

ADI Energy Harvesting Power Solutions

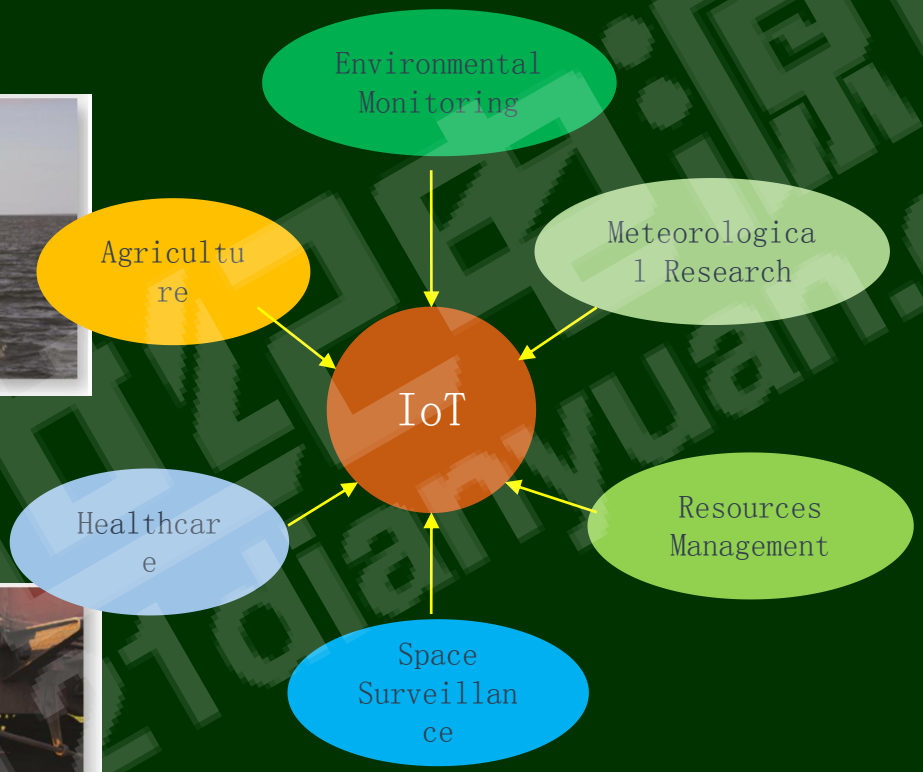
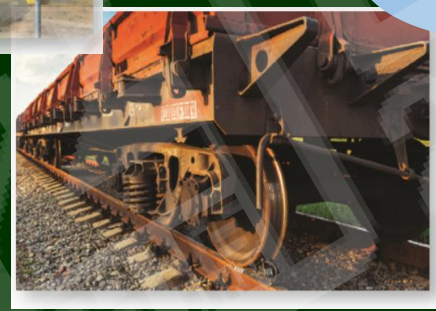
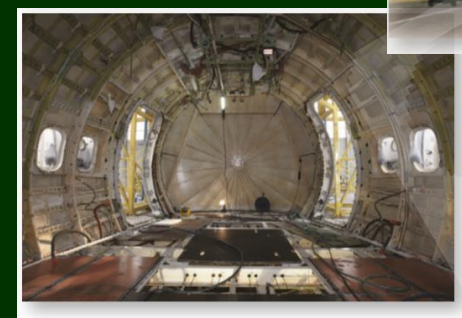
Grant Wang

2019, Sep

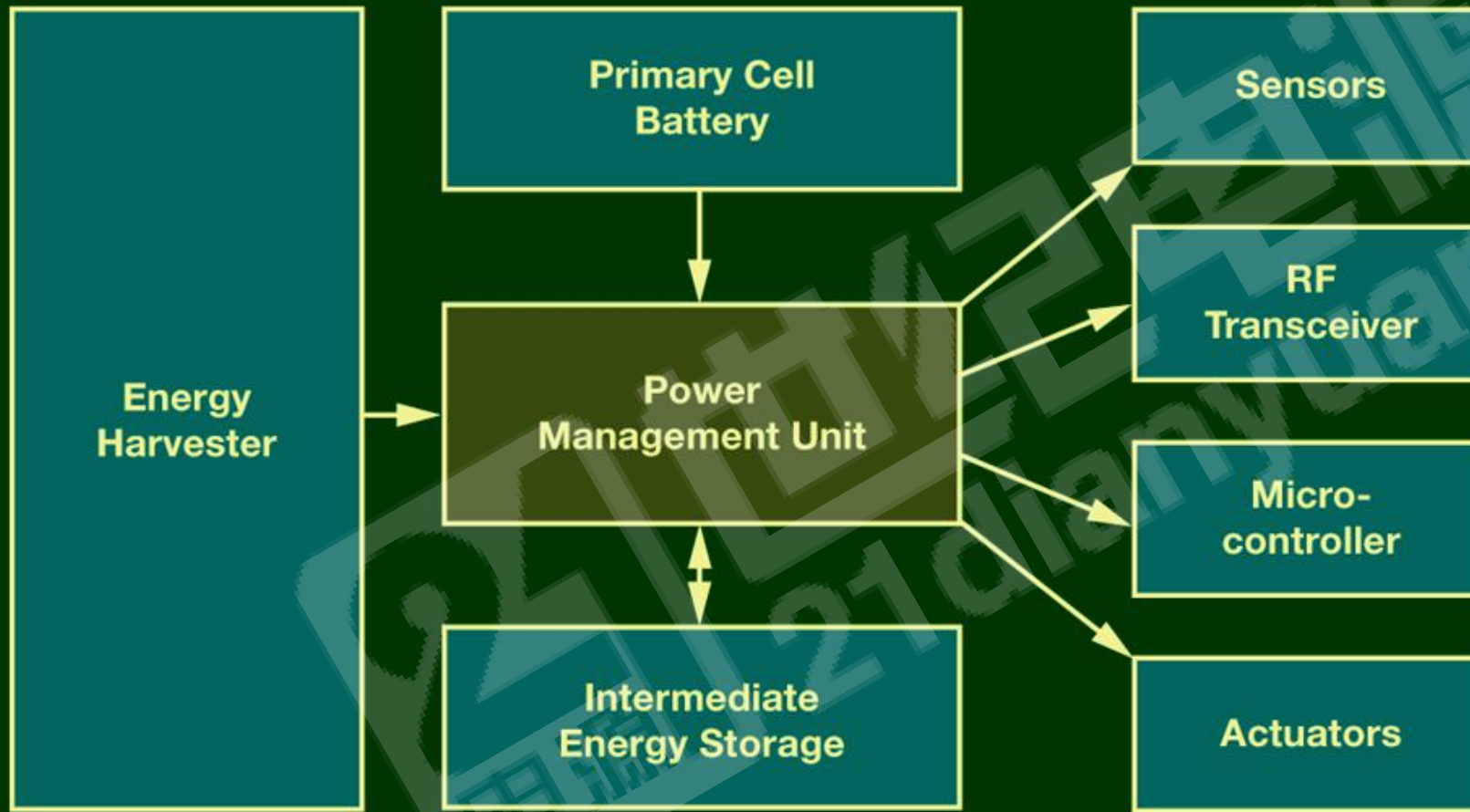


AHEAD OF WHAT'S POSSIBLE™

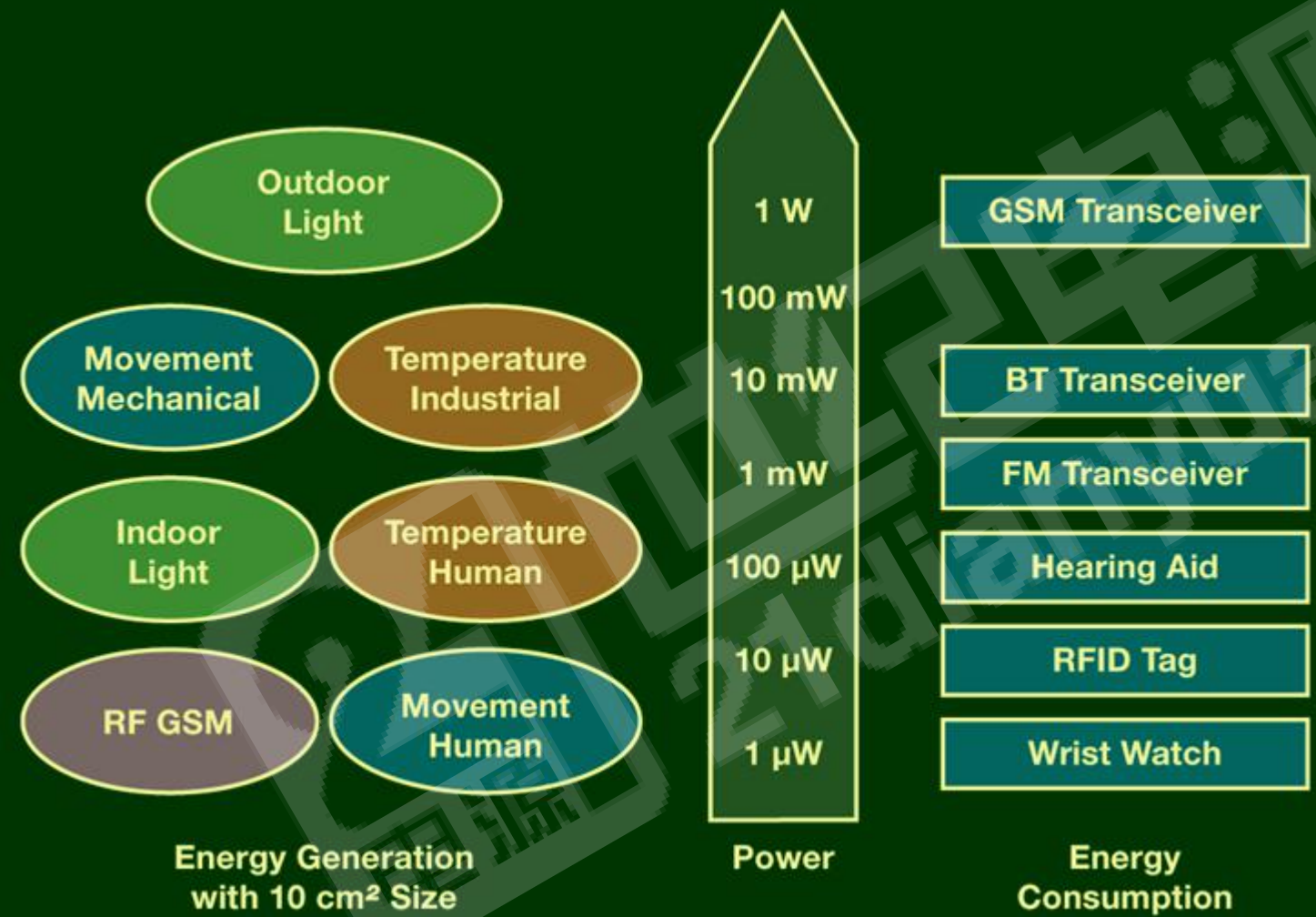
Where Energy Harvesting to Be Used?



Energy Harvesting System

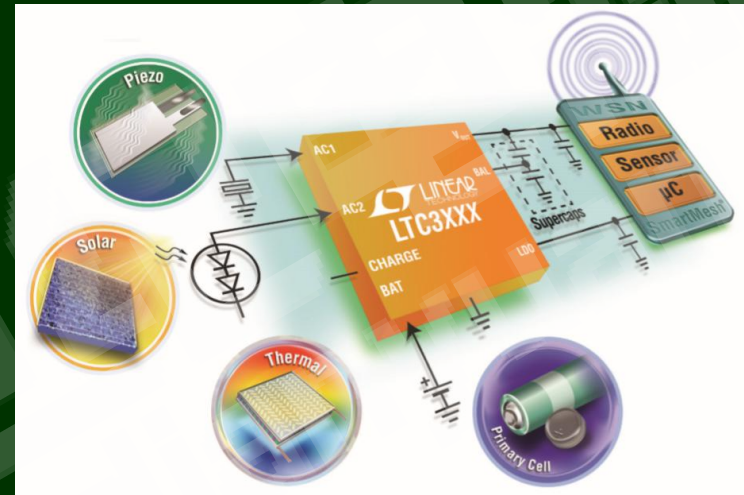


Different Sources of Energy

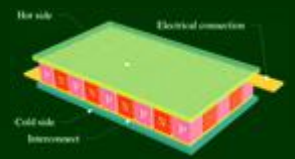


Single Nano-Power ICs

Part Number	Energy Source	Description
LTC [®] 3105		400mA boost converter with MPP control and 250mV start-up
LTC3106		300mA buck-boost converter and power manager with MPPC
LTC3107		Ultralow voltage converter and primary battery life extender
LTC3108		Ultralow voltage boost converter and system manager
LTC3109		Auto-polarity version of LTC3108
LTC3330/31		Energy harvesting DC/DC converter with battery life extender
LTC3588		Piezoelectric energy harvesting power supply
LT [®] 3652/HV		Power tracking 2A solar battery charger
LTC4070/71		Nanoamp operating current shunt Li-Ion battery charger



LTC3108



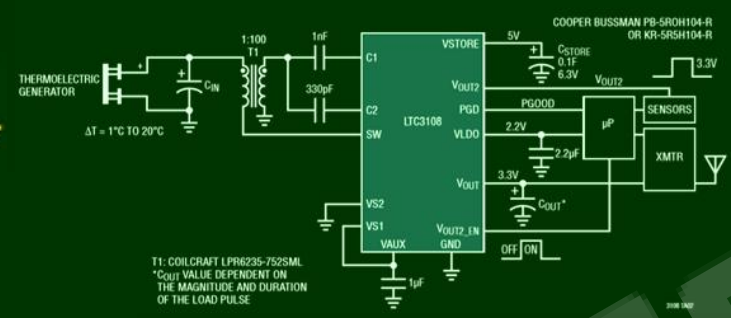
FEATURES

- Operates from Inputs of 20mV
- Complete Energy Harvesting Power Management System
 - Selectable V_{OUT} of 2.35V, 3.3V, 4.1V or 5V
 - LDO: 2.2V at 3mA
 - Logic Controlled Output
 - Reserve Energy Output
- Power Good Indicator
- Uses Compact Step-Up Transformers
- Small 12-Lead (3mm × 4mm) DFN or 16-Lead SSOP Packages

APPLICATIONS

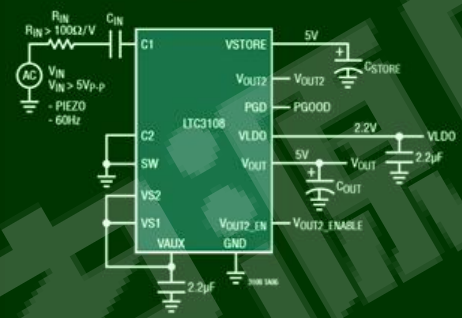
- Remote Sensors and Radio Power
- Surplus Heat Energy Harvesting
- HVAC Systems
- Industrial Wireless Sensing
- Automatic Metering
- Building Automation
- Predictive Maintenance

Peltier-Powered Energy Harvester for Remote Sensor Applications

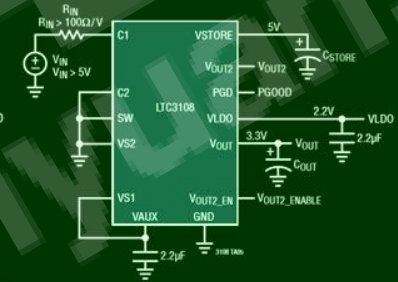


T1: COILCRAFT LPR6235-752SML
 * C_{OUT} VALUE DEPENDENT ON THE MAGNITUDE AND DURATION OF THE LOAD PULSE

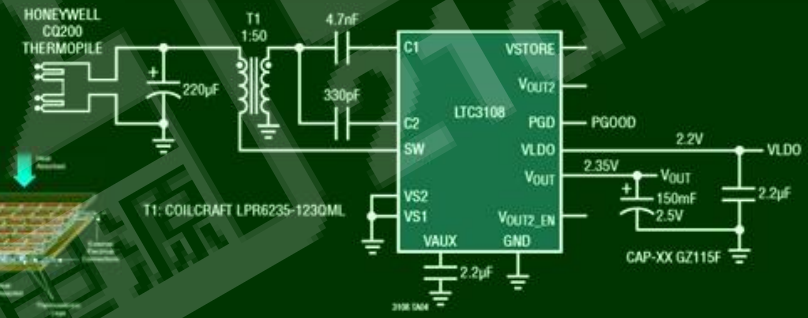
AC Input Energy Harvester and Power Manager



DC Input Energy Harvester and Power Manager



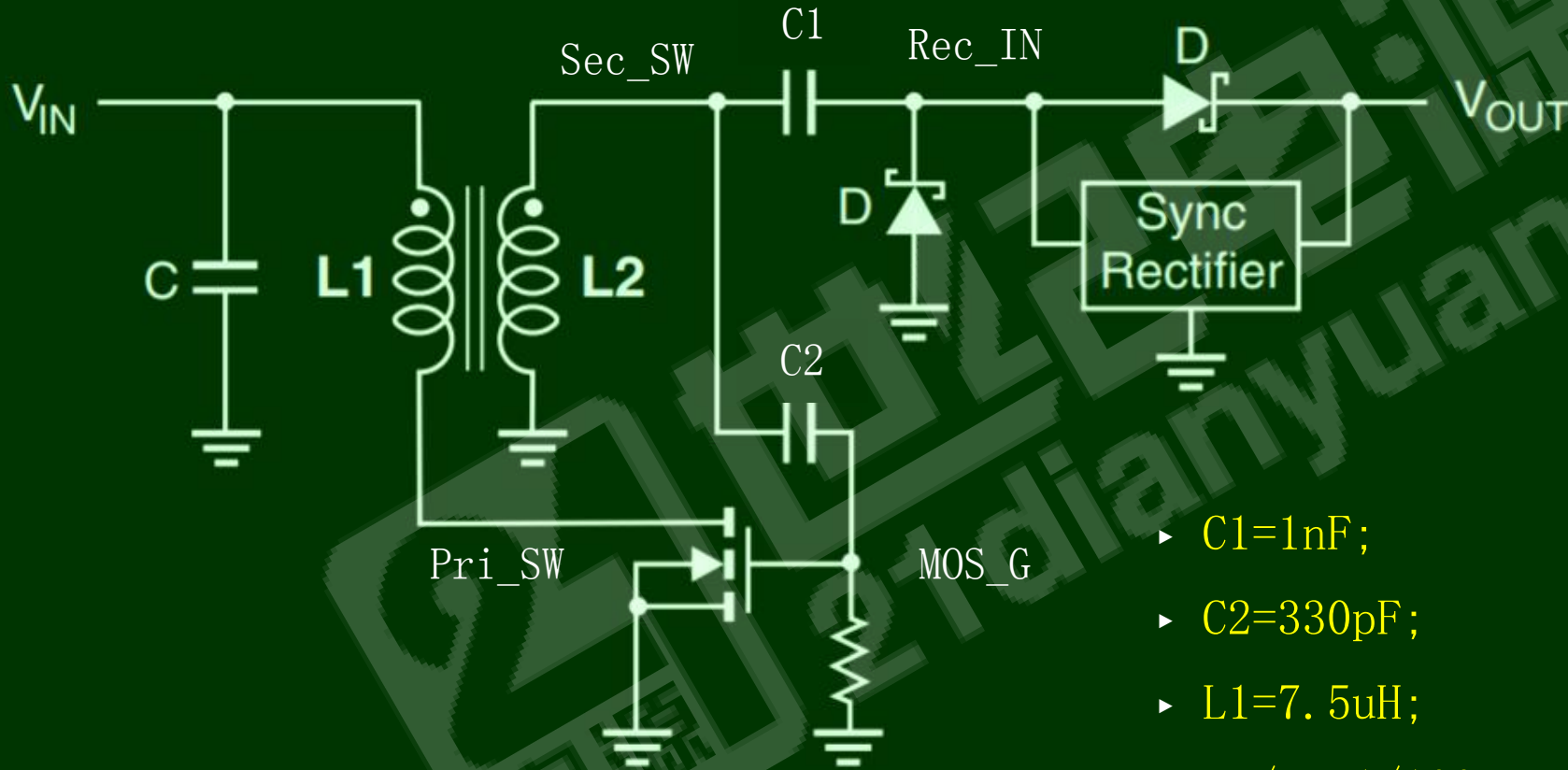
* 2" DIAMETER MONOCRYSTALLINE CELL
 LIGHT LEVEL > 900 LUX
 T1: COILCRAFT LPR6235-253PML



T1: COILCRAFT LPR6235-123QML



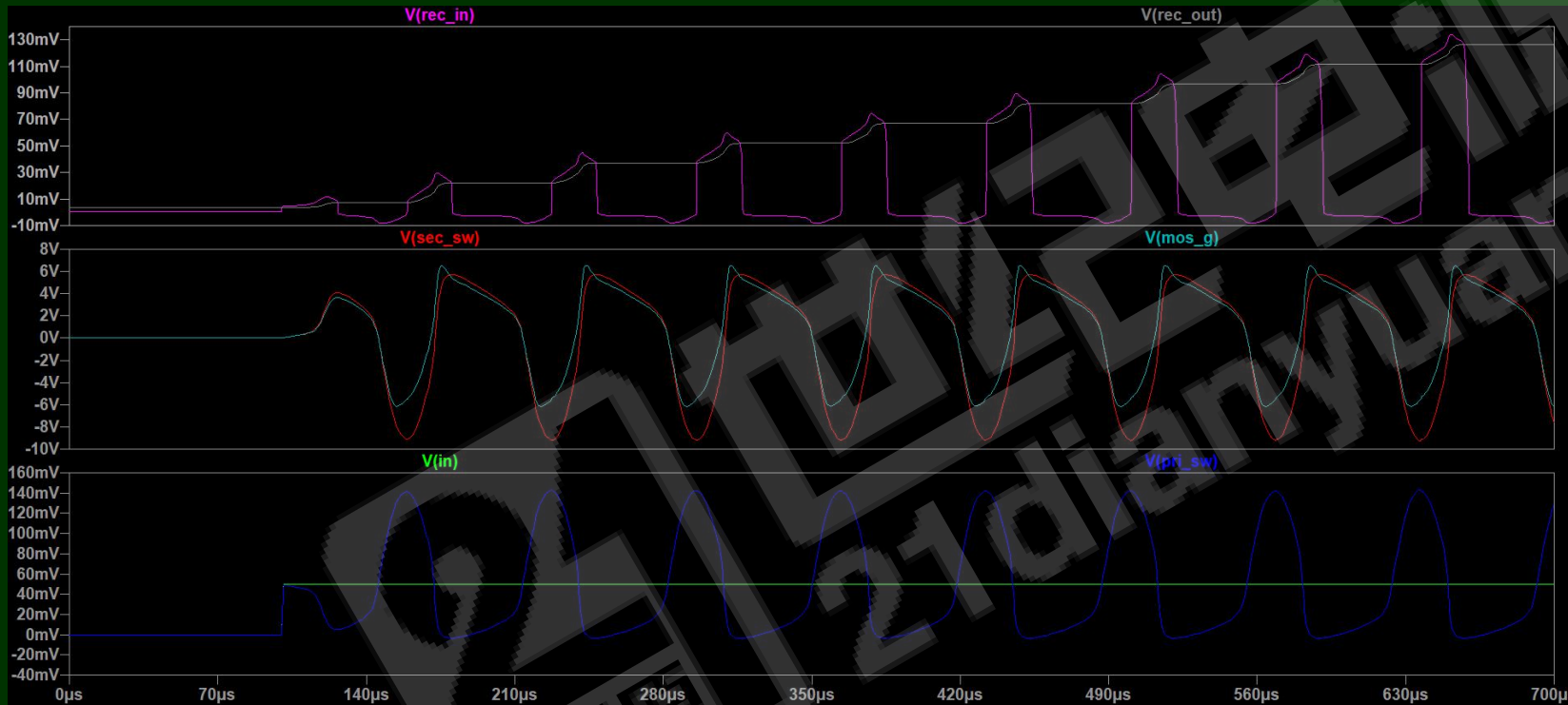
Ultralow Input Voltage Step-Up Converter



- ▶ $C1=1\text{nF}$;
- ▶ $C2=330\text{pF}$;
- ▶ $L1=7.5\mu\text{H}$;
- ▶ $N_p/N_s=1/100$;

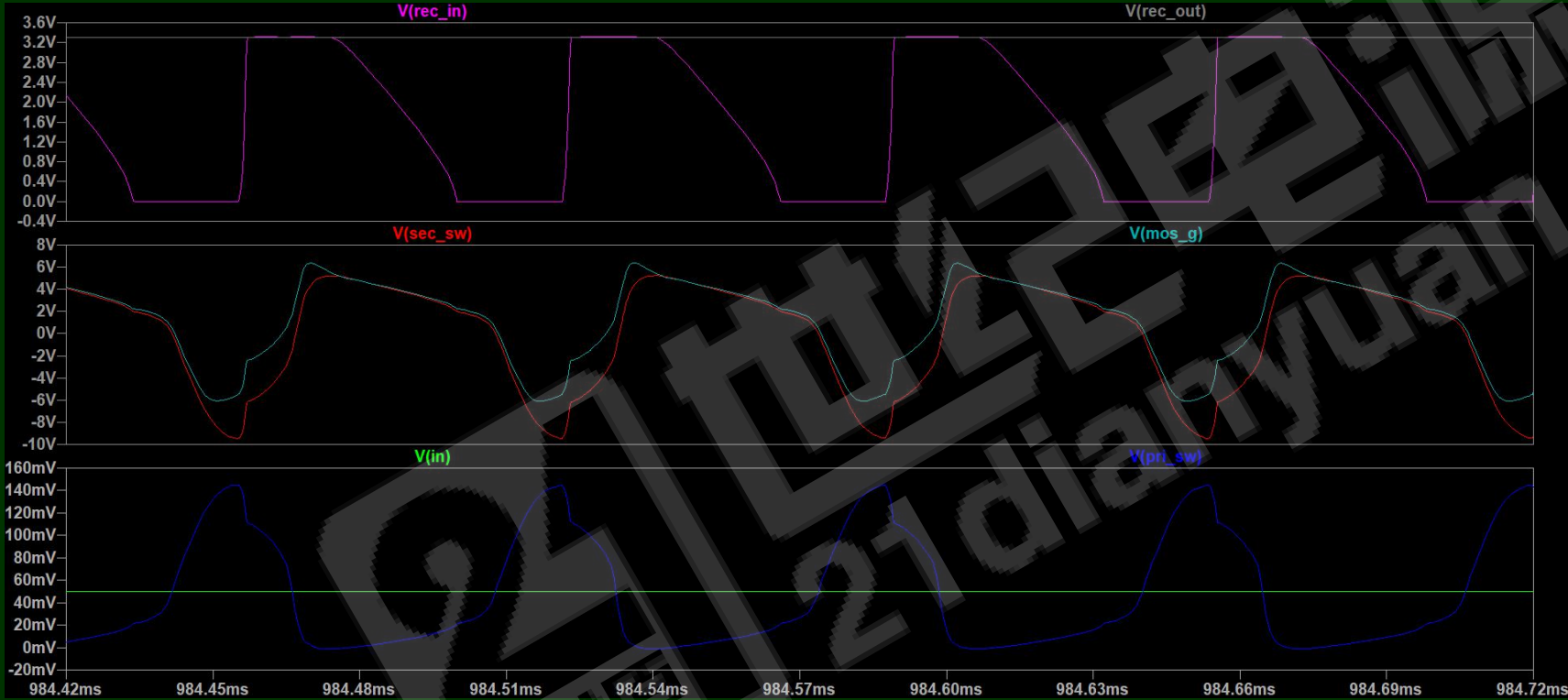


Step-Up Converter Start-up



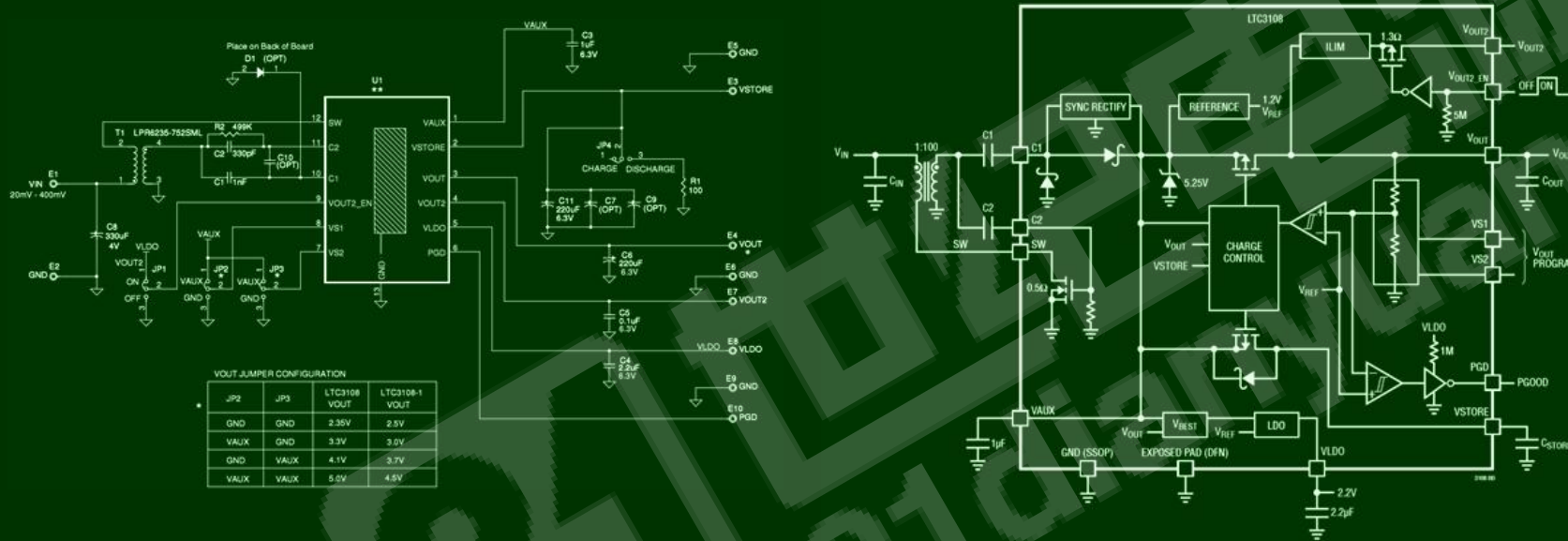


Step-Up Converter in Steady State





LT3108 Demo Board Schematic

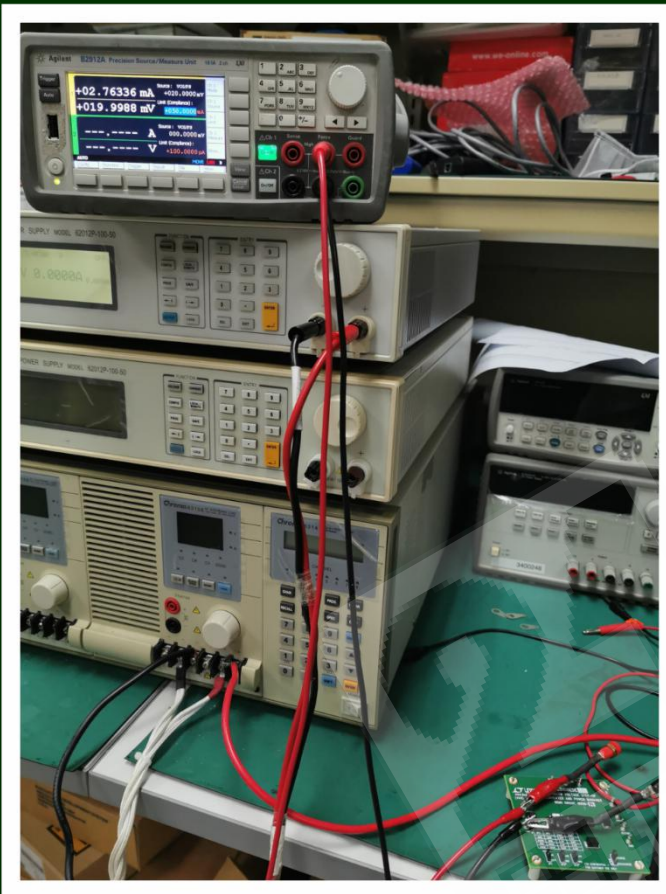


VOUT JUMPER CONFIGURATION

JP2	JP3	LT3108 VOUT	LT3108-1 VOUT
GND	GND	2.35V	2.5V
VALUX	GND	3.3V	3.0V
GND	VALUX	4.1V	3.7V
VALUX	VALUX	5.5V	4.5V

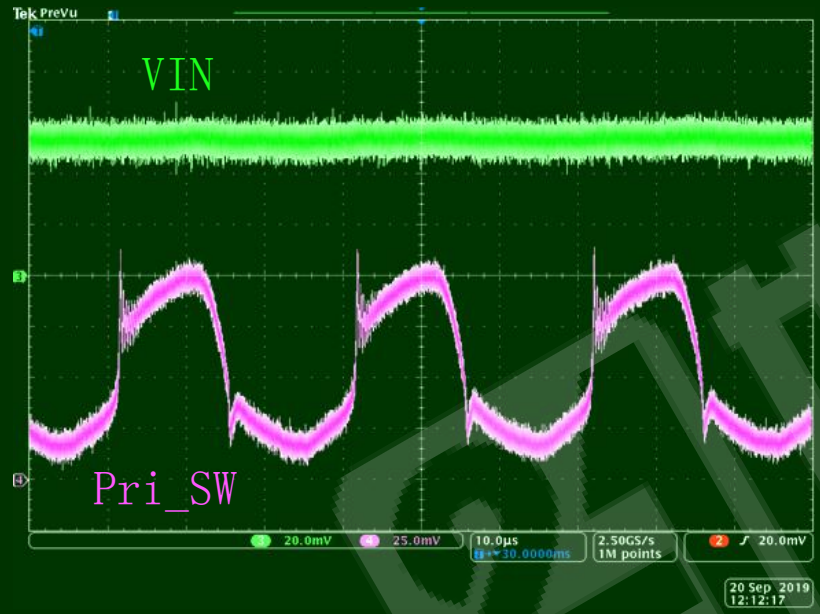


Bench Test Set-Up

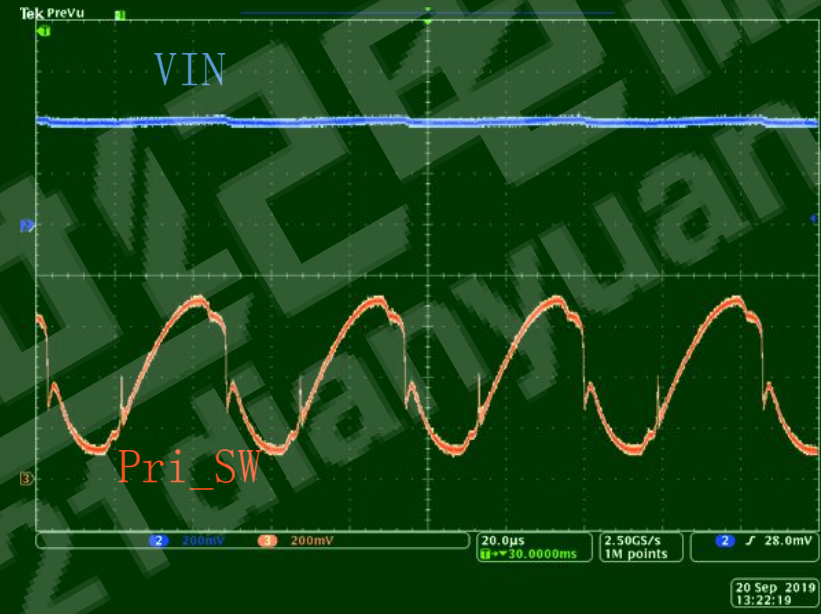


Waveforms of VIN and Pri_SW

VIN=50mV

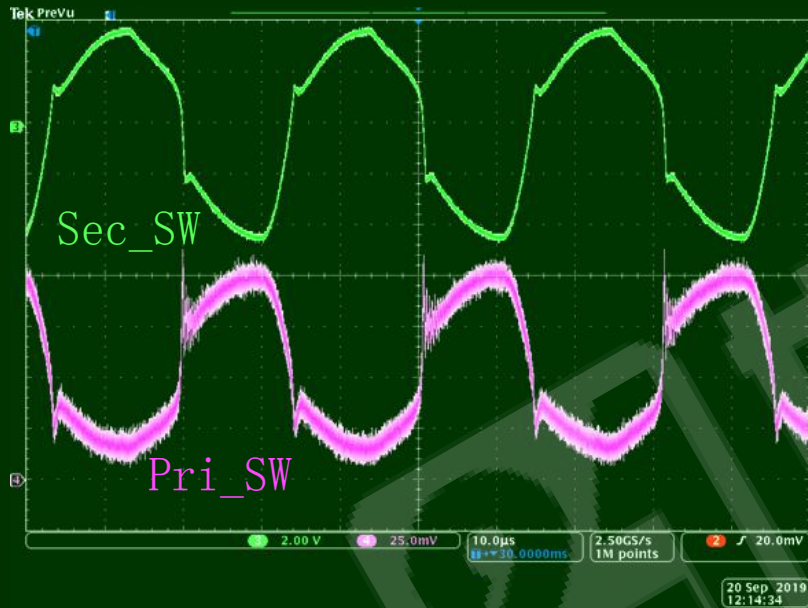


VIN=400mV

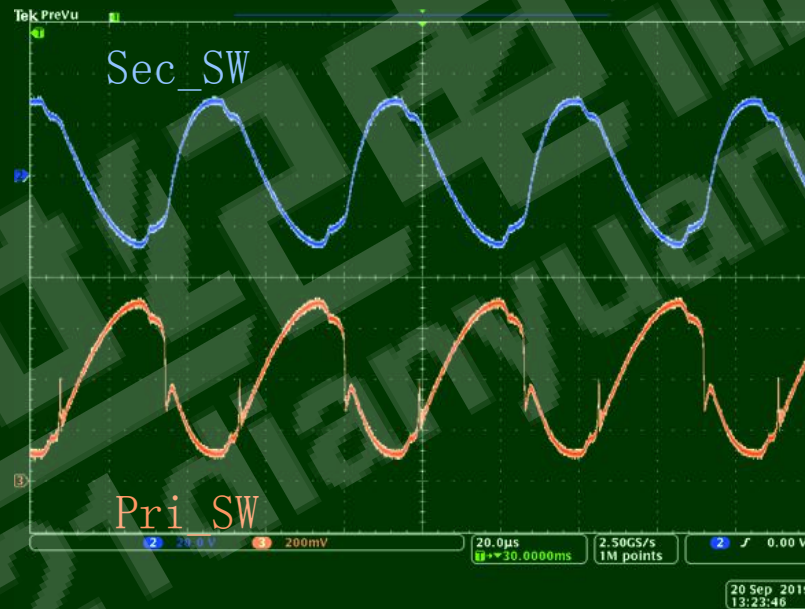


Waveforms of Pri_SW and Sec_SW

VIN=50mV

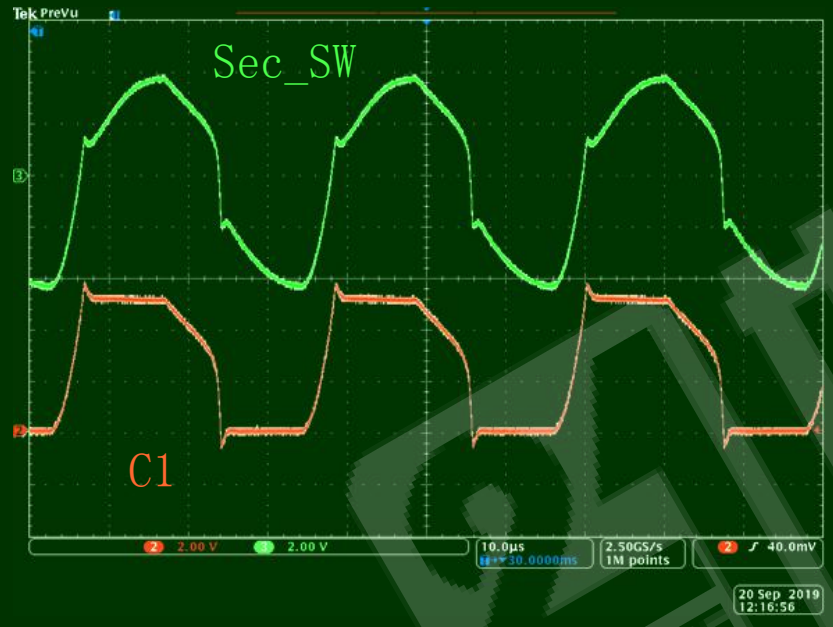


VIN=400mV

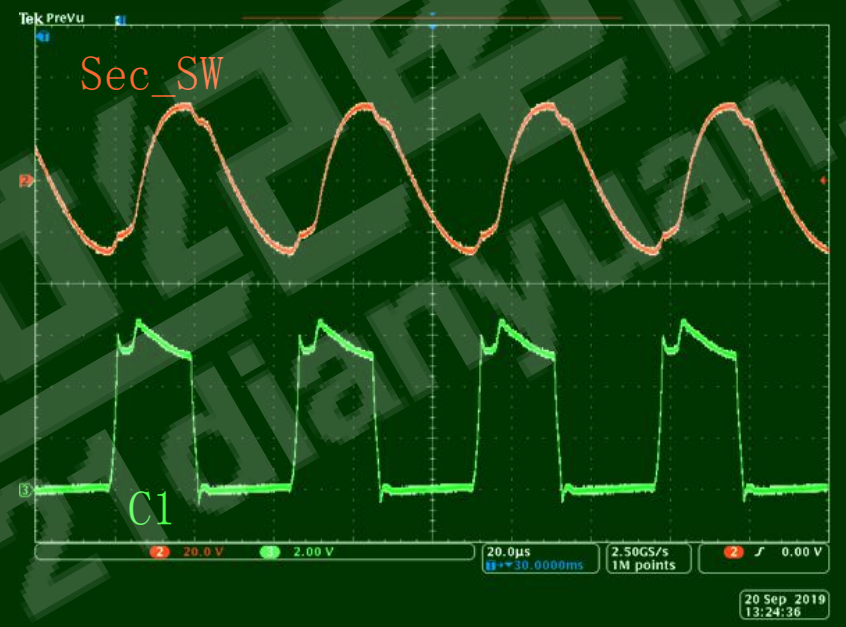


Waveforms of Sec_SW and C1

VIN=50mV

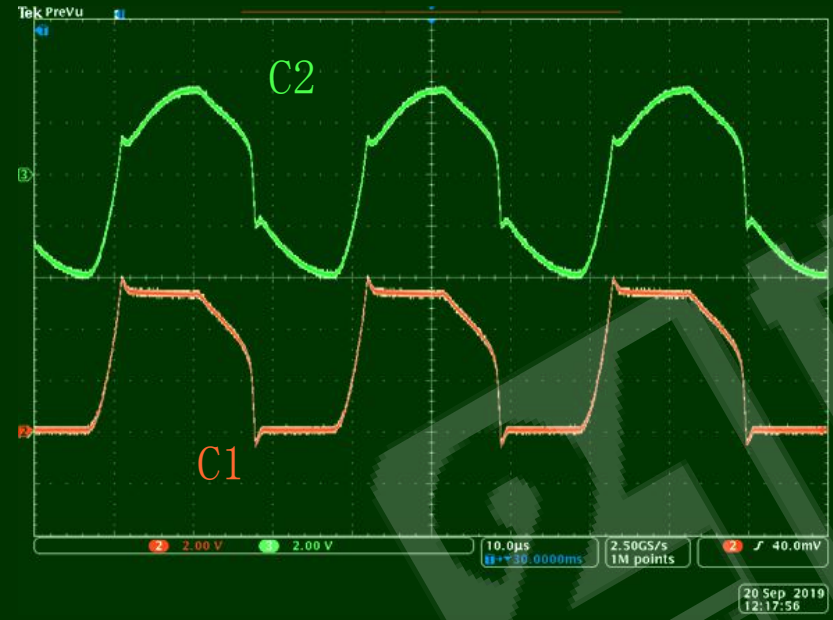


VIN=400mV

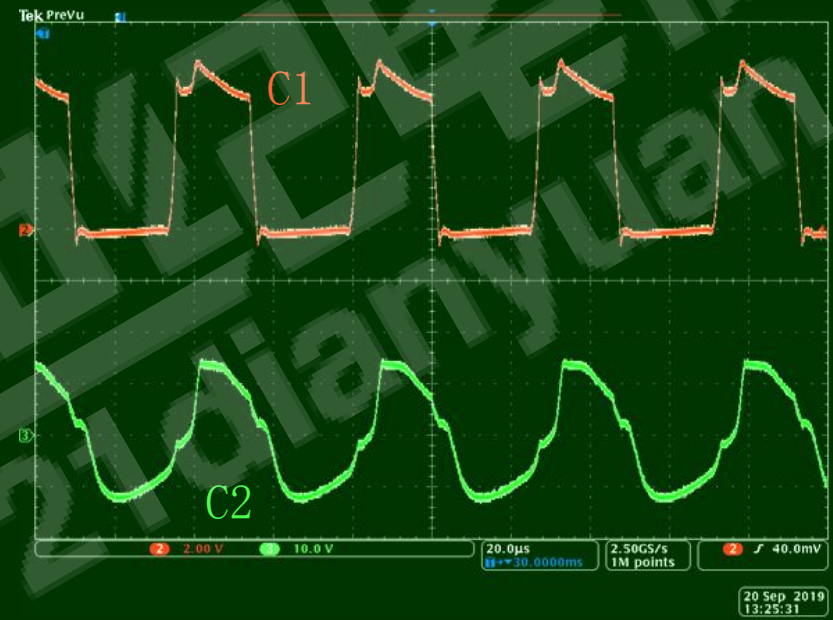


Waveforms of C1 and C2

VIN=50mV

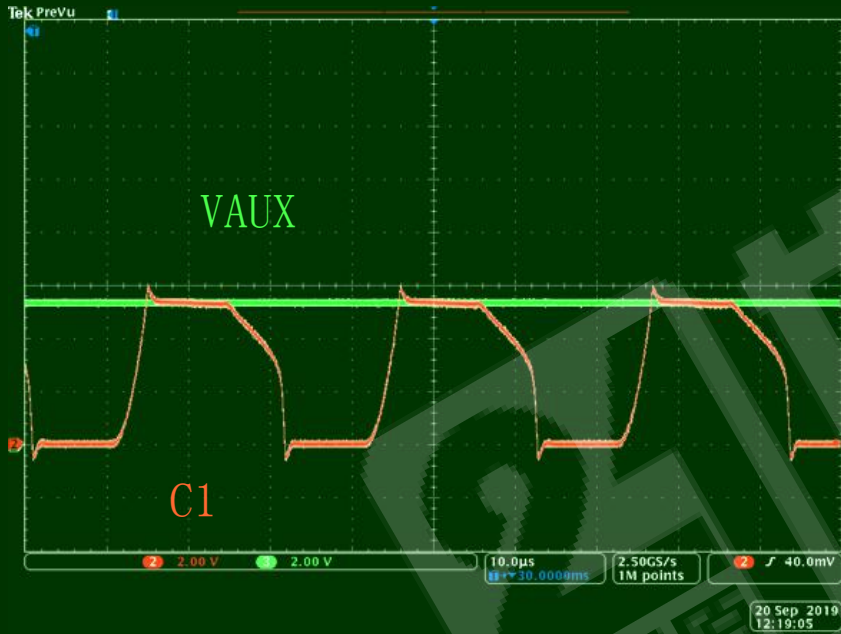


VIN=400mV

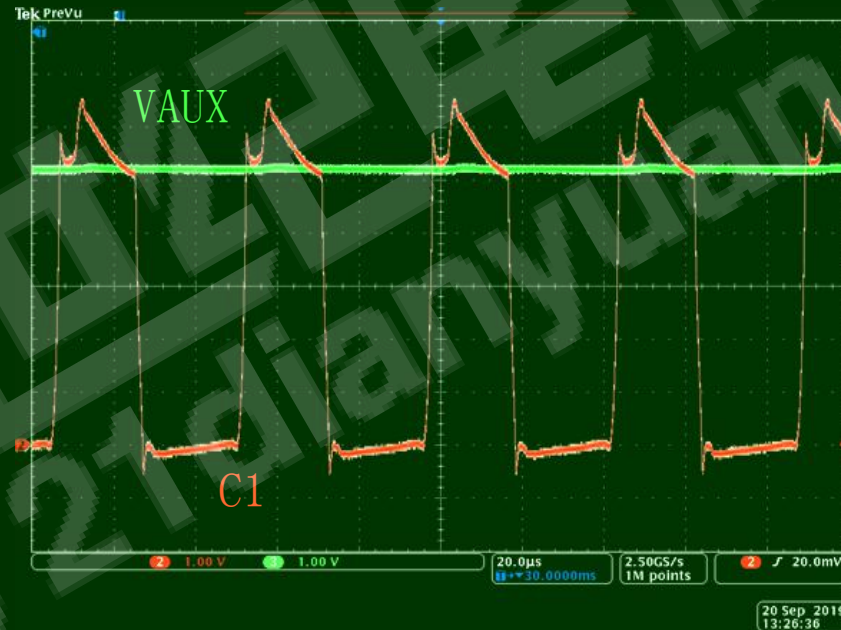


Waveforms of C1 and VAUX

VIN=50mV

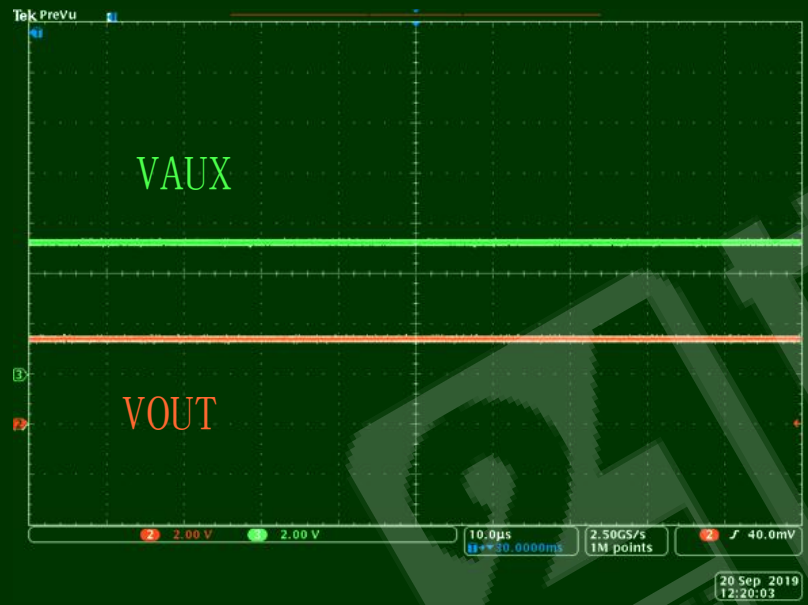


VIN=400mV

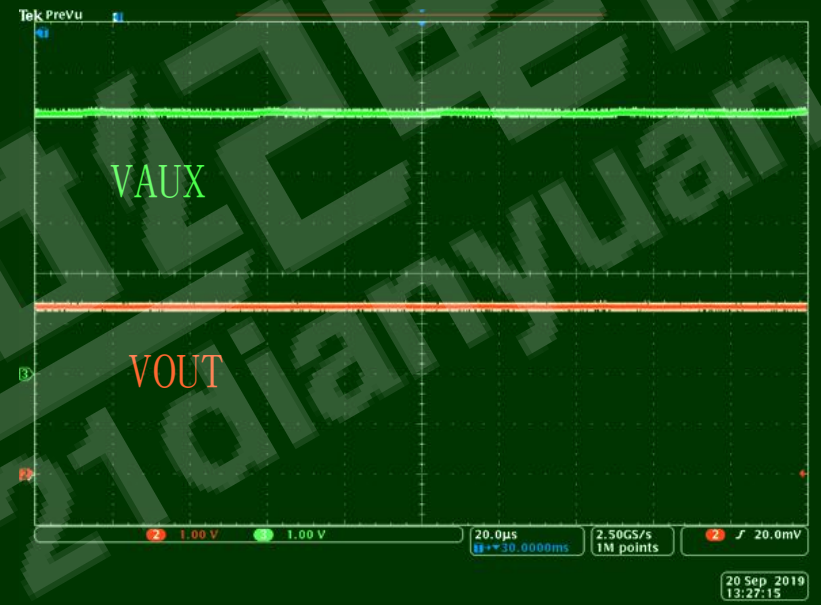


Waveforms of VAUX and VOUT

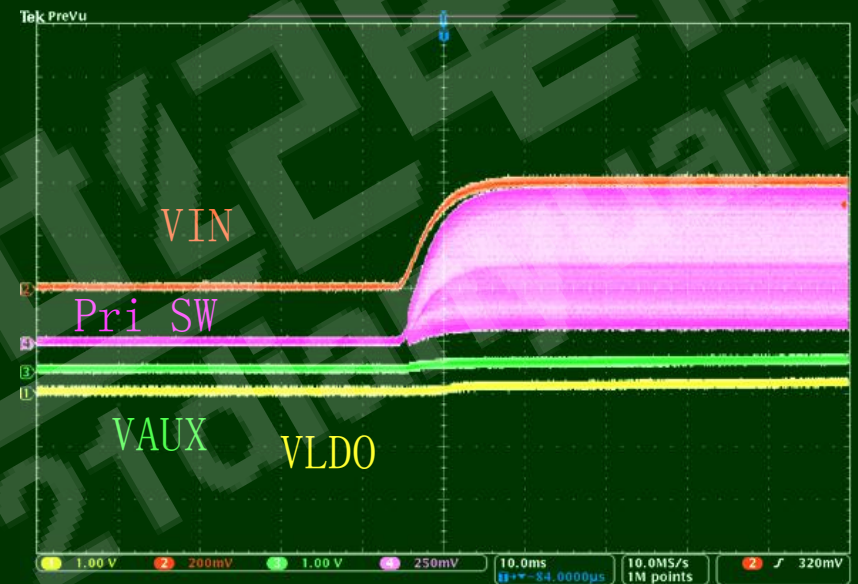
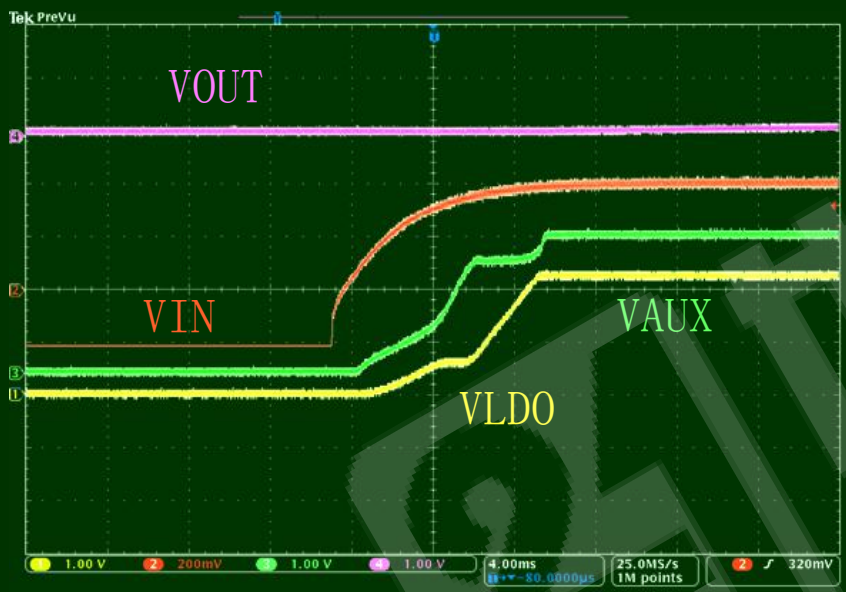
VIN=50mV



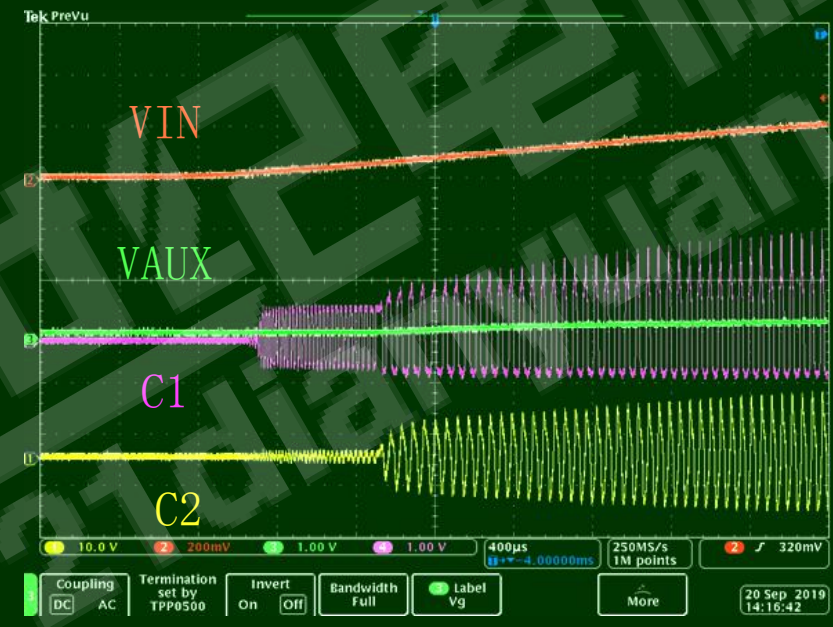
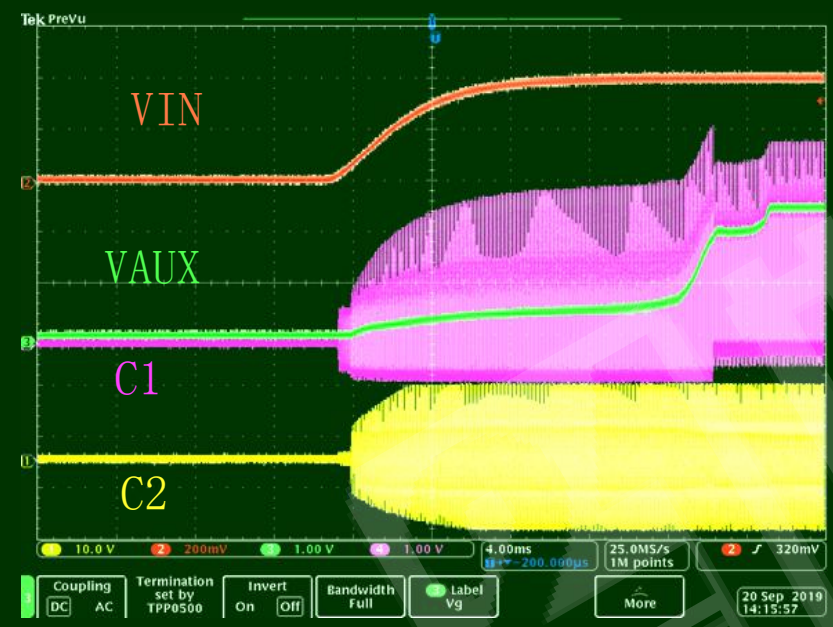
VIN=400mV



Waveforms of LTC3108 Power-Up @ VIN=400mV

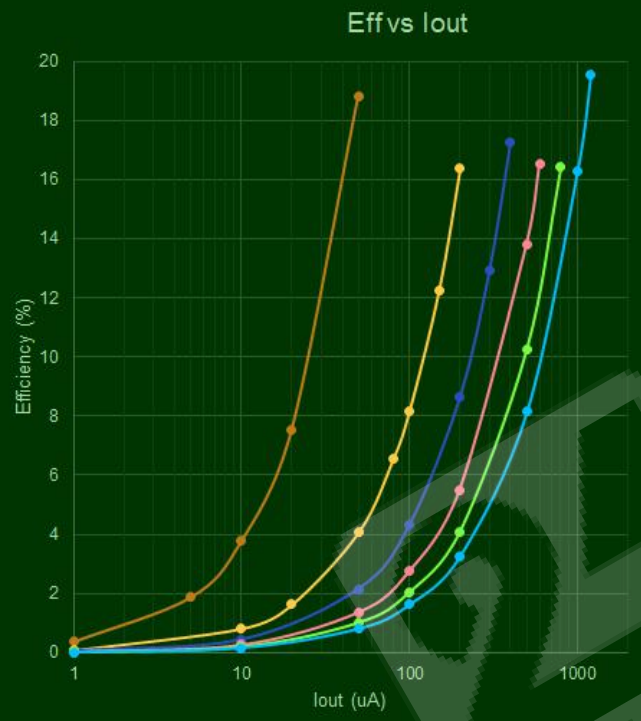


Waveforms of LTC3108 Power-Up @ VIN=400mV

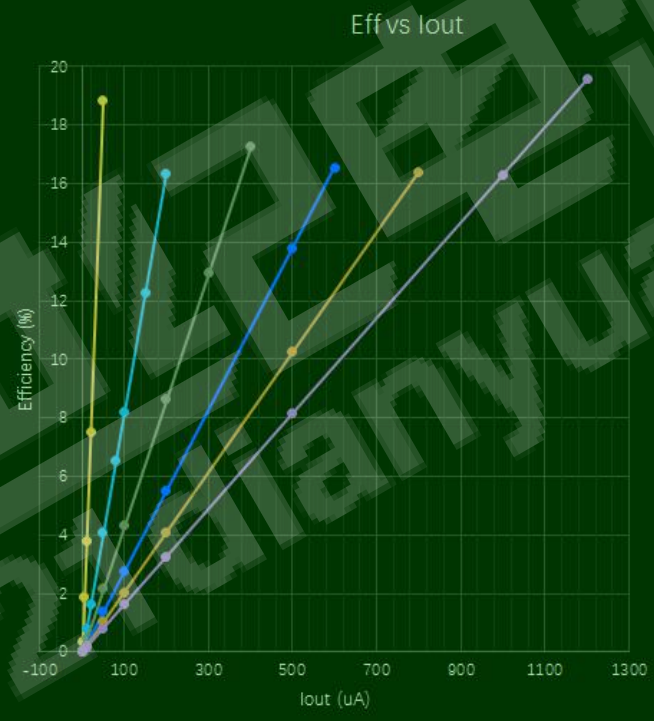




Efficiency vs. Iout

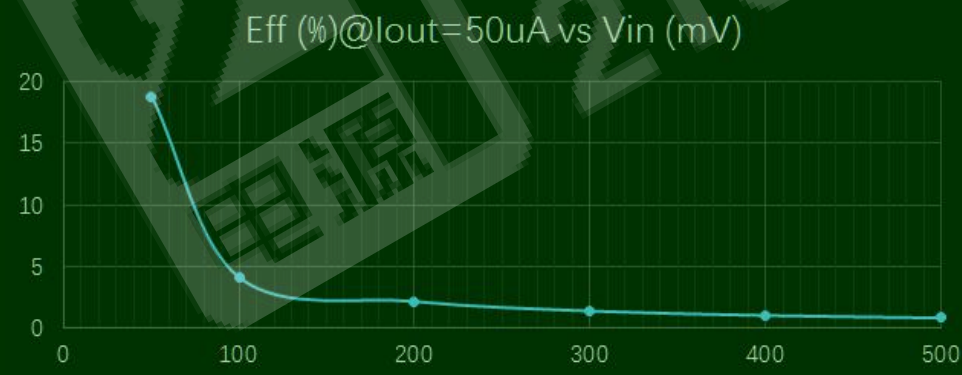
