Analog

Power & Analog program

European
Multi System Market Competence Center
• **Standard linear**
  – Linear regulators
  – Comparators
  – Operational amplifier

• **Sensors**
  – Temperature
  – Proximity
  – Industrial I/O peripheral
  – MEMS
• **Standard linear**
  – **Linear regulators**
  – Comparators
  – Operational amplifier

• **Sensors**
  – Temperature
  – Light
  – Proximity
  – Industrial I/O peripheral
  – MEMS
• **Standard linear**
  – Linear regulators
  – **Comparators**
  – Operational amplifier

• **Sensors**
  – Temperature
  – Proximity
  – Industrial I/O peripheral
  – MEMS
Comparators – product portfolio

**General purpose**
- **Bipolar**
  - LM2901/3
    - 200µA / Comp
    - 1.3µs resp time
    - Open collector
  - TS372/4
    - 150µA / Comp
    - 0.6µs resp time
    - Open drain
  - TS339/393
    - 9µA / Comp
    - 1.5µs resp time
    - Open drain
- **CMOS**
  - TS3702/3704
    - 9µA / Comp
    - 1.5µs resp time
    - Push-Pull

**Micropower**
- **CMOS**
  - TS339/393
    - 9µA / Comp
    - 1.5µs resp time
    - Open drain
  - TS3702/3704
    - 9µA / Comp
    - 1.5µs resp time
    - Push-Pull
- **BiCMOS**
  - TS86x (R2R)
    - 6µA / Comp
    - 3µs resp time
    - Push-Pull
  - TS7211/21 (R2R)
    - 6µA
    - 3µs resp time
    - Push-Pull & Open drain

**High Speed**
- **Bipolar**
  - LM311
    - 5mA
    - 200ns resp time
    - Open E & C
  - TS302x (R2R)
    - 64µA
    - 33ns resp time
    - Push-Pull
- **BiCMOS**
  - LM319
    - 8mA
    - 80ns resp time
    - Open Collector
**PRODUCT DESCRIPTION**
- **64µA** power consumption
- **33ns** response time
- Operating From Vcc = 1.8V to 5V
- **Rail to Rail** Inputs
- Push-pull Outputs
- **TS3022 / SO8 miniSo8**

**APPLICATIONS**
- Telecom
- Industrial
- Consumer
TS86x micropower comparators

• PRODUCT DESCRIPTION
  – 6µA power consumption
  – 3µs response time
  – Operating From Vcc= 2.7V to 10V
  – Rail to Rail Inputs / Outputs
  – SOT23-5 packages for single
  – SO and TSSOP for the dual & quad

• APPLICATIONS
  – Portable electronics
  – Low voltage
  – Alarms
• **Standard linear**
  – Linear regulators
  – Comparators
  – **Operational amplifier**

• **Sensors**
  – Temperature
  – Proximity
  – Industrial I/O peripheral
  – MEMS
Operational amplifier – used technologies

**BIPOLAR**
- Lowest noise
- Highest gain
- Low offset voltage
- Wide bandwidth

**WEAKNESS**
- Fairly low Z input
- High current noise
- High current consumption

**CMOS**
- Low voltage
- Micropower
- Single supply
- Low input current
- High output voltage

**FET**
- High gain-BW
- High slew rate
- Low input current

**WEAKNESS**
- Higher input noise voltage
- Input voltage offset is worse than bipolar
## Op-amp – new products

<table>
<thead>
<tr>
<th>Op-amp</th>
<th>channels</th>
<th>Vcc [V] min/max</th>
<th>Vio [mV] max</th>
<th>Iib [nA] max</th>
<th>Icc [µA] typ</th>
<th>GBP [MHz] typ</th>
<th>package</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSV911 TSV912 TSV914</td>
<td>1/2/4</td>
<td>2.5/5.5</td>
<td>1.5/4.5</td>
<td>0.010</td>
<td>780</td>
<td>8</td>
<td>SOT23-5L, SO8, MiniSO8, TSSOP14, SO14</td>
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<tr>
<td>TSV991 TSV992 TSV994</td>
<td></td>
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<tr>
<td>TSV991 TSV992 TSV994</td>
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<tr>
<td>TS507</td>
<td>1</td>
<td>2.7/5.5</td>
<td>0.1</td>
<td>70</td>
<td>850</td>
<td>1.9</td>
<td>SOT23-5L, SO8</td>
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</table>
FEATURES

