Standard analog products for automotive

General Purpose Analog
Signal conditioning and interface
April 2023
ST provides a wide range of analog products dedicated to the challenging and demanding automotive market.

This presentation introduces an extended automotive high-performance analog portfolio of ST’s products and solutions dedicated to signal amplification, current sensing, interface, reset, supervisors and automotive-grade logic ICs.

Thanks to innovative design techniques and a continuous focus on improving quality, ST offers high-performance devices that meet the specific requirements of the rigorous AEC-Q100 standard.
Automotive standard analog portfolio
Automotive signal conditioning

Extended automotive high-performance analog portfolio

Operational amplifiers
Comparators
Current sense amplifiers
Interfaces
Reset and supervisors
Automotive Logic

For all automotive applications
Operational amplifiers & comparators

- Low-power operational amplifiers
- Precision operational amplifiers
- High output current & capacitive load operational amplifiers
- Fast operational amplifiers
- Comparators
- Grade 0 (150°C) amplifiers & comparators
The main features of ST’s portfolio of current sensing ICs ensure robustness and application safety:

- -20 to +70 V line monitoring
- Bidirectional or unidirectional current measurement.
- Integrated solutions for faster design time and reduced bill of materials
  - Integrated EMI filters
  - Pin selectable gain
  - Shutdown function
- Robust devices that do not require external protection
- Automotive-grade qualified
The STWD100 watchdog timer circuits are self-contained devices which prevent system failures caused by certain types of hardware errors (including nonresponding peripherals and bus contention) or software errors (such as a bad code jump or code stuck in loop). A watchdog input (WDI) signal periodically resets the internal watchdog timer within a specified timeout period. If the system fails, the watchdog timer is not reset, a system alert is generated and the watchdog output is asserted.
The Automotive-grade logic ICs offer a range of products including counters / encoders / decoders, gates, flip-flop / registers and buffer drivers.

Supporting temperature ranges that can go up to 125°C, our automotive logic devices offer:

- AEC-Q100 and Q101 compliance
- TS-16949 certification
- PPAP availability
- AEC-Q001 and Q002 guidelines for Statistical Yield Analysis (SYA) and Part Average Testing (PAT) at EWS
- Specific screening and test methods above and beyond AEC-Q100 compliance, such as performance of a 100% hot test (125°C) during the back-end (packaging and testing) stage
- Highly reliable standard SO and TSSOP packages
<table>
<thead>
<tr>
<th>Function</th>
<th>Commercial product</th>
<th>Package</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buffer</td>
<td>74LCX125YMTR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Quad Bus Buffer (3-State)</td>
</tr>
<tr>
<td>Inverter</td>
<td>74VHC14YMTR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Hex Schmitt Inverter</td>
</tr>
<tr>
<td>Buffer</td>
<td>74LCX07YMTR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Hex Buffer</td>
</tr>
<tr>
<td>Gate</td>
<td>74LCX00YMTR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Quad 2-Input NAND Gate</td>
</tr>
<tr>
<td>Schmitt Trigger</td>
<td>HCF40106YM013TR</td>
<td>SO14</td>
<td>Hex Schmitt Trigger</td>
</tr>
<tr>
<td>Buffer</td>
<td>HCF4010YMO13TR</td>
<td>SO16</td>
<td>Dual D Flip-Flop</td>
</tr>
<tr>
<td>Inverter</td>
<td>HCF4013YM013TR</td>
<td>SO14</td>
<td>Dual D Flip-Flop</td>
</tr>
<tr>
<td>Shift Register</td>
<td>HCF4021YM013TR</td>
<td>SO16</td>
<td>8-Stage Static Shift Register</td>
</tr>
<tr>
<td>Mux / Demux</td>
<td>HCF4051YM013TR</td>
<td>SO16</td>
<td>Single 8-Channel Analog Mux / Demux</td>
</tr>
<tr>
<td>Counter/Driver</td>
<td>HCF4060YM013TR</td>
<td>SO16</td>
<td>14-Stage Counter/Driver AND Oscillator</td>
</tr>
<tr>
<td>Inverter</td>
<td>HCF4069YUM013TR</td>
<td>SO14</td>
<td>Hex Inverter</td>
</tr>
<tr>
<td>Gate</td>
<td>HCF4070YM013TR</td>
<td>SO14</td>
<td>Quad Ex-OR Gate</td>
</tr>
<tr>
<td>Schmitt Trigger</td>
<td>HCF4093YM013TR</td>
<td>SO14</td>
<td>Quad 2-Input NAND Schmitt Trigger</td>
</tr>
<tr>
<td>Bus register</td>
<td>HCF4094YM013TR + YTTR</td>
<td>SO16</td>
<td>8-Stage Shift-AND-Store Bus Register</td>
</tr>
<tr>
<td>Mux / Demux</td>
<td>M74HC4851YM13TR + YTTR</td>
<td>SO16 + TSSOP16</td>
<td>Single 8 Channel Analog Mux / Demux</td>
</tr>
<tr>
<td>Mux / Demux</td>
<td>M74HC4852YM13TR + YTTR</td>
<td>SO16</td>
<td>Dual 4 Channel Analog Mux / Demux</td>
</tr>
<tr>
<td>Inverter</td>
<td>M74HC04YRM13TR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Hex Inverter</td>
</tr>
<tr>
<td>Gate</td>
<td>M74HC08YRM13TR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Quad 2-Input AND Gate</td>
</tr>
<tr>
<td>Buffer</td>
<td>M74HC126YRM13TR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Quad Bus Buffer (3-State)</td>
</tr>
<tr>
<td>Gate</td>
<td>M74HC132YRM13TR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Quad 2-Input Schmitt NAND Gate</td>
</tr>
<tr>
<td>Inverter</td>
<td>M74HC14YRM13TR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>Hex Schmitt Inverter</td>
</tr>
<tr>
<td>Multiplexer</td>
<td>M74HC151YRM13TR + YTTR</td>
<td>SO14 + TSSOP14</td>
<td>8-Channel multiplexer</td>
</tr>
<tr>
<td>Latch</td>
<td>M74HC259YRM13TR + YTTR</td>
<td>SO16 + TSSOP16</td>
<td>8 Bit Addressable Latch</td>
</tr>
<tr>
<td>Generator</td>
<td>M74HC280YRM13TR</td>
<td>SO14</td>
<td>9 Bit Parity Generator</td>
</tr>
<tr>
<td>Counter</td>
<td>M74HC4060YRM13TR + YTTR</td>
<td>SO16 + TSSOP16</td>
<td>14-Stage Binary Counter/Oscillator</td>
</tr>
<tr>
<td>Shift Register</td>
<td>M74HC4094YRM13TR + YTTR</td>
<td>SO16 + TSSOP16</td>
<td>8 Bit SIPO Shift Register Latch (3-State)</td>
</tr>
<tr>
<td>Shift Register</td>
<td>M74HC595YRM13TR + YTTR</td>
<td>SO16 + TSSOP16</td>
<td>8 Bit Shift Register Output Latch (3-State)</td>
</tr>
<tr>
<td>Inverter</td>
<td>M74HC365YRM13TR + YTTR</td>
<td>SO16 + TSSOP16</td>
<td>Hex Bus Buffer (3-State)</td>
</tr>
</tbody>
</table>
Quality, process, and packages
Automotive grade qualification process

