



Analog Solutions for Automotive Applications Design Guide

*This design guide includes analog solutions for Motor Control,
Power Supply, LED, Signal Chain and Sensor Applications*



Being one of the first companies to apply Non-Volatile Memory (NVM) technology to the development process for analog products, Microchip has utilized its NVM experience to deliver innovative analog solutions with unchallenged electrical characteristics.

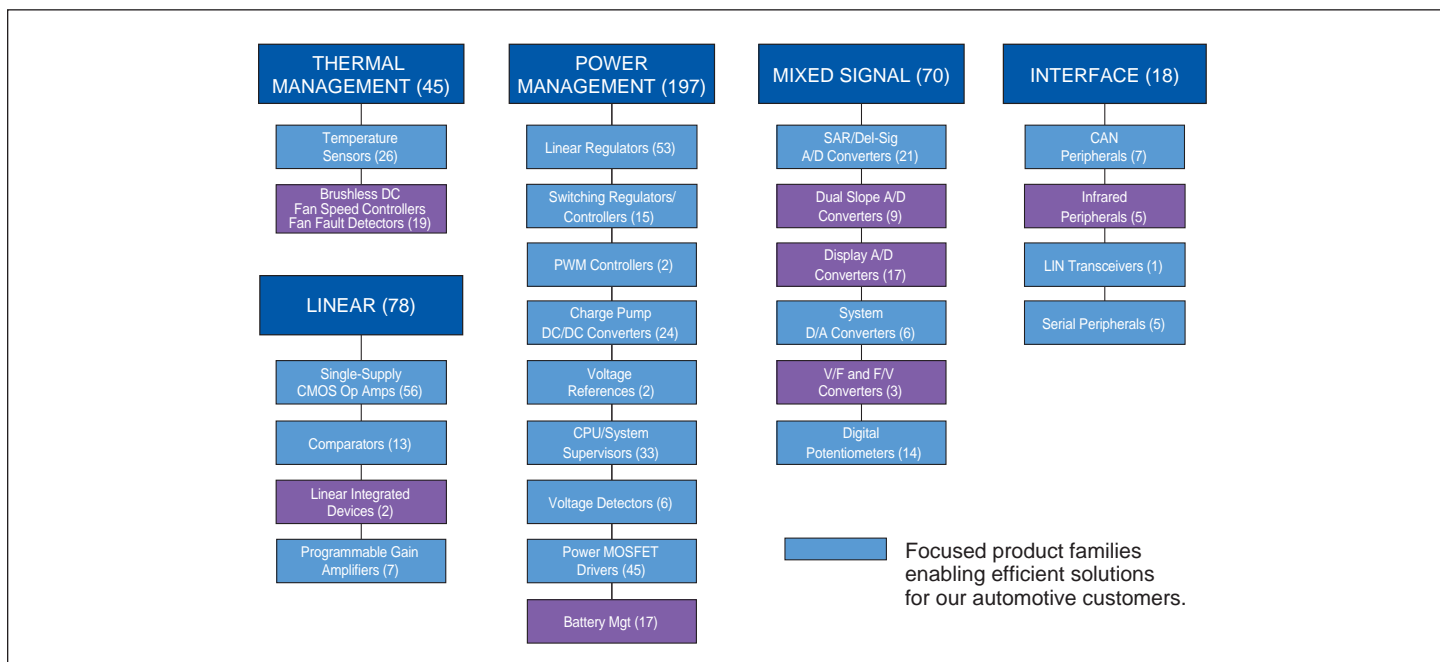
Analog and Interface Product Attributes

- Op Amp family with the lowest power for a given gain bandwidth
- 600 nA/1.4V/10 kHz bandwidth Op Amps
- 1.5V and 1.8V charge pumps and comparators
- Lowest power 12-bit ADC in a SOT-23 package

- One of the first to market integrated LDOs with Reset, fan controllers with temperature sensors and switcher regulators with LDOs and power good
- PGA integrates MUX, resistive ladder, gain switches, high-performance amplifier, SPI interface

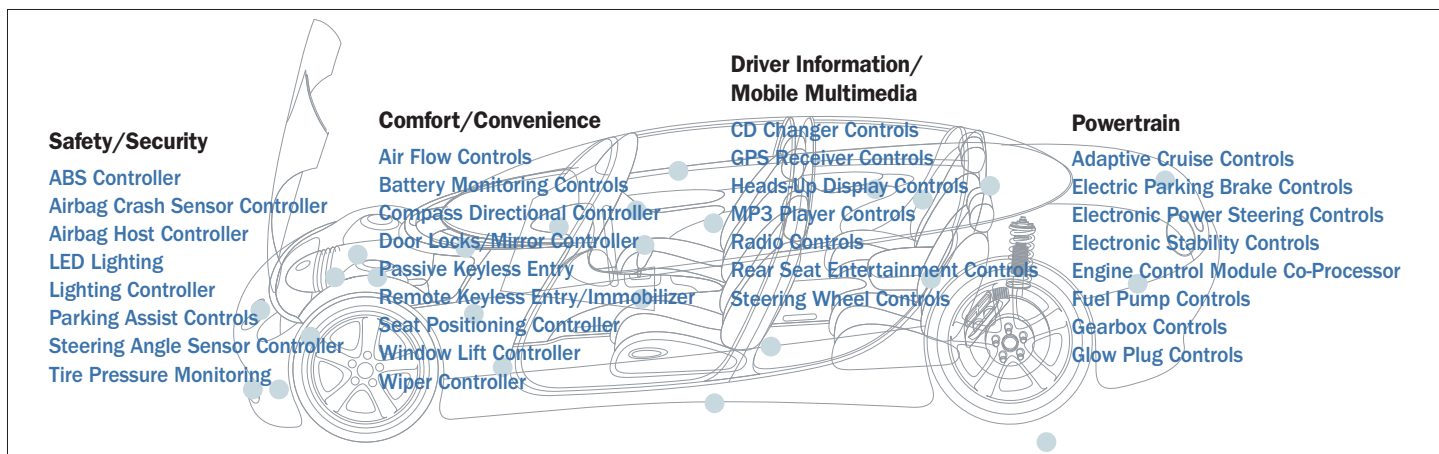
- Resets, comparators, op amps, temperature sensors and LDOs in a SC-70 package, ADCs in a 5-lead SOT-23 package

