ST offering in Wearable

Analog and Mixed Signal Portfolio

March 2014
Wearable devices attributes

Devices being worn for an extended period of time with the user experience significantly enhanced as a result

- Always on
- Low power
- Compact
- Environment aware
- Intelligent
- Connected
Market and Applications

• **Fitness and Wellness** – monitor activity and emotions
  - Activity monitors, foot pods and pedometers, sleep sensors, heart rate monitors
  - Emotional measurement
  - Smart clothing, smart watches, heads-up displays

• **Healthcare and Medical** – monitor vital signs
  - Blood pressure monitors, ECG monitors, continuous glucose monitoring
  - Insulin pumps, drug delivery products

• **Infotainment** – entertain and enhance lifestyle
  - Headsets
  - Smart glasses, smart watches

• **Industrial** – receive/transmit real-time data
  - Hand-worn terminals, heads-up displays, smart clothing, wearable detection devices
ST Offering for Wearable

The only company to offer a complete smart system

- Sensors
- Secure microcontrollers and memories
- Ultra-low power connectivity
- Analog and mixed signal components
- Smart energy management
ST Analog and Mixed signal portfolio for wearable devices

The most complete set of building blocks for wearable devices

<table>
<thead>
<tr>
<th>Operational amplifiers</th>
<th>Smart reset</th>
<th>Analog switches</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large portfolio of highly power-efficient op amp in tiny packages</td>
<td>Customizable products providing safe and convenient reset</td>
<td>Compact single and dual switches for audio and USB</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Audio amplifiers</th>
<th>BlueNRG</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-efficiency Class D and G amplifiers for headsets and speakers</td>
<td>Bluetooth® smart solution with best-in-class power consumption</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Current sensors</th>
<th>Battery gas gauges</th>
<th>MEMS microphone</th>
</tr>
</thead>
<tbody>
<tr>
<td>High accuracy current measurement for contactless battery chargers</td>
<td>Low-power gas gauge providing very accurate battery life indicators</td>
<td>Power-efficient microphone solutions for smarter voice-controlled devices</td>
</tr>
</tbody>
</table>
Wearable devices
Analog and mixed signal products partitioning
Solutions for Analog Front-End
Analog Front-End

Analog transducers, getting the best from your sensor

Analog sensors need signal transducers to deliver the information to the MCU

- **Accurate and stable** to guarantee the maximum precision of the information
- **Low power** to guarantee a longer user experience
- **Small** to be integrated in the most stylish and thin designs

| ST offers a dedicated set of op amp to deliver the best match of current consumption and precision, for a wide range of applications |

| Operational Amplifiers |

| Analog sensors | Analog front-end | MCU |

### Analog Front-End

#### Analog transducers, getting the best from your sensor

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- **Accurate and stable** to guarantee the maximum precision of the information
- **Low power** to guarantee a longer user experience
- **Small** to be integrated in the most stylish and thin designs

<table>
<thead>
<tr>
<th>Input offset voltage [µV]</th>
<th>Input offset voltage drift [µV]</th>
<th>Supply current [µA]</th>
<th>GBP [kHz]</th>
<th>Supply voltage [V]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OAxNP</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very low power</td>
<td>100</td>
<td>5</td>
<td>0.6</td>
<td>8</td>
</tr>
<tr>
<td><strong>OAxMPA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low power precision</td>
<td>50</td>
<td>10</td>
<td>9</td>
<td>120</td>
</tr>
<tr>
<td><strong>OAxZHA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High precision zero drift</td>
<td>1</td>
<td>0.01</td>
<td>28</td>
<td>400</td>
</tr>
</tbody>
</table>

Analog Front-End
Signal transducers application: electromyography

**Analog sensors**

- **OAxZHA** family is the perfect match offering:
  - $V_{\text{IO}} = 1\, \mu\text{V}$
  - $\Delta V_{\text{IO}}/\Delta T = 0.010\, \mu\text{V}$

**Analog front-end**

**OAxMPA** is the perfect match offering:
- $V_{\text{IO}} = 50\, \mu\text{V}$
- $I_{\text{CC}} = 9\, \mu\text{A}$

**MCU**

- Application example

A **low input offset voltage with zero drift** amplifier is mandatory. Otherwise the electrodes information would be less accurate or lost.

Once the signal dynamic has been restored **precision** and **micro power consumption** amplifiers are needed before the signal is fed to the MCU.