80% of all innovations in the automotive industry today are enabled by electronics

- Very high level of in-house parametric testing equipment
- 100% electrical testing with very extensive coverage coupled with automatic visual inspection
- Part Average Testing (PAT) to detect and remove parts tested “pass” but potentially weak in reliability
- Hot test & Junction Verification Test (JVT) at Final test for SOT23, Mini-SO, SO, TSSOP, QFN/DFN
- A specific commercial product number
# Automotive parts production process

<table>
<thead>
<tr>
<th>Part number (example)</th>
<th>Grade</th>
<th>Process control</th>
<th>Visual inspection of wafers</th>
<th>EWS</th>
<th>PPAT</th>
<th>GPAT</th>
<th>SBL</th>
<th>SYL</th>
<th>Thermal cycles</th>
<th>Final electrical test</th>
<th>Junction verification test</th>
<th>PPAP report</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSZ181ILT</td>
<td>Non AG</td>
<td>Sampling</td>
<td>Sampling</td>
<td>No</td>
<td>100%</td>
<td>No</td>
<td>No</td>
<td></td>
<td>25°C</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>TSZ181IYLT</td>
<td>AG Grade 1</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>Yes</td>
<td>100%</td>
<td>Yes</td>
<td></td>
<td>25°C 125°C</td>
<td>125°C</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>TSZ181HYLT</td>
<td>AG Grade 0</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>Yes</td>
<td>100%</td>
<td>Yes</td>
<td></td>
<td>25°C 150°C</td>
<td>150°C</td>
<td>Yes</td>
<td></td>
</tr>
</tbody>
</table>
Package roadmap

Automotive grade 1 (125°C)
Automotive grade 0 (150°C)

PCB Space saving

Thickness reduction

Reduced environmental footprint
Automotive grade DFN packages

Wettable flanks for Automated Optical Inspection (AOI)

Immune to soldering crack for more than 2000 thermal cycles
-40 to 125 °C, 1 cycle per hour, 1.0 mm thick high Tg FR4 PCB
Product highlights
High bandwidth (30 MHz) Low offset (200 µV) Rail-to-rail 5 V op amp

KEY FEATURES
- Gain bandwidth product 30 MHz, unity gain stable
- Slew rate 20V/µs
- Low input offset voltage: 50µV typ., 200 µV max.
- Low input bias current: 2 pA typ.
- Low noise : 7nV/√Hz
- Wide supply voltage range: 2.0 V to 5.5 V
- Rail-to-rail input and output