- Offset trimmed after packaging using Non-Volatile Memory

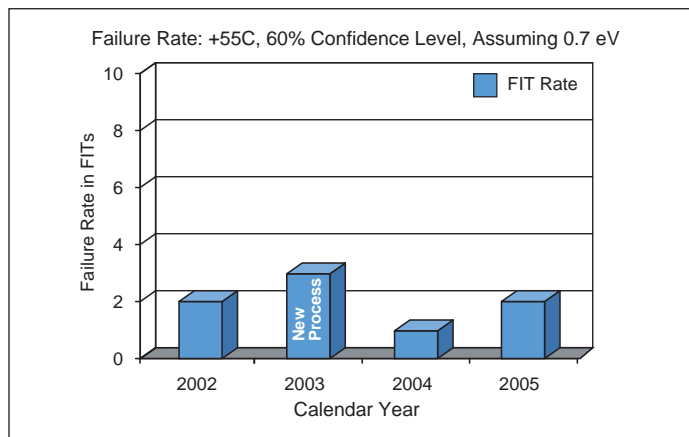


LOW-POWER ANALOG SOLUTIONS FOR AUTOMOTIVE APPLICATIONS

Microchip Analog Solutions Cover a Broad Range of Products and Applications in Automotive Systems



2002-2005 Analog Products FIT Rate Dynamic Life Test @ +150°C



Stress Test Qualification

Microchip has experience with the automotive industry's quality requirements. Our automotive customers may request incremental device qualification testing such as the AEC-Q100, shown below.

AEC-Q100 Device Qualification Plan*

| Test Name | Conditions |
|------------------------------------|---|
| ELFR | 150°C for 24 hours; Electrical test pre- and post-stress at +25°C and +125°C. |
| HTOL/DLT | 150°C for 408 hours; Electrical test pre- and post-stress at -40, +25 and +125°C. Readouts at 0, 96 and 408 hours. |
| EDR Endurance Cycling | Specified erase/write cycles at +85°C; Electrical test pre- and post-stress at +25°C and 125°C. |
| EDR High-Temp Bake/ Retention Bake | 175°C for 504 hours; Electrical test pre- and post-stress at +25°C and +125°C. Readouts at 0, 96 and 504 hours. |
| EDR HTOL/DLT | 150°C for 408 hours; Electrical test pre- and post-stress at -40, +25, and +125°C. Readouts at 0, 96 and 408 hours. |
| ESD - HBM | Electrical test pre- and post-stress at +25°C and +125°C. Test at each voltage: 500V, 1 KV, 2 KV, 4 KV. |
| ESD - MM | Electrical test pre- and post-stress at +25°C and +125°C. Test at each voltage: 100V, 200V, 300V, 400V. |
| Latch-Up (Overvoltage) | Test to ±14V and ±200 mA at +25°C and ±14V and ±100 mA at +125°C. Electrical test pre- and post-stress at +25°C and +125°C. |

*Additional package level qualification is performed per AEC-Q100 recommendation.

Quality to Serve the Automotive Market

Our manufacturing meets the demanding quality and logistics requirements imposed by the automotive market environment. In 2003, Microchip became one of the first semiconductor manufacturers to achieve **ISO/TS-16949** certification.

Microchip Technology Automotive Certification History

Tempe, AZ – Fab

ISO 9001 Registered (1996)
ISO/TS 16949 Registration (2003)
Recertification (2006)

Gresham, OR – Fab

ISO/TS 16949 Registration (2004)
Recertification (2006)

Bangkok, Thailand – Assembly & Test

ISO 9002 Registered (1997)
ISO/TS 16949 Registration (2003)
Recertification (2006)
ISO 14001 (2004)

LOW-POWER ANALOG SOLUTIONS FOR AUTOMOTIVE APPLICATIONS

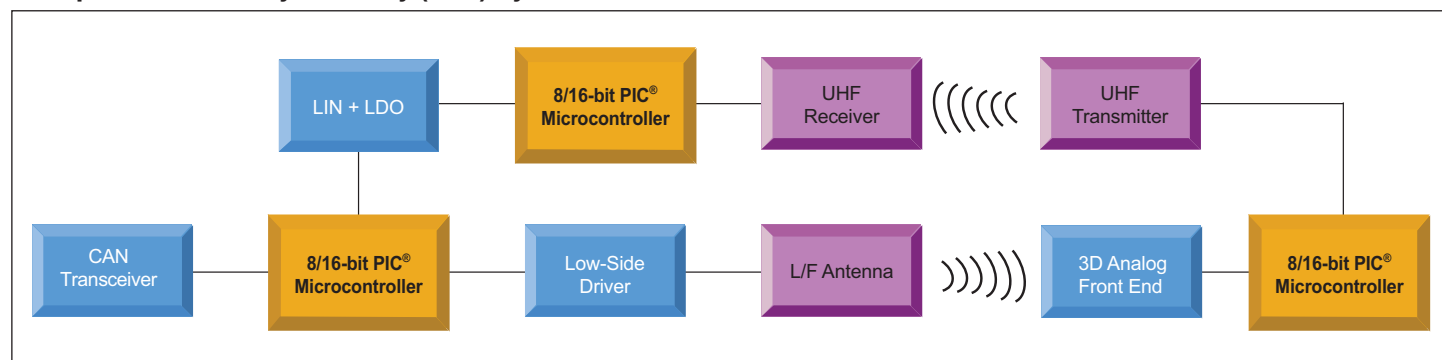
Solutions for Low-Frequency Communications Applications