**Raw input signal**

- 50µVpp-5mVpp

**Conditioned output signal**

- Input signal envelope
Analog Front-End Switches

In portable applications, switches are used to route a great variety of signal – audio to the speaker or the headphones, or other signal from and towards sensors

- Guarantee a **simple** yet **efficient** system implementation
- Compatibility with **high-speed** signals, for USB 2.0 applications

STA analog switches line up is meant to cover all the possible signal typologies from audio to USB, to fit most of the applications

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>AS11P2TLRQ SPDT single</td>
<td>1.65 - 4.5</td>
<td>0.1 (max)</td>
<td>-75 @ 100Hz</td>
<td>-80 @100Hz</td>
<td>150</td>
</tr>
<tr>
<td>AS21P2TLRQ SPDT dual</td>
<td>1.65 - 4.3</td>
<td>0.05</td>
<td>-72 @ 100 Hz</td>
<td>-66 @100 Hz</td>
<td>55</td>
</tr>
<tr>
<td>AS21P2THBQ SPDT Dual</td>
<td>1.65 - 4.3</td>
<td>0.2 (max)</td>
<td>-78 @ 1 MHz</td>
<td>-78 @1 MHz</td>
<td>800</td>
</tr>
</tbody>
</table>

**Analog Front-End**

Switches application: dual mode microphones

**AS11P2TRLQ** analog switch can be used to supply the mic with different voltage level so to enable the different operating modes depending on the MCU needs thus enabling voice activity detection features.

**High Supply voltage Vdd_H**

*Normal mode*: the acoustical parameters are set to the optimal level for voice control applications.

**Low power voltage Vdd_L**

*Sniffing mode*: the device reduces the power consumption at minimum whilst guaranteeing an adequate set of performances for voice activity detection.
Solutions for User Interface
ST offers **highly-efficient** devices capable of delivering **high quality** audio into **small, low power** solutions.

**CLASS G HEADPHONE AMPLIFIER**

- **A22H165**
- **A22H165M (μ-less)**
  - Power supply range: **2.3 V - 4.8 V**
  - Low stand by current: **0.6 μA**
  - $V_{out} = 0.8 \text{ Vrms into } 16 \Omega$, at **1 % THD+N, VCC = 3.6 V**
  - **SNR = 100 dB @ 1 kHz**
  - Reduced external BOM
  - Flip-chip package

**3W CLASS D MONO SPEAKER AMPLIFIER**

- **A21SP16J**
  - Power supply range: **2.4 V - 5.5 V**
  - Low stand by current: **<1 μA**
  - $P_{out} = 0.8 \text{ W into } 8 \Omega$, at **10 % THD+N, VCC = 3 V**
  - **SNR = 85 dB @ 1 kHz**
  - Reduced external BOM
  - Small flip-chip package

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**http://www.st.com/web/catalog/sense_power/FM125/CL1503/SC977**
Solutions for Power Management
### GG25LJ - Gas gauge IC with alarm output for wearable devices

<table>
<thead>
<tr>
<th>Feature</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Accuracy</strong></td>
<td>• Coulomb counter mode, voltage mode and mixed mode operations</td>
</tr>
<tr>
<td></td>
<td>• 0.25 % accuracy battery voltage monitoring</td>
</tr>
<tr>
<td><strong>Robustness</strong></td>
<td>• Analog and temperature compensation</td>
</tr>
<tr>
<td></td>
<td>• Internal temperature sensor</td>
</tr>
<tr>
<td><strong>Flexibility</strong></td>
<td>• Low battery level alarm output with programmable thresholds</td>
</tr>
<tr>
<td></td>
<td>• Custom battery OCV curve</td>
</tr>
<tr>
<td><strong>Low power</strong></td>
<td>• 2 µA in standby, 45 µA in operating</td>
</tr>
<tr>
<td><strong>Small size</strong></td>
<td>• Flip chip, 2.01 x 1.37 x 0.6 mm, 10 bumps, 0.4 mm pitch</td>
</tr>
</tbody>
</table>

ST offers an **integrated** solution combining **current integration** and **voltage variation** over the time thus providing the **most accurate** battery status measurement.

http://www.st.com/web/catalog/sense_power/FM142/CL848/SC274
Power Management
Current sensing

ST current sensing ICs portfolio cover most of the application needs

- Independent supply and common mode voltages
- Wide supply voltage range
- Selectable gains
- Low power solutions

### Power management in wearable devices

- Wired or wireless battery chargers
- Precision current sources from sensors
- Photovoltaic systems

