and wide common-mode range.



Key Features

- 3.3-V supply saves on cost and power by eliminating need for 5-V supply in 3.3-V applications
- Low-power replacement for PCA82C250
- 16-kV ESD bus pin protection provides reliability
- High-input impedance allows up to 120 nodes on a bus
- Programmable driver output transition time (SN65HVD230/1) improves signal quality and allows longer stub lengths
- 370-µA current-standby mode (SN65HVD230) and 40-ns sleep mode (SN65HVD231) provide low idle power consumption
- Signaling rates up to 1 Mbps

Applications

- Motor control
- Industrial automation
- Base station control and status
- Robotics
- Automotive
- UPS control

CAN

Supply Voltage (V)	Device	Description	Transient Pulse Protection (V)	I_{CC} Max (mA)	ESD (kV)	Bus Fault Protection (V)	Footprint	Temp Range °C	Pin/ Package(s)	Price[1]
5	**SN65HVD251**	Standby Mode, Improved Drop-In Replacement for PCA82C250 and PCA82C251	–200 to 200	65	14	±36	PCA82C250	–40 to 125	8PDIP, 8SOIC	0.82
	SN65HVD1040	Improved Drop-In Replacement for TJA1040	–200 to 200	70	6	–27 to 40	TJA1040	–40 to 125	8SOIC	Preview
	SN65HVD1039	Same as HVD1040 w/o Dominant Time-Out Mode	–200 to 2000	70	6	–27 to 40	TJA1040	–40 to125	8SOIC	Preview
	SN65HVD1050	Improved Drop-in Replacement for TJA1050	–200 to 200	70	6	–27 to 40	TJA1050	–40 to 125	8SOIC	Preview
	SN65HVD1049	Same as HVD1050 w/o Dominant Time-Out Mode	–200 to 200	70	6	–27 to 40	TJA1050	–40 to 125	8SOIC	Preview
	SN65LBC031	500 Kbps	–150 to 100	20	2	–5 to 20	SN75LBC031	–40 to 125	8SOIC	1.43
	SN75LBC031	500 Kbps	–150 to 100	20	2	–5 to 20	SN75LBC031	–40 to 85	8SOIC	1.32
3.3	SN65HVD230	Standby Mode	–25 to 25	17	16	–4 to 16	PCA82C250	–40 to 85	8SOIC	1.35
	SN65HVD231	Sleep Mode	–25 to 25	17	16	–4 to 16	PCA82C250	–40 to 85	8SOIC	1.35
	SN65HVD232	Cost Effective	–25 to 25	17	16	–4 to 16	SN65HVD232	–40 to 85	8SOIC	1.27
	SN65HVD230Q	Automotive Temp, Standby Mode	–25 to 25	17	15	–7 to 16	PCA82C250	–40 to 125	8SOIC	2.03
	SN65HVD231Q	Automotive Temp, Sleep Mode	–25 to 25	17	15	–7 to 16	PCA82C250	–40 to 125	8SOIC	2.03
	SN65HVD232Q	Automotive Temp, Cost Effective	–25 to 25	17	15	–7 to 16	SN65HVD232	–40 to 125	8SOIC	1.89
	SN65HVD233	Standby Mode, Diagnostic Loop-Back	–100 to 100	6	16	±36	—	–40 to 125	8SOIC	1.46
	SN65HVD234	Standby Mode, Sleep Mode	–100 to 100	6	16	±36	—	–40 to 125	8SOIC	1.43
	SN65HVD235	Standby Mode, Autobaud Loop-Back	–100 to 100	6	16	±36	—	–40 to 125	8SOIC	1.48
	SN65HVD1040v33	TJA1040 w/ 3 V MCU I/Os	±200	70	6	–27 to 40	TJA1040	–40 to 125	8SOIC	Preview
	SN65HVD1050v33	TJA1050 w/ 3 V MCU I/Os	±200	70	6	–27 to 40	TJA1050	–40 to 125	8SOIC	Preview
	SN65HVD6250v33	Standby Mode w/o Bus Monitor	±200	70	6	–27 to 40	TLE6250V33	–40 to 125	8SOIC	Preview

All devices have a signaling rate of 1 Mbps except LBC031.
*New products appear in **BOLD RED**.*
[1]Suggested resale price in U.S. dollars in quantities of 1,000.
*Preview devices appear in **BOLD BLUE**.*
For a complete product listing visit **interface.ti.com**

RS-485

Device	Number of TX/RX	Supply Voltage (V)	Signaling Rate (Mbps)	I_{CC} Max (mA)	ESD (kV)	Number of Nodes	Fail-Safe	Package(s)	Footprint	Price[2]
SN65HVD08[1]	1/1	3.3 – 5	40	16	15	256	Short, Open	DIP, SOIC	SN75176	1.82
SN65HVD10[1]	1/1	3.3	30	15.5	16	64	Short, Open	DIP, SOIC	SN75176	1.75
SN65HVD11[1]	1/1	3.3	10	15.5	16	256	Short, Open	DIP, SOIC	SN75176	1.70
SN65HVD12[1]	1/1	3.3	1	15.5	16	256	Short, Open	DIP, SOIC	SN75176	1.65

[1]Available in Commercial Temperature option (SN75) in addition to Industrial Temperature (SN65).
[2]Suggested resale price in U.S. dollars in quantities of 1,000.
For a complete product listing visit **interface.ti.com**

RS-232

Generic Part Number	Data Rate (kbps)	Drivers per Package	ESD HBM (kV)	Footprint	I_{CC} Max (mA)	Receivers per Package	Supply Voltages (V)
MAX3221	250	1	15	MAX3221	1	1	3.3, 5
MAX3232	250	2	15	MAX3232	1	2	3.3, 5
MAX3238	250	5	15	MAX3238	2	3	3.3, 5
MAX3243	250	3	15	MAX3243	1	5	3.3, 5

For a complete product listing visit **interface.ti.com**

Prices are quoted in U.S. dollars and represent year 2004 suggested resale pricing. This is intended as budgetary pricing only and is subject to change without notice. Contact your local distributor for current pricing.

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