Low-frequency communication systems provide many benefits in and around the vehicle. In sensing applications, it allows for the distribution of remote sensors while eliminating the concern for wired connection between the sensor and control module. In other applications, a transponder becomes a mobile device that can remain with the driver, or is attached to another apparatus that can be transferred to/from the vehicle when needed.

Application Examples

- Remote Keyless Entry (RKE)
- Passive Keyless Entry (PKE)
- Tire Pressure Monitoring Systems (TPMS)
- Child Seat Detection
- Immobilizers

Example of Passive Keyless Entry (PKE) Systems



Recommended Product Families for PKE Applications

| Family | Features | Device Examples |
|---------------------|--|---|
| 3D Analog Front End | Bidirectional low-frequency communications, low-operating and standby currents, programmable antenna tuning capacitance | MCP2030 |
| CAN/LIN Products | CAN transceivers and stand-alone controllers with SPI, LIN transceivers with integrated voltage regulators | MCP2515, MCP2551X, MCP201 |
| Op Amps | Single, dual and quad op amps, low quiescent current (600 nA), lowest I _q for a given Gain Bandwidth Product (GBWP); offered in space-saving packages | MCP6041/2/3/4, MCP6141/2/3/4 MCP601/2/3/4/6/7/8/9, MCP6021/2/3/4 |
| Low-Side Drivers | Single, dual and quad MOSFET Drivers, 0.5 to 12A peak output currents, inverting and non-inverting outputs | TC4420/1/2/3/4/5/6/7/8/9/A, TC1410/1/2/3, TC4451/2, TC4467/8/9 |
| Microcontrollers | Wide range of 8/16- RISC-based microcontrollers and digital signal controllers | PIC12, PIC16, PIC18, PIC24 |

Development Tools

| Part Number | Product |
|----------------|---|
| DV251001 | MCP2510/2515 CAN Developer's Kit |
| APGRD001 | Passive Keyless Entry Reference Design |
| APGAC011 | Accessory Key Fob For APGRD001 PKE Reference Design |
| DM163007/11/15 | PICDEM™ CAN-LIN 1 2 and 3 Demonstration Boards |
| DM163005 | PICDEM™ LIN Demonstration Board |

LOW-POWER ANALOG SOLUTIONS FOR AUTOMOTIVE APPLICATIONS

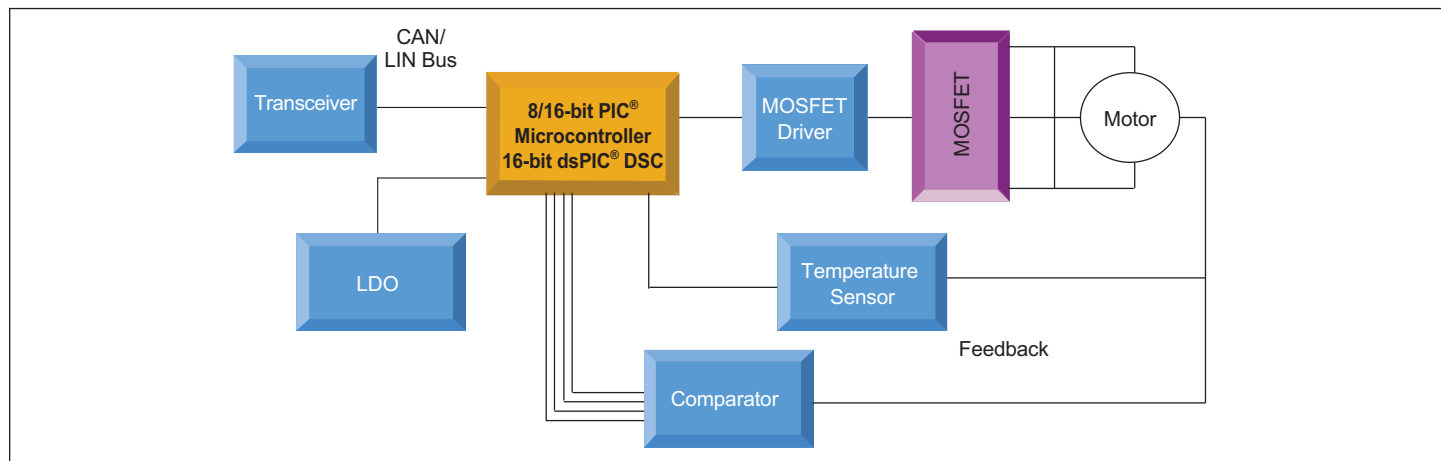
Solutions for Motor Control

A broad product portfolio provides a complete system solution for your stepper motor, brushed DC motor, AC induction motor, variable speed brushless DC motor and switched reluctance motor applications.