### ST current sensing ICs portfolio

<table>
<thead>
<tr>
<th></th>
<th>Independent $V_{IO}$ and $V_{CC}$</th>
<th>Common mode operating range [V]</th>
<th>Supply voltage range [V]</th>
<th>Supply current [$\mu$A]</th>
<th>Gain [V/V]</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CS30</strong></td>
<td>$\checkmark$</td>
<td>2.8 - 30.0</td>
<td>4.0 - 24.0</td>
<td>165</td>
<td>20, 50, 100 fixed internally</td>
</tr>
<tr>
<td><strong>CS70</strong></td>
<td>$\checkmark$</td>
<td>2.9 - 70.0 -2.1 - 65.0</td>
<td>2.7 - 5.5</td>
<td>200</td>
<td>20, 50, 100 pin selectable</td>
</tr>
</tbody>
</table>

Power Management

Current sensing application: wireless battery charging

When swimming water pressure can reach up to 5 atm

Wearable technology **needs to be sealed**. All the electrical connections with the external have to be removed

**Wireless battery charging** is mandatory

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**High side current sensing** through the transmitter coil

to dynamically regulate the charger power output

Diagram:

- **19V power source**
- **Current sensing**
- **CS70**
- **Digital controller**
- **Half bridge gate driver 30 V Mosfets**

Transmitter / Base station

Receiver / Device
Power Management
Smart resetting

Wearable devices getting smarter, software complexity grows exponentially

The possibility of and end-user misuse of the product increases accordingly

System crashes are likely to happen and it is mandatory to provide an escape sequence to restart the application and maintain a perception of quality

ST smart reset IC line up
provide a full set of functionalities guaranteeing an escape sequence from OS or application failures

<table>
<thead>
<tr>
<th></th>
<th># of RST button</th>
<th># of PWR button</th>
<th>Supply voltage range [V]</th>
<th>Supply current [μA]</th>
<th>RST assertion time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR1</td>
<td>1</td>
<td>-</td>
<td>2.0 - 5.5</td>
<td>0.4</td>
<td>fixed at factory</td>
</tr>
<tr>
<td>Smart reset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SR2</td>
<td>2</td>
<td>-</td>
<td>1.65 - 5.5</td>
<td>1.1</td>
<td>fixed at factory</td>
</tr>
<tr>
<td>Smart reset</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SRC0</td>
<td>1</td>
<td>1</td>
<td>1.6 - 5.5</td>
<td>0.6</td>
<td>selectable via ext condenser</td>
</tr>
<tr>
<td>Smart power and reset</td>
<td></td>
<td></td>
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</table>

http://www.st.com/web/catalog/sense_power/FM1946/SC1753
Solutions for Connectivity
BlueNRG the Bluetooth® SMART solution

Single mode Bluetooth® SMART wireless network processor

Integration
- 2.4 GHz RF transceiver
- Cortex-M0 microcontroller (running the BT single mode protocol)
- AES 128-bit co-processor

Flexibility
- Master and slave single mode BLE (4.0) network processor
- On chip non-volatile Flash memory allows OTA BLE-stack upgrade. Stack qualified

Low power
- $I_{CC\,RX} \, 7.3 \, mA$
- $I_{CC\,TX} \, 8.2 \, mA \, @ \, 0 \, dBm$
- $I_{CC\,Sleep} \, 1.7 \, \mu A$
- $I_{CC\,Shutdown} \, 2.5 \, nA$

Small size
- Package: QFN32, 5 x 5 x 1 mm
- Flip-chip

External MCU
- Application MCU
- BLE profiles
- Application controller interface

BLE network processor BlueNRG
- Application controller interface
- BLE protocol stack
- Link layer
- 2.4 GHz radio

Solutions for Analog Sensors
MEMS microphones
The voice control enablers

Voice control is a wide spreading trend across many portable applications, making the interaction easier, faster and smoother.

It enables fashionable designs by reducing the number of button.

**Next microphones trend is to allow dual mode operations:**

- **Normal mode**: the acoustical parameters are set to the optimal level for voice control applications.
- **Sniffing mode**: the device reduces the power consumption at minimum whilst guaranteeing an adequate set of performances for voice activity detection.

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</tr>
</thead>
<tbody>
<tr>
<td>MP23AB02B</td>
<td>-38±3</td>
<td>64</td>
<td>125</td>
<td>1.6 - 3.6</td>
<td>150</td>
<td>-</td>
</tr>
<tr>
<td>MP23ABE03</td>
<td>-38±1</td>
<td>64</td>
<td>125</td>
<td>1.6 - 3.6</td>
<td>140</td>
<td>-</td>
</tr>
<tr>
<td>MP23ABE03DM</td>
<td>-38±1</td>
<td>64</td>
<td>125</td>
<td>1.6 - 3.6</td>
<td>140 (normal) 26 (sniff)</td>
<td>✓</td>
</tr>
</tbody>
</table>

ST MEMS Microphones pave the road toward smarter and efficient voice-controlled devices combining performances, small size and low power consumption.


* Q3 2014
ST stands for life.augmented