- Rail to rail output
- CMOS input
- 2.5V to 5.5V supply operation
- High merit factor GBP/ICC
  - 8 MHz – 780µA per amplifier 8MHz
- 1pA (typ) input Bias Current

APPLICATIONS

- Battery-powered applications
- Portable devices
- Sensor signal conditioning
- Medical instrumentation
- Active filtering, buffering
FEATURES

- Rail to rail input / output
- CMOS input
- 2.5V to 5.5V supply operation
- Very high slew rate & GBP
  - 20MHz for gain≥3, CL=100pF
  - SR=10V/µs
  - ICC=780µA
- 1.5mV (max) input offset voltage
- 1pA (typ) input Bias Current

APPLICATIONS

- Motor control
- Battery-powered applications
- Sensor signal conditioning
- Medical instrumentation
- Active filtering, buffering
- Instrumentation / factory automation

Voltage gain and phase vs. frequency at \( V_{CC} = 5V \) and \( V_{ICM} = 2.5V \) for the TSV99x
• The Current Sensing Amplifiers is a new standard product family introduced by ST in 2007

• Different methodologies for current measurements
  – transformer sensor (high power)
  – hall-effect sensor (high power)
  – shunt resistor
    • low-side shunt: can be done with a rail-to-rail operational amplifier chosen among standard linear IC’s portfolio (example: TS507)
    • high-side shunt: new TSCxxx family
Introduction to current sensing
Principle of operation

- current measured by a shunt resistor
- differential voltage accurate amplification
- output voltage is referenced to GND

from supply to load

Dedicated input stage structure:
Common-mode voltage can be higher than supply voltage!

Vcc

Vp Vm

Out

Gnd

TSCxxx

Rsense

Vsense

Vreg 5V

μC ADC

Vout=Av.Vsense

ADC

5V

Vcc

TSCxxx

Vicm

common mode operating range

Vcc

Current sensing amplifier

Standard

Rail-to-rail
Introduction to current sensing
How TSC101 is supplied?

- A current proportional to \( V_{\text{sense}} \) is sunk into \( V_p \) pin:
  \[ I_{\text{ib+}} = \frac{V_{\text{sense}}}{5K} \]

- The same current \( I_{\text{ib+}} \) flows into a 500K ground-referenced resistor (gain \( A_v=100V/V \))

- The resulting voltage is duplicated to output pin by a buffer

- The buffer amplifier is supplied by \( V_{\text{cc}} \)

\[ V_{\text{out}} = A_v \cdot V_{\text{sense}} \]
- Independent supply and input common-mode voltages
- Wide common-mode operating range: 2.8 to 30V
- Wide common-mode surviving range: -0.3 to 60V
- Wide supply voltage range: 4 to 24V
- Low current consumption: $I_{cc \text{ max}} = 300\mu A$
- Internally fixed gain: 20V/V, 50V/V or 100V/V
- Buffered output
- 2kV ESD protection

- BCD Technology (Bipolar / Cmos / Dmos)
- SOT23-5 package
- -40 to 125°C operating temperature range
- Automotive grade qualification:
  - PPAP done
  - PAT in Q1 2008
  - Hot Test Q3 2008

Demonstration board available (bare PCB)
• **Standard linear**
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• **Sensors**
  – Temperature
  – Proximity
  – Industrial I/O peripheral
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TEMPERATURE SENSORS
ST has recently added to its existing family of precision analog temperature sensors and developed a new family of precision digital temperature sensors. Both types are suitable for use in a wide range of applications in market segments such as industrial, consumer, medical and computer.

The **analog** temperature sensors feature *low power consumption* and *good linearity* and can operate over a temperature range as wide as **-55°C to +130°C**.