Application Examples

- Electro Hydraulic Power Steering
- Electric Power Steering
- Wiper Control
- Water Pump, Oil Pump, Fuel Pump
- Window Lift
- Sun Roof
- Air Flaps
- Interior and External Mirrors

Microchip Solutions for Motor Control



Recommended Product Families for Motor Control Applications

| Family | Features | Device Examples |
|------------------------|--|--|
| Temperature Sensors | Typical accuracy: $\pm 0.5^{\circ}\text{C}$, $\pm 1.0^{\circ}\text{C}$; Output options: 1) logic outputs, 2) voltage outputs, 3) serial outputs: SMBus/I ² C™, SPI | TC6501/2/3/4, MCP9700/1/A, MCP9800/1/2/3/5, TC72/4/5/7 |
| Comparators | Single, dual and quad comparators, low-power consumption, low quiescent current, small packages | TC1027, TC1037/8/9, MCP6541/2/3/4/6/7/8/9 |
| MOSFET Drivers | Single, dual and quad MOSFET Drivers, 0.5 to 12A peak output currents, inverting and non-inverting outputs | TC4420/1/2/3/4/5/6/7/8/9/A, TC1410/1/2/3, TC4451/2, TC4467/8/9 |
| Low-Dropout Regulators | Low-operating current for longer battery life, very low-dropout voltage, high-output voltage accuracy: $\pm 0.4\%$ (typ), overcurrent and overtemperature protection, requires only 1 μF ceramic output capacitance | MCP1700/1/2 |
| Transceivers | CAN transceivers and stand-alone controllers with SPI; LIN transceivers with integrated voltage regulators | MCP2515, MCP2551X, MCP201 |
| Microcontrollers | Wide range of 8/16- RISC-based microcontrollers and digital signal controllers | PIC12, PIC16, PIC18, PIC24, dsPIC30, dsPIC33 |

Development Tools

| Part Number | Product |
|--|---|
| Free at www.microchip.com | Motor Control Graphical User Interface |
| Free at www.microchip.com | FilterLab® Active Filter Design Software |
| DM183011 | PICDEM™ MC Development Board |
| DM300020 | dsPICDEM™ MC1 Motor Control Development Board |
| AC300020 (requires DM300020) | 3-phase BLDC Low Voltage Motor (24V) |
| APGRD002 | Window Lift Reference Design |
| MCP9700DM-PCTL | MCP9700 Temperature-to-Voltage Converter PICtail™ Demonstration Board |
| MCP9800DM-DL | MCP9800 Temperature Data Logger Demonstration Board |
| MCP9800DM-PCTL | MCP9800 Temperature Sensor PICtail™ Demonstration Board |

LOW-POWER ANALOG SOLUTIONS FOR AUTOMOTIVE APPLICATIONS

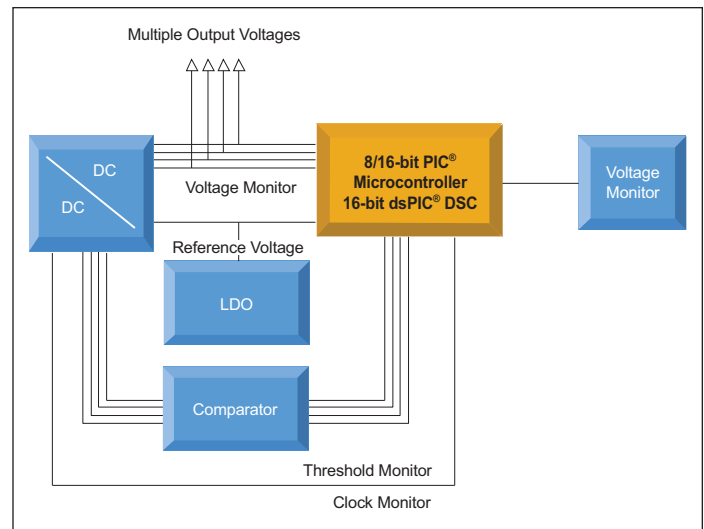
Solutions for Power Supply Applications

The growing deployment of navigation, entertainment and communication equipment in modern cars, as well as the utilization of most advanced semiconductor technologies, has been changing the needs for voltage regulation in the car. Automotive power supplies are used for DC-DC conversion, DC voltage monitoring, pulse-width modulation and digital control. Electronic Control Units are using SEPIC and Buck Converters with multiple level output voltages and different current ratings.

Application Examples

- Car Radio
- Navigation System
- Car Communication/Entertainment Center
- GPS

Example of Infotainment Power Supply Unit



Recommended Product Families for Power Supply Applications

| Family | Features | Device Examples |
|------------------------|--|---|
| Comparators | Single, dual and quad comparators, low-power consumption, low quiescent current, small packages | TC1027, TC1037/8/9, MCP6541/2/3/4 |
| Voltage Monitors | Low cost, precision system voltage supervisors; brown-out protection; wide range of output types, reset trip points and package options; watchdog input option | MCP102/3, MCP121, MCP131, MCP1316/17/18/19/20/21/22 |
| Pulse Width Modulator | High-speed microcontroller adaptable PWM; excellent current mode controller, fast response time, provides a very tight limit to the maximum switch current over a wide range of input voltages, low quiescent current | MCP1630 |
| Low-Dropout Regulators | Low-operating current for longer battery life, very low-dropout voltage, high-output voltage accuracy: $\pm 0.4\%$ (typ), overcurrent and overtemperature protection, requires only 1 μF ceramic output capacitance | MCP1700/1/2 |
| Switching Regulators | Step-up and step-down DC-DC converters with soft start, programmable voltage/current supply, point-of-load sequencing, intelligent temperature compensation, overvoltage and overcurrent handling | MCP1601, MCP1650/1/2/3, MCP1612, TC105, TC120/5/6 |
| Microcontrollers | Wide range of 8/16- RISC-based microcontrollers and digital signal controllers | PIC12, PIC16, PIC18, PIC24, dsPIC30, dsPIC33 |