KEY APPLICATIONS
- Industrial and Automotive
- Power management

KEY BENEFITS
- Accuracy virtually unaffected by noise or input bias current
- Signal conditioning for high frequencies

TSV782 overview

Dual
DFN8 2mmx2mm
MiniSO8
SO8

Industrial
TSV782IQ2T
TSV782IST
TSV782IDT

Automotive
TSV782IYST
TSV782IYDT
High bandwidth (22 MHz) Low offset (200 µV) Low-rail 5 V op amp

KEY FEATURES
• Gain bandwidth product 22 MHz, unity gain stable
• Low input offset voltage 50 µV typ, 200 µV max
• Low input voltage noise density: 7 nV/√Hz
• Wide supply voltage range: 1.8 to 5.5 V
• Power saving: 1.7 mA typical, 2.5 nA in shut-down
• Output rail-to-rail
• Automotive grade and shut-down versions available

KEY APPLICATIONS
• Industrial and Automotive
• Telecom infrastructure

KEY BENEFITS
• Accuracy virtually unaffected by noise or input bias current
• Signal conditioning for high frequencies

TSV7721 TSV7722 TSV7723 overview

TSV772 TSV782 TSV791 TSV792

low rail to rail

TSV772 TSV772 TSV772

20 MHz 30 MHz 50 MHz

Industrial

TSV7721ILT

TSV7722Q2T

TSV7722IST

TSV7722IDT

TSV7723IST

Automotive

TSV7721IYLT

TSV7722IYST

TSV7722IYDT

Single

SOT23-5

Dual

DFN8 2mmx2mm

MiniSO8

SO8

Dual + Shut-down

MiniSO10
High bandwidth (20 MHz) Low offset (200 µV) Rail-to-rail 5 V op amp

**KEY BENEFITS**
- Accuracy virtually unaffected by noise or input bias current
- Signal conditioning for high frequencies

**KEY FEATURES**
- Gain bandwidth product 20 MHz, unity gain stable
- Low input offset voltage: 50 µV typ., 200 µV max.
- Low input bias current: 2 pA typ.
- Low noise: 7 nV/\sqrt{Hz}
- Slew rate: 10.5 V/µs
- Wide supply voltage range: 2.0 V to 5.5 V
- Rail-to-rail input and output

**KEY APPLICATIONS**
- Industrial and Automotive
- Power management

**TSV772 overview**

<table>
<thead>
<tr>
<th>TSV772</th>
<th>TSV782</th>
<th>TSV791</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 MHz</td>
<td>30 MHz</td>
<td>50 MHz</td>
</tr>
</tbody>
</table>

Dual DFN8 2mmx2mm
MinSO8
SO8

Industrial
TSV772IQ2T
TSV772IST
TSV772IDT

Automotive
TSV772IYST
TSV772IYDT
**High bandwidth (50MHz) Low offset (200 µV) Rail-to-rail 5 V op amp**

**KEY FEATURES**
- Gain bandwidth product 50MHz, unity gain stable
- Slew rate 30V/µs
- Low input offset voltage 50µV typ, 200 µV max
- Low input voltage noise density 6.5nV/√Hz @10kHz
- Wide supply voltage range: 2.2 V to 5.5 V
- Rail-to-rail input and output
- Extended temperature range: -40 °C to +125 °C

**KEY APPLICATIONS**
- Industrial and Automotive
- Power management

**KEY BENEFITS**
- Accuracy virtually unaffected by noise or input bias current
- Signal conditioning for high frequencies

**KEY BENEFITS**
- Single: SOT23-5, TSV791ILT
- Dual: DFN8 2mmx2mm, MiniSO8, SO8, TSV792Q2T, TSV792IST, TSV792IDT
  - Industrial: TSV791ILT, TSV792IST, TSV792IDT
  - Automotive: TSV791YLT, TSV792YST, TSV792YDT
High bandwidth (10 to 16MHz) rail-to-rail 16V op amp

KEY BENEFITS
- Direct supply by +5V/-5V power lines
- Signal conditioning for high frequencies

KEY FEATURES
- Rail-to-rail input and output
- Gain bandwidth product 10 MHz (unity gain stable) or 16 MHz (stable for gain > 2)
- Low power consumption: 2.8 mA
- Low input bias current: 10 pA typ
- High tolerance to ESD: 4 kV HBM
- Automotive qualification

KEY APPLICATIONS
- Communications
- Process control

TSX9 overview

Industrial
- TSX921ILT
- TSX920ILT
- TSX922IQ2T
- TSX922IST
- TSX922IDT
- TSX923IST
- TSX9291ILT
- TSX9292IQ2T
- TSX9292IST
- TSX9292IDT

