Design challenges of wearable healthcare and patient monitoring

Kelvin Le
SEM – Medical
Agenda

- TI in medical
- Market trends
- Fundamentals and challenges
- Reference designs
TI semiconductors in every medical category

- Medical imaging
- Patient monitoring & diagnostics
- Medical equipment
- Home healthcare
- Personal care & fitness
Medical sensor patches

Temperature Analog Front End

Temperature AFE drives the temperature sensors as well as conditions the signal coming from analog temperature sensors. The temperature signal is converted to digital domain by using ADC for further processing.

Digital Temperature Sensors

- TMP117 – ±0.1°C accurate digital temperature sensor with integrated NV memory
- TMP112 – 1.4V Capable ±0.5°C Accuracy Digital Temperature Sensor in the Compact SOT-663 Package
- TMP100 – 1.4V Capable Temperature Sensor with I2C/SMBus Interface and Alert Function in SOT-663

Data converters (14)

- Bioresonance AFEs (6)
  - AFE4420 – Ultra-small integrated AFE with FIFO for multi-sensor wearable optical heart rate monitoring
  - AFE4300 – Ultra-low-power integrated AFE for wearable optical, electrical biosensing

PPG/Optical/Spectroscopy Front End

The optical front end has two sections: one for driving the LEDs and other for processing the signal received from photo diodes. LED drivers are operated with digital data coming from DAC and transimpedance amplifier with a PGA conditions signal coming from photo diode. This subsystem can be used for PPG as well as spectroscopy measurement.

Products (31)

- Amplifiers (11)
- General-Purpose Op Amps (3)
- Instrumentation Amplifiers (1)

Switches & multiplexers (6)

- Memory Card
- User Interface

Reference Design

- Simplify integration
- Achieve...

Texas Instruments
Reference design

Comprehensive design guides

Detailed design considerations & applications info

Full schematics

Design files

Bill of materials

Comprehensive test results

Boards available for evaluation

TINA-TI spice simulation

The following list provides details about the design:

- Supply Voltage = 5 V
- Charging current = 0.1 A
Remote monitoring enhances quality of care and reduces healthcare cost

Wearable wireless medical technology enables accurate and reliable data in a smaller form factor: multi-modalities, longer battery life, SHIP mode

Artificial Intelligence uses analytics and big data to improve decision making and early prevention
Patient monitoring basics

The electrocardiogram (ECG) measures electrical activity of the heart.

Photoplethysmography (PPG) is an optical measurement of an organ’s volume.
# ECG vs. PPG

<table>
<thead>
<tr>
<th>Feature Description</th>
<th>ECG</th>
<th>PPG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measurement type</td>
<td>Electrical</td>
<td>Optical</td>
</tr>
<tr>
<td>Sensor type</td>
<td>Electrodes</td>
<td>Photodiode</td>
</tr>
<tr>
<td>Can measure heart rate?</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Diagnostic information</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Minimum number of skin contacts</td>
<td>2 (Across chest)</td>
<td>1 (Finger or wrist)</td>
</tr>
<tr>
<td></td>
<td>≥1</td>
<td>1</td>
</tr>
<tr>
<td>Number of ADC channels required</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
## ECG lead and ADC channels

<table>
<thead>
<tr>
<th>Number of Leads</th>
<th>Leads Used</th>
<th>Number of ADC Channels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Lead I</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>Lead I, Lead II, Lead III</td>
<td>2</td>
</tr>
<tr>
<td>6</td>
<td>Lead I, Lead II, Lead III, aVR, aVL, aVF</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>Lead I, Lead II, Lead III, aVR, aVL, aVF, V1 – V6</td>
<td>8</td>
</tr>
</tbody>
</table>
ECG characteristics

Frequency domain

- **EMG Signal**
  - ~10mV
  - ~5mV

- **ECG Signal**
  - ~5mV
  - ~1mV

- **EEG Signal**
  - ~1mV

- **Respiration**
  - 0 to 0.4Hz

- **Pacemaker Signal**
  - ~500Hz

- **Frequency**
  - 0.05Hz to 10 KHz

*Amplitude dependent on external current source

*Frequency ranges are estimates. Actual frequency range will depend on specific application
Challenges in measuring ECG

50/60 Hz pick-up

Alternating Current (AC) Interference
Challenges in optical bio-sensing

• Low power for longer battery life
• Skin tone variation
• Best PPG signal for motion cancellation algorithms
• Performance with glass
• Low temperature performance
• Ambient light
Multiparameter front-end for vital signs patient monitor reference design