Development Tools

| Part Number | Product |
|-----------------|--|
| MCP1601EV | MCP1601 Buck Regulator Evaluation Board |
| MCP1612EV | MCP1612 Synchronous Buck Regulator Evaluation Board |
| MCP1630DM-DDBS1 | MCP1630 Automotive Input Boost Converter Demonstration Board |
| MCP1630RD DDBK1 | MCP1630 +12V Dual Output Buck Converter Reference Design |
| MCP1650EV | MCP1650 Boost Controller Evaluation Board |
| MCP1726EV | MCP1726 1A LDO Evaluation Board |
| TC1016/17EV | TC1016/17 LDO Linear Regulator Evaluation Board |
| TC1303BDM-DDBK1 | TC1303B Buck Regulator LDO Demonstration Board |

Solutions for LED Applications

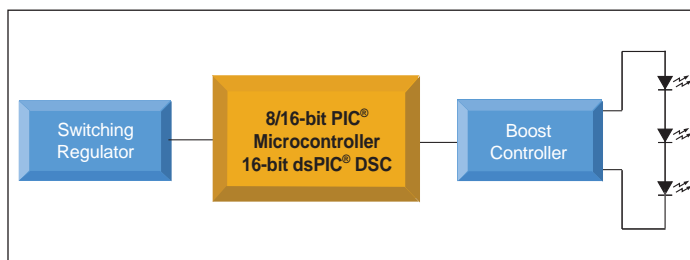
Traditional incandescent lamps are increasingly being replaced by Light Emitting Diodes (LEDs). LEDs offer compelling advantages, including a high level of light efficiency, reliability, mechanical stability and long operating lifetime. Because LEDs must be operated at constant current, DC-DC converters with the capability of efficiently translating the operating voltage into the LED forward voltage are required. Further key elements of LED control circuits are overcurrent protection, over heating protection (temperature sensing) and efficient energy utilization.

Application Examples

- Dashboard Illumination
- Signal and Warning Lights
- Daytime Running Lights
- Interior Lighting
- Tail Light
- Head up Displays
- Infrared Cameras

A typical LED solution can be as simple as a battery and a resistor, but with more complex dimming, flashing and multi-color applications; and more rigorous requirements in terms of matching brightness and color, there is an increasing need to control and monitor the current in an LED application.

Multiple White LED Solutions



Recommended Product Families for LED Applications

| Family | Features | Device Examples |
|-----------------------|---|---|
| Switching Regulators | Step-up and step-down DC-DC converters w/soft start, programmable voltage/current supply, point-of-load sequencing, intelligent temperature compensation, overvoltage and overcurrent handling | MCP1252/3, MCP1601, MCP1612, MCP1650/1/2/3, TC105, TC120/5/6 |
| Pulse Width Modulator | High-speed microcontroller adaptable PWM; excellent current mode controller, fast response time, provides a very tight limit to the maximum switch current over a wide range of input voltages, low quiescent current | MCP1630 |
| Temperature Sensors | Typical Accuracy: $\pm 0.5^{\circ}\text{C}$, $\pm 1.0^{\circ}\text{C}$; Output Options: 1) digital outputs, 2) analog outputs, 3) serial outputs: SMBus/I ² C™, SPI | TC6501/2/3/4, MCP9700/1/A, MCP9800/1/2/3/5, TC72/4/5/7 |
| Op Amps | Single, dual and quad op amps, low quiescent current (600 nA), lowest I _q for a given Gain Bandwidth Product (GBWP); offered in space-saving packages | MCP6041/2/3/4, MCP6141/2/3/4, MCP601/2/3/4/6/7/8/9, MCP6021/2/3/4 |
| Microcontrollers | Wide range of 8/16- RISC-based microcontrollers and digital signal controllers | PIC12, PIC16, PIC18, PIC24, dsPIC30, dsPIC33 |

Development Tools

| Part Number | Product |
|------------------|---|
| DV164101 | PICkit™ 1 Flash Starter Kit |
| AC163002 | PICDEM™ MSC1 Infrared (IR) Driver Daughter Board |
| MCP1650DM-LED1 | MCP1650 3W White LED Demonstration Board |
| MCP1650DM-LED2 | MCP1650 Multiple White LED Demonstration Board |
| MCP6SX2DM-PCTLPD | MCP6SX2 PGA Photodiode PICTail™ Demonstration Board |
| MCP1252DM-BKLT | MCP1252 Charge Pump Backlight Demonstration Board |

Solutions for Sensor Applications



Modern vehicles are networked PCs on wheels where sensors provide the interface to the real world. The number of sensors in automotive applications is rapidly increasing. Of all sensing technologies,

temperature sensing is the most common. Knowing and using the actual or relative temperature is critical. For instance, other sensors such as pressure, force, flow, level and position many times require temperature monitoring in order to ensure accuracy.