The **digital** temperature sensors feature *low power consumption*, up to *12-bit resolution* and can operate over a temperature range as wide as **-55°C to +125°C**.
Ultra low POWER Analog temperature sensor available in ultra small mDFN package

Features

- Analog temperature sensor:
  - -55°C/+130°C: SC70 package
  - -40°C/+85°C: uDFN package

- Supply voltage:
  - 2.7 to 5.5V across -55°C/+130°C
  - 2.4 to 5.5V across -40°C/+130°C

- Current max across all conditions: 8μA

- Accuracy:
  - @ 25°C: +/- 1.5%
  - @ -55°C/+130°C: 2.5%

- Ultra small uDFN package (1.3x1.0mm)

\[ V_{out} = -11.79 mV/°C \times T + 1.8528 V \]
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PROXIMITY SENSORS

• TDE0160 and TDA0161 proximity detectors.
  – TDA0161 is a 2 wires detector housed in SO-8 or DIP-8 package.
  – TDE0160 is a 3 wires detector housed in SO-14 package, it is a double-output detector with adjustable hysteresis

• Designed for ST’s proximity detector devices, they can be coupled with any type of inductive, capacitive, ultrasonic or optical detectors.

• *Metal body detection* in home & building automation

<table>
<thead>
<tr>
<th>Part number</th>
<th>Technology</th>
<th>Package</th>
<th>$V_{CC}$ [V]</th>
<th>$I_{CC}$ supply [mA]</th>
<th>$I_{out}$ [mA]</th>
</tr>
</thead>
<tbody>
<tr>
<td>TDA0161DP</td>
<td>Bipolar</td>
<td>DIP-8</td>
<td>4 to 35</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>TDA0161FP</td>
<td>Bipolar</td>
<td>SO-8</td>
<td>4 to 35</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>TDE0160FP</td>
<td>Bipolar</td>
<td>SO-14</td>
<td>4 to 36</td>
<td>1.2</td>
<td>40</td>
</tr>
</tbody>
</table>

APPLICATION NOTES

• AN1213: TDE1707 noise immunity, short circuit and reverse output protection characterization

• AN495: Effective filtering of TDE1707
• **Standard linear**
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CLT3-4B Current limited termination

- **CURRENT LIMITER**
  - Current limiter: $I_{\text{LIM}} = 3\,\text{mA}$
  - Meet IEC61131-2 type 1 & 3 input
  - Temperature compensated

- **WIDE RANGE OPERATION**
  - Input: - 30 to 35V ($R_i = 1.2\,\text{K}$)
  - Vcc: - 0.3 to 35V ($R_C = 4.7\,\text{K}$)
  - $T_{\text{AMB}}$: - 25 to 85ºC

- **OPTO-COUPLER INTERFACE**
  - Bypass opto-coupler for $I_{\text{IN}} < 1.5\,\text{mA}$
  - Feed opto-coupler when $V_1 > 11\,\text{V}$

- **INPUT PROTECTION**
  - Voltage **surge** IEC61000-4-5, 1kV
  - Burst immunity IEC 61000-4-4, 4kV
  - **ESD** IEC 61000-4-2, 8kV
  - Input reverse polarity biasing
CLT3-4B Current limited termination

- **REDUCED DISSIPATION**
  - 50% to 67% in the full sensor chain
  - 35% to 67% in the module

- **HIGHER DENSITY OF MODULE**
  - SMD Thin TSSOP20 package
  - Compact for high integration
  - Low component count

- **HIGHER RELIABILITY**
  - Over-voltage protected
  - Immune to fast transient
  - Limited input current

- **OPERATION INSENSITIVE TO**
  - Sensor impedance
  - Voltage & temperature
  - Reverse polarity connection
### Current limited termination – key benefit