**Benefits**
- Single IC does both ECG, Respiration.
- Pace Detection
- ECG with 3 electrodes
- Three temperature sensors for temperature measurement

**Features**
- System measures ECG, Heart Rate, SPO2, Respiration rate using ADS1292R and AFE4403 and Skin temperature using TMP117
- Circuit enables three electrode operation including right leg drive with good CMRR
- Pace detection circuit indicates presence of pacemaker
- Supports three 0.1 Celsius accurate sensors (TMP117) to measure the skin temperature
- Enables data transfer over isolated UART interface
- Works with 3.7V Li ion rechargeable battery
- On board memory for data logging

**Applications**
- Multiparameter Patient Monitor
- Medical Sensor Patches
- Pulse Oximeter
- Electrocardiogram (ECG)
Detailed block diagram for TIDA-01614
Design challenges TIDA-01614 solves

**Design challenge 1**
Integration of multiple modalities at optimum SNR levels and small form factor

- Monitoring of ECG, Heart Rate, SPO2, PTT, Respiration rate and Skin temperature
- Single Lead ECG with RLD (ADS1292R)
  - Signal amplitude: 0.2mV~2mV (p-p); BW 0.05 Hz to 2000 Hz
- Supports 3 LED and 3 Photodiodes with ambient subtraction for SPO2 and Heart Rate monitoring with AFE4403
- Supports three 0.1 Celsius accurate sensors to measure the skin temperature (TMP117)

**Design challenge 2**
Protection and isolation

Isolated UART interface using an onboard MSP432P401, ISOW7842, TRS3232
ECG analog front end

Important parameters:
• Input bias current
• Input impedance
• Input current noise
• Input voltage noise
• Power consumption
• DC/AC CMRR

TIDA-01614: Multiparameter front-end reference design for vital signs patient monitor
TIDA-01614 test setup and test results

Design specs

<table>
<thead>
<tr>
<th>CHARACTERISTICS</th>
<th>SPECIFICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECG</td>
<td>One lead ECG operation with RLD. Sampling rate of 500 samples per second,</td>
</tr>
<tr>
<td></td>
<td>supports ECG sensitivity of 100 µV.</td>
</tr>
<tr>
<td>SPO2 Measurement</td>
<td>Works in transmissive SPO2, refresh rate of 500 Hz.</td>
</tr>
<tr>
<td>Skin Temperature</td>
<td>Three temperature sensor with 0.1 degree accuracy.</td>
</tr>
<tr>
<td>Measurement</td>
<td></td>
</tr>
<tr>
<td>Pace pulse Rise-time (TR) measurement range</td>
<td>30–200 µs</td>
</tr>
<tr>
<td>Pace pulse duration (TD) measurement range</td>
<td>0.1–2 ms</td>
</tr>
<tr>
<td>Input Pace signal amplitude range</td>
<td>8 mV–700 mV</td>
</tr>
<tr>
<td>Input Voltage (Vin)</td>
<td>5 V from Micro-USB.</td>
</tr>
</tbody>
</table>

Test setup

GUI display

![GUI Display](image-url)
Test pacemaker detection with TIDA-010005 & TIDA-01614
TIDA-01580
Wearable, wireless, multiparameter patient monitor reference design

Features
- Simple Wearable Multi-Parameter Patient Monitor for Photoplethysmography (PPG) and Electrocardiography (ECG)
- Provides Raw data to calculate heart-rate, Oxygen Concentration in Blood (SpO2) and Pulse-transit Time (PTT)
- Uses Single-chip Bio-sensing Front-End AFE4900 for Synchronized ECG & PPG
  - PPG (Optical heart-rate monitoring and SpO2) supports 4 LEDs and 3 PDs with Digital Ambient subtraction to improve the SNR
  - ECG (LEAD I) signals
- Integrated ARM Cortex-M3 + 2.4GHz RF Transceiver (CC2640R2F) supports wireless data transfer – BLE 4.2 and 5
- Operated from CR3032 (3V, 500mA Coin Cell Battery) with battery life of 30 days using highly efficient DC/DC converters
- Small form factor helps in easy adaptation to wearable applications

Target applications
- Wireless patient monitor
- Pulse Oximeter
- Wearable fitness & activity Monitor
- ECG

Benefits
- PPG supports 4 LEDs and 3 PDs with Digital Ambient subtraction to improve the SNR
- AC and DC lead off detection helps in correct measurement of vital signs
- Continuous Monitoring with lower operating power ensures battery life of 30 days
- Flexibility of ultra low power modes and integrated FIFO can keep MCU into sleep to increase the battery operation time