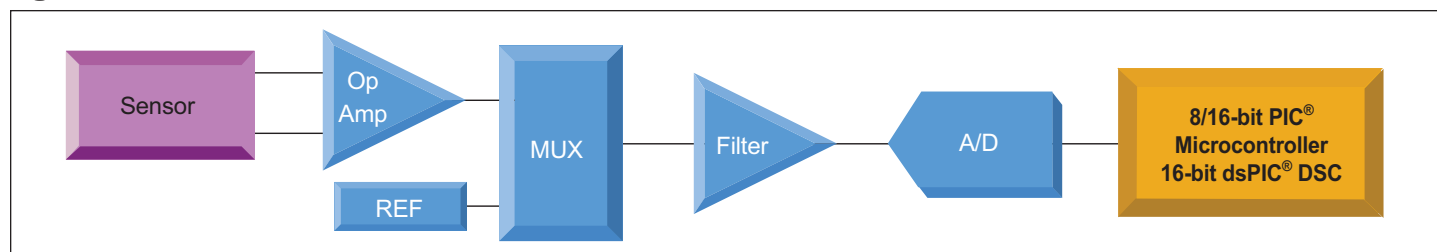
Signal Chain Solutions

Our extensive analog portfolio includes operational amplifiers and programmable gain amplifiers, voltage references, digital potentiometers, analog-to-digital converters and silicon IC temperature sensors to meet today's demanding measurement design requirements.

Application Examples

- Key-off Applications Requiring Low Power
- Humidity and Pressure Sensors
- Level and Tilt Sensors
- Air Quality Sensor
- Light and Temperature Sensor
- Rain Sensor
- ABS
- TPMS
- PKE/RKE
- Dashboard Illumination
- Car Audio (Infotainment)
- Air Bags (Occupant Detect)
- Electronic Power Steering
- Hybrid Electric Vehicle Battery Monitors
- Signal, Warning and Daytime Running Lights
- Approach, Crash and Steering Angle Sensors

Signal Chain Solutions



Recommended Product Families for Sensor Applications

| Family | Features | Device Examples |
|------------------------------------|---|--|
| Serial Output Temp Sensors | Offer excellent temperature accuracy with very low operating current; communication is accomplished via I ² C™ or SPI; all devices are offered in space-saving packages and feature very fast temperature conversion times | MCP9800/1/2/3/5, TC72/4/5/7/A |
| Voltage Output Temp Sensors | Temperature conversion accuracy, linear temperature slopes, small packages | MCP9700/1/A, TC1046/7/A |
| Logic Output Temp Sensors | Excellent temperature accuracy ($\pm 1^{\circ}\text{C}$ typical); low operating current ($<600\ \mu\text{A}$); features include programmable hysteresis, remote temperature sensing and dual temperature limit output | TC620/1/2/3/4, TC6501/2/3/4, TCN75A |
| Programmable Gain Amplifiers (PGA) | Programmable over SPI bus, adds gain control and input channel selection to the embedded control system; reduces complexity of multiple sensor system to one amplifier; lower system costs, requires less space | MCP6S21/2/6/8, MCP6S91/2/3 |
| Op Amps | Single, dual and quad op amps, low quiescent current (600 nA), lowest I _q for a given Gain Bandwidth Product (GBWP); offered in space-saving packages | MCP6041/2/3/4, MCP6141/2/3/4, MCP601/2/3/4/6/7/8/9, MCP6021/2/3/4 |
| Voltage References | Voltage references in SOT23-3 and TO-92 packages | MCP1525/41 |
| Digital Potentiometers | A family of digital potentiometers combine high performance and low power consumption in a small package | MCP4011/2/3/4, MCP4021/2/3/4, MCP41010/050/100, MCP42010/050/100 |
| Analog-to-Digital Converters (ADC) | Broad portfolio of high-precision SAR, Delta-Sigma and Dual Slope A/D Converters; SAR ADCs up to 13-bit with low power consumption combined in a small package | MCP3X01/2/4/8, MCP3X21, MCP3550/1/3, TC500/00A/10/14/20A/30/34, TC835/50, TC7135/14433/A |
| Microcontrollers | Wide range of 8/16- RISC-based microcontrollers and digital signal controllers | PIC12, PIC16, PIC18, PIC24, dsPIC30, dsPIC33 |

Development Tools for Sensor Applications

| Part Number | Product |
|------------------|--|
| DV250501 | MCP250XX CAN I/O Expander Developer's Kit |
| DV3201A | MCP3XXX Single/Dual ADC MXDEV® Daughter Board |
| DV3204A | MCP3204/08 MXDEV® Daughter Board |
| DV42XXX | MCP42XXX Digital Pot MXDEV® Daughter Board |
| DVMCPA | MXDEV Analog Evaluation System |
| MCP3221DM-PCTL | MCP3221 PICtail™ Demo Board |
| MCP3551DM-PCTL | MCP3551 Delta-Sigma ADC Demo Board |
| MCP355XDV-MS1 | MCP355X Sensor Application Developer's Board |
| MCP402XEV | MCP402X Non-Volatile Digital Potentiometer Evaluation Board |
| MCP4XXDM-DB | MCP4XXX Digital Potentiometer Daughter Board |
| MCP6S22DM-PICTL | MCP6S22 PGA PICtail™ Demo Board |
| MCP6S2XEV | MCP6S2X PGA Evaluation Board |
| MCP6SX2DM-PCTLTH | MCP6SX2 PGA Thermistor PICtail™ Demo Board |
| MCP9700DM-PCTL | MCP9700 Temperature-to-Voltage Converter PICtail™ Demo Board |
| MCP9800DM-DL | MCP9800 Temperature Data Logger Demo Board |
| MCP9800DM-PCTL | MCP9800 Temperature Sensor PICtail™ Demo Board |
| TC72DM-PICTL | TC72 Digital Temperature Sensor PICtail™ Demo Board |
| TC74DEMO | TC74 Serial Digital Thermal Sensor Demo Board |
| TC77DM-PICTL | TC77 Thermal Sensor PICtail™ Demo Board |
| TC1047ADM-PICTL | TC1047A Temp-to-Voltage Converter PICtail™ Demo Board |

