

TI.com.cn: 为您提供一站式体验

选型



- **10万**种产品覆盖电源、处理器、无线连接、音频、放大器、时钟、DLP、传感、电机驱动等
- 提供工业、汽车、通信设备、个人消费电子等应用 **系统级解决方案**
- 提供**交叉参照**搜索多个供应商的产品

设计



- **2500**款 **TI Designs** 参考设计，覆盖工业、汽车、医疗、个人消费电子等应用领域
- 提供定制电源、照明、滤波、时钟和传感设计的 **WEBENCH®** 设计中心



支持



- **7/24在线支持社区**，技术疑难解答、海量技术博文分享
- 全年无歇 **在线培训**，理论基础、动手实验，为您充电加油
- Deyisupport (中文)
- E2E (英文)



购买



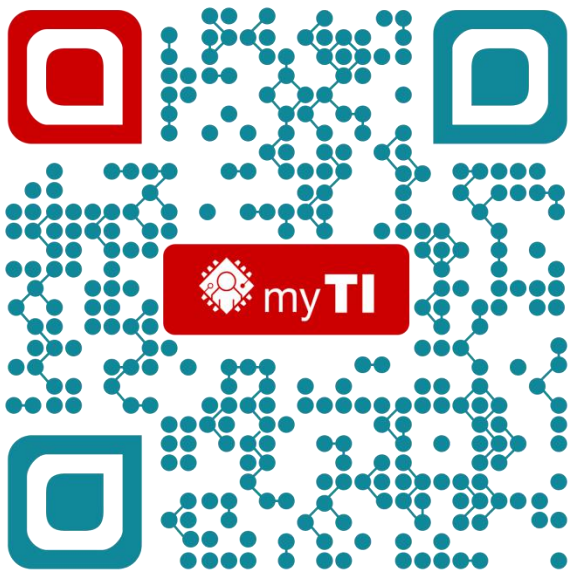
- 全球响应，数万样片开发板任君选择，尽在 **TI Store**



myTI账户：个性化服务及定制

myTI 账户: 专属您的私人订制

<https://my.ti.com>



加入myTI 会员的好处:

- [Tlstore](#) 一站式购物平台, 数万样片开发工具, 一网打尽
- 参与 [TI 在线技术支持社区](#)
- 利用 [WEBENCH® 设计工具](#) 轻松进行设计和模拟
- 订阅产品更新, 获得最新设计工具, 系统方框图与指南等信息
- [标记您最喜爱的产品](#)
- 管理 / [订阅新闻简报](#)
- 注册 / 参加[在线培训与活动](#)
- 获得个性化的建议

TI 在线培训: 打破时空, 随手可得

- 提供包括从理论基础到深入的动手实验在内的各种在线和现场的培训, 协助您将新一代的设计化为现实。我们整合式的培训项目包括 1000+ 的线上培训课程, 网络研讨会和线下研讨会, 有助于您使用TI产品, 开发工具, 软件和各类应用设计。



<http://www.ti.com.cn/training>

经典热门课程:

- C2837x 入门指南
- 2016 EP 研讨会线下课程
- 2016 工业研讨会
- 高精度实验室
- BMS电池设计探讨
- WEBENCH 系列课程
- Engineer It 系列课程

TI（德州仪器）智能可穿戴设备解决方案分享

内容简介

- 可穿戴市场的发展和新科技;
- TI可穿戴设备总体解决方案;
- TI针对可穿戴设备的生物信号采集和调理方案;
- 可穿戴设备的电源管理方案;
- 环境信息检测方案
- TI最新支持Simplelink MCU更新

可穿戴设备市场的发展和新科技

IDC预测可穿戴市场CAGR (2017-2021) 18.2%

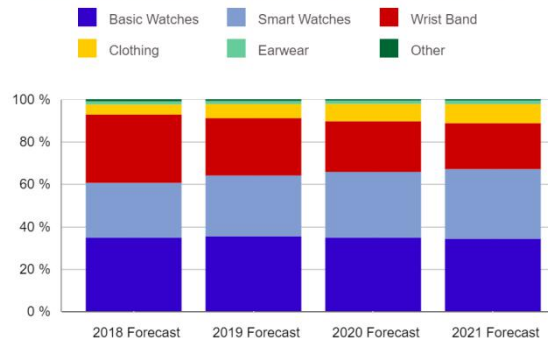
Top Wearable Devices by Product, Volume, Market Share, and CAGR

Product	Shipment Volume 2017	Market Share 2017	Shipment Volume 2021*	Market Share 2021*	CAGR (2017-2021)*
Watches	71.4	56.9%	161.0	67.0%	26.5%
Wristbands	47.6	37.9%	52.2	21.7%	1.2%
Clothing	3.3	2.6%	21.6	9.0%	76.1%
Earwear	1.6	1.3%	4.0	1.7%	39.7%
Others	1.6	1.3%	1.4	0.6%	-16.0%
Total	125.5	100.0%	240.1	100.0%	18.2%

Source: IDC Worldwide Quarterly Wearables Device Tracker, June 21, 2017



Worldwide Wearables Forecast by Product Type, 2016 - 2021



可穿戴设备的新科技



Levi's and Google Jacquard



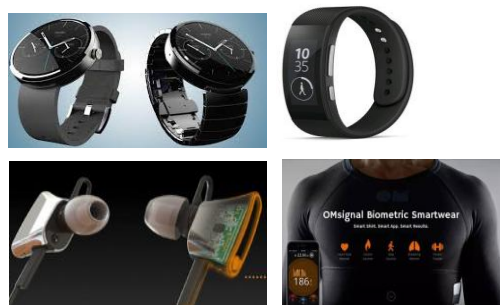
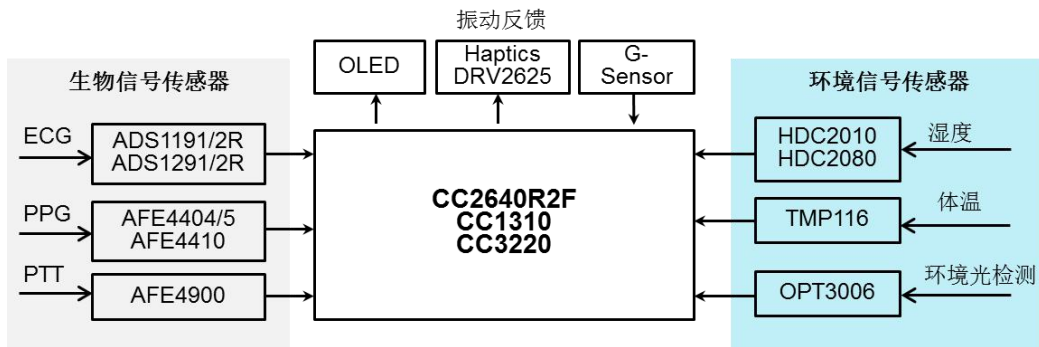
Fitbit Sleep Apnea Diagnosis



Arrow 360 Smartwatch

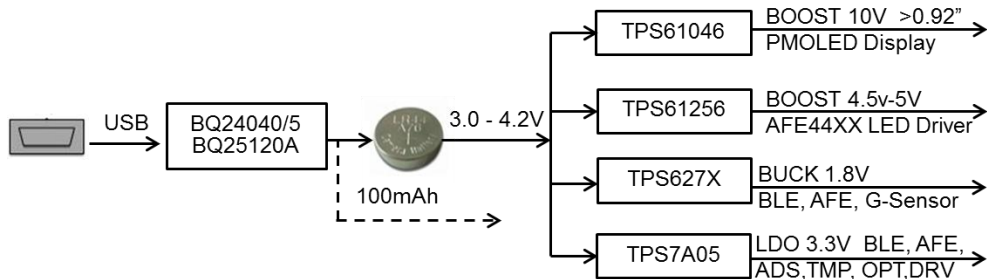
TI可穿戴设备总体解决方案

信号链解决方案



注：图片来自网络

电源解决方案



参考设计	简介
TIDU875	无线多参生物信号监测
TIDA00011	蓝牙心率手表参考设计
TIDA00824	高精度NFC体温计
PMP9775	PMOLED电源参考设计

TI 针对可穿戴设备的生物信号采集和调理方案

Haroad Chen

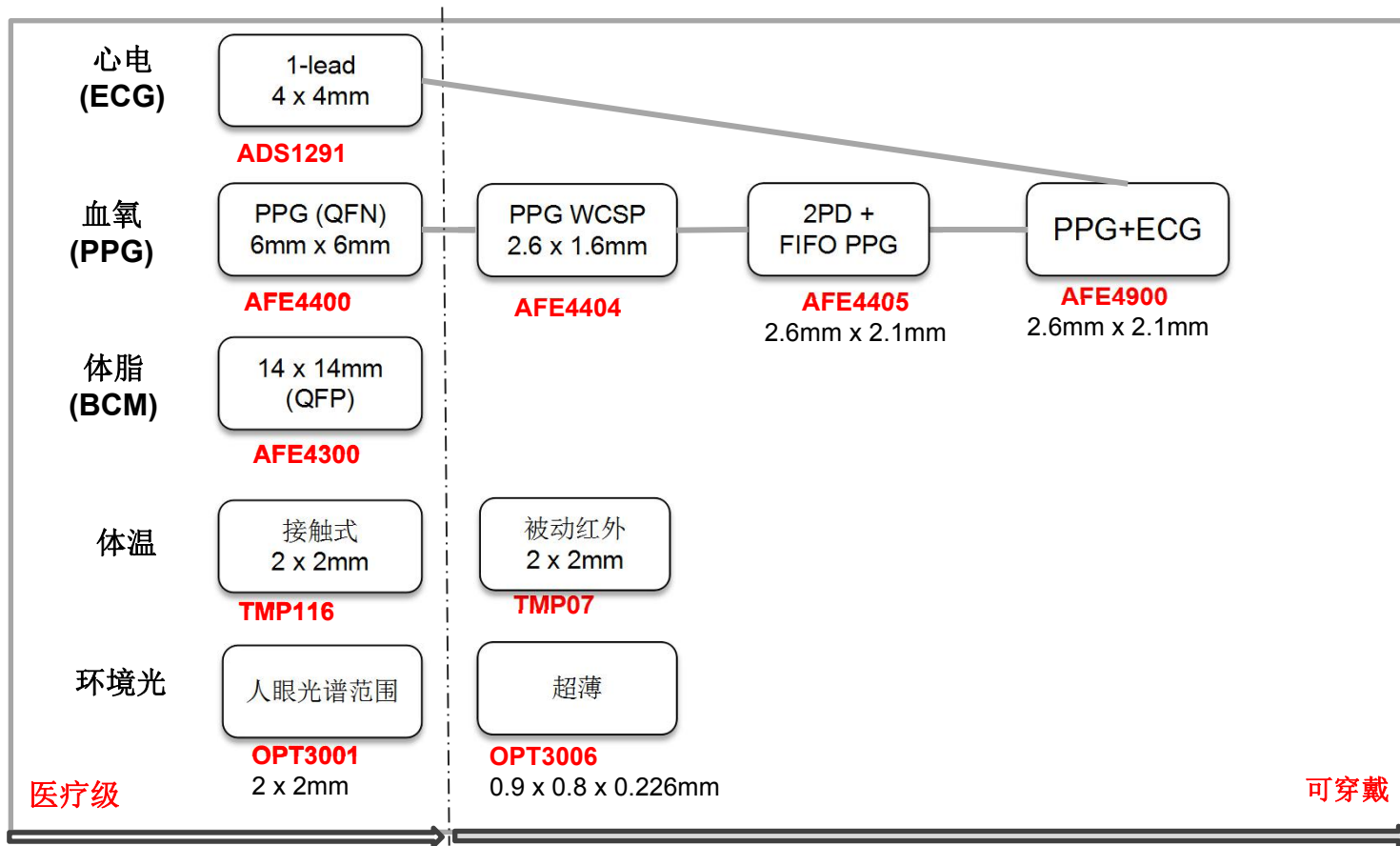
信号链现场应用工程师, TI 技术委员会委员

Contributions by: Praveen Aroul PhD, Lijoy Philipose, Karthikeyan Soundarapandian, Anand Udupa

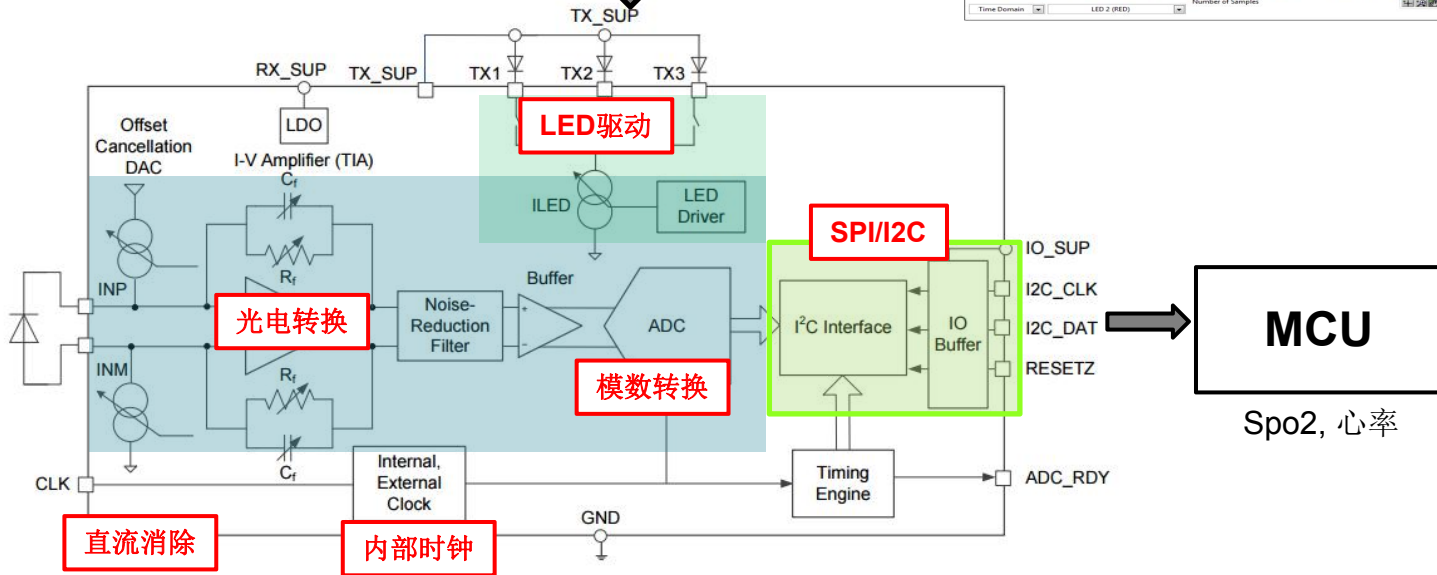
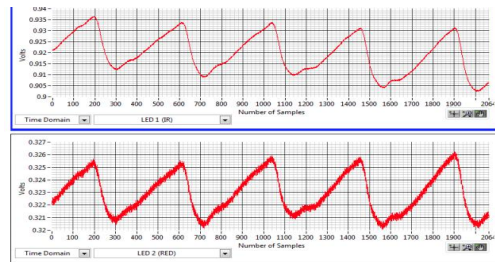
内容简介

- TI生物模拟前端测量简介
- 脉搏血氧测量原理以及PPG信号特征
- 生物光电信号测量的挑战
- TI光学生物传感器AFE44XX功能介绍以及解决方案
- TI生物光学信号检测生态系统
- TI心电信号检测模拟前端