<table>
<thead>
<tr>
<th>INPUT COUNT PER MODULE</th>
<th>16</th>
<th>32</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOLUTION</td>
<td>ACTIVE CLT3</td>
<td>PASSIVE DISCRETE</td>
</tr>
<tr>
<td>CHANNEL DISSIPATION</td>
<td>0.11W</td>
<td>0.3W</td>
</tr>
<tr>
<td>MODULE DISSIPATION</td>
<td>1.77W</td>
<td>4.8W</td>
</tr>
<tr>
<td>CONCLUSION</td>
<td>FOR SAME INPUT COUNT, DIVIDE MODULE SIZE BY 2</td>
<td>FOR SAME MODULE SIZE, MULTIPLY BY 2 INPUT COUNT</td>
</tr>
<tr>
<td></td>
<td>REDUCE COST</td>
<td>INCREASE PERFORMANCE</td>
</tr>
<tr>
<td>CLT PRODUCT</td>
<td>CLT3-4B</td>
<td>PCLT-2A</td>
</tr>
<tr>
<td>-------------</td>
<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>IEC 61131-2 input</td>
<td>Type 1 &amp; 3</td>
<td>Type 1, 2, 3</td>
</tr>
<tr>
<td>Front End LED status</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Output drive</td>
<td>Isolated</td>
<td>Isolated or un-isolated</td>
</tr>
<tr>
<td></td>
<td>Opto transistor</td>
<td>Opto transistor</td>
</tr>
<tr>
<td></td>
<td>CMOS compatible</td>
<td></td>
</tr>
<tr>
<td>APPLICATION</td>
<td>High Input count module</td>
<td>Low Input count module</td>
</tr>
<tr>
<td></td>
<td>PLC</td>
<td>Proxy Sensor interface</td>
</tr>
<tr>
<td></td>
<td>Distributed I/O</td>
<td>Distributed I/O</td>
</tr>
<tr>
<td>Channel count</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Input current reg</td>
<td>2.8mA</td>
<td>Adj: 2.5 to 7.5mA</td>
</tr>
<tr>
<td>Surge level</td>
<td>1kV</td>
<td>Type 1 &amp; 3: 1kV</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Type 2: 0.5kV</td>
</tr>
<tr>
<td>ESD Level</td>
<td>8kV</td>
<td>15kV</td>
</tr>
<tr>
<td>Package</td>
<td>TSSOP20 (14+6)</td>
<td>TSSOP14 exposed pad</td>
</tr>
</tbody>
</table>
• **Standard linear**
  – Linear regulators
  – Comparators
  – Operational amplifier

• **Sensors**
  – Temperature
  – Proximity
  – Industrial I/O peripheral
  – MEMS
• Micro Electro Mechanical System Technology exploits the mechanical properties of silicon to create movable structures that are able to sense acceleration or vibration in each direction.

• Applications in home & building automation:
  – User interfaces
  – Anti-theft systems
  – Remote device control
MEMS Portfolio

All product supported by Evaluation Kits
A world of applications

- Mobile phones and PDAs
- Portable media players
- Toys and games
- Laptop and pocket PCs
- Sports and health
- Audio and video devices
- Automotive
- Home appliances
- Industrial appliances
- Home security systems
MEMS: analog output

Analog output – key features
- Analog output with additional multiplexer output
- 2- and 3-axis
- Selectable full scale: +/- 2 g or +/- 6 g
- Power-down mode
- Resolution better than 0.5 mg @ 100 Hz
- <1 mA current consumption in normal mode
- <10 μA current consumption in power-down mode
- Embedded self test
- Temperature range -40 to +85 °C
- Factory trimmed parameters
- High shock survivability: 10,000G for 0.1 ms
- High thermal stability
- High lifetime stability
- LGA packages available
MEMS: digital output

Digital output – key features
- MEMS sensor and interface chip in one package
- 2- and 3-axis
- Direction detection
- Click and double click recognition
- Embedded high-pass filter
- I²C/SPI output
- Programmable bandwidth and data rate
- Resolution better than 1 mg
- Power-down mode
- 2 independent, programmable interrupt pins
- Wake-up/free-fall interrupt signal with programmable thresholds
- Temperature range -40 to +85 °C
- Factory trimmed parameters
- High shock survivability: 10,000G for 0.1 ms
- High thermal stability
- High lifetime stability
- LGA and QFN packages available
## MEMS Portfolio