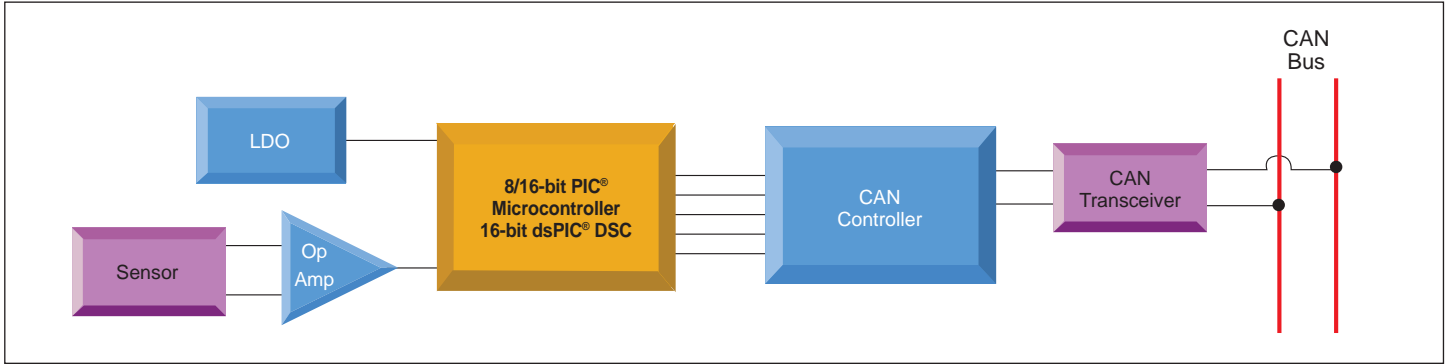
LOW POWER ANALOG SOLUTIONS FOR AUTOMOTIVE APPLICATIONS

Solutions for Connectivity Applications

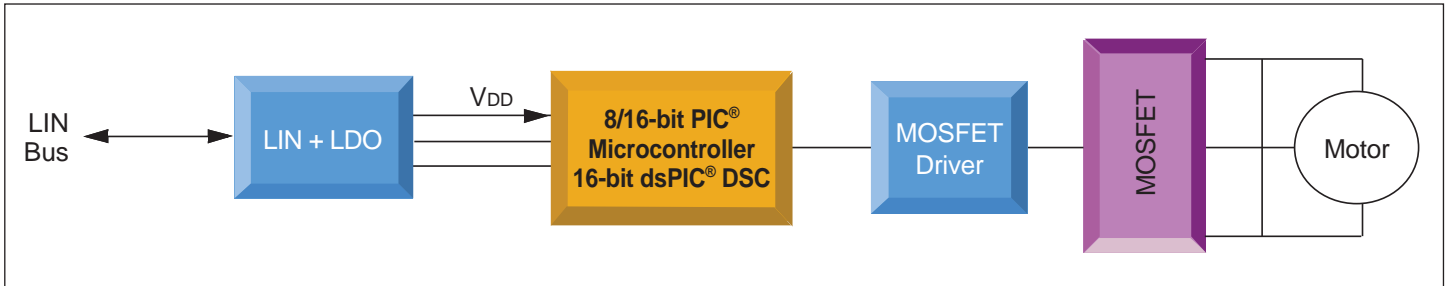
Connectivity within the vehicle is dominated today by two main network protocols: CAN (Controller Area Network) and LIN (Local Interconnect Network). CAN utilizes a robust, high-speed protocol, usually linking major nodes or

subsystems within the vehicle, such as ABS, airbag, powertrain and suspension control modules. LIN is a low-speed, single-wire network that usually links nodes within a vehicle subsystem, such as body electronics, headlight controls and occupant detection.

Simple Sensor Node Using MCP2515 Standalone CAN Controller



Motor Control Node Using MCP201 LIN Transceiver



Recommended Interface Product Families for Connectivity Applications

| Family | Features | Device Examples |
|------------------|---|-------------------|
| CAN Controller | CAN V2.0B at 1Mb/s, two receive buffers, three transmit buffers high-speed SPI (10 MHz) | MCP2515 |
| CAN Transceiver | Implements ISO 11898-2 physical layer requirements, ±40V short-circuit protection, ±250V transient protection | MCP2551X |
| CAN I/O Expander | CAN V2.0B, eight general purpose I/Os, four 10-bit A/D converters, two 10-bit PWM outputs | MCP25020/25/50/55 |
| LIN Transceiver | Integrated LDO regulator (5V ±5%), supports LIN rates up to 20 Kbaud, short-circuit and thermal overload protection | MCP201 |

Development Tools

| Part Number | Product |
|------------------------------|---|
| DM163005 | PICDEM™ LIN Demonstration Board |
| DM163007, DM163011, DM163015 | PICDEM™ CAN-LIN 1, 2 and 3 Demonstration Boards |
| DV250501 | MCP250XX CAN I/O Expander Developer's Kit |
| DV251001 | MCP2510/2515 CAN Developer's Kit |
| MCP2515DM-PCTL | MCP2515 CAN Controller PICtail™ Demonstration Board |
| SOIC8EV | SOIC 8-Lead Evaluation Board |

