Body Composition Analyzer

Solution Proposal by Toshiba
Toshiba Electronic Devices & Storage Corporation provides comprehensive device solutions to customers developing new products by applying its thorough understanding of the systems acquired through the analysis of basic product designs.
Block Diagram
Body Composition Analyzer

Overall block diagram

- Battery
- LDO
- Op-amp
- Piezoelectric Element
- Constant Current Circuit
- TVS
- MCU
- LCD Module
- Sound
- Human Body Impedance Measurement Terminal
Body Composition Analyzer

Details of analog signal line (1)

**Power supply**

- Battery
- LDO
- MCU

**Piezoelectric element**

- Power Supply
- Op-amp
- MCU

---

**Criteria for device selection**

- PSRR (Power Supply Rejection Ratio) is a key characteristic for microcomputer.
- The use of small packages reduces the circuit board area.

**Proposals from Toshiba**

- **Optimum power supply for environments with high power supply noise**  
  Small surface mount LDO regulator
- **Amplify the detected weak signal with low noise**.  
  Low noise operational amplifier
- **Built-in analog input interface at low power consumption and efficient software development**  
  MCU

※ Click the number in the circuit diagram to jump to the detailed description page
Body Composition Analyzer  

Human body impedance measurement

Criteria for device selection
- MCU output voltage, base-emitter voltage and transistor DC current are important factors in selecting transistors.
- The use of small packages reduces the circuit board area.

Proposals from Toshiba
- **Amplify the detected small signal with low noise.**
  Low noise operational amplifier
- **Static electricity (ESD) from external terminals is absorbed to prevent circuit malfunction and device breakdown.**
  TVS diode
- **Realize a set with low power consumption by low on-resistance**
  Small signal MOSFET
- **Amplify the detected small signal.**
  Low current consumption operational amplifier
- **Built-in analog input interface at low power consumption and efficient software development**
  MCU

※ Click the number in the circuit diagram to jump to the detailed description page
Body Composition Analyzer

Details of Main operation unit

Panel display system

Criteria for device selection
- Data processing of various sensing data and its analyzation within very short time period

Proposals from Toshiba
- Built-in analog input interface at low power consumption and efficient software development

※ Click the number in the circuit diagram to jump to the detailed description page
Recommended Devices
Device solutions to address customer needs

As described above, in the design of body composition analyzer, “Miniaturization of circuit boards”, “Low power consumption of the set” and “Robust operation” are important factors. Toshiba’s proposals are based on these three solution perspectives.
Device solutions to address customer needs

<table>
<thead>
<tr>
<th></th>
<th>Small size packages</th>
<th>High efficiency • Low loss</th>
<th>Noise immunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Small surface mount LDO regulator</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Low noise operational amplifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>TVS diode</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Small signal MOSFET</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Low current consumption operational amplifier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>MCU</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Wide line up from general-purpose type to small package type are provided. Contribute to realize a stable power supply not affected by fluctuation of battery.

1. **Low dropout voltage**
   
   The newly developed new-generation process significantly improved the dropout voltage characteristics.

2. **High PSRR Low output noise voltage**
   
   Many product series that realize both high PSRR (Power Supply Rejection Ratio) and low output noise voltage characteristics are provided. They are suitable for stable power supply for analog circuit.

3. **Low current consumption**
   
   0.34 μA of $I_{B(ON)}$ is realized by utilizing CMOS process and unique circuit technology.

### Low dropout voltage

<table>
<thead>
<tr>
<th>Conventional process</th>
<th>New generation process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output current $I_{OUT}$ (mA)</td>
<td>Significant improvement</td>
</tr>
<tr>
<td>Dropout voltage $V_{DO}$ (mV)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Toshiba internal comparison

### Rich package line up

### Line up

<table>
<thead>
<tr>
<th>Features</th>
<th>Part number</th>
<th>TCR15AG</th>
<th>TCR13AG</th>
<th>TCR8BM</th>
<th>TCR5BM</th>
<th>TCR5RG</th>
<th>TCR3RM</th>
<th>TCR3U</th>
<th>TCR2L</th>
<th>TAR5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Low dropout voltage</td>
<td>High PSRR</td>
<td>High PSRR</td>
<td>Low current consumption</td>
<td>15V Input voltage Bipolar type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$I_{OUT}$ (Max) [A]</td>
<td>1.5</td>
<td>1.3</td>
<td>0.8</td>
<td>0.5</td>
<td>0.3</td>
<td>0.2</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PSRR (Typ.) [dB] @ f=1 kHz</td>
<td>95</td>
<td>90</td>
<td>98</td>
<td>98</td>
<td>100</td>
<td>100</td>
<td>70</td>
<td>-</td>
<td>70</td>
<td></td>
</tr>
<tr>
<td>$I_S$ (Typ.) [$\mu$A]</td>
<td>25</td>
<td>52</td>
<td>20</td>
<td>19</td>
<td>7</td>
<td>7</td>
<td>0.34</td>
<td>1</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>

◆ Return to Block Diagram TOP
Low noise operational amplifier
TC75S67TU

Value provided

Very weak signals detected by various sensors can be amplified with very low noise.

1. **Low noise**
   \[ V_{NI} = 6.0 \text{ [nV/√Hz]} \text{ (Typ.)} \] at \( f = 1 \text{ kHz} \)

   Very small signals detected by various sensors [Note 1] can be amplified with low noise using CMOS operational amplifier by optimizing the processing. We achieved one of the industry’s lowest [Note 2] input equivalent noise voltage.

2. **Low current consumption**
   \[ I_{DD} = 430 \text{ [μA]} \text{ (Typ.)} \]

   The low current consumption characteristics of CMOS processing contributes to the extension of battery life of the compact IoT devices.

3. **Enhancement type**

   It is easy to handle because it is an enhancement type in which no drain current flows when no gate voltage is applied.

---

**Low noise characteristic**
(Toshiba internal comparison)

![Graph showing low noise characteristic]

**Conventional products:** TC75S63TU

**New product:** TC75S67TU

- **Part number:** TC75S67TU
- **Package:** UFV
- **VDD, VSS (Max) [V]:** ±2.75
- **VDD, VSS (Min) [V]:** ±1.1
- **I_{DD} (Max) [μA]:** 700
- **V_{NI} (Typ.) [nV/√Hz] @f = 1 kHz:** 6

[Note 1] Sensor types: vibration detection sensor, shock sensor, accelerometer, pressure sensor, infrared sensor, and temperature sensor, etc.

[Note 2] Based on Toshiba data (as of May 2017)

---

© 2019-2021 Toshiba Electronic Devices & Storage Corporation

12
Absorbs static electricity (ESD) from external terminals, prevents circuit malfunction and protects devices.

1. **High ESD pulse absorption performance**
   For some products, both low operating resistance and low capacitance are realized and ensures high signal protection performance and signal quality.

2. **Suppress ESD energy by low clamp voltage**
   Steadily protect the connected circuits/devices using proprietary technology.

3. **Suitable for high-density mounting**
   A variety of compact packages are available.

### Line up

<table>
<thead>
<tr>
<th>Part number</th>
<th>DF2B7AFU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>USC</td>
</tr>
<tr>
<td>$V_{\text{ESD}}$ (Max) [kV]</td>
<td>±30</td>
</tr>
<tr>
<td>$V_{\text{RWM}}$ (Max) [V]</td>
<td>5.5</td>
</tr>
<tr>
<td>$C_\text{r}$ (Max) [pF]</td>
<td>10.0</td>
</tr>
<tr>
<td>$R_{\text{DYN}}$ (Typ.) [Ω]</td>
<td>0.2</td>
</tr>
</tbody>
</table>

Note: This product is an ESD protection diode and cannot be used for purposes other than ESD protection.
Suitable for the load switch with partial power-down and greatly contributes to miniaturization.

1. **Low voltage drive**
   Drive at $V_{GS} = 2.5$ V.

2. **Low on-resistance**
   By reducing on-resistance between the source and drain, heat generation and power consumption can be kept low.

3. **Small package**
   SOT-723 / VESM package.

**SSM3K15AMFV**
- Internal connection

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>SSM3K15AMFV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>VESM</td>
</tr>
<tr>
<td>$V_{DSS}$ (Max) [V]</td>
<td>30</td>
</tr>
<tr>
<td>$I_D$ (Max) [mA]</td>
<td>100</td>
</tr>
<tr>
<td>$R_{DS(ON)}$ (Ω) @$V_{GS} = 2.5$ V</td>
<td>Typ. 3.5</td>
</tr>
<tr>
<td>Polarity</td>
<td>N-ch</td>
</tr>
</tbody>
</table>

© 2019-2021 Toshiba Electronic Devices & Storage Corporation
Low current consumption type operational amplifiers maximize the performance of system.

1. Low voltage operation

We have a lineup of low power supply voltage-driven operational amplifiers using CMOS process for low power supply voltage-driven body composition analyzer.

2. Low current consumption

I_{DD} = 0.27 \, \mu A \, \text{(Typ.)}

CMOS processes have been used to achieve lower current consumption. This contributes to lower power consumption and longer life of wearable equipment.

3. I/O full range

(I/O Rail to Rail)

It is possible to amplify and process a wide range of input signals from GND voltage to power supply voltage at low power supply voltage.

TC75S102F

Current Consumption Characteristic
(Toshiba internal comparison)

<table>
<thead>
<tr>
<th>TC75S102F</th>
<th>TC75S103F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Package</td>
<td>SMV</td>
</tr>
<tr>
<td>V_{DD} - V_{SS} (Max) [V]</td>
<td>1.5 to 5.5</td>
</tr>
<tr>
<td>V_{O} (Max) [mV]</td>
<td>1.3</td>
</tr>
<tr>
<td>CMVIN (Max) [V]</td>
<td>V_{DD}</td>
</tr>
<tr>
<td>I_{DD} (Typ. / Max) [\mu A]</td>
<td>0.27 / 0.46 (@V_{DD}=1.5 V)</td>
</tr>
<tr>
<td>f_{T} (Typ.) [kHz]</td>
<td>0.5</td>
</tr>
</tbody>
</table>
System cost down, high efficiency system, development efficiency improvement.

1. **Built-in Arm® Cortex®-M0 CPU core**
   Built-in Cortex-M0 core with Thumb instruction set improves energy efficiency. Various development tool and their partners allow users many options.

2. **Suitable for sensing analog signal**
   Built-in multi-channel ADC and CPU system executes sensing data processing efficiently at low cost.

3. **Small package and very low power consumption**
   Cortex-M0 and original NANOFLASH™ technology bring to the small package and low power consumption. They contribute footprint and power consumption reduction.

**Line up**

<table>
<thead>
<tr>
<th>Part number</th>
<th>TMPM061FWFG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum operation frequency</td>
<td>16 MHz</td>
</tr>
<tr>
<td>Instruction ROM</td>
<td>128 KB</td>
</tr>
<tr>
<td>RAM</td>
<td>8 KB</td>
</tr>
<tr>
<td>Timer</td>
<td>9ch</td>
</tr>
<tr>
<td>UART/SIO</td>
<td>4ch</td>
</tr>
<tr>
<td>ADC</td>
<td>1ch(10bits), 3ch(24bits)</td>
</tr>
<tr>
<td>LCDD</td>
<td>40 seg x 4 com</td>
</tr>
</tbody>
</table>

© 2019-2021 Toshiba Electronic Devices & Storage Corporation
If you are interested in these products and have questions or comments about any of them, please do not hesitate to contact us below:

Contact address: https://toshiba.semicon-storage.com/ap-en/contact.html
Terms of use

This terms of use is made between Toshiba Electronic Devices and Storage Corporation ("We") and customers who use documents and data that are consulted to design electronics applications on which our semiconductor devices are mounted ("this Reference Design"). Customers shall comply with this terms of use. Please note that it is assumed that customers agree to any and all this terms of use if customers download this Reference Design. We may, at its sole and exclusive discretion, change, alter, modify, add, and/or remove any part of this terms of use at any time without any prior notice. We may terminate this terms of use at any time and for any reason. Upon termination of this terms of use, customers shall destroy this Reference Design. In the event of any breach thereof by customers, customers shall destroy this Reference Design, and furnish us a written confirmation to prove such destruction.

1. Restrictions on usage
1. This Reference Design is provided solely as reference data for designing electronics applications. Customers shall not use this Reference Design for any other purpose, including without limitation, verification of reliability.
2. This Reference Design is for customer's own use and not for sale, lease or other transfer.
3. Customers shall not use this Reference Design for evaluation in high or low temperature, high humidity, or high electromagnetic environments.
4. This Reference Design shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

2. Limitations
1. We reserve the right to make changes to this Reference Design without notice.
2. This Reference Design should be treated as a reference only. We are not responsible for any incorrect or incomplete data and information.
3. Semiconductor devices can malfunction or fail. When designing electronics applications by referring to this Reference Design, customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of semiconductor devices could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Customers must also refer to and comply with the latest versions of all relevant our information, including without limitation, specifications, data sheets and application notes for semiconductor devices, as well as the precautions and conditions set forth in the "Semiconductor Reliability Handbook".
4. When designing electronics applications by referring to this Reference Design, customers must evaluate the whole system adequately. Customers are solely responsible for all aspects of their own product design or applications. WE ASSUME NO LIABILITY FOR CUSTOMERS' PRODUCT DESIGN OR APPLICATIONS.
5. No responsibility is assumed by us for any infringement of patents or any other intellectual property rights of third parties that may result from the use of this Reference Design. No license to any intellectual property right is granted by this terms of use, whether express or implied, by estoppel or otherwise.
6. THIS REFERENCE DESIGN IS PROVIDED "AS IS". WE (a) ASSUME NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (b) DISCLAIM ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO THIS REFERENCE DESIGN, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

3. Export Control
Customers shall not use or otherwise make available this Reference Design for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). This Reference Design may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of this Reference Design are strictly prohibited except in compliance with all applicable export laws and regulations.

4. Governing Laws
This terms of use shall be governed and construed by laws of Japan.
RESTRICTIONS ON PRODUCT USE

- Toshiba Electronic Devices & Storage Corporation, and its subsidiaries and affiliates (collectively “TOSHIBA”), reserve the right to make changes to the information in this document, and related hardware, software and systems (collectively “Product”) without notice.

- This document and any information herein may not be reproduced without prior written permission from TOSHIBA. Even with TOSHIBA’s written permission, reproduction is permissible only if reproduction is without alteration/omission.

- Though TOSHIBA works continually to improve Product’s quality and reliability, Product can malfunction or fail. Customers are responsible for complying with safety standards and for providing adequate designs and safeguards for their hardware, software and systems which minimize risk and avoid situations in which a malfunction or failure of Product could cause loss of human life, bodily injury or damage to property, including data loss or corruption. Before customers use the Product, create designs including the Product, or incorporate the Product into their own applications, customers must also refer to and comply with (a) the latest versions of all relevant TOSHIBA information, including without limitation, this document, the specifications, the data sheets and application notes for Product and the precautions and conditions set forth in the “TOSHIBA Semiconductor Reliability Handbook” and (b) the instructions for the application with which the Product will be used with or for. Customers are solely responsible for all aspects of their own product design or applications, including but not limited to (a) determining the appropriateness of the use of this Product in such design or applications, (b) evaluating and determining the applicability of any information contained in this document, or in charts, diagrams, programs, algorithms, sample application circuits, or any other referenced documents; and (c) validating all operating parameters for such designs and applications. TOSHIBA ASSUMES NO LIABILITY FOR CUSTOMERS’ PRODUCT DESIGN OR APPLICATIONS.

- PRODUCT IS NEITHER INTENDED NOR WARRANTED FOR USE IN EQUIPMENTS OR SYSTEMS THAT REQUIRE EXTRAORDINARILY HIGH LEVELS OF QUALITY AND/OR RELIABILITY, AND/OR A MALFUNCTION OR FAILURE OF WHICH MAY CAUSE LOSS OF HUMAN LIFE, BODILY INJURY, SERIOUS PROPERTY DAMAGE AND/OR SERIOUS PUBLIC IMPACT (“UNINTENDED USE”). Except for specific applications as expressly stated in this document, Unintended Use includes, without limitation, equipment used in nuclear facilities, equipment used in the aerospace industry, lifesaving and/or life supporting medical equipment, equipment used for automobiles, trains, ships and other transportation, traffic signaling equipment, equipment used to control combustions or explosions, safety devices, elevators and escalators, and devices related to power plant. IF YOU USE PRODUCT FOR UNINTENDED USE, TOSHIBA ASSUMES NO LIABILITY FOR PRODUCT. For details, please contact your TOSHIBA sales representative or contact us via our website.

- Do not disassemble, analyze, reverse-engineer, alter, modify, translate or copy Product, whether in whole or in part.

- Product shall not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable laws or regulations.

- The information contained herein is presented only as guidance for Product use. No responsibility is assumed by TOSHIBA for any infringement of patents or any other intellectual property rights of third parties that may result from the use of Product. No license to any intellectual property right is granted by this document, whether express or implied, by estoppel or otherwise.

- ABSENT A WRITTEN SIGNED AGREEMENT, EXCEPT AS PROVIDED IN THE RELEVANT TERMS AND CONDITIONS OF SALE FOR PRODUCT, AND TO THE MAXIMUM EXTENT ALLOWABLE BY LAW, TOSHIBA (1) ASSUMES NO LIABILITY WHATSOEVER, INCLUDING WITHOUT LIMITATION, INDIRECT, CONSEQUENTIAL, SPECIAL, OR INCIDENTAL DAMAGES OR LOSS, INCLUDING WITHOUT LIMITATION, LOSS OF PROFITS, LOSS OF OPPORTUNITIES, BUSINESS INTERRUPTION AND LOSS OF DATA, AND (2) DISCLAIMS ANY AND ALL EXPRESS OR IMPLIED WARRANTIES AND CONDITIONS RELATED TO SALE, USE OF PRODUCT, OR INFORMATION, INCLUDING WARRANTIES OR CONDITIONS OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, ACCURACY OF INFORMATION, OR NONINFRINGEMENT.

- Product may include products using GaAs (Gallium Arsenide). GaAs is harmful to humans if consumed or absorbed, whether in the form of dust or vapor. Handle with care and do not break, cut, crush, grind, dissolve chemically or otherwise expose GaAs in Product.

- Do not use or otherwise make available Product or related software or technology for any military purposes, including without limitation, for the design, development, use, stockpiling or manufacturing of nuclear, chemical, or biological weapons or missile technology products (mass destruction weapons). Product and related software and technology may be controlled under the applicable export laws and regulations including, without limitation, the Japanese Foreign Exchange and Foreign Trade Law and the U.S. Export Administration Regulations. Export and re-export of Product or related software or technology are strictly prohibited except in compliance with all applicable export laws and regulations.

- Please contact your TOSHIBA sales representative for details as to environmental matters such as the RoHS compatibility of Product. Please use Product in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. TOSHIBA ASSUMES NO LIABILITY FOR DAMAGES OR LOSSES OCCURRING AS A RESULT OF NONCOMPLIANCE WITH APPLICABLE LAWS AND REGULATIONS.