### 2-axis

<table>
<thead>
<tr>
<th>Package Type</th>
<th>Device Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO 24</td>
<td>LIS2L02AS4</td>
<td>Analog, PD 2g/6g FS</td>
</tr>
<tr>
<td>QFN</td>
<td>LIS2L02AQ3</td>
<td>Analog, PD 2g/6g FS, QFN-44</td>
</tr>
<tr>
<td>LGA</td>
<td>LIS2L02AL</td>
<td>Analog 2g FS, LGA-8, 5x5x1.5 mm</td>
</tr>
<tr>
<td></td>
<td>LIS2L06AL</td>
<td>Analog 2g/6g FS, LGA-8 5x5x1.5 mm</td>
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<tr>
<td></td>
<td>LIS3L02AQ5</td>
<td>Analog, PD 2g/6g FS, QFN-44</td>
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<td>LIS3L06AL</td>
<td>Analog 2g/6g FS, LGA-8, 5x5x1.5 mm</td>
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<td>LIS3LV02DQ</td>
<td>SPI/FC, PD 2g/6g FS, QFN-28</td>
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<td>LIS3LV02DL *</td>
<td>SPI/FC, PD, 2g/6g FS, LGA16 7.5x4.4x1 mm</td>
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<td>LIS302ALB</td>
<td>Analog 2g FS, LGA-14, 3x5x0.9 mm</td>
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<td>LIS302ALK</td>
<td>Analog 2g FS, LGA-14, 3x5x0.9 mm</td>
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<td>LIS302DL*</td>
<td>SPI/FC, PD, 2INT 2g/8g FS, LGA-14 3x5x0.9 mm</td>
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<td>LIS244AL*</td>
<td>Analog, 3.5g FS, LGA-16, 4x4x1.5 mm</td>
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### 3-axis

<table>
<thead>
<tr>
<th>Package Type</th>
<th>Device Code</th>
<th>Description</th>
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<tr>
<td>SO 24</td>
<td>LIS3L02AS4</td>
<td>Analog, PD 2g/6g FS</td>
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<tr>
<td>QFN</td>
<td>LIS3L02AQ3</td>
<td>Analog, PD 2g/6g FS, QFN-44</td>
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<tr>
<td>LGA</td>
<td>LIS3L02AL</td>
<td>Analog 2g FS, LGA-8, 5x5x1.5 mm</td>
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<td>LIS302ALB</td>
<td>Analog 2g FS, LGA-14, 3x5x0.9 mm</td>
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<td>LIS302ALK</td>
<td>Analog 2g FS, LGA-14, 3x5x0.9 mm</td>
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<td>LIS302DL*</td>
<td>SPI/FC, PD, 2INT 2g/8g FS, LGA-14 3x5x0.9 mm</td>
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<td>LIS202DL*</td>
<td>SPI/FC, PD, 2INT 2g/8g FS, LGA-14 3x5x0.9 mm</td>
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### Sensors
- **Analog Output**
- **Digital**
<table>
<thead>
<tr>
<th>Evaluation Kit Program</th>
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<tbody>
<tr>
<td><strong>STEVAL-MKI001V1</strong></td>
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<tr>
<td><strong>STEVAL-MKI002V1</strong></td>
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<tr>
<td><strong>STEVAL-MKI003V1</strong></td>
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<td><strong>STEVAL-MKI004V1</strong></td>
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<td><strong>STEVAL-MKI005V1</strong></td>
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<td><strong>STEVAL-MKI006V1</strong></td>
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<td><strong>STEVAL-MKI007V1</strong></td>
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<td><strong>STEVAL-MKI008V1</strong></td>
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<td><strong>STEVAL-MKI009V1</strong></td>
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<td><strong>STEVAL-MKI010V1</strong></td>
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<tr>
<td><strong>STEVAL-MKI011V1</strong></td>
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<tr>
<td><strong>STEVAL-MKI012V1</strong></td>
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