LOW POWER ANALOG SOLUTIONS FOR AUTOMOTIVE APPLICATIONS

Application Notes and Additional Documentation Available

| Application | Document Number | Title |
|----------------------------------|-----------------|--|
| Connectivity | AN228 | A CAN Physical Layer Discussion |
| Connectivity | AN729 | LIN Protocol Implementation Using PIC® MCUs |
| Connectivity | AN754 | Understanding Microchip's CAN Module Bit Timing |
| Connectivity | AN816 | A CAN System Using Multiple MCP25025 I/O Expanders |
| Low-Frequency Communications/PKE | AN232 | Low-Frequency Magnetic Transmitter Design |
| Low-Frequency Communications/PKE | AN238 | Tire Pressure Monitoring (TPM) System |
| Low-Frequency Communications/PKE | AN879 | Using the Microchip Ultra Low-power Wake-up |
| Low-Frequency Communications/PKE | AN959 | Using the PIC16F639 MCU for Smart Wireless |
| Low-Frequency Communications/PKE | AN1024 | PKE System Design Using the PIC16F639 |
| Low-Frequency Communications/PKE | TB090 | MCP2030 Three-Channel Analog Front-End |
| Low-Frequency Communications/PKE | TB088 | PIC16F639 Microcontroller Overview |
| Motor Control | AN799 | Matching MOSFET Drivers to MOSFETs |
| Motor Control | AN894 | Motor Control Sensor Feedback Circuits |
| Motor Control | AN898 | Determining MOSFET Driver Needs for Motor Drive Applications |
| Motor Control | AN885 | Brushless DC (BLDC) Motor Fundamentals |
| Motor Control | AN857 | Brushless DC Motor Control Made Easy |
| Motor Control | AN763 | Latch-Up Protection for MOSFET Drivers |
| Motor Control | AN807 | Low-Cost DC Motor Speed Control with CMOS ICs |
| Power Supply | AN216 | DC-DC Converter Controller using a PIC® Microcontroller |
| Power Supply | AN686 | Understanding and Using Supervisory Circuits |
| Power Supply | AN761 | LDO Thermal Considerations |
| Power Supply | AN765 | Using Microchip's Micropower LDOs |
| Power Supply | AN766 | Pin-compatible CMOS Upgrades to Bipolar LDOs |
| Power Supply | AN763 | Latch-Up Protection for MOSFET Drivers |
| Power Supply | TB081 | Soft-Start for Switching Power Supplies |
| Power Supply | TB085 | A Simple Circuit for Driving Microcontroller Friendly PWM Generators |
| LED/Lighting | AN874 | Buck Configuration High-Power LED Driver |
| LED/Lighting | AN948 | Efficiently Powering Nine White LEDs with the MCP1650 |
| LED/Lighting | TB029 | Complementary LED Drive |
| LED/Lighting | TB060 | Drive High Intensity White LEDs Efficiently Using the PIC16C781 |
| LED/Lighting | TB062 | High-Power IR LED Driver Using the PIC16C781/782 |
| LED/Lighting | DS40040 | PIC® Comparator Tips 'n Tricks |
| LED/Lighting | DS41215 | 8-pin Flash PIC® Microcontroller Tips 'n Tricks |
| Sensors/Signal Chain | AN251 | Bridge Sensing with the MCP6S2X PGAs |
| Sensors/Signal Chain | AN679 | Temperature Sensing Technologies |
| Sensors/Signal Chain | AN688 | Layout Tips for 12-bit A/D Converter Application |
| Sensors/Signal Chain | AN691 | Optimizing the Digital Potentiometer in Precision Circuits |
| Sensors/Signal Chain | AN695 | Interfacing Pressure Sensors to Microchip's Analog Peripherals |
| Sensors/Signal Chain | AN699 | Anti-Aliasing, Analog Filters for Data Acquisition Systems |
| Sensors/Signal Chain | AN845 | Communicating with the MCP3221 using PIC Microcontrollers |
| Sensors/Signal Chain | AN865 | Sensing Light with a Programmable Gain Amplifier |
| Sensors/Signal Chain | AN866 | Temperature Sensing with a Programmable Gain Amplifier |
| Sensors/Signal Chain | AN981 | Interfacing the MPC9700 Analog Output Temperature Sensor to a PIC® Microcontroller |
| Sensors/Signal Chain | AN988 | Interfacing the MCP9800 I ² C™ Digital Temperature Sensor to a PIC® Microcontroller |
| Sensors/Signal Chain | TB051 | Precision Temperature Measurement using a TC1046/TC1047 Sensor and a PIC16F872 Microcontroller |

Support

Microchip is committed to supporting its customers in developing products faster and more efficiently. We maintain a worldwide network of field applications engineers and technical support ready to provide product and system assistance. In addition, the following service areas are available at www.microchip.com:

- **Support** link provides a way to get questions answered fast: <http://support.microchip.com>
- **Sample** link offers evaluation samples of any Microchip device: <http://sample.microchip.com>
- **Forum** link provides access to knowledge base and peer help: <http://forum.microchip.com>
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Tel: 765-864-8360

Los Angeles

Tel: 949-462-9523

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Tel: 408-961-6444

Toronto

Mississauga, Ontario

Tel: 905-673-0699

EUROPE

Austria - Wels

Tel: 43-7242-2244-39

Denmark - Copenhagen

Tel: 45-4450-2828

France - Paris

Tel: 33-1-69-53-63-20

Germany - Munich

Tel: 49-89-627-144-0

Italy - Milan

Tel: 39-0331-742611

Netherlands - Drunen

Tel: 31-416-690399

Spain - Madrid

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UK - Wokingham

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