Automotive
- TSX921YLT
- TSX921YL
- TSX922YST
- TSX922YDT
- TSX9291YLT
- TSX9291YL
- TSX9292YDT
- TSX9292YT
High accuracy (Vio < 200 µV) rail-to-rail 16V op amp

KEY APPLICATIONS
- Instrumentation amplifier
- Active filtering

KEY BENEFITS
- Direct supply by +5V/-5V power lines
- High accuracy signal conditioning

KEY FEATURES
Low input offset voltage: 200 µV max
- Low input offset voltage: 100 µV max for “A” version
- Rail-to-rail input and output
- Gain bandwidth product 2.7 MHz (unity gain stable) or 9 MHz (stable for gain > 10)
- Low supply voltage: 2.7 - 16 V

2.7 MHz
Unity gain stable

9 MHz
Stable for Gain >10

Industrial
TSX711LT
TSX712IST
TSX712IDT

TSX711AILT
TSX712IYLT

TSX7191ILT
TSX7192IST
TSX7192IDT

TSX7191AIT
TSX7192IYDT

TSX711IYLT
TSX712IYST
TSX712IYDT
Low offset (300 μV), 6 MHz and 20 MHz, 36 V Rail-to-rail 36 V op amp

KEY FEATURES
• Wide supply voltage range:
  • 2.7 to 36 V
• Gain bandwidth product:
  • 6 MHz (TSB71x, unity gain stable)
  • 22 MHz (TSB719x, stable for gain > 10)
• Rail-to-rail input and output
• Low offset voltage:
  • 300 μV maximum (A version)
  • 800 μV maximum (Standard)

KEY APPLICATIONS
• Motor control
• Strain gauge

KEY BENEFITS
• Accuracy virtually unaffected by noise or input bias current
• Signal conditioning for high frequencies

KEY BENEFITS
• Accuracy virtually unaffected by noise or input bias current
• Signal conditioning for high frequencies

Industrial
TSB711AILT
TSB711ILT
TSB712AIST
TSB712IST
TSB712AIDT
TSB712IDT

Automotive
TSB7191AILT
TSB7191ILT
TSB7192AIST
TSB7192IST
TSB7192AIDT
TSB7192IDT
TSC2010 TSC2011 TSC2012 overview

70 V bidirectional current sensing

KEY APPLICATIONS
- High-side current sensing
- Low-side current sensing
- Motor control

KEY FEATURES
- Bidirectional current measurement
- Gain:
  - x20 (TSC2010)
  - x60 (TSC2011)
  - x100 (TSC2012)
- $V_{ICM}$ operating: -20 to 70 V surviving: -25 to 76 V
- $V_{CC}$: 2.7 to 5.5 V
- $V_{IO}$ max 700 µV
- Bandwidth:
  - 1 MHz (TSC2010)
  - 750 kHz (TSC2011)
  - 300 kHz (TSC2012)
- Operating temperature -40 to 125°C, MiniSO8 SO8
- extended temperature range (-40 to 150 °C): TSC2010H, TSC2011H and TSC2012H.

KEY BENEFITS
- High-side current measurement on high voltages
- Tolerant to voltage surge and battery reverse

Link:
TSC210 TSC211 ... TSC215 overview

26 V bidirectional current sensing

KEY APPLICATIONS
- Power management
- Battery chargers

KEY BENEFITS
- High-side current measurement on high voltages
- Tolerant to voltage surge and battery reverse

KEY FEATURES
- Bidirectional current measurement
- Gain selectable by part number option
  - x50 TSC213
  - x75 TSC215
  - x100 TSC214
  - x200 TSC210
  - x500 TSC211
  - x1000 TSC212
- $V_{ICM}$ operating -0.3 to 26 V
- $V_{CC}$ 2.7 to 26 V
- $V_{IO}$ max 35 µV
- Bandwidth 16 kHz (TSC210)
- Operating temperature -40 to 125 °C
TSZ181, TSZ182 overview

3 MHz chopper op amp

KEY APPLICATIONS
- High accuracy signal conditioning
- Automotive current measurement and sensor signal conditioning

KEY BENEFITS
- Accuracy virtually unaffected by temperature change

KEY FEATURES
- Very high accuracy and stability:
  - 25 µV max at 25 °C,
  - 35 µV -40 °C to 125 °C
- Gain bandwidth product: 3 MHz
- Rail-to-rail input and output
- Low supply voltage: 2.2 - 5.5 V
- Low power consumption: 1 mA max. at 5 V
- extended temperature range (-40 to 150 °C): TSZ181H, TSZ182H and (-40 to 175 °C): TSZ181H1, TSZ182H1
High temperature zero drift amplifier

KEY APPLICATIONS
- High accuracy signal conditioning
- Current measurement
- Sensor signal conditioning

KEY BENEFITS
- Outstanding accuracy on an ultra wide temperature range
- Long mission profile