TI 生物信号测量模拟前端发展历程



TI 脉搏血氧和心率监测的高性能模拟前端功能模块



Spo2, 心率

AFE44xx 传统产品比较

		AFE4490	AFE4400	AFE4403	AFE4404
Applications		Clinical Grade Pulse-ox	Finger Clip Pulse-ox, Wearable	Wearables, Clinical Pulse-ox Patches	Wearables, Optical Bio-Sensing
Transmit Path	Integrated LED Driver	2 LEDs in either H-bridge or common anode configuration		2 LEDs in either H-bridge of common anode config. + 3rd LED in common anode config.	3 LEDs in common anode config.
	LED Driver Supply Min Voltage	1V above VLED		0.5V above VLED	0.5V above VLED
	Dynamic Range (dB)	110 dB	95 dB	110 dB	100 dB
	LED Current	Programmable up to 200mA with 8-bit current resolution	Programmable up to 50mA with 8-bit current resolution	Programmable up to 100mA with 8-bit current resolution	Programmable up to 50mA with 6-bit current resolution
	LED On Time	Programmable from 50µS to 4mS			Programmable from 50µS
	Independent Current Reference For Red and IR LEDs	Separate LED1 and LED2 current reference			Separate LED1, LED2 and LED3 current reference
Receive Path	Dynamic Range (dB)	105 dB	100 dB	105 dB	100 dB
	TIA with Separate Red and IR Settings	Programmable LED1 and LED2 settings			
	Analog Ambient Cancellation Scheme	Selectable 1µA to 10µA ambient current			Selectable +/-7.5µA cancellation (separate for each phase)
Flexible Sequencing and Timing		Yes			
External Input Clock Frequency		8Mhz ± 2%		4-60Mhz	4-60Mhz
Crystal Clock Frequency Range		8Mhz ± 2%		8-24Mhz	N/A
Integrated Fault Diagnostics		LED and photodiode open/short detect			Photodiode fault detect
Power Supply		Rx: 2V to 3.6V. Tx: 3V to 5.25V			Rx: 2V to 3.6V. Tx: 3V to 5.25V. IO: 1.8 to 3.6V
Dynamic Rx Power Saving Mode		N/A		Yes	Yes
Specified Temperature Range		-40 deg C to 85 deg C	0 deg C to 70 deg C	-20 deg C to 70 deg C	-20 deg C to 70 deg C
Interface		Serial SPI			I2C
SPI Tristate		Shared with other pins		Separate bit control	N/A
Package size/Type		40-pin QFN, 6 x 6 x 0.85 mm	40-pin QFN, 6 x 6 x 0.85 mm	DSBGA 3 x 3 x 0.5 mm	DSBGA 2.6 x 1.6 x 0.5 mm ¹²

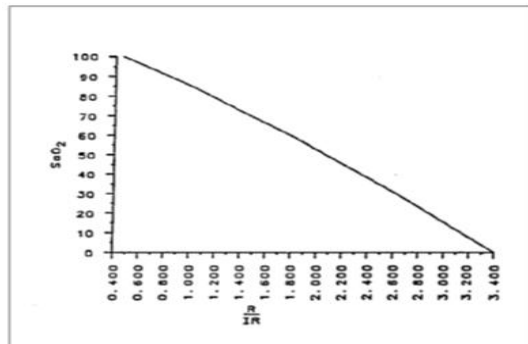
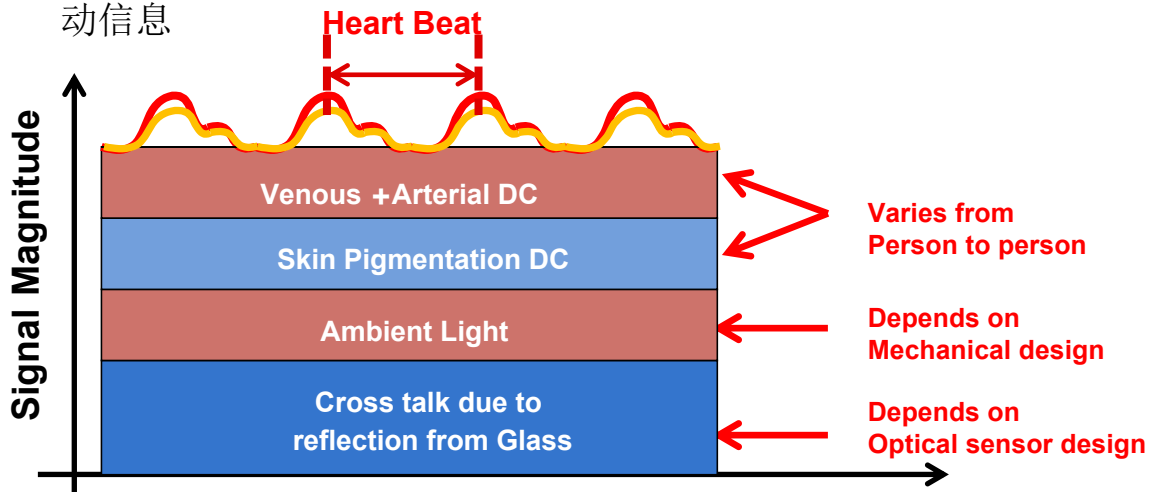


模拟前端最新产品比较

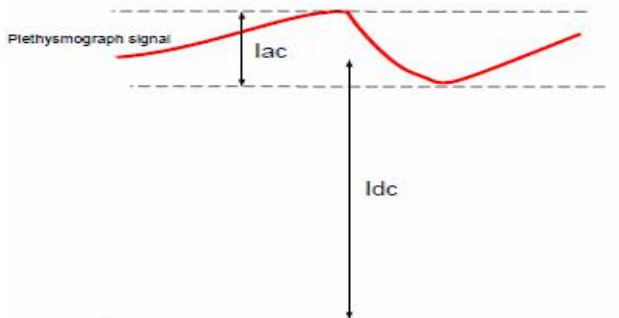
		AFE4410	AFE4900
Applications		Wearables, Optical Bio-Sensing	Wearables, Optical and Electrical Bio-Sensing
Transmit Path	Integrated LED Driver	4 LEDs in common anode config. Total of 4 phases including ambient.	4 LEDs in common anode config. Total of 4 phases including ambient.
	LED Driver Supply Min Voltage	0.32V above VLED for 50 mA; 0.45V above VLED for 100 mA	
	Parallel LED operation	Two LEDs with equal current setting can be turned on simultaneously	
	Dynamic Range (dB)	100 dB	
	LED Current	Programmable up to 200mA with 8-bit control	
	LED Control	Separate for LED1, LED2, LED3 and LED4	
Receive Path	Dynamic Range (dB)	100 dB	
	Inputs	3 PD	
	TIA gain and BW	Programmable for all 4 LEDs	
	Noise reduction filter	2.5/ 5/ 10 kHz (programmable)	
	Offset cancellation DAC	Selectable from +/-15.75 uA to +/-126 uA	
ECG signal chain		No	Yes; 1-lead ECG with RLD output for input bias
Ambient cancellation scheme		Manual/ Automatic	
External Input Clock Frequency		32KHz - 4Mhz	
Power Supply		Rx:1.8-1.9V (LDO bypass), 2-3.6V (LDO Enable), Tx:3-5.25V, IO:1.7-3.6V (and < Rx)	
Rx current		50 uA	50 uA – PPG only at 50 Hz PRF 200uA – PPG and ECG at 100 Hz PRF
Interface		I2C addr(2devices), SPI	
FIFO		128 samples FIFO Additional flexible readout mode based on watermark level	
Decimation mode		Option to store all phases of Decimation mode data in FIFO	
Specified Temperature Range		-20 deg C to 70 deg C	
Package size/Type		DSBGA 2.6 mm x 2.1 mm, 0.4 mm pitch	

原理 - 脉搏血氧(氧饱和度)

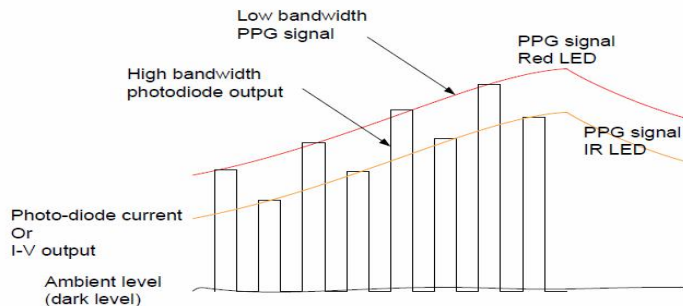
- PPG 信号幅度取决于每个心脏心动周期泵出的血液量，血液对光的吸收量，皮肤对光的吸收量，皮下组织对光的吸收量
- 我们称PPG的脉动信号为交流分量；非脉动信号，主要是静脉血，皮肤，组织的光吸收信号，为直流分量
- 归一化 $\frac{R}{IR} = \left(\frac{AC_R}{DC_R} / \frac{AC_{IR}}{DC_{IR}} \right)$ 就和氧饱和度近似相关: $SaO_2\% = A - B \cdot (R/IR)$
- 如果采用合适的算法， PPG信号就可以和心脏的脉动信号拟合，这样就可以通过PPG信号来监测心脏跳动信息



PPG信号特征



- PPG → 脉动信号 (AC) + DC
 - 脉动信号 → 动脉血
 - DC → 静止组成部分(如组织, 静脉血, 皮肤, 保护罩等)
- I_{ac}/I_{dc} → 灌注指数 (PI) ~ 0.05%- 0.5%
- AC freq. → 0.3 – 4Hz



- 虽然PPG信号是低频的, 但TI AFE44XX 采用脉冲发光和光电转换来采集, → 节约功耗
- 每个LED发光脉冲就是PPG信号的采样, 然后光电二极管就采集接收到的光信号强度 → 光电二极管输出就是高带宽信号

光电生物信号测量的挑战

Challenges

- 低功耗，更长的电池使用时间



- 肤色的差异性



- 抗运动消噪算法



- 保护膜的透光性



- 低温性能

- 抗环境光的影响

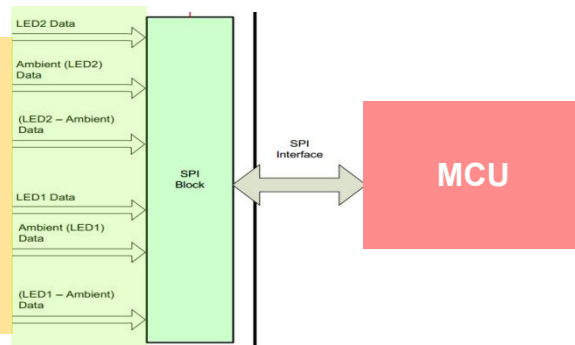
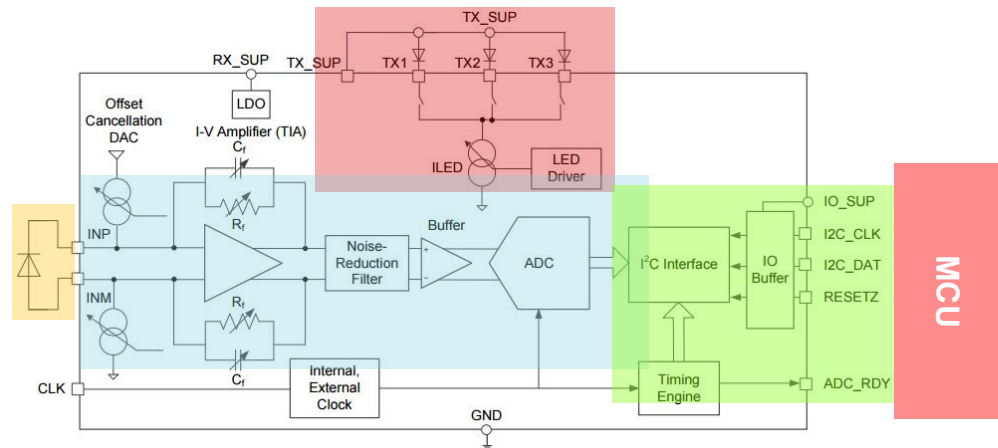
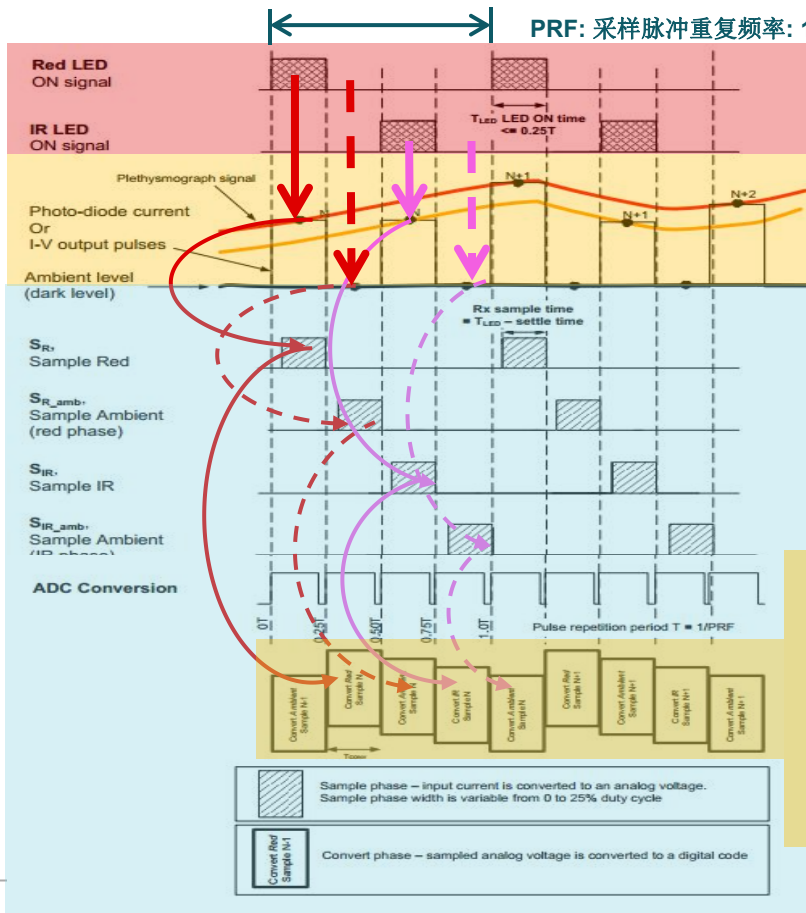


Solutions in the market today are either

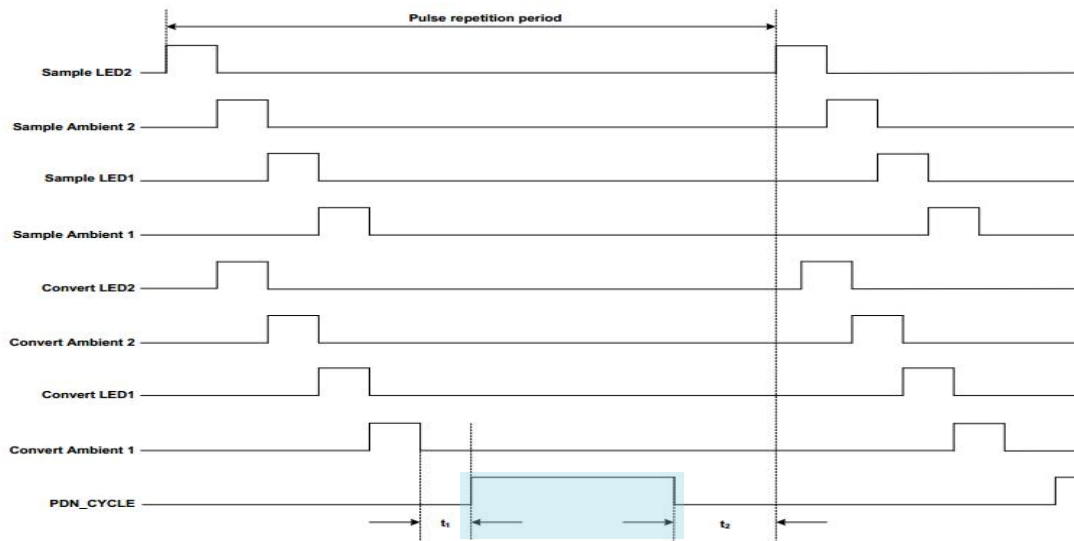
- Too big!
- Just don't work!

AFE44XX 工作流程

PRF: 采样脉冲重复频率: 10SPS to 1000 SPS

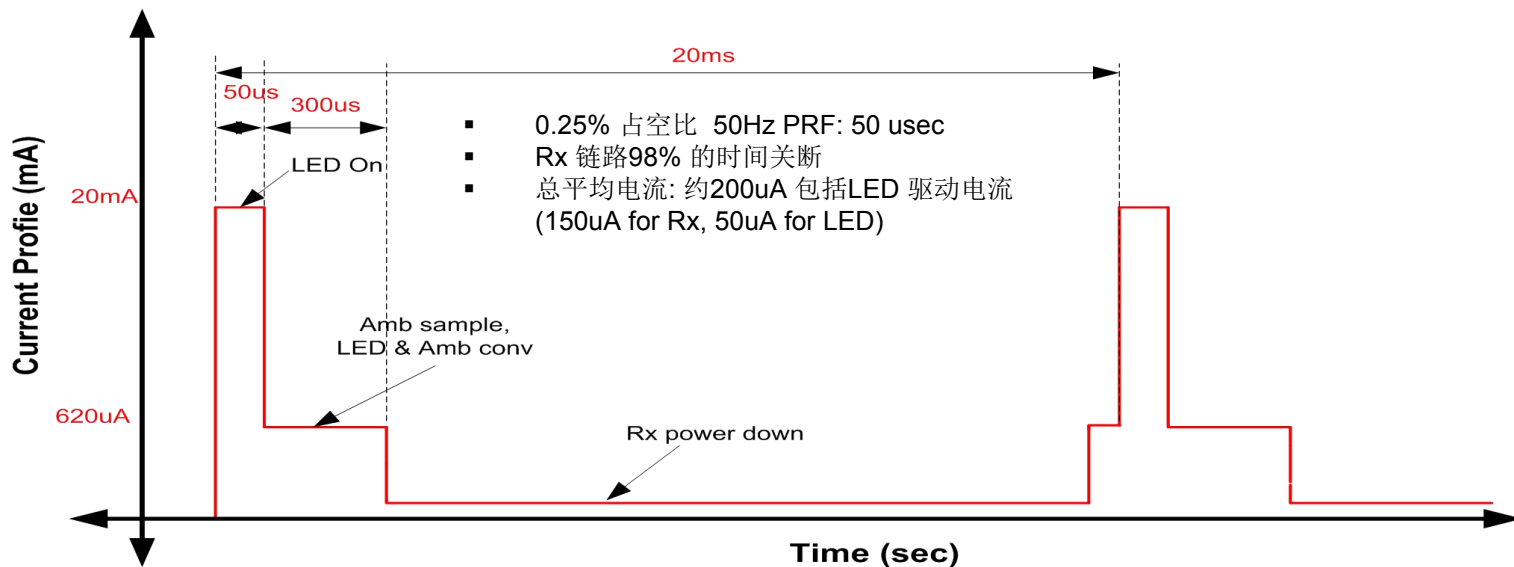


AFE44XX 动态功率控制模式



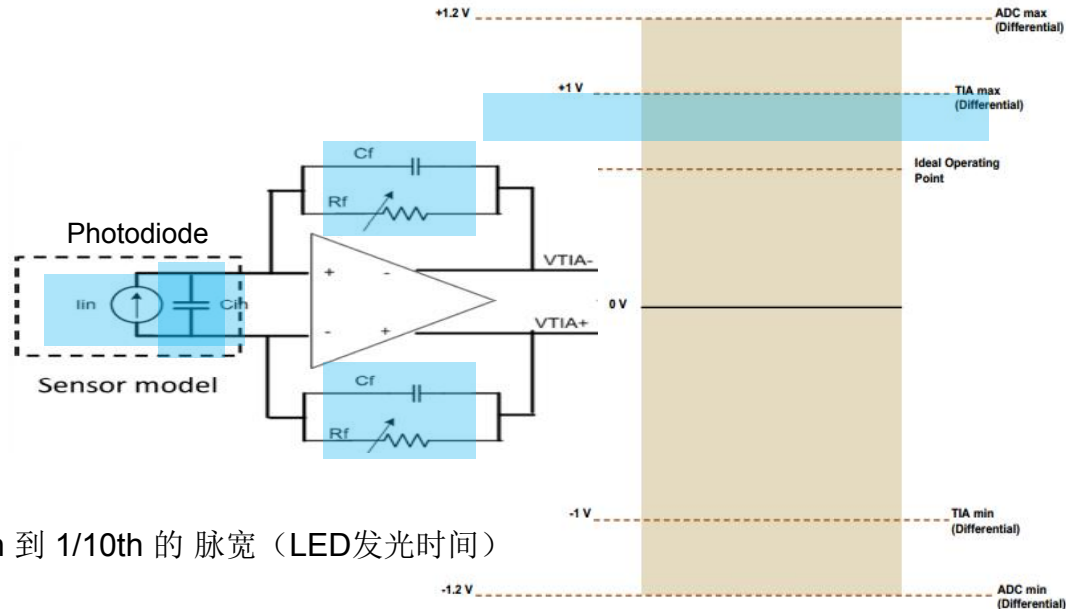
- PDN_CYCLE 可以在每个脉冲重复周期内，在发光，采样转换完成后，关掉AFE44XX内部的一些模块，来进一步降低功耗
- 采样PDN_CYCLE控制模式，AFE44XX 可以降低35%-70%的功耗
- The DYNAMIC1 (TX模块), DYNAMIC2 (ADC 模块), DYNAMIC3 (TIA 模块), and DYNAMIC4 (ADC其它部分) 控制位 决定哪些模块在PDN_CYCLE 中会关掉 (PDN_CYCLE is high)

AFE44XX 如何降耗并延长电池寿命 动态功率控制实例



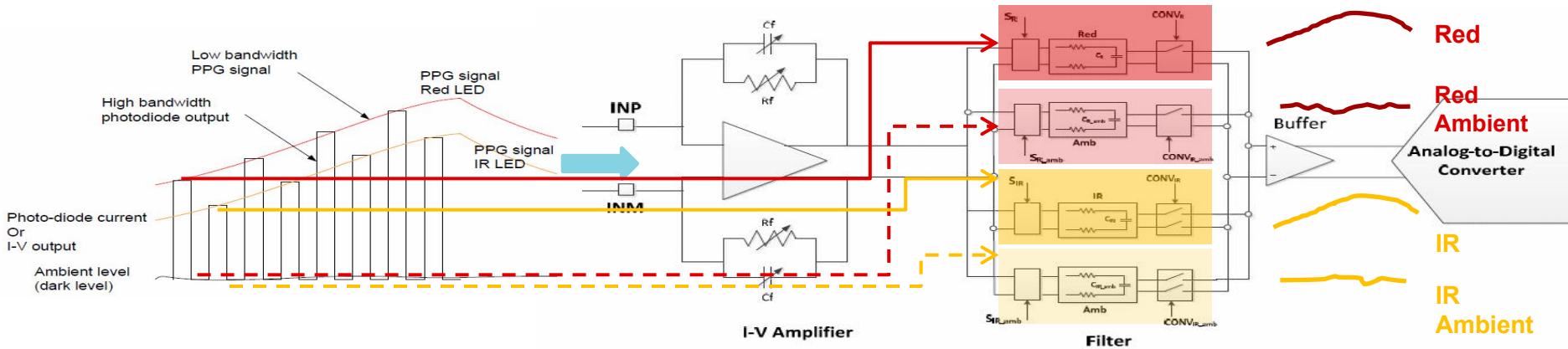
AFE44XX Receiver - TIA

- (PD) 模型可简化为电容 C_{in} 和电流源 I_{in} 的并联。
- 电流大小(I_{in}) 随PPG信号幅度改变。
- 大 PD \rightarrow 更大的电流 \rightarrow 更好的信噪比SNR
- $V_{TIA} = V_{TIA+} - V_{TIA-} = 2 \times I_{in} \times R_f$
 - Where $R_f = \{2 \text{ M}\Omega, 1 \text{ M}\Omega, 500 \text{ k}\Omega, 250 \text{ k}\Omega, 100 \text{ k}\Omega, 50 \text{ k}\Omega, 25 \text{ k}\Omega, 10 \text{ k}\Omega\}$



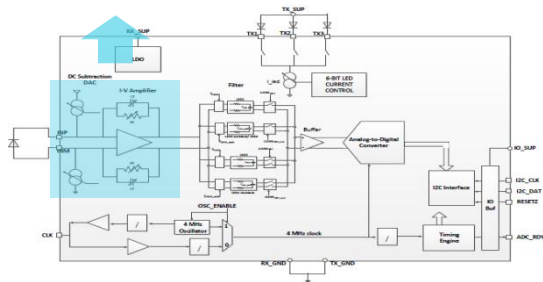
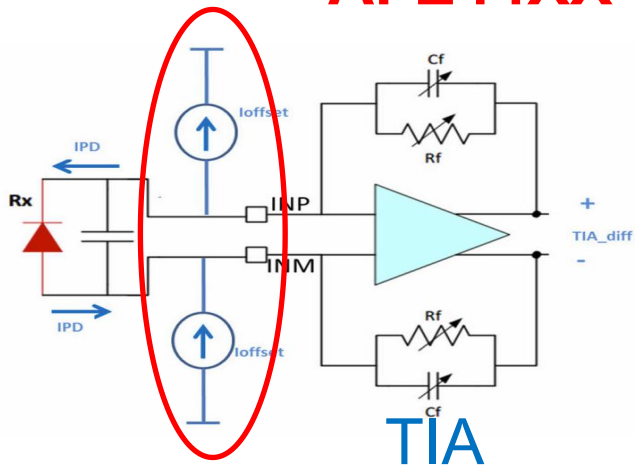
- TIA 输出范围 +/-1V
- ADC 满刻度输入范围 +/-1.2V.
- TIA 需要足够高的带宽 \rightarrow 时间常量 $C_f \times R_f$ 设在 1/5th 到 1/10th 的脉宽 (LED发光时间)
使方波信号更好通过
- 如, 如果采用50 usec 的脉宽, 时间常量 $R_f \times C_f$ 需要设在5-10 us. 如果 TIA 的gain (R_f) 设为1M Ω , C_f 就应当为 5 pF ($5e-6 / 1e6 = 5e-12$) 或 10 pF.
 - $C_f \rightarrow 2.5\text{pF}, 5 \text{ pF}, 7.5 \text{ pF}, 10 \text{ pF}, 17.5 \text{ pF}, 20 \text{ pF}, 22.5 \text{ pF}$ and 25 pF.

AFE44XX Receiver – 采样和保持滤波器



- PD输出的电信号带宽很高(LED 的发光脉冲采样PPG信号).
- 另外，AFE也需要很高的带宽使光电管的输出脉冲更真实的给到 ADC，但是我们又需要减小带宽，来降低ADC的输入端的噪声。AFE44XX 内部创新结构可以非常好的解决这个问题
- AFE44XX每个单独的采样周期 (LED2, LED3 / AMB2, LED1, AMB1) 可以设置对应的独立的滤波器，来匹配相应的 TIA 的输出信号，并在ADC的采样时间内，建立至相应的幅度

AFE44XX Receiver –DC校正机制



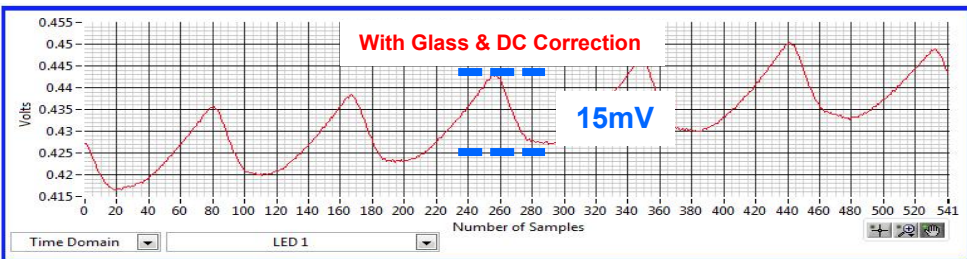
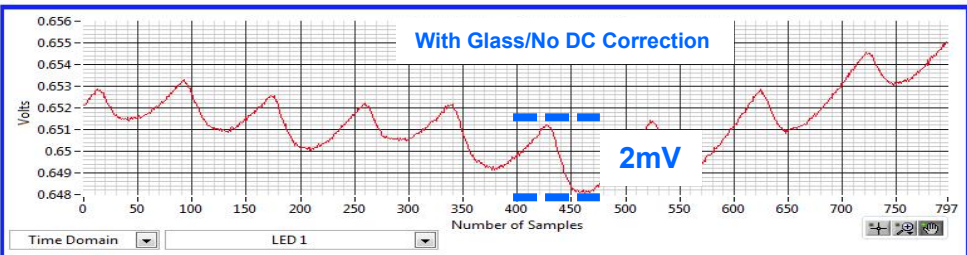
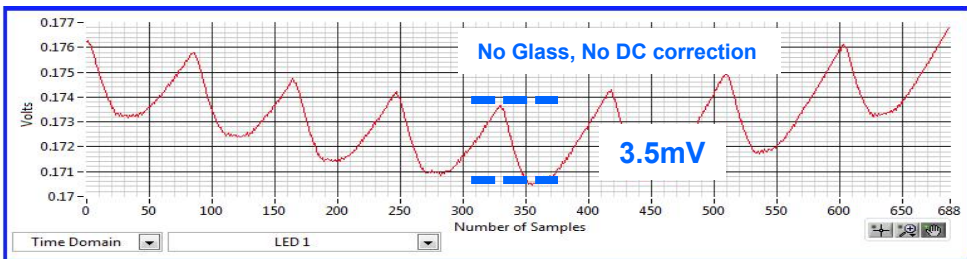
- 环境光 (很高的DC信号) 问题:
 - 造成整个信号链路饱和
 - 降低信噪比
- 保护罩反射LED的光, 也会带来很高的DC信号
- 环境光抵消:
 - AFE44XX 有独立的周期来采样和转换环境光. 环境光的数值可以从每个LED采样值中减掉, 这样就可以消除PPG采样信号中环境光带来的噪声。
 - AFE4404/5的TIA输入端有DC失调抵消DAC, 可以提供相对应的反向电流(-7 uA to 7 uA, 0.47uA 步进), 来抵消TIA输入端的直流分量。
 - 更高的 TIA 增益可以得到更大的AC信号
- 后端处理器可以根据环境光/反射光的数值来评估光的泄漏的大小, 并通过设置电流DAC来尽可能的消除
- 这样就可以使机械设计和光学设计更简单
- 可以减小整个系统的功耗

The current to voltage gain in the TIA after applying the offset DAC current is given by

$$VTIA (diff) = VTIA^+ - VTIA^- = 2 * (Ipd - Ioffset) * Rf$$

直流信号校正性能---玻璃保护罩的反射

测试者 A - 高灌注

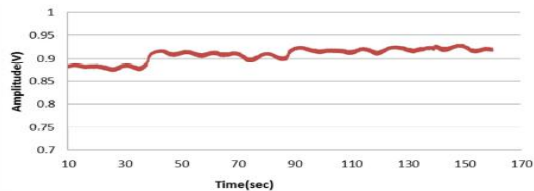


Study Case A	Photodiode/LED condition	Offset Subtraction DAC condition	Participant A High Perfusion			
			Settings	AC	DC	AC/DC
Simulate current solutions on market.	No Glass (not real product)	Not in others' solutions	LED1: 12mA, TIA gain: 250K Ohm	3.5 mV	170 mV	20.0E-3

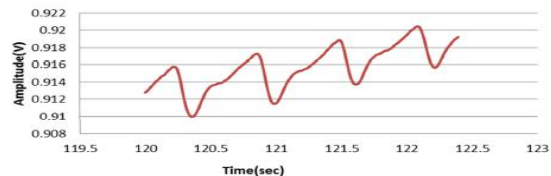
Study Case A	Photodiode/LED condition	Offset Subtraction DAC condition	Participant A High Perfusion			
			Settings	AC	DC	AC/DC
Simulate current solutions on market.	Sealed with Glass (real wearables)	Not in others' solutions	LED1: 12mA, TIA gain: 250K Ohm	2 mV	650 mV	3.0E-3

Study Case A	Photodiode/LED condition	Offset Subtraction DAC condition	Participant A High Perfusion			
			Settings	AC	DC	AC/DC
With AFE4404	Sealed with Glass (real wearables)	AFE4404 Ready	LED1: 12mA, TIA gain: 250K Ohm. DAC: 1uA	15 mV	430 mV	34.9E-3

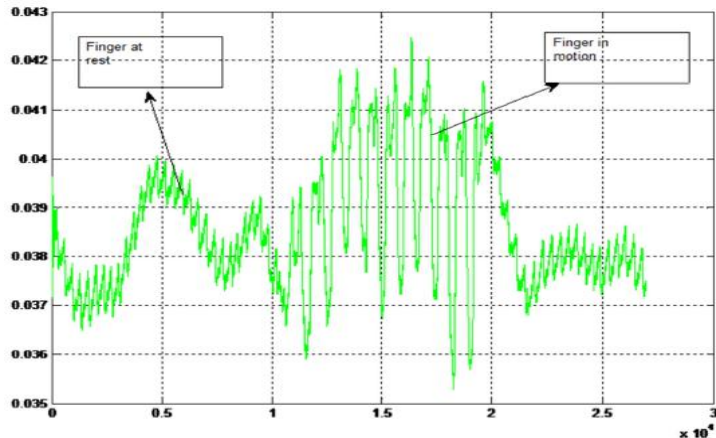
静止和运动时的心率监测



A zoomed in version of the same signal is shown below:



即使是在静止时，DC分量会突然改变，因为一些生理机能的因素，如呼吸和肌肉移动等。



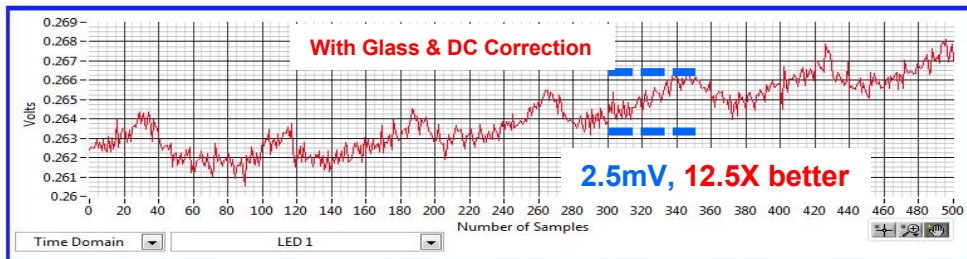
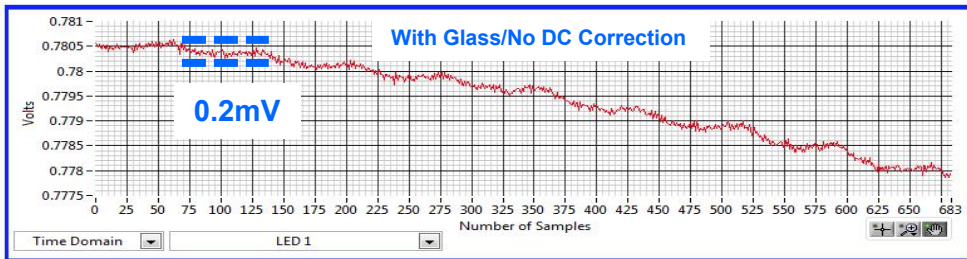
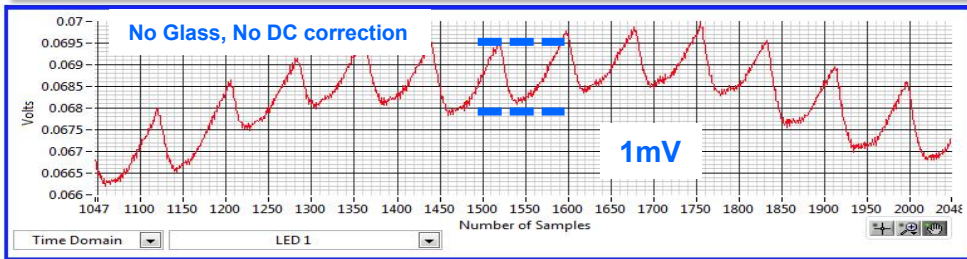
在运动时，PPG信号可能会被淹没.为了更好地在运动时测量心率，可以采用加速度计来估算运动因素，并在算法里做相应的处理。

■ AFE44xx 在运动和静止环境下的优点:

- 医疗级别的内核，100+ dB TX & RX 动态范围，这样在弱信号时也能得到很好的SNR
- 高SNR的内核，可以让用户采用更小的LED电流，从而降低功耗
- DC抵消 DAC 可以使交流信号进一步放大（因为DC已尽可能减小，可以采用更大的TIA增益放大交流信号）。
- 信号链路的专利架构，进一步降低噪声

直流信号校正性能---玻璃保护罩的反射

测试者B - 弱灌注

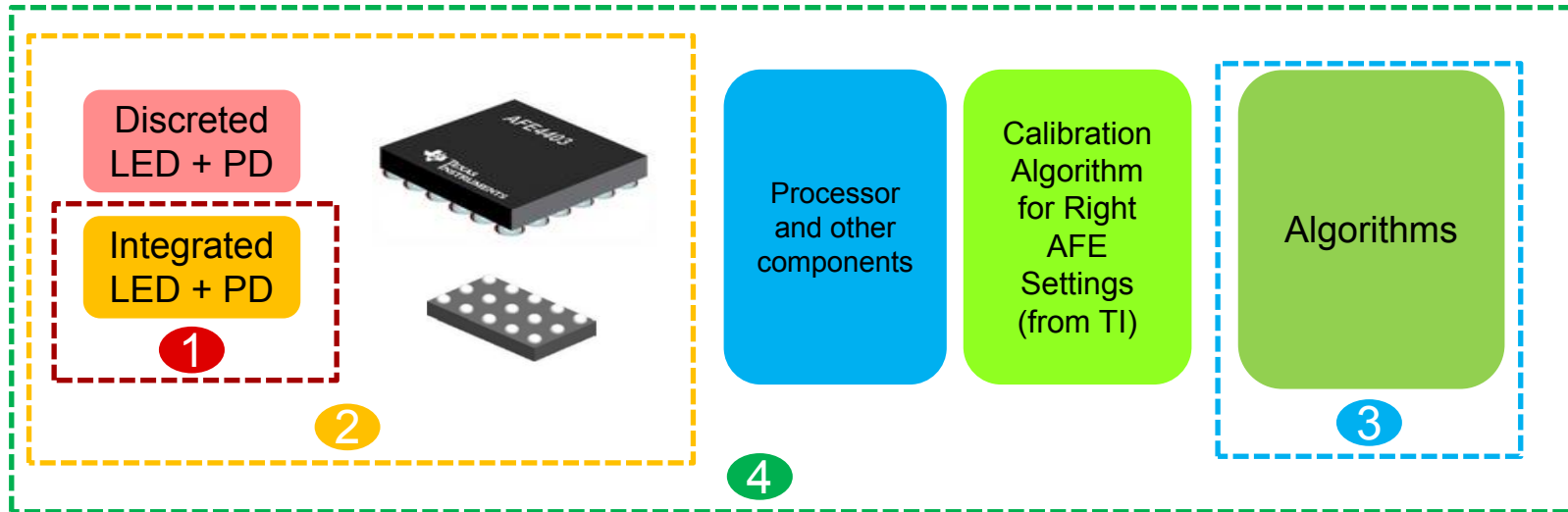


Study Case B	Photodiode/LED condition	Offset Subtraction DAC condition	Participant B Low Perfusion			
			Settings	AC	DC	AC/DC
Simulate current solutions on market.	No Glass (not real product)	Not in others' solutions	LED1: 12mA, TIA gain: 250K Ohm (same as A)	1 mV	68 mV	14.7E-3

Study Case B	Photodiode/LED condition	Offset Subtraction DAC condition	Participant B Low Perfusion			
			Settings	AC	DC	AC/DC
Simulate current solutions on market.	Sealed with Glass (real wearables)	Not in others' solutions	LED1: 12mA, TIA gain: 250K Ohm (same as A)	0.2 mV	770 mV	0.9E-3

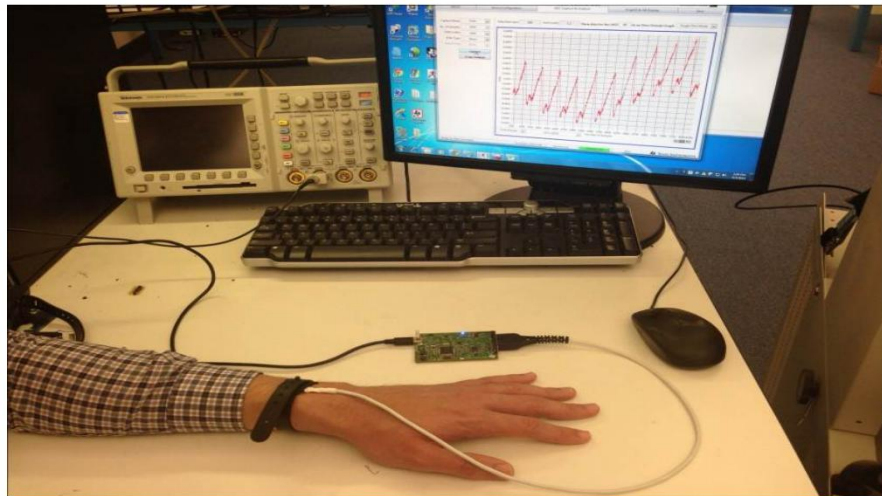
Study Case B	Photodiode/LED condition	Offset Subtraction DAC condition	Participant B Low Perfusion			
			Settings	AC	DC	AC/DC
With AFE4404	Sealed with Glass (real wearables)	AFE4404 Ready	LED1: 25mA, TIA gain: 2M Ohm. DAC: 2.5 uA (8X TIA gain, no problem)	2.5 mV	260 mV	9.6E-3

TI 光电心率解决方案 生态系统



- 1 集成LED+PD的传感器厂商
- 2 LED + PD + AFE 模块厂商
- 3 第三方：提供抗运动算法, SpO2算法, HRM算法等
- 4 完整的设计方案

AFE44XXEVM



- 传感器连接线
- AFE44XX寄存器控制和波形显示的图形界面
- 带NJRC NJL5310R (2G + PD) and OSRAM SFH7050 (1G/1R/1IR + PD) sensor boards

Star Your Own Design With TI Today

Solution Features

- Measure pulse from veins in wrist using the **AFE4400**
- **MSP430F5528** microcontroller for holding algorithm and motion cancellation calibration data
- BLE module connection featuring TI's **CC2541**
- **BQ24072** USB charger and **BQ27425-G1** fuel gauge devices for battery management

Tools & Resources

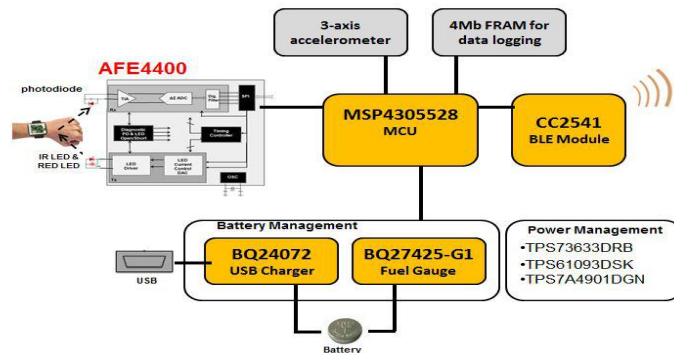


- <http://www.ti.com/tool/TIDA-00011>
- Includes
 - Schematics
 - Layout
 - Gerber files
 - BOM

Solution Benefits

- Accelerate and simplify your wrist based HRM design while ensuring measurement performance needed for Fitness designs
- Easy connectivity to BLE enabled smartphones, tablets, etc.
- Ultra-low power consumption

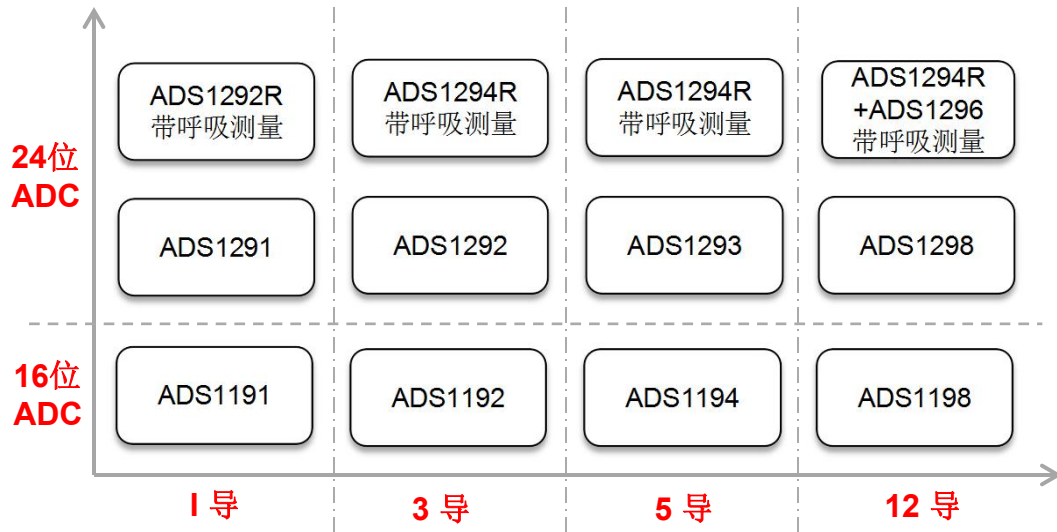
Optical Wrist Based HRM



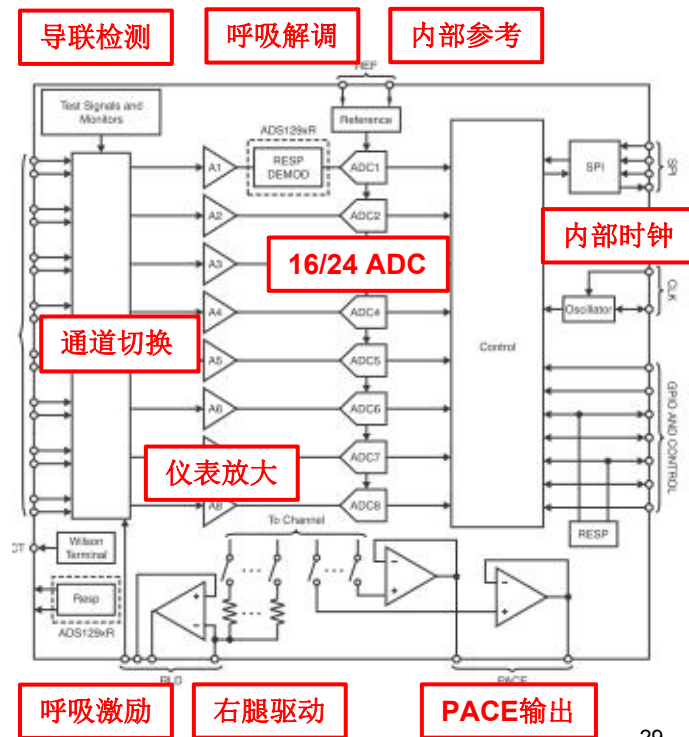
TI 心电信号模拟前端

特点:

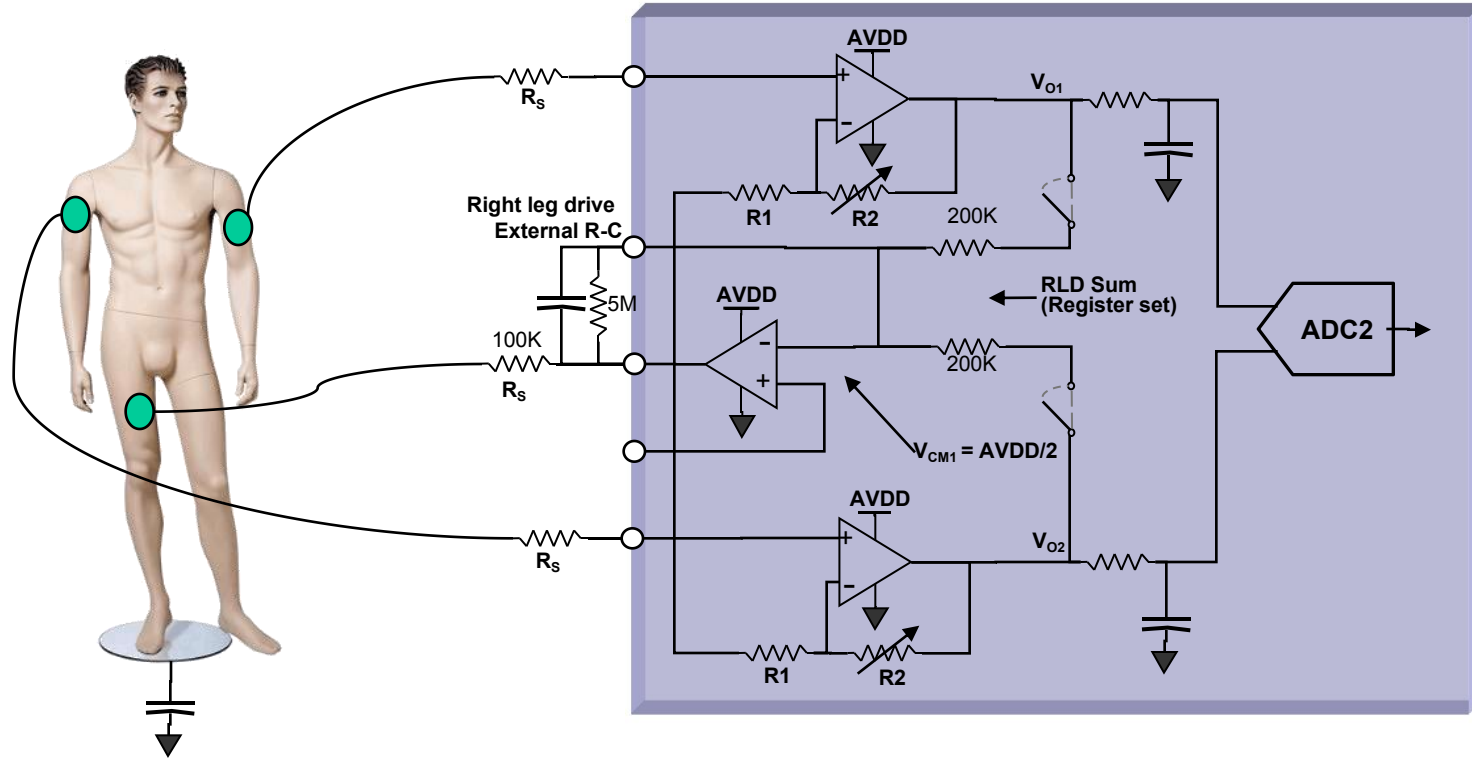
- 低功耗: 335uW/通道 (ADS1X91/2); 750uW/通道 (ADS1X94/6/8)
- 低噪声: 8uVpp(ADS1291/2); 4uVpp(ADS1294/6/8)
- 高共模抑制比: 105dB(ADS1291/2); 115dB(ADS1294/6/8)
- 可编程增益: 1,2,4,6,8,12
- 采样率125-2kSPS(ADS1291/2); 250-32kSPS(ADS1294/6/8)
- 支持双极性输入(0-5V或 +/-2.5V)



功能模块



ADS1291 I 导心电示例



ADS1292 右腿驱动

- 右腿驱动是什么？

- 在ECG测量系统里，会有很多共模干扰，如50、60hz工频，电源噪声，荧光等。
- 右腿驱动就是检测相关的ECG输入通道的共模信号，通过负反馈电路，将反向的共模信号加到人体上。使共模干扰信号限制在比较小的范围。
- 这个电路的效果取决于反馈电路的环路增益，零，极点的设定等。
- SBAA-188----Improve ADS129X CMRR

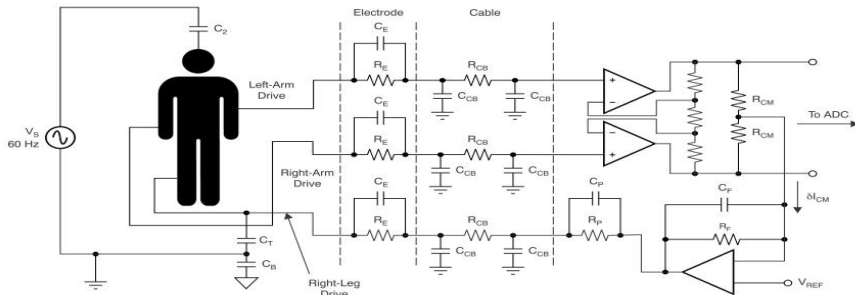
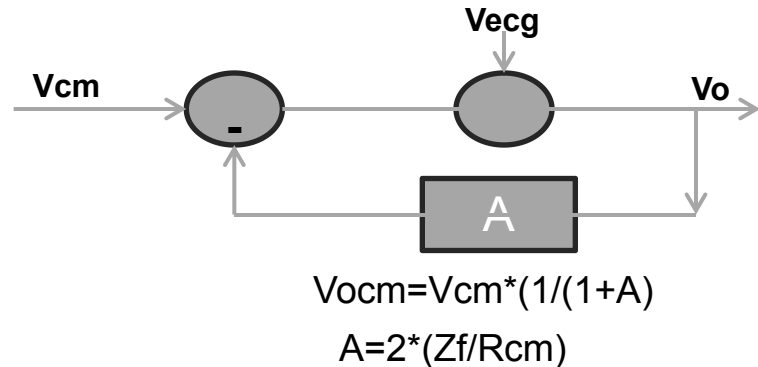
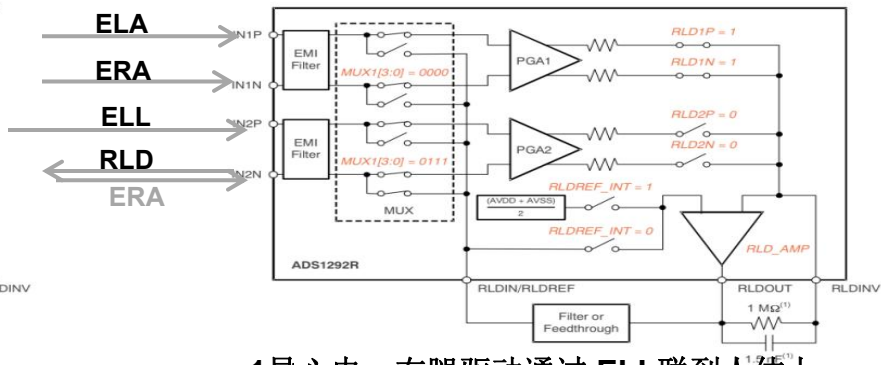
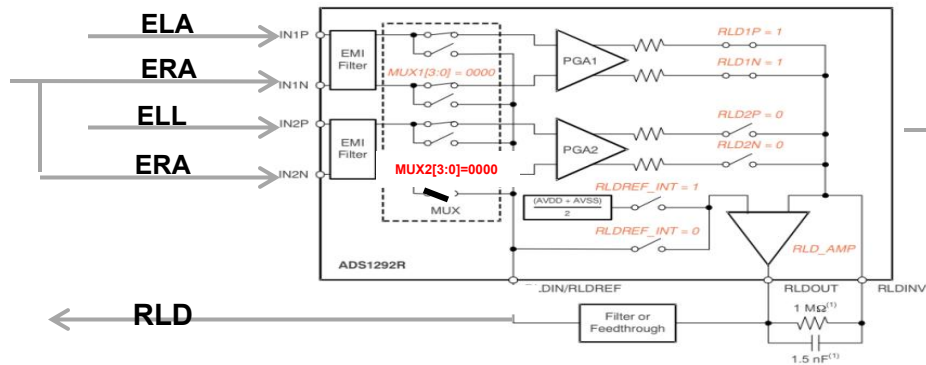


Figure 5. Improving CMRR by Completing RLD Feedback Loop



ADS1292R 右腿驱动几种配置方式

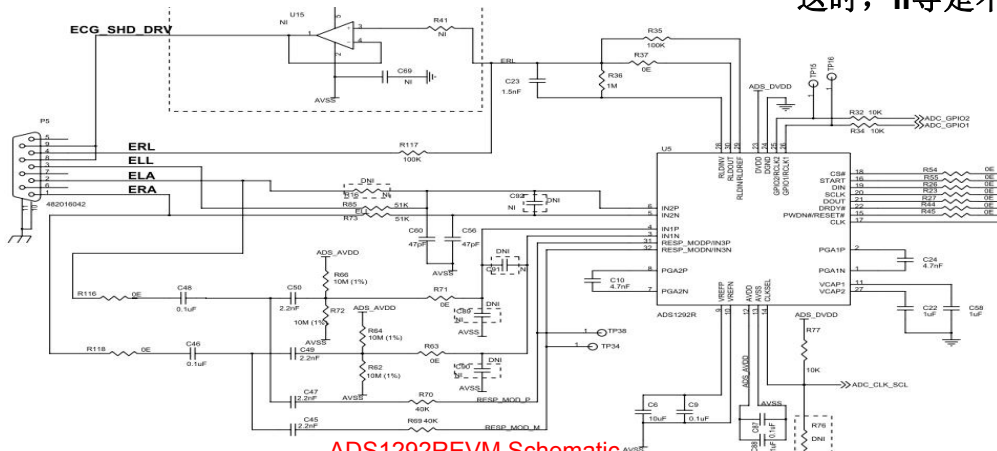


1导或3导联，独立右腿驱动电极，共模信号从CH1/2提取

1导心电图，右腿驱动通过 ELL 联到人体上，这时，II导是不能实现的。共模信号从CH1提取

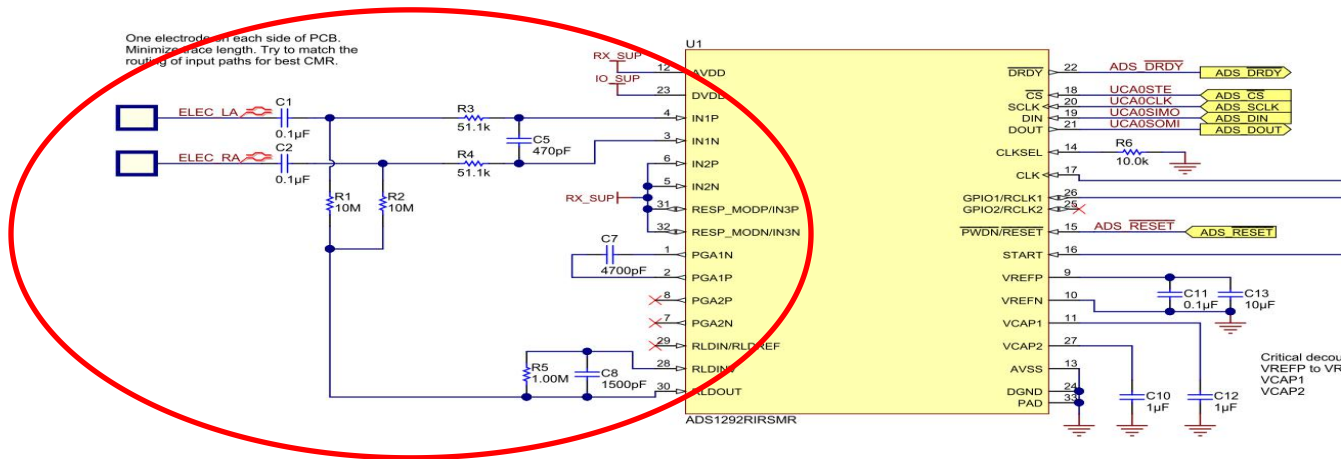
- I=ELA-ERA (HW)
- II=ELL-ERA (HW)
- III=II-I=ELL-ELA (SW)
- CH1SET 04h= 0X00
- CH2SET 05h= 0X00
- RLDSENS 06h=0X23
- RESP2 0Ah=0x03

- I=ELA-ERA (HW)
- II=ELL-ERA (HW)
- III=II-I=ELL-ELA (SW)
- CH1SET 04h= 0X00
- CH2SET 05h= 0X87
- RLDSENS 06h=0X23
- RESP2 0Ah=0x03



ADS1292REVM Schematic

ADS1292 无右腿驱动



1导心电，无右腿驱动，通过交流耦合电容后，由RLD提供输入共模信号

$I = ELA - ERA$ (HW)
 $II = ELL - ERA$ (HW)
 $III = II - I = ELL - ELA$ (SW)
 CH1SET 04h = 0X00
 CH2SET 05h = 0X81
 RLDSENS 06h = 0X23
 RESP2 0Ah = 0x03

TI 针对可穿戴设备电源管理方案

Andonis Wang

模拟现场应用工程师

内容简介

- 充电管理解决方案
- PMOLED 屏幕驱动的解决方案
- 降压Buck电源解决方案
- 降压LDO电源解决方案

穿戴设备的集成化充电管理方案 – BQ25120A

FEATURES

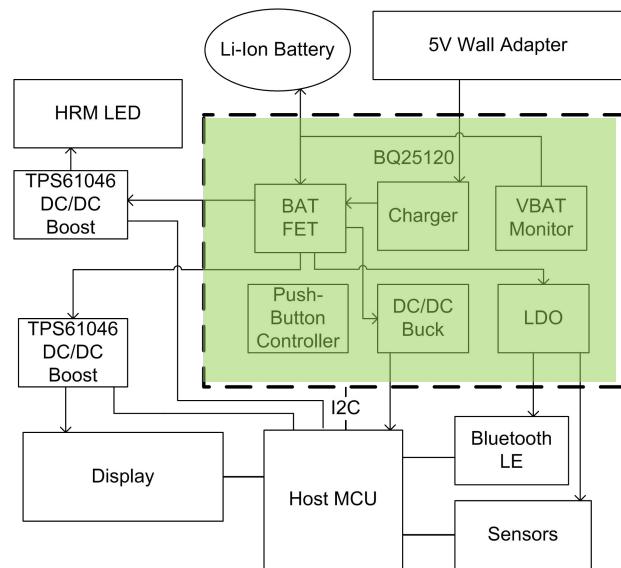
- 集成化的充电管理方案，内部包含：
 - 带路径管理的线性充电管理功能；
 - 100mA LDO/ 负载开关
 - 300mA电路输出的DCDC
- 按钮开关控制
- 超小封装，2.5mm*2.5mm
- 超低静态功耗，静态功耗<750nA
- Shipmode下功耗仅2nA
- 截至电流低值500uA，最大可能将电池充满

APPLICATIONS

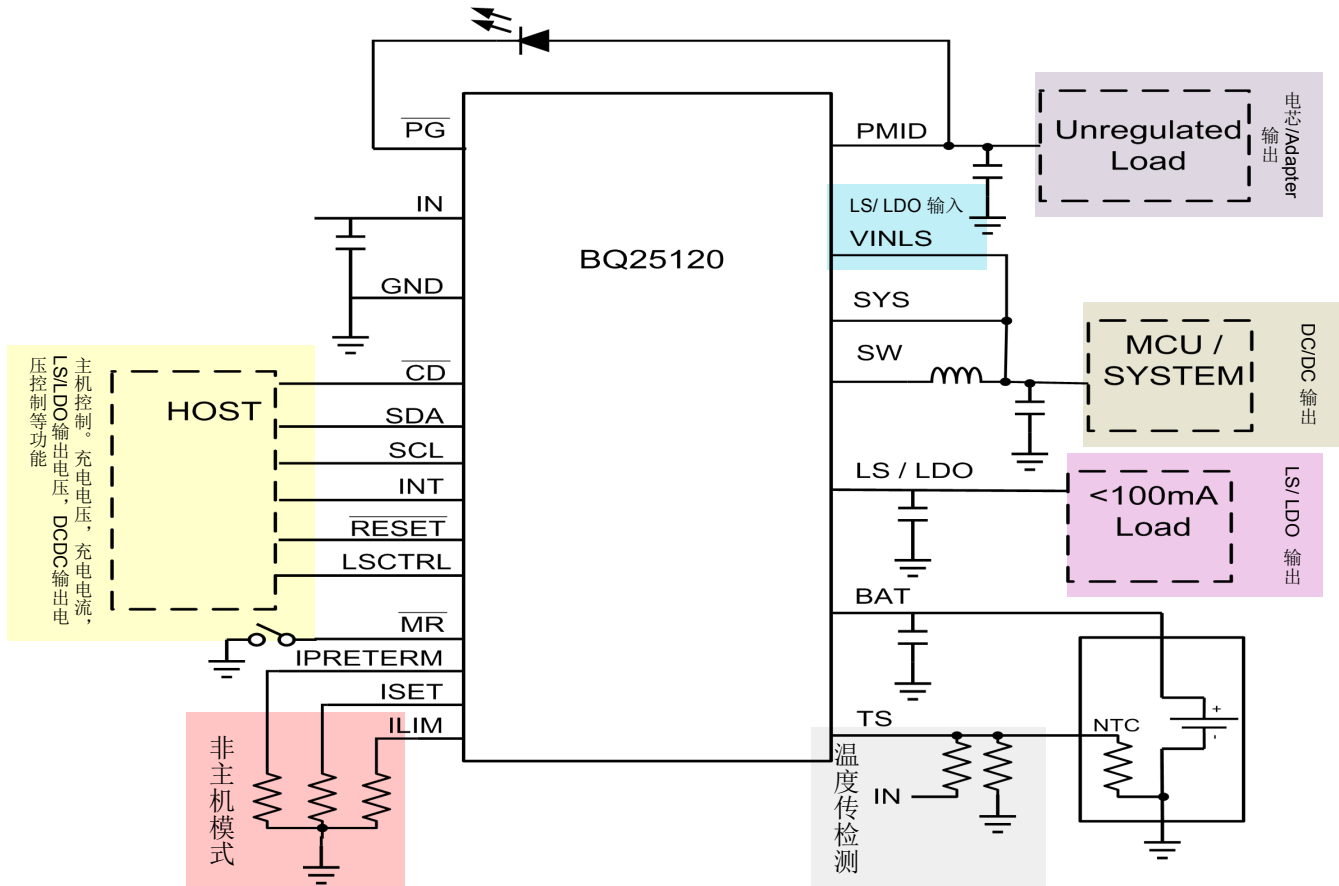
- 可穿戴设备
- 充电玩具
- 医疗检测

BENEFITS

- 集成化方案极大减少了器件数目
- 单颗芯片解决方案，极大节省了PCB面积
- 低的静态功耗，最大化电池的使用时间



bq25120A – 应用原理图



Power Management Reference Design for a Wearable Device with Wireless Charging Using the bq51003 and bq25120A

TI Designs Number: PMP11311



Solution Features

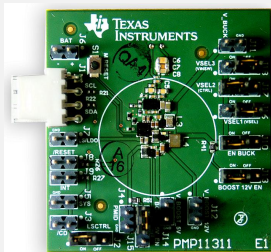
- Battery management with bq25120A includes Linear Charger, Low Iq DC/DC, Push-button input, and I2C configurability
- Wireless Charging with bq51003
- 5V boost output for HRM or LCD Display with TPS61240
- 12V boost output for PMOLED Display with TPS61046
- 1.8V output for Radio or Processor with TPS62743/6

Solution Benefits

- Complete Power Management Solution for Wearables
- Scalable to remove rails that are not needed
- Lowest quiescent current for always on operation
- Lowest quiescent current when device is completely powered off

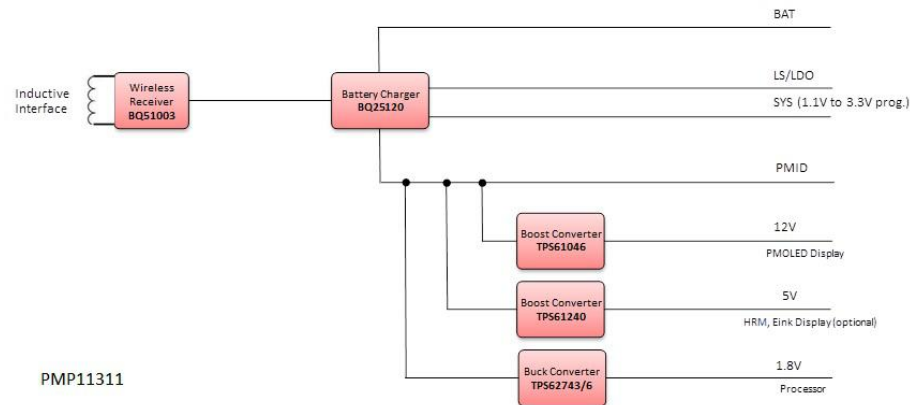
Tools & Resources

Board Image



- [PMP11311 Tools Folder](#)
- [Design Guide](#)
- **Design Files:** Schematics, BOM, Gerbers, Software, and more
- **Device Datasheets:**
 - bq25120A
 - bq51003
 - TPS61046
 - TPS61240
 - TPS62743/6

Block Diagram



穿戴设备的充电管理方案 – BQ2510X

FEATURES

- 最大可承受**30V**输入电压
- 精确的充电电流控制
- **+/- 0.5%**的精确充电电压控制
- 截至电流低至**1mA**，最大化充满电池
- 静态功耗仅仅**75nA**
- 预冲电流，截至电流可调
- **WCSP**超小封装**0.9mm x 1.6mm**
- **Standalone**模式使用简单

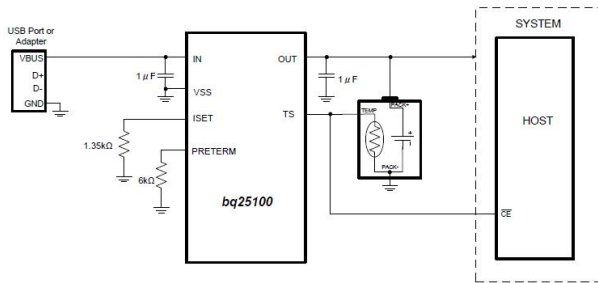
APPLICATIONS

- 蓝牙耳机
- 可穿戴设备
- 小型移动设备

BENEFITS

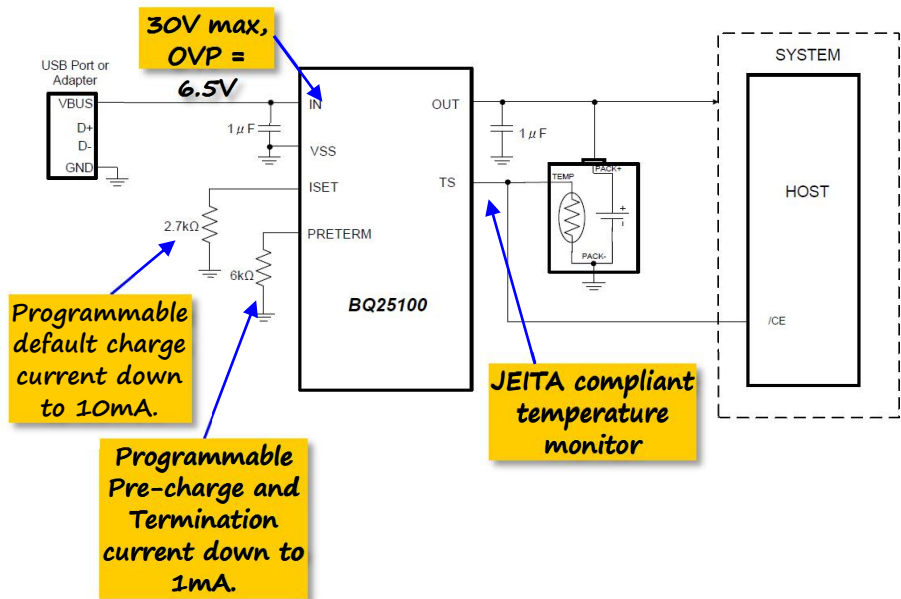
- 高输入电压可有效抵御输入电压波动
- 低静态功耗最大化电池使用时间
- 有效节省**PCB**面积

Part Number	Preterm or /CHG	Battery Voltage
bq25100	Preterm	4.2V
bq25100A	Preterm	4.3V
bq25100H	Preterm	4.35V
bq25101	/CHG	4.2V
bq25101H	/CHG	4.35V

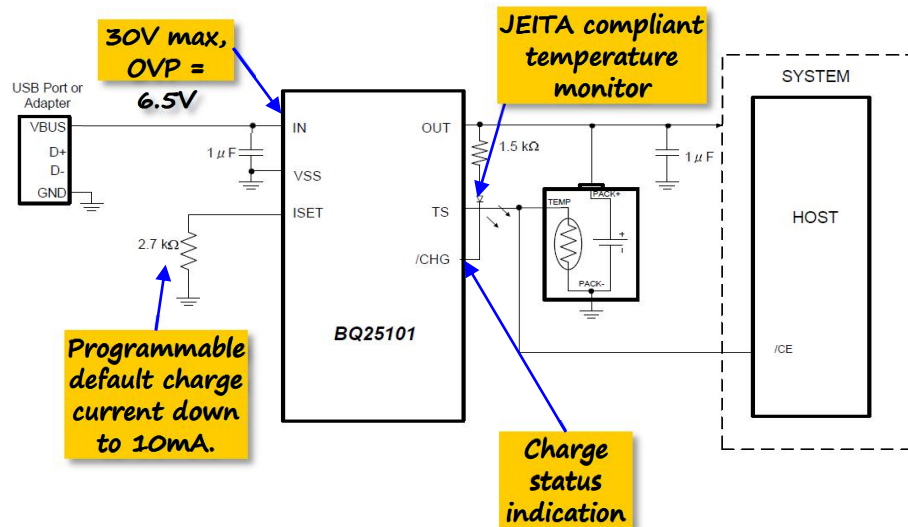


Bq2510x – 应用原理图

bq25100/100H



bq25101/101H



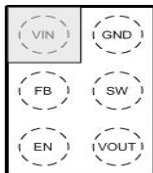
PMOLED 屏幕驱动解决方案 – TPS61046

FEATURES

- 1.6V – 6V宽电压输入范围
- 最高支持28V电压输出
- 关断电流低至500nA
- 参考电压精度在0-125°C范围内可达±2.0%
- 支持轻载高校模式，提升轻载效率
- 内部带有软启动功能，有效抑制启动过冲电流
- 输出过压、短路保护
- WCSP超小封装0.8mm x 1.2mm

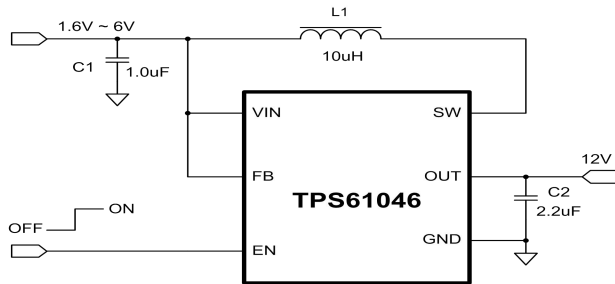
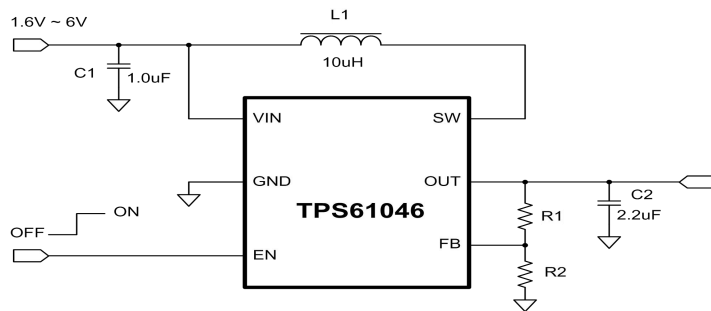
APPLICATIONS

- PMOLED 电源驱动
- 可穿戴设备
- 便捷移动设备
- 楼宇自动化



BENEFITS

- 超小封装尺寸
- 最大化电池使用时间



降压Buck电源解决方案 – TPS62743/31/6

FEATURES

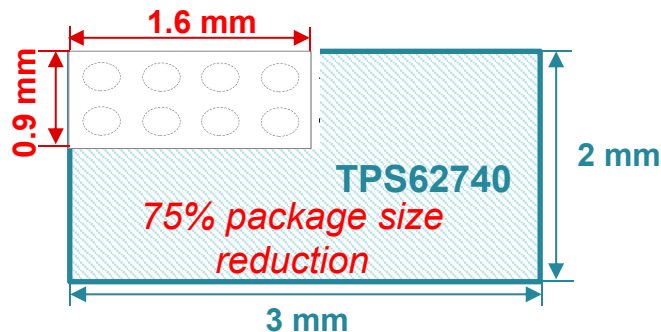
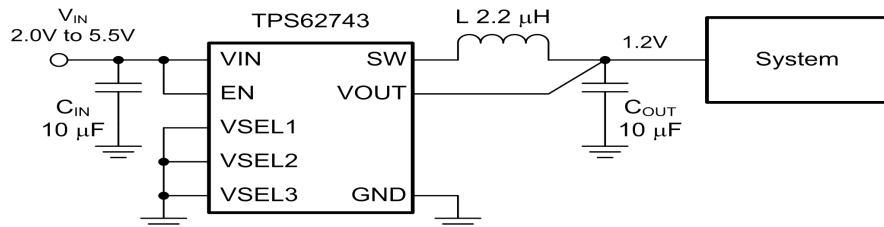
- 2.0V – 5.5V宽电压输入范围
- 360nA超低静态输出电流
- 10uA轻载效率高达90%以上
- TPS62743/31支持300mA和400mA电流输出
- 支持多种电压输出：
 - X43支持8种用户引脚编程输出电压（1.2V、1.5V、1.8V、2.1V、2.5V、2.8V、3.0V、3.3V）
 - X431支持8种用户引脚编程输出电压（1.3V、1.4V、1.6V、1.7V、1.9V、2.0V、2.9V、3.1V）
 - X46支持2种用户引脚编程输出电压（1.2V、1.8V）
- WCSP超小封装 1.6mm x 0.9mm

APPLICATIONS

- MCU、BLE、传感器电源
- 可穿戴设备
- 家居自动化
- 医疗健康

BENEFITS

- 超小封装尺寸
- 超低静态功耗，最大化电池使用时间
- 输出快速放电



降压LDO电源解决方案 – TPS7A05

FEATURES

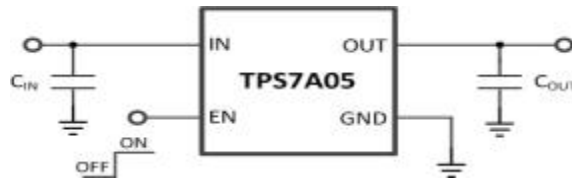
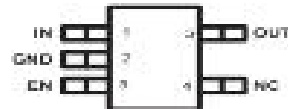
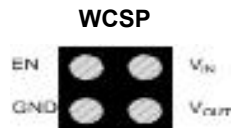
- **1uA超低静态功耗**, -40 - +85°C静态功耗2uA
- **1%电压输出精度**, -40 - +85°C电压精度1.5%
- **快速动态响应**,
 - 1mA到100mA负载变化, 电压恢复时间仅需50us
- **低压差**
 - 204mV(max) @ $I_{OUT}=200mA, V_{OUT}=3.3V$
- **0.8V – 3.3V 可变输出电压选择**
- **WCSP (0.65mm X 0.65mm), SON-4 (1x1)**

APPLICATIONS

- 可穿戴设备
- 便捷移动设备
- 平板、电子阅读器

BENEFITS

- 低功耗利于最大化电池使用时间
- 超小封装, 适合面积受限应用场合



Device	V_{IN}	I_{OUT}	V_{DO}	I_q	Package
TPS7A05	1.4V – 5.5V	200mA	204mV (max) @ $V_{OUT}=3.3V$	1uA	WCSP (0.35mm pitch) QFN-4 (1x1); SOT23-5

TI 针对可穿戴设备环境检测方案

Andonis Wang

模拟现场应用工程师

内容简介

- 环境光检测，让产品拥有更舒适的使用体验
- 线性马达驱动，让产品拥有个性化的定制体验
- 环境温湿度检测，让产品更加智能化
- 人体温度检测，让产品更加关注个人健康

OPT3006/7 环境光检测，让产品拥有更舒适的使用体验

为什么需要环境光检测？



延长电池使用时间

- 在大多数终端设备中，屏幕显示一般占到总耗电量的30% - 40%
- 在可穿戴设备、移动设备等电池容量较小的场合，延长电池使用时间尤为重要
- 根据环境光强度，调节显示亮度有助于提升延长电池使用时间



提升视觉感受

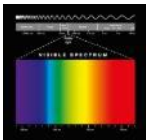
- 基于周围环境调节显示亮度可以有更好的显示体验



提升屏幕的使用寿命

- 屏幕消耗的功率更低，有助于延长使用寿命

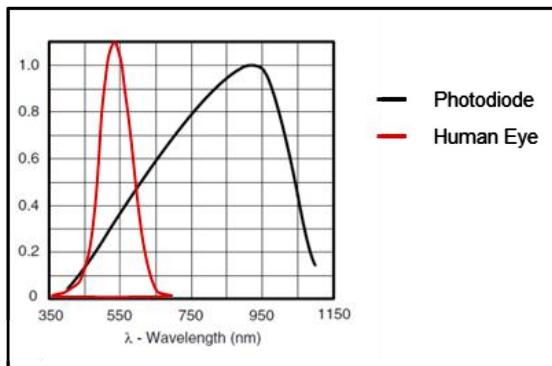
环境光检测方法



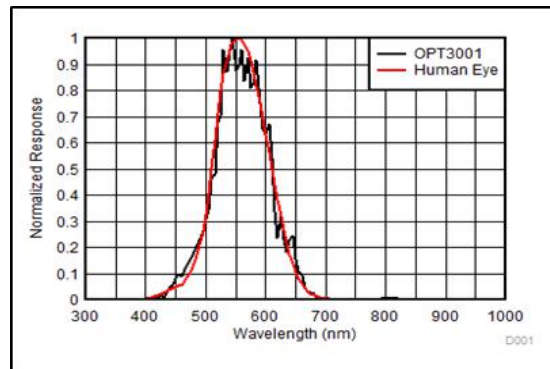
- 专用环境光检测芯片OPT300X
- 光电二极管

OPT3006/7 环境光检测，让产品拥有更舒适的使用体验

为什么使用
OPT300X?



Human Eye vs Photodiode



Human Eye vs OPT3001

优点

- OPT300X相比于光电二极管对光线的敏感度与人眼更加接近吻合。
- 深色玻璃对可见光的衰减比对红外光要大，OPT300X对红外光敏感度有非常强的抑制作用，相比于光电二极管更适合深色玻璃罩应用场合。

OPT3006/7 环境光检测，让产品拥有更舒适的使用体验

FEATURES

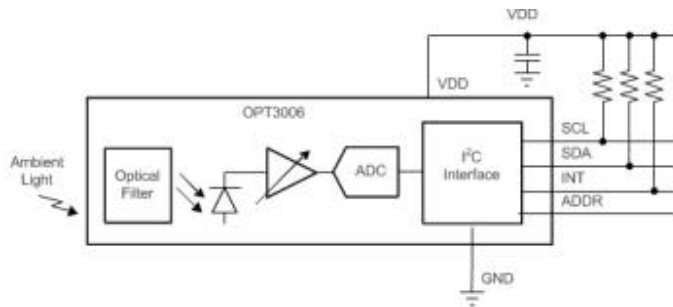
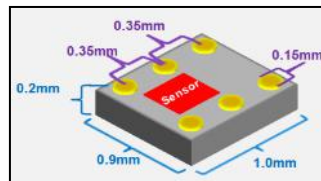
- 目前业界最小最薄封装**0.94 x 0.85 x 0.226mm**
- 与人眼对可见光的敏感度高度吻合
- 对红外光的抑制**>99%**
- 宽的照度测量范围：**0.01Lux – 83KLux**可以满足基本上所有的应用场合
- 测量量程自动动态调整
- 超低的功耗，正常工作是仅需**1.8uA**电流
- 灵活的中断功能
- 宽电压输入范围：**1.6V – 3.6V**

APPLICATIONS

- 可穿戴设备
- 楼宇自动化
- IoT设备
- 手机、平板、PC

BENEFITS

- 超小封装，适合面积受限应用场合
- 超低功耗，消耗的电量对电池负担很小
- 软件操作简单，无需MCU动态调整量程



DRV2625 线性马达驱动，让产品拥有个性化的定制体验

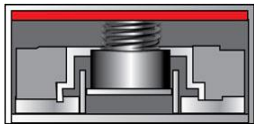
Eccentric Rotating Mass (ERM)

转子马达



Linear Resonant Actuator (LRA)

(LRA)
线性马达



Lowest Cost, Lowest Performance Medium Cost, Medium Performance

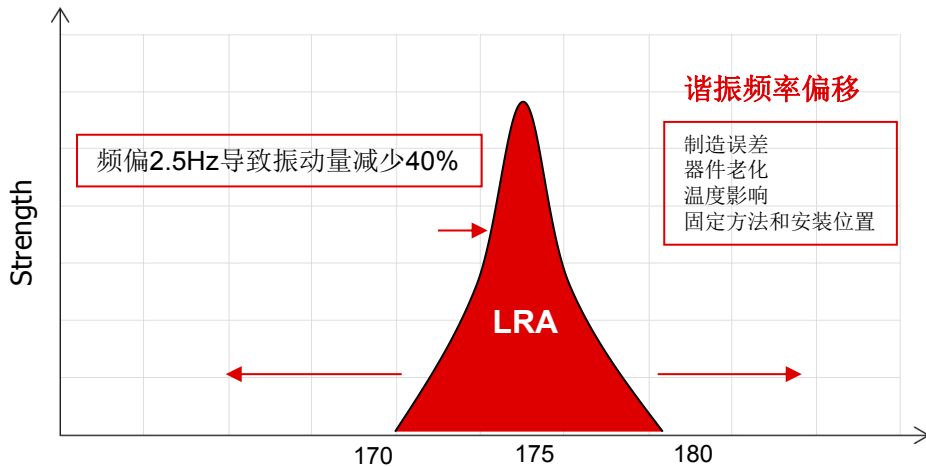
Voltage	1 – 10 V _{DC}	2.5 – 10 V _{DC}
Acceleration (G)	~1	~1-2
Power Consumption	Good	Best
Freq. Response	Limited	Limited
Audible Noise	Very Noisy	Moderately Noisy
Response Time	40 – 80 ms	20 – 30 ms
Waveform	DC Voltage	Sine Wave
Min. Size (mm)	Ø5 x 8 long	Ø10 x 3 high
HD Haptics	No	No

自动谐振频率追踪

- 输出驱动频率跟踪振子的谐振频率
- 针对LRA线性马达
- 谐振频率追踪是实时的
- 谐振频率在振动的过程中发生了变化也可以追踪到

解决线性马达振子频响的高Q值问题的必要性

- 同样的振动强度，驱动在谐振频率点的功耗能降低50%
- 不用频率追踪技术就无法实现有效的启动和停止!振动效果差
- 驱动频率偏移谐振点会导致振动强度快速减弱



* Based on current market devices 49

DRV2625 线性马达驱动，让产品拥有个性化的定制体验

FEATURES

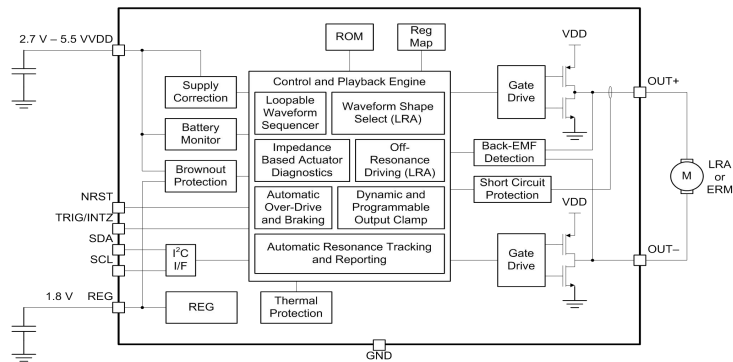
- 超低关机功耗 (< 500 nA)
- 自动进入待机模式 (< 2 uA)
- 电池电压监控
- 自动谐振频率追踪
- 自动过驱动启动和刹车
- 集成振动效果库
- 基于负载阻抗测量的振子诊断
- DSBGA封装1.5mm X 1.36mm

APPLICATIONS

- 手机和平板
- 运动手环智能手表等穿戴式设备
- 触控设备

BENEFITS

- 直接连接电池
- 更长的电池工作时间
- 清脆和一致的振动效果
- 兼容市场上所有振子
- 低延迟振动控制
- 检测振子失效，方便生产测试，提高产品安全性



HDC2010 环境温湿度检测，让产品更加智能化

FEATURES

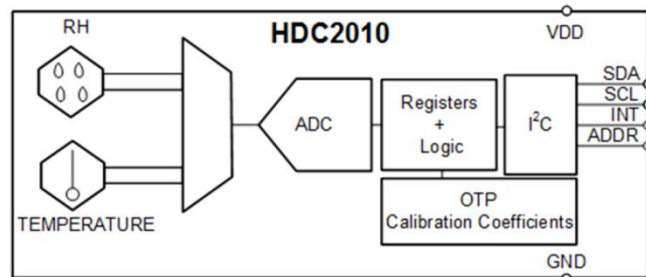
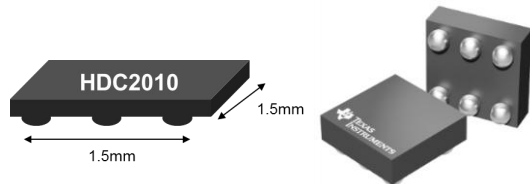
- 输入电压范围1.6 – 3.2V
- 支持测量结果数字输出
- 测量相对湿度范围：0 – 100%，测量精度 $\pm 2\%$
- 测量温度范围：-40 – 125 $^{\circ}\text{C}$ ，精度 $\pm 0.2\%$
- 1sps采样速率时，平均电流仅0.6 μA ，休眠模式下电流仅50nA
- 可编程温度、湿度阈值范围和中断提醒
- 支持多种可编程采样速率
- 传感器在芯片底部，具有更强的抗灰尘功能
- WLCSP (1.5mm x 1.5mm)

APPLICATIONS

- 可穿戴设备
- 物联网设备
- IoT设备
- 智能温度计

BENEFITS

- 低功耗利于最大化电池使用时间
- 超小封装，适合面积受限应用场合
- 性价比优势



TMP116 人体温度检测，让产品更加关注个人健康

FEATURES

- 超高测量精度
 - -25°C 到 85°C 之间测量精度可达到 $\pm 0.2^{\circ}\text{C}$
 - -55°C 到 125°C 之间测量精度可达到 $\pm 0.3^{\circ}\text{C}$
 - 16位的分辨率
- 集成EEPROM
- 超低功耗
 - 最大 $3.5\mu\text{A}$ 静态电流
 - 最大 500nA 关断电流
- 支持 $1.9\text{V} - 5.5\text{V}$ 宽电压输入范围
- WSON封装 $2\text{mm} \times 2\text{mm}$

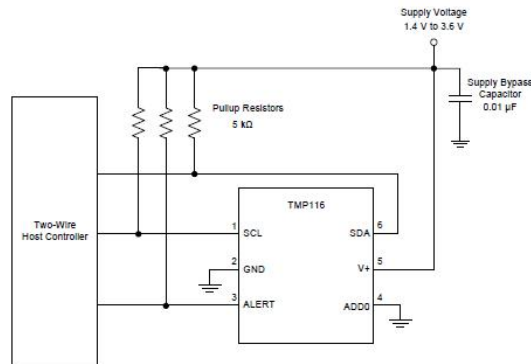
APPLICATIONS

- 医疗温度计
- 可穿戴设备
- 测试仪器仪表

BENEFITS

- 低功耗利于最大化电池使用时间
- 超小封装，适合面积受限应用场合
- 超高测量精度

Generic Part Number	Accuracy (Max)	Accuracy (Max) Across Full Temp Range (-55°C to 125°C)
TMP116	0.2°C @ -25°C to 85°C	0.3°C
TMP116N	0.3°C @ -25°C to 85°C	0.4°C



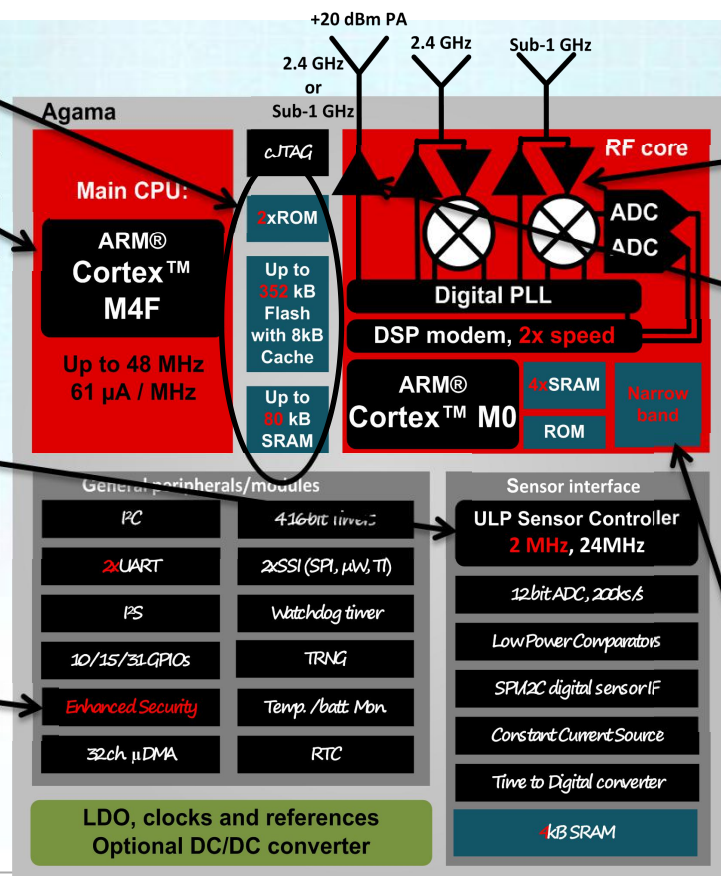
TI新一代无线连接Simplelink MCU平台

大容量FLASH和RAM, 支持更多软件协议

强大的 ARM Cortex M4F.

- 超低功耗协处理器, 用于休眠模式g-sensor, 心率传感器数据采集。
- 全新 2MHz 低功耗运行模相比前一代产品功耗降低4-10倍。

• 增强安全性加密种类 (AES-128/256, SHA-512, ECC, RSA-2048)



双频段RF:

- Sub 1GHz + 2.4 GHz
- Sub 1GHz + BLE

+20 dBm PA更远的传输距离

More capable modem

- 2x speed for more advanced modulation

支持窄带 + 169 MHz

- 具有更好的接收灵敏度
- 支持更多的表计类协议 (WMBUS)

Simplelink MCU五元新增大将

CC1352P (SUB1G + BLE)

CC2652R in WCSP (BT5/ZIGBEE)

CC2642R-Q1(BT5 for Auto)

CC2652RB (BT5/ZIGBEE)

CC2652RP (+20dBm BT5/ZIGBEE)

Part of the SimpleLink™ MCU Platform



Thank you

TI.com.cn: 为您提供一站式体验

选型



- **10万**种产品覆盖电源、处理器、无线连接、音频、放大器、时钟、DLP、传感、电机驱动等
- 提供工业、汽车、通信设备、个人消费电子等应用 **系统级解决方案**
- 提供**交叉参照**搜索多个供应商的产品

设计



- **2500**款 **TI Designs** 参考设计，覆盖工业、汽车、医疗、个人消费电子等应用领域
- 提供定制电源、照明、滤波、时钟和传感设计的 **WEBENCH®** 设计中心



支持



- **7/24在线支持社区**，技术疑难解答、海量技术博文分享
- 全年无歇 **在线培训**，理论基础、动手实验，为您充电加油
- Deyisupport (中文)
- E2E (英文)



购买



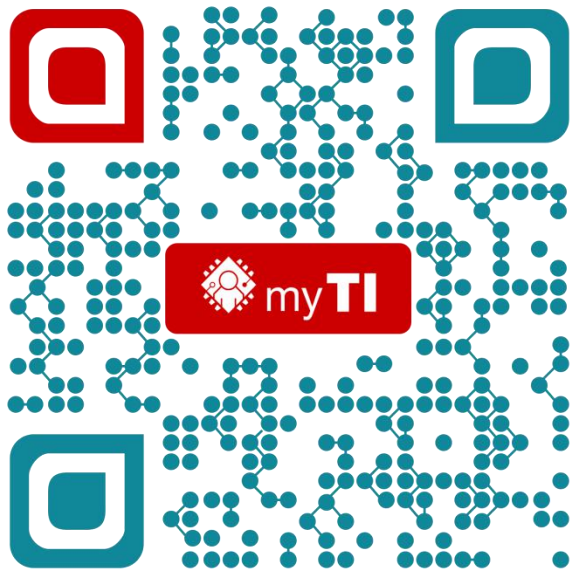
- 全球响应，数万样片开发板任君选择，尽在 **TI Store**



myTI账户：个性化服务及定制

myTI 账户: 专属您的私人订制

<https://my.ti.com>



加入myTI 会员的好处:

- **Tlstore** 一站式购物平台, 数万样片开发工具, 一网打尽
- 参与 **TI 在线技术支持社区**
- 利用 **WEBENCH® 设计工具** 轻松进行设计和模拟
- 订阅产品更新, 获得最新设计工具, 系统方框图与指南等信息
- **标记您最喜爱的产品**
- 管理 / **订阅新闻简报**
- 注册 / 参加**在线培训与活动**
- 获得个性化的建议

TI 在线培训: 打破时空, 随手可得

- 提供包括从理论基础到深入的动手实验在内的各种在线和现场的培训, 协助您将新一代的设计化为现实。我们整合式的培训项目包括 1000+ 的线上培训课程, 网络研讨会和线下研讨会, 有助于您使用TI产品, 开发工具, 软件和各类应用设计。



<http://www.ti.com.cn/training>

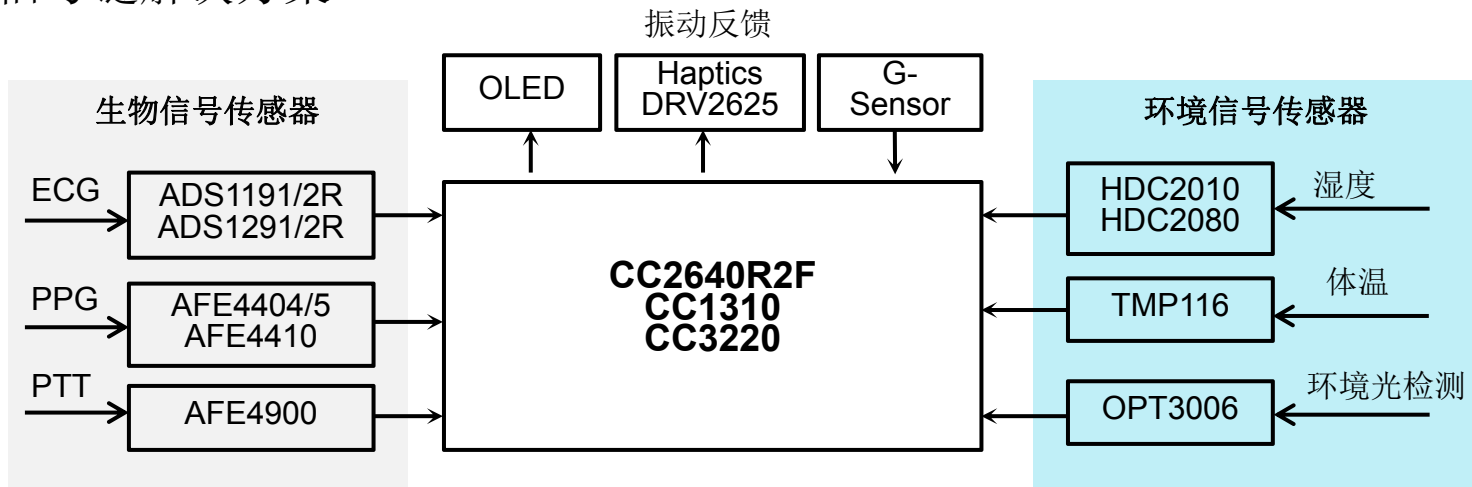
经典热门课程:

- C2837x 入门指南
- 2016 EP 研讨会线下课程
- 2016 工业研讨会
- 高精度实验室
- BMS电池设计探讨
- WEBENCH 系列课程
- Engineer It 系列课程

Back up

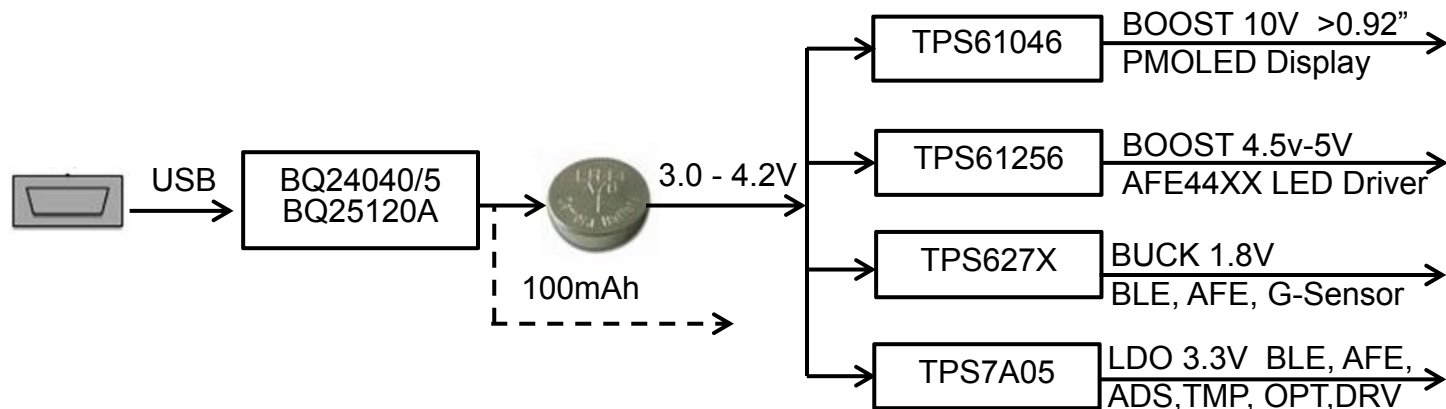
TI可穿戴设备总体解决方案

信号链解决方案



TI可穿戴设备总体解决方案

电源解决方案

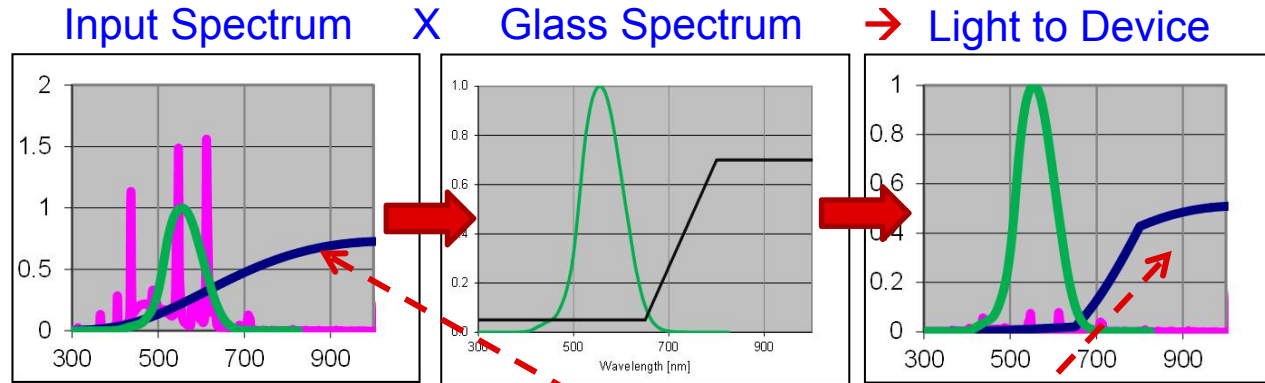


OPT3006 Key Differentiator

Excellent IR Rejection (1/2)



Sensors Hidden
Behind Black Glass



Problem:

Light measurement changes under different light inputs

- User discomfort
- Non-optimum display power

Reason:

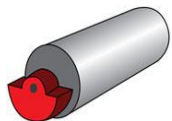
- Dark Glass transmits IR
 - Sources like Incandescent has high IR that reaches sensor due to glass transmissivity
- Wrong Ambient Light measurement with wideband photodiode

HDC2010 环境温湿度检测，让产品更加智能化

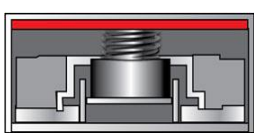
Content title	Content type	Link to content or more details
Humidity sensor landing page	Landing page	http://www.ti.com/lscs/ti/sensing-products/humidity-sensors/humidity-sensors-overview.page
Humidity sensor Product	Humidity sensor product list	http://www.ti.com/lscs/ti/sensing-products/humidity-sensors/humidity-sensors-products.page#
Humidity sensor Tools and software	EVM, GUI, TI Design(s)	http://www.ti.com/lscs/ti/sensing-products/humidity-sensors/humidity-sensors-tools-software.page
Humidity sensor Technical document	App note, FMEA test	http://www.ti.com/lscs/ti/sensing-products/humidity-sensors/humidity-sensors-technical-documents.page
Humidity sensor forum	E2E forums	https://e2e.ti.com/support/sensor/humidity/

DRV2625--线性马达驱动器

Eccentric Rotating Mass (ERM)
转子马达



Linear Resonant Actuator (LRA)
线性马达



Lowest Cost, Lowest Performance | **Medium Cost, Medium Performance**

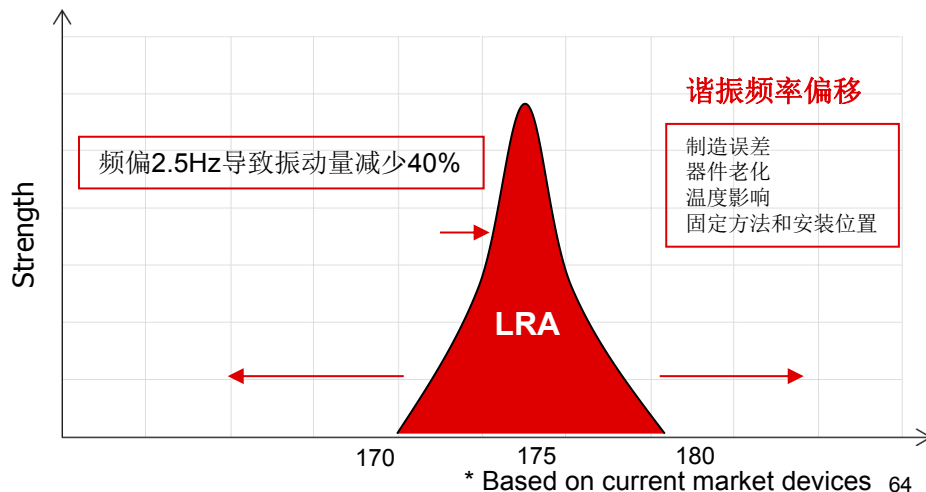
Voltage	1 – 10 V _{DC}	2.5 – 10 V _{DC}
Acceleration (G)	~1	~1-2
Power Consumption	Good	Best
Freq. Response	Limited	Limited
Audible Noise	Very Noisy	Moderately Noisy
Response Time	40 – 80 ms	20 – 30 ms
Waveform	DC Voltage	Sine Wave
Min. Size (mm)	Ø5 x 8 long	Ø10 x 3 high
HD Haptics	No	No

自动谐振频率追踪

- 输出驱动频率跟踪振子的谐振频率
- 针对LRA线性马达
- 谐振频率追踪是实时的
- 谐振频率在振动的过程中发生了变化也可以追踪到

解决线性马达振子频响的高Q值问题的必要性

- 同样的振动强度，驱动在谐振频率点的功耗能降低50%
- 不用频率追踪技术就无法实现有效的启动和停止!振动效果差
- 驱动频率偏移谐振点会导致振动强度快速减弱



DRV2625 低电压LRA/ERM振子驱动

Features

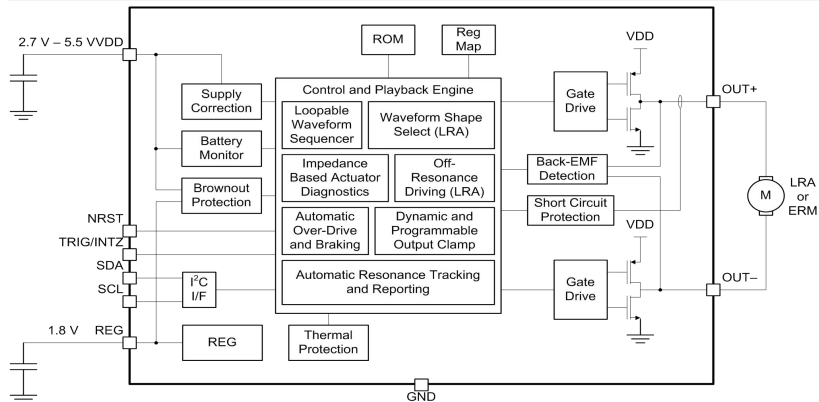
- 超低关机功耗 (< 500 nA)
- 自动进入待机模式 (< 2 μ A)
- 电池电压监控
- 自动谐振频率追踪
- 自动过驱动启动和刹车
- 正弦波输出失谐驱动
- 开环驱动下自动刹车功能
- 单线触发模式
- 集成振动效果库
- 基于负载阻抗测量的振子诊断

Applications

- 手机和平板
- 运动手环智能手表等穿戴式设备
- 触控设备
- 遥控器鼠标等外设
- 人机界面

Benefits

- 直接连接电池
- 更长的电池工作时间
- 清脆和一致的振动效果
- 简单易用
- 兼容市场上所有振子
- 配置灵活
- 低延迟振动控制
- 检测振子失效，方便生产测试，提高产品安全性

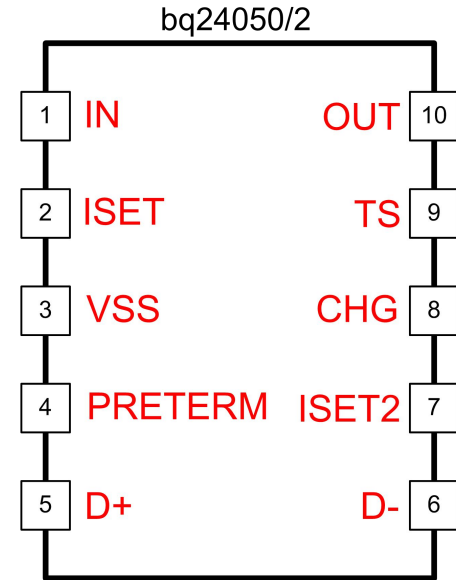


bq2404x/5x

1A Linear Charger in 2x2 QFN with D+/D- Based Adapter Detection

Features

- Single input AC/USB Li-Ion charger compatible with mini-USB interface
- 28V maximum input voltage with OVP at 6.5V
- Support applications for very low charge currents (i.e 30 – 50mA and above).
- Automatic AC/USB detection using integrated D+/D- pins (bq24050)
- Adjustable Pre-Charge/Termination Current (5% - 50% ISET)
- V(IN) based current reduction loop for USB applications
- Thermal Regulation Loop: Charge current clamping as die temperature increases
- TS pin to monitor pack temperature (NTC) during charging
 - Compatible with JEITA safety standard
- Status pins: CHG, PGOOD
- Fixed pre-charge and safety timers
- 2x2 mm 10 pin thermally enhanced power pad packages



Wearable charger: BQ25100

Ultra small 250mA Linear Charger in 0.9mm x 1.6mm WCSP

1. NEW! Ultra small 0.9mm x 1.6mm WCSP package.

Industry smallest single cell charger. Save **40%** space for total solution.

2. NEW! Accurate charge current control at very low level

Programmable charge current down to **10mA**. Ideal for very small battery capacity.

3. NEW! 1mA Termination current with 25% accuracy

Prevent pre-mature battery from termination, maximize battery life with the desired regulation voltage.

4. Adjustable Pre-charge/Termination current

Range from 5% -50% of fast charge current. Offers great flexibility to satisfy the requirements of different batteries.

5. TS to monitor pack temperature (NTC) during charging

Compatible with JEITA safety standard. Control the charging in high and low temperature.

6. Compact

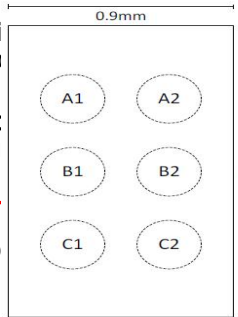
Applicable for

7. Wide input

30V maximum

8. Low BAK

Extends battery



JSB interface

Used interfaces for portable applications.

VP

Minimizing leakage current from the battery due to the charger.



Smallest size & Maximized battery life!!!

Part Number	Preterm or /CHG	Battery Voltage
bq25100	Preterm	4.2V
bq25100A	Preterm	4.3V
bq25100H	/CHG	4.2V
bq25101H	/CHG	4.35V

TMP116

Ultra High Precision Digital Temp Sensor with integrated non-volatile memory

Features

Ultra high accuracy

- $\pm 0.2^{\circ}\text{C}$ Accuracy from -25°C to 85°C
- $\pm 0.3^{\circ}\text{C}$ Accuracy from -55°C to 125°C
- 16-bit Resolution (0.0078°C)

Integrated EEPROM

Low power consumption

- 3.5 μA of Quiescent Current (max)
- 500nA of Shutdown current (max)
- Supply: 1.9V – 5.5V

I2C/SMBus Compatible Interface

6pin WSON 2x2 package

Applications

- Medical
- Cold Chain
- Refrigeration
- Wearables
- Instrumentation & Test
- Thermocouple – Reference

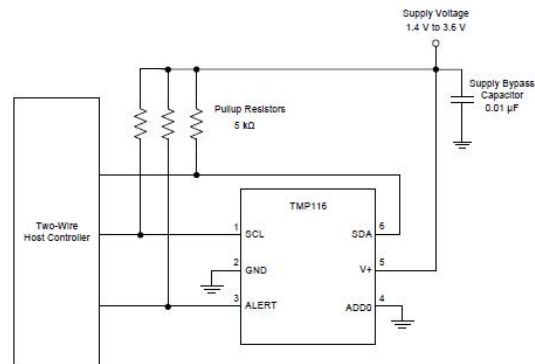
Tools & Resources

- EVM
- Datasheet

Benefits

- Maintains accuracy across a wide temperature range
- Non-volatile memory enables automatic configuration at power up with additional 16-bits of free memory for customer storage
- Smallest Ultra-High accuracy temp sensor on the market

Generic Part Number	Accuracy (Max)	Accuracy (Max) Across Full Temp Range (-55°C to 125°C)
TMP116M (preview)	0.1 $^{\circ}\text{C}$ @ 30°C to 45°C	0.2 $^{\circ}\text{C}$
TMP116	0.2 $^{\circ}\text{C}$ @ -25°C to 85°C	0.3 $^{\circ}\text{C}$
TMP116N	0.3 $^{\circ}\text{C}$ @ -25°C to 85°C	0.4 $^{\circ}\text{C}$



TMP116

Ultra High Precision Digital Temp Sensor with integrated non-volatile memory

Features

Ultra high accuracy

- $\pm 0.2^{\circ}\text{C}$ Accuracy from -25°C to 85°C
- $\pm 0.3^{\circ}\text{C}$ Accuracy from -55°C to 125°C
- 16-bit Resolution (0.0078°C)

Integrated EEPROM

Low power consumption

- 3.5 μA of Quiescent Current (max)
- 500nA of Shutdown current (max)
- Supply: 1.9V – 5.5V

I2C/SMBus Compatible Interface

6pin WSON 2x2 package

Applications

- Medical
- Cold Chain
- Refrigeration
- Wearables
- Instrumentation & Test
- Thermocouple – Reference

Tools & Resources

- EVM
- Datasheet

Benefits

- Maintains accuracy across a wide temperature range
- Non-volatile memory enables automatic configuration at power up with additional 16-bits of free memory for customer storage
- Smallest Ultra-High accuracy temp sensor on the market

Generic Part Number	Accuracy (Max)	Accuracy (Max) Across Full Temp Range (-55°C to 125°C)
TMP116	0.2°C @ -25°C to 85°C	0.3°C
TMP116N	0.3°C @ -25°C to 85°C	0.4°C