Tools & resources
- Device Datasheets:
  - AFE4900
  - CC2640R2F
  - TPS61098
  - TPS63036
  - TPD1E10B06

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TIDA-01580 for medical patch

Bottom side is touching the wrist of one hand (ELECTRODE 1)

Other hand is touching the PAD on the top layer of the main board. (ELECTRODE 2)

- LAUNCHXL-CC2640R2F receives the signals remotely and displays on LabView GUI
- The design uses BLE 5.0 with an advertising time = 100ms
Design challenge #1

Integration of multiple modalities at optimum SNR levels and small form factor

- Capturing synchronized ECG and PPG to enable PTT and BP calculations (non-invasive and without cuff)
- Pulse Transit Time (PTT): Time difference between the R-peak in the ECG waveform and the arrival of the blood pressure wave
- Simultaneous measurement of ECG and PPG together
- Along with other variables, such as the patient’s size, weight, age, etc., algorithms show the correlation between PTT and systolic blood pressure.
- Challenging to synchronize both measurements – timing is the key! (Powering up, clock timing, phase, drift with temperature)
Design challenges TIDA-01580 solves

Design challenge # 2
BLE connectivity that does not interfere with measurement accuracy

- Signal amplitude: 0.2mV to 2mV (p-p)
- BW: as broad as 0.05 Hz to 300 Hz (Pace detection increases the bandwidth further)
- Reject environmental electrical signals, such as ac mains, security systems, and RFI to amplify and display the ECG signal
- Good CMRR of the signal chain and Right-leg drive (RLD) for CM rejection
- Differential- and common-mode filtering, environmental shielding, and algorithms
Design challenges TIDA-01580 solves

Improving battery life in wearable patient monitors and medical patches

By Sanjay Pithadia
System Engineer, Medical Sector, System Engineering and Marketing

Introduction
The market for wearable patient monitors is growing fast. The two main attributes for wearable monitors are portability (or size) and operating time (or battery life). Today’s wearable medical products not only measure vital signs but can also act as personal emergency-response systems.

Portable and wearable applications are typically battery powered, and for consumers, battery life is one of the key purchasing considerations. The life of the battery is critical because most patient monitors measure and monitor continuously.

Battery-powered systems require careful partitioning, tight space utilization and efficient use of the available charge. It is important to enable more functionality while delivering power more efficiently in a tight space for a longer time. Functions like standby, sleep, power save, hibernate and shutdown are critical for designers to hydride (NiMH), lithium iron phosphate, lithium manganese and zinc are popular battery chemistries in medical devices, and each type needs a different charging circuit. It is also important to note that rechargeable batteries have a self-discharge rate. To reduce overall bill of materials (BOM) and size, designers may connect batteries directly to the radio module and other peripherals, but running directly from the battery voltage is not the most efficient way to use the battery.

Choosing the right battery charger to improve battery life
Battery charging for wearables is challenging because batteries must be both small in size and capacity. Charge currents vary greatly depending on whether a 50-mAh, 100-mAh or 200-mAh battery is used, and whether to charge at 0.5 C-rate (C), 1 C or 2 C. The key is to include

TIDA-01624 Bluetooth-enabled high accuracy skin temperature measurement flex PCB patch

**Features**
- High Accuracy, Low Power Temperature Sensor
- BLE 4.2 and 5 enabled microcontroller
- Thin-Film Flexible Battery Power, enabling entirely flexible design
- Integrated PCB antenna
- Temperature updates every second

**Benefits**
- Low power consumption and long battery life
- Extremely long shelf life (3+ Years)
- Small, Flexible Form Factor
- Connects to Smart Device
- Zero-Calibration to ±0.1°C Accuracy

**Applications**
- Medical Sensor Patches
- Multiparameter Patient Monitors
- Smart Patches

**Tools & resources**
- TIDA-01624 and/or Tools Folder
- Design Guide
- Design Files: Schematics, BOM, Gerbers, Software, etc.
- Device datasheets:
  - TMP117
  - CC2640R2F

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Skin Temperature TMP117
I2C
BLE MCU CC2640R2F

---

98.6°F
98.6°F
**Features**

<table>
<thead>
<tr>
<th>TI Part</th>
<th>Accuracy (°C) Full Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMP117M</td>
<td>±0.1°C @ (30°C to 45°C) ±0.2°C @ (0°C to 85°C)</td>
</tr>
<tr>
<td>TMP117N</td>
<td>±0.2°C @ (-40°C to 100°C) ±0.3°C @ (-55°C to 150°C)</td>
</tr>
</tbody>
</table>

**Accuracy**
- 16-bit Resolution (0.0078°C)
- Minimum PSRR: 1LSB = 7.8 m°C/V

**Integrated EEPROM**
- Low power consumption
  - 140uA Iq during conversion
  - 3.5uA Average Iq @ 1Hz
  - 150nA Shutdown Iq
- 1.8V – 5.5V

**Digital feature**: Automatic offset NVM / Soft Reset

**Interface**: Single wire

**Packaging**
- 6pin WSON (2 x 2) mm
- 6pin WCSP (1.6 x 1) mm

**Applications**
- Gas Meter
- Medical
- Cold Chain
- Wearables
- Instrumentation & Test
- Thermocouple – Reference

**Benefits**

**Ultra-high accuracy**
- Meets ASTM E1112 & ISO medical standards:
  - 0.1°C acc. range 35.8°C to 42°C
- No calibration needed; NIST Traceable

**Integrated non-volatile memory**
- Store configuration even after losing power
- 64 Bits of general-purpose scratch pad memory

**Low power consumption**
- 3.5uA Average Iq @ 1Hz; serial bus inactive
- 150nA Shutdown Iq; serial bus inactive

**Digital feature & I2C interface**
- Programmable Temperature Alert & Offset value
- Soft Device Rest

**Smallest package**
- 6 PIN, QFN & CSP
Full system: Multiparameter patient monitor + wireless sensors

Nurse’s station / Doctor’s office
Why TI SimpleLink™ for multiparameter patient monitor + sensor patch?

**Low power**
- BLE SoC with integrated Ultra low Power Sensor Controller
- Wi-Fi low power IoT
- Best-in-class standby current

**Ease of use**
- CC3135/CC3235 Wi-Fi modules
- 5GHz Wi-Fi to reliably connect to hospital network
- BLE multi-role support, up to 32 simultaneous connections

**Secure**
- FIPS 140-Level 1 validation
- Offload CPU bandwidth – HW crypto accelerators
- Secure boot

**Small size**
- BAW: First crystal-less wireless BLE SoC – 12% area savings in reference design
- Tiny BLE SoC: CC2640R2F – 2.7mm x 2.7mm DSBGA
Invest once, reuse effortlessly

- Learn more about SimpleLink code portability
- SimpleLink Medical Resources
- CC2640R2F: How do I design an accurate and thermally efficient wearable temperature monitoring system?
Achieving isolation and enabling patient safety
Patient safety

- Patient safety is a global health priority. Recalling resolution WHA55.18 (2002), which urged Member States to “pay the closest possible attention to the problem of patient safety and to establish and strengthen science-based systems, necessary for improving patients’ safety and the quality of health care”, the seventy-second World Health Assembly (WHA72), in May 2019, adopted WHA72.6, a resolution on ‘Global action on patient safety’. (Source: https://www.who.int/patientsafety/en/)
Isolation requirements and safety limits

• IEC60601-1: International basic safety and essential performance standard for electrical medical equipment and medical electrical systems.
  – Regional compliance
  – Editions and versions

• Levels of isolation – patient focus

• Spacing – creepage & clearances

• Safety insulation for transformers

• Leakage current limits
  – Isolation at the sensing side
  – Isolation at the data/power side
Data and power isolation

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage range</td>
<td>Option – 1: 3.3 V to 24 V from AC/DC power supply</td>
</tr>
<tr>
<td></td>
<td>Option – 2: From 15-45 battery (3.7 V to 16 V)</td>
</tr>
<tr>
<td>Output Voltage</td>
<td>Option – 1: 3.3 V or 5 V</td>
</tr>
<tr>
<td></td>
<td>Option – 2: 3.5 V or 5.5 V to be followed by an Low Drop-out</td>
</tr>
<tr>
<td></td>
<td>Regulator (LDO)</td>
</tr>
<tr>
<td>Output power</td>
<td>Typical 5 watts to 7 watts</td>
</tr>
<tr>
<td>Isolation</td>
<td>5 kV and above</td>
</tr>
</tbody>
</table>

Programmable
(typ.
3.5V/5V/12V
@ 1A max)

5V/12V/18V
Or
2S/3S/4S (7.2V
to 16.8V)

5kV Isolation
Key design challenges

- Input voltage ranging from 3.3V to 24V
  - Regulated input vs. non-regulated input
- Output voltage ranging from 3.3V to 6V
- Output power up to 5W
- Open-loop or closed-loop (voltage/current)
  - achieving < 1% load regulation
- Isolation ~1kV to 5kV
- Emission (CISPR22/25, IEC60601-1)
- Small form factor (New trend – electronics in cable and portable MPMs)
  - reduced BoM
- Low cost

One size doesn’t fit all the requirements

Possible Architectures

- Flyback
- Push-pull
- Isolated power module
- Isolated power and data module
PSR flyback topology

**Primary-side regulated flyback**

- Simplified transformer design
- No optocouplers required
- Smaller size
- Total BoM = 21 components (including passives)
- Tight load regulation achieved

**Conventional Flyback**

- Tertiary feedback winding needed
- Optocoupler needed

---

**Parameter** | **Value**
--- | ---
Input voltage (Vin) | 4.5V to 65V (70V max)
Output voltage (Vout) | Adjustable
Output power (Pout) | 7W max
Isolation level | 5kV (can be tuned as per transformer design)
Size | 45mm x 25mm x 11mm (Depends on transformer design)
Output regulation | 1% achievable

**Suggested TI devices:**
LM5180
LM25180

Refer to “Design Calculator” for complete schematics, BoM and simulation results
Design calculator for LM25180
Push-pull topology

Push-pull topology (Open-loop)

- Tight output regulation due to feedback
- Total BoM = 46 components (including passives)
- Optocoupler based design – reliability

Push-pull topology (Closed-loop)

- No opto-couplers required
- Smaller size, total BoM = 10 components (including passives)
- Needs regulated input

Parameter | Value
--- | ---
Input voltage (Vin) | 2.2V to 5.5V
Output voltage (Vout) | 5V unregulated
Output power (Pout) | 5W max
Isolation level | 5kV (can be tuned as per transformer design)
Size | 30mm x 25mm x 6mm (Depends on transformer design)
Output regulation | 5 to 10%

Suggested TI devices:
SN6505A
SN6505B
Isolated power module

**UCC12050 schematic**

- Input voltage (Vin): 4.5V to 5.5V
- Output voltage (Vout): Regulated 3.3V or 5V
- Output power (Pout): 0.5 W
- Isolation level: 5kV RMS reinforced
- Size: 10.3mm x 7.5mm x 2.65mm
- Output regulation: 1.5%

**Scalability**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage (Vin)</td>
<td>4.5V to 5.5V</td>
</tr>
<tr>
<td>Output voltage (Vout)</td>
<td>Regulated 3.3V or 5V</td>
</tr>
<tr>
<td>Output power (Pout)</td>
<td>0.5 W</td>
</tr>
<tr>
<td>Isolation level</td>
<td>5kV RMS reinforced</td>
</tr>
<tr>
<td>Size</td>
<td>10.3mm x 7.5mm x 2.65mm</td>
</tr>
<tr>
<td>Output regulation</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

Same (apple-to-apple) EVM configuration: no ferrite beads, no LDO, no stitch capacitors, on 2 layer PCB
Tested to CISPR32 Limit, in 10m chamber, on same day, in same certified lab.

**Suggested TI device:**

UCC12050
**Integrated transformer technology benefits**

**Discrete Solution**
- Total bias area: 273 mm^2
- Dimensions: 38mm x 21mm x 7.5mm
- Biased area: 21mm²

**UCC12050**
- Total bias area: 127 mm^2
- Dimensions: 53% Less Area
- Biased area: 3.5mm

**Single chip solution (UCC12050) advantages:**
- Smaller size and low profile
- Very low isolation capacitance Cps for better CMTI and less noise
- Simplify design with less components and easy board layout

**Isolated bias UCC12050**

**Digital isolator**

*Source: Texas Instruments*
Efficiency and thermal Image

- Thanks to the 2X peak efficiency, temperature rise of magnetic core solution is ~30°C lower than air-core solution when operating at 5 $V_{\text{IN}}$/5 $V_{\text{OUT}}$ 100 mA.
ISO Watt – Isolated power and data

**ISOW7841 schematic**

**Integrated isolated power & data**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Input voltage (Vin)</td>
<td>3V to 5.5V</td>
</tr>
<tr>
<td>Output voltage (Vout)</td>
<td>Regulated 3.3V or 5V</td>
</tr>
<tr>
<td>Output power (Pout)</td>
<td>0.65 W</td>
</tr>
<tr>
<td>Isolation level</td>
<td>5kV RMS reinforced</td>
</tr>
<tr>
<td>Size</td>
<td>10.3mm x 7.5mm x 2.65mm</td>
</tr>
<tr>
<td>Output regulation</td>
<td>1%</td>
</tr>
</tbody>
</table>

Suggested TI device: ISOW7841, ISOW7821
Digital isolators – signal isolation

ISO7741DW & ISO7841DWW

Parameter | ISO7741DW | ISO7841DWW
--- | --- | ---
Viso | 5kVrms | 5.7kVrms
Creepage/ Clearance | 8 mm | 14 mm
Data rate | 100 Mbps | 100 Mbps
IEC 60601-1 Capability | 2 MOPP up to 240Vrms | 2 MOPP up to 400Vrms
Size | 10.3 x 7.5 mm | 10.3 x 14.0 mm

Suggested TI device:
ISO7741DW
ISO7841DWW

SPI Isolation: ISO7741DW vs traditional optocoupler solution

Application diagram:
Layout comparison – power and 4-ch data isolation

- SN6505S
- DC-DC converter
- LDO
- Digital Isolator (ISO7741)
- VCC
- Data lines

- UCC12050
- Isolation Transformer
- DC-DC Secondary
- VCC
- Data lines

- ISOW7841
- Isolation Transformer
- DC-DC Secondary
- VCC
- Data lines

SN6505A
- Push-pull transformer
- Digital Isolator (ISO7741)
- 25mm
- 30mm
- Z = 7.6mm

- Digital Isolator (ISO7741) is on bottom layer
- 15mm
- 30mm
- Z = 6mm

- Z = 4.25mm

- Texas Instruments
## Summary

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Conventional flyback</th>
<th>PSR flyback (LM25180)</th>
<th>Open-loop push-pull (SN6505)</th>
<th>Closed-loop push-pull (LM25037)</th>
<th>Isolated power module (UCC12050)</th>
<th>Isolated power with digital isolator (ISOW7841)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Output power level</strong></td>
<td>Flexible (transformer and PWM controller dependent)</td>
<td>5 W to 7 W</td>
<td>5 W</td>
<td>Flexible (transformer and PWM controller dependent)</td>
<td>0.5 W</td>
<td>0.65 W</td>
</tr>
<tr>
<td><strong>Input voltage range</strong></td>
<td>Up to 42V/65V</td>
<td>Up to 42V/65V</td>
<td>Up to 5.5V</td>
<td>Up to 75V</td>
<td>Up to 5.5V</td>
<td>Up to 5.5V</td>
</tr>
<tr>
<td><strong>Output regulation</strong></td>
<td>1% or less</td>
<td>1%</td>
<td>5 to 10%</td>
<td>1% or less</td>
<td>1.5%</td>
<td>1%</td>
</tr>
<tr>
<td><strong>No. of discrete components</strong></td>
<td>More than 30</td>
<td>21</td>
<td>10</td>
<td>46</td>
<td>Less than 10</td>
<td>Less than 10</td>
</tr>
<tr>
<td><strong>Isolation rating</strong></td>
<td>Flexible (Transformer dependent)</td>
<td>Flexible (Transformer dependent)</td>
<td>Flexible (Transformer dependent)</td>
<td>Flexible (Transformer dependent)</td>
<td>5000 Vrms Reinforced</td>
<td>5000 Vrms Reinforced</td>
</tr>
<tr>
<td><strong>Emission</strong></td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Moderate to high</td>
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Application Report

Topology Selection for Isolated Power Supplies in Patient Monitor

Sanjay Pithadia

ABSTRACT

Multiparameter Patient Monitors measure vital signs and use isolated modules for achieving the patient safety. These modules are small in size as they are inserted into the main monitor and support up to 5kV isolation. The data and power both are isolated using digital isolators and isolated power supplies, respectively. This application report talks about different topologies for isolated power and data. It dwells deeper into the critical design challenges associated with isolated power and data such as output regulation, feedback mechanism, input voltage range, output power and size considerations along with suitable power architectures. Finally, it compares the topologies on the basis of all these different parameters.

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Part number: TLV320ACM4268-H-4 all, I have to read two stereo channels, so two I2S outputs A and B of the Codec are used. Both I2S A and B outputs are connected to an FPGA on two IP QSI. Is it possible to read I2S_A (Audio Serial Data Bus A) and I2S_B (Audio Serial Data Bus B) outputs simultaneously? That means both I2S outputs are independent. Is no data multiplexed? Best regards, Pa...

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