KEY FEATURES
- Very high accuracy and stability: $V_{IO} \leq 25 \mu V$ max
- Gain bandwidth product: 3 MHz
- Wide supply voltage range: 2.2 V to 5.5 V
- Rail-to-rail input and output
- Automotive grade
- High temperature range:
  - -40 °C to +150 °C (auto grade zero)
  - -40 °C to +175 °C (auto grade H1 version)
Zero-drift amplifiers

KEY APPLICATIONS
• Battery-powered applications
• Signal conditioning

KEY BENEFITS
• Accuracy virtually unaffected by temperature change

KEY FEATURES
• Very high accuracy (Vio)
• 5 μV max at 25 °C
• 8 μV max -40 °C to 125 °C
• dVIO/dT < 30 nV/°C
• Low supply voltage: 1.8 - 5.5 V
• Maximum supply current 40 μA
• Gain bandwidth product 400 kHz
• Automotive grade
STWD100Y overview

Standalone watchdog

KEY APPLICATIONS
- Industrial and automotive
- Telecommunications
- UPS (uninterruptible power supply)

KEY BENEFITS
- Highest security level applications
- Robust and reliable
- Targeted applications: ADAS, front and rear LED lighting, mirror LED, emergency LED

KEY FEATURES
- Software code execution monitoring
- Hardware failure supervision
- System recovery

Watchdog timeout period | Output type | Chip enable | Icc (µA) |
-------------------------|------------|------------|----------|
3.4 ms                   | open       | yes        | 13       |
6.3 ms                   | drain      |            |          |
102 ms                   |            |            |          |
1.6 s                    |            |            |          |

Standalone watchdog

SOT23-5

Motor driver
- Headlamp Up/Down
- Headlamp Left/Right
Motor driver
Front-Light
Rear-Light
Emergency & Day-light

Memory
MCU
STWD100
Voltage regulation
STUSB1700Y overview

Stand-alone USB Type-C controller

**KEY APPLICATIONS**
- USB car chargers
- Front seats and Rear seats charging
- Infotainment systems

**KEY FEATURES**
- Role: Source
- Configurable start-up profiles
- Integrated VCONN switch:
  - Adjust. current limit (600mA max)
  - OVP, OCP, UVP, short protection
- 22 V short-to-VBUS protection on CC
- Direct interface to MCU through I²C + IRQ
- Dual power supply capability:
  - VBUS 4.1 V to 22 V - AMR = 28 V
  - VSYS 3.0 V to 5.5 V

**KEY BENEFITS**
- Standalone IC (MCU optional)
- Plug & Play,
- Robustness to high voltage spikes
- Configurable and flexible
- Integrated solution (reduced PCB area and cost vs. discrete)
- Type-C r1.2 compliant

Ideal solution for 15 W charging (5V / 3A) with or without USB DATA

QFN24 4x4 wettable flanks

Link on st.com
**STUSB4700Y overview**

**Stand-alone USB Type-C PD controller**

**KEY APPLICATIONS**
- USB car chargers
- Front seats and Rear seats charging
- Infotainment systems

**KEY FEATURES**
- Role: Source
- Support all USB PD profiles
- Configurable start-up profiles
- Dedicated Voltage & Current control Interface
- Integrated Voltage monitoring
- High Voltage Protections on connector pins (including CC)
- Integrated VBUS discharge path
- Auto-run support
- Nominal power supply: VBUS 4.1 V to 22 V (AMR 28 V)

**KEY BENEFITS**
- Can run without MCU support
- Robustness to high voltage spikes
- Configurable and flexible
- Integrated solution (reduced PCB area and cost vs discrete)
- Low pin count
- Reference designs on request

**Ideal solution for <60 W charging (<20 V / 3 A) with or without USB data without infotainment (ALT MODE)**

[Link on st.com]
Automotive applications
Added value for smart driving

- Temperature measurement
  Op Amp
  TSZ124IYPT
  WWW

- Rain and light sensor
  Op Amp
  TSV631IYLT
  WWW

- Power seat motor current control
  Current sensing
  TSC103IYPT
  WWW

- Pedal angle measurement
  Op Amp
  TSX922IYDT
  WWW

- Advanced driver assistance system
  Watchdog timer
  STWD100Y
  WWW

- Headlight Levelling
  Op Amp
  TSB572IYST
  WWW

- Audio buffer
  Op Amp
  TS922IYPT
  WWW
Added value for greener driving

- **Low-side current measurement for motor control**
  - Op Amp
  - TSZ124IYPT
  - www

- **NOx sensor for Selective Catalytic Reduction**
  - Op Amp
  - TSV912HYDT
  - www

- **Electric Power Steering angle measurement**
  - Op Amp
  - TSX564IYPT
  - www

- **Power switches for 48V battery applications**
  - Current sensing
  - TSC103IYPT
  - www

- **O2 sensor**
  - Op Amp
  - TSV522AIYST
  - www
Adjustment of headlight angle helps to compensate the car pitch angle, whatever the car loading or road conditions. The levelling becomes more and more critical as the headlights power increases, to prevent other drivers being dazzled.

The ECU provides a PWM signal proportional to the desired headlight angle. The first op amp acts as a level shifter, and the second as a low pass filter in order to provide a voltage proportional to battery voltage to the actuator.
The automotive industry is committed to meet future emission regulations, and the implementation of intermediate battery voltage of 48 V appears as a very promising solution.

**Principle of operation**

The current sense amplifier measures the current through a shunt resistor. In case the current would exceed the programmed threshold, the microcontroller would inhibit the gate drive.

**ST Offer**

- **STC103IYPT**: Intelligent power switches for 48 V battery applications

**Feature**

- Input pins sustain: -16 to 75V
  - ESD 2.5kV

**Benefit**

- No protection needed for:
  - Load dump, reversed battery, ESD surges

- Output voltage accuracy:
  - ±2.5% @25°C
  - ±4% from -40 to 125°C

- Minimizes shunt value and cost
Temperature measurement

Temperature is measured to guarantee safe operation of Motors, Converters and electronic control units. In Hybrid and Electric vehicle temperature measurement helps to monitor and maximize battery efficiency.

**Context**

**Principle of operation**

The thermocouple probe creates a reference voltage proportional to temperature, amplified by high accuracy op amp in differential amplifier configuration.

**ST Offer**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input offset voltage</td>
<td>Excellent measurement without trimming</td>
</tr>
<tr>
<td>( V_{io} &lt; 5 \mu V ) @25°C</td>
<td>Stability of measurement versus temperature change</td>
</tr>
<tr>
<td>( V_{io} &lt; 8 \mu V ) -40 to 125°C</td>
<td>Compatible with high impedance sensor</td>
</tr>
<tr>
<td>Input offset voltage drift</td>
<td></td>
</tr>
<tr>
<td>( \Delta V_{io}/\Delta T ) 30nV/°C max</td>
<td></td>
</tr>
<tr>
<td>Input bias current</td>
<td></td>
</tr>
<tr>
<td>( I_{ib} &lt; 200 ) pA</td>
<td></td>
</tr>
</tbody>
</table>

**Op Amp – Zero Drift**

TSZ124IYPT
Electric power steering angle measurement

**Context**

Electric Power Steering is replacing hydraulics system due to the possibility to tailor steering-gear response according to driving conditions. In addition, EPS is a major contributor to fuel-saving efforts.

**Principle of operation**

Angle is measured by a resolver. Sine wave is amplified to primary winding of a rotary transformer. Secondary side signal is modified by angle.

**ST Offer**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>High output current</td>
<td>Capability to drive coils</td>
</tr>
<tr>
<td>$I_{out} = 90\text{mA typ}$</td>
<td></td>
</tr>
<tr>
<td>Slew rate</td>
<td>Enables high sampling frequency</td>
</tr>
<tr>
<td>$1.1\text{V/µs typ}$</td>
<td></td>
</tr>
<tr>
<td>Supply voltage range</td>
<td>High voltage biasing of the magnetic coil</td>
</tr>
<tr>
<td>$3$ to $16\text{V}$</td>
<td></td>
</tr>
</tbody>
</table>

**Equations**

$$V_{out} = V_{ref} \cdot \cos(\theta)$$

$$V_{out} = V_{ref} \cdot \sin(\theta)$$

---

Op Amp – 16V CMOS

TSX564IYPT
Rain and light sensors are widely used for automatic mode of windscreen wipers and automatic lights. Further applications can include the automatic closing of electric roof and windows or adjustment of dashboard backlight.

**Context**

Rain and light sensors are widely used for automatic mode of windscreen wipers and automatic lights. Further applications can include the automatic closing of electric roof and windows or adjustment of dashboard backlight.

**Principle of operation**

The photodiode generates a reverse current proportional to the amount of light. This current is converted into voltage and amplified by op amp.

**ST Offer**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input bias current</td>
<td>Maintains excellent accuracy by not affecting diode current</td>
</tr>
<tr>
<td>I&lt;sub&gt;b&lt;/sub&gt; &lt; 10pA @ 25°C</td>
<td></td>
</tr>
<tr>
<td>I&lt;sub&gt;b&lt;/sub&gt; &lt; 100pA @ 125°C</td>
<td></td>
</tr>
<tr>
<td>Supply voltage range</td>
<td>Compatible with wide choice of supplies</td>
</tr>
<tr>
<td>1.5 to 5.5V</td>
<td>SOT23-5</td>
</tr>
<tr>
<td>Micro package enhances sensor form factor</td>
<td></td>
</tr>
</tbody>
</table>

**Op Amp – Low Power**

TSV631

**AN4451**: Signal conditioning for a UV sensor
Watchdog ICs improve system reliability by monitoring the system for software code execution errors and hardware failures. This is especially critical for Advanced Driving Assistance Systems paving the way to autonomous vehicles.

**Context**

When operating correctly, a vehicle’s systems regularly reset the STWD100 watchdog timer. If the timer exceeds the specified timeout period, an alert is triggered.

**ST Offer**

- Variety of available watchdog timeout periods
- Simple, robust and reliable implementation
- Supply voltage range 2.7 to 5.5V
- Compatible with wide choice of supplies
- SOT23-5
- Micro package enhances sensor form factor
Low-side current measurement for motors

The pervasion of brushless DC motors in automotive leads to removal of energy-wasting belts for the transmission of power to sub-systems.

### Context

The current is measured in each branch of the 3-phase Mosfets bridge. Shunt resistor voltage drop is amplified by high accuracy op amp.

### Principle of operation

![Diagram of current measurement](Diagram)

### ST Offer

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input offset voltage Vio &lt; 5 µV @25°C Vio &lt; 8 µV -40 to 125°C</td>
<td>Minimizes shunt resistor value and cost</td>
</tr>
<tr>
<td>TSSOP14</td>
<td>Facilitates integration</td>
</tr>
</tbody>
</table>

UM1737: How to use the product evaluation board STEVAL-ISQ014V1 for low-side current sensing with the TSZ121 operational amplifier

Op Amp – Zero Drift TSZ124IYPT
Measurement of exhaust or inlet gas concentration of oxygen enables emission control by adjustment of combustion. Other applications include measurement of the partial pressure of oxygen in passengers breathing gas.

**Principle of operation**

O2 level is translated into current by the electrochemical sensor. Current is converted into voltage and amplified by op-amp in trans-impedance configuration.

**ST Offer**

- **Feature**
  - Input offset voltage: $V_{io} < 800 \mu V$
  - Input bias current: $I_{ib} < 10 \ pA$

- **Benefit**
  - Excellent measurement without trimming
  - Compatible with high impedance sensor
  - Micro package enhances sensor form factor

AN4348: Signal conditioning for electrochemical sensors

Op Amp – Low Power

TSV522AIYST
Vehicle have to comply with environmental regulations requiring dramatic reduction of Nitrogen Dioxides emissions (NO\textsubscript{x} and NO\textsubscript{2}). This pressure implies new technologies such as real-time measurement of NO\textsubscript{x} and selective catalytic reduction (SCR).

The NO\textsubscript{x} is measured in the exhaust gas by amperometric or potentiometric method. Aqueous ammonia (also named urea) is injected in the catalyst in order to transform NO\textsubscript{x} into N\textsubscript{2} and water.

**Context**

**Principle of operation**

- Low input bias current \( I_{ib} < 10\text{pA} \)
- Maintains sensor accuracy

- Operating temperature -40 to 150°C
- Compatible with extreme working conditions

- ESD HBM 5kV
- Increased reliability in assembly line and during lifetime

**ST Offer**

**Feature**

**Benefit**

- **AN4348**: Signal conditioning for electrochemical sensors
Measurement of pedal position is mandatory to drive-by-wire, enabling new features as adaptive cruise control. Other applications include throttle valve angle measurement, windows wipers control.

**Context**

The magnetic field created by a permanent magnet is measured by Anisotropic Magneto Resistor included in Wheatstone bridge. Electrical signal is amplified by op amp in difference amplifier configuration.

**Principle of operation**

The magnetic field created by a permanent magnet is measured by Anisotropic Magneto Resistor included in Wheatstone bridge. Electrical signal is amplified by op amp in difference amplifier configuration.

**ST Offer**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Gain Bandwidth Product: 10 MHz</td>
<td>Minimum phase shift between sensor and ADC</td>
</tr>
<tr>
<td>Supply voltage range 4 to 16V</td>
<td>Compatible with high voltage sensor</td>
</tr>
</tbody>
</table>

**Op Amp – 16V CMOS**

TSX922IYDT
Power seat current control

Power seat allows the user to fine tune the seat position using a joystick. Advanced feature can include automatic recall of user-customized settings. Modern cars can use 3 to 6 motors per seat for position adjustment.

Principle of operation

The current flowing to the motor is measured through a shunt resistor. The current sense amplifier is directly connected to the shunt, and thanks to internal gain the output pin feedbacks current.

ST Offer

- Input pins sustain: -16 to 75V
- ESD 2.5kV
- No protection needed for: Load dump, reversed battery, ESD surges

Output voltage accuracy:
- ±2.5% @25°C
- ±4% from -40 to 125°C
- Minimizes shunt value and cost

Current sense amplifier
TSC103IYPT

Context

The current flowing to the motor is measured through a shunt resistor. The current sense amplifier is directly connected to the shunt, and thanks to internal gain the output pin feedbacks current.

Feature

- Input pins sustain: -16 to 75V
- ESD 2.5kV
- No protection needed for: Load dump, reversed battery, ESD surges

Benefit

- Output voltage accuracy:
  - ±2.5% @25°C
  - ±4% from -40 to 125°C
- Minimizes shunt value and cost
Audio quality has direct impact on the end-user perception of quality of the vehicle. Audio is now required not only for music, but also for navigation and user vocal interface.

**Principle of operation**

The amplifier is used to buffer and amplify the audio signal. Amplifiers with good audio performances are required.

**ST Offer**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low noise: 9 nV/√ Hz</td>
<td>Maintain audio quality</td>
</tr>
<tr>
<td>High output current: 80 mA</td>
<td>Ability to drive 32 Ω loads</td>
</tr>
<tr>
<td>Supply voltage range 2.7 to 12 V</td>
<td>High level of signal ensures disturbance rejection</td>
</tr>
</tbody>
</table>
Promotion tools
TSC2010 TSC2011 TSC2012 evaluation board

STEVAL-A1ETKT1V2

Motherboard

Daughter boards:

Link
TSC210/211/212/213/214/215 demo board

STEVAL-AETKT2V1

Motherboard

Daughter boards:
TSC210, TSC213

Link
# Automotive Op Amps sample kit 2020

Discover our operational amplifiers and comparators for automotive

**Order code:** KITAUTOPAMP03  
(min 30 pcs or multiple)

<table>
<thead>
<tr>
<th>Product</th>
<th>Description</th>
<th>Package</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Operational amplifiers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM2904WHYST</td>
<td>30 V, low-power dual bipolar, 150 °C op amp</td>
<td>Mini S08</td>
</tr>
<tr>
<td>TSB572IYQ2T</td>
<td>36 V, low-power dual rail-to-rail BiCMOS op amp in side-wettable flanks</td>
<td>DFN8 3x3</td>
</tr>
<tr>
<td>TSB611IYL2T</td>
<td>36 V, low-power, rail-to-rail output, op amp</td>
<td>SOT23-5</td>
</tr>
<tr>
<td>TSB712IYST</td>
<td>36 V, precision, 6 MHz, rail-to-rail I/O, BiCMOS op amp</td>
<td>Mini S08</td>
</tr>
<tr>
<td>TSV911IYL2T</td>
<td>5 V, wide bandwidth 8 MHz, single rail-to-rail I/O CMOS op amp</td>
<td>SOT23-5</td>
</tr>
<tr>
<td>TSV912HYDT</td>
<td>5 V, wide bandwidth 8 MHz, 150 °C, dual rail-to-rail I/O CMOS op amp</td>
<td>S08</td>
</tr>
<tr>
<td>TSX921IYL2T</td>
<td>16 V, wide bandwidth 10 MHz, single rail-to-rail I/O CMOS op amp</td>
<td>SOT23-5</td>
</tr>
<tr>
<td>TSZ182IYST</td>
<td>5 V, very-high-accuracy, zero drift, CMOS op amp</td>
<td>Mini S08</td>
</tr>
<tr>
<td><strong>Comparators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LM2903YQ3T</td>
<td>36 V, low-power dual bipolar comparator in side-wettable flanks</td>
<td>DFN8 2x2</td>
</tr>
<tr>
<td>TS3011IYQ3T</td>
<td>5 V, rail-to-rail, high-speed comparator in side-wettable flanks</td>
<td>DFN8 2x2</td>
</tr>
<tr>
<td>TS3021IYLT</td>
<td>1.8 V, rail-to-rail, high-speed, 150 °C comparator</td>
<td>SOT23-5</td>
</tr>
<tr>
<td>TS3022IYST</td>
<td>5 V, rail-to-rail, high-speed micropower comparator</td>
<td>Mini S08</td>
</tr>
<tr>
<td>TSX3702IYDT</td>
<td>16 V, micropower dual CMOS push-pull comparator</td>
<td>S08</td>
</tr>
<tr>
<td><strong>Current sensing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TSC101GYLT</td>
<td>High-side current sense amplifier</td>
<td>SOT23-5</td>
</tr>
<tr>
<td>TSC103IYPT</td>
<td>High-voltage high-side current sense amplifier</td>
<td>TSS0P8</td>
</tr>
</tbody>
</table>
ST’s eDesignSuite is a smart design and simulation tool that greatly simplifies the task of engineers working on various application types. This platform helps to select the best product for your application and speeds-up the design-in!

eDesignSuite tool makes the «Product PN» circuit design easy

Available modules
- Power management
- Thermo-electrical simulator
- Signal conditioning
- NFC/RFID calculators

Design your SMPS or analog circuit, get a quick preview with fully annotated schematic and BOM, and then run the electrical simulation through eDSim for fast and accurate simulations and reliable design validation.

Run the eDSim tool to crunch the electrical simulations 10-50 times faster than traditional analog SPICE simulators!
Download the latest mobile version

Parameters in green are better or equivalent.
Our technology starts with You

Find out more at www.st.com/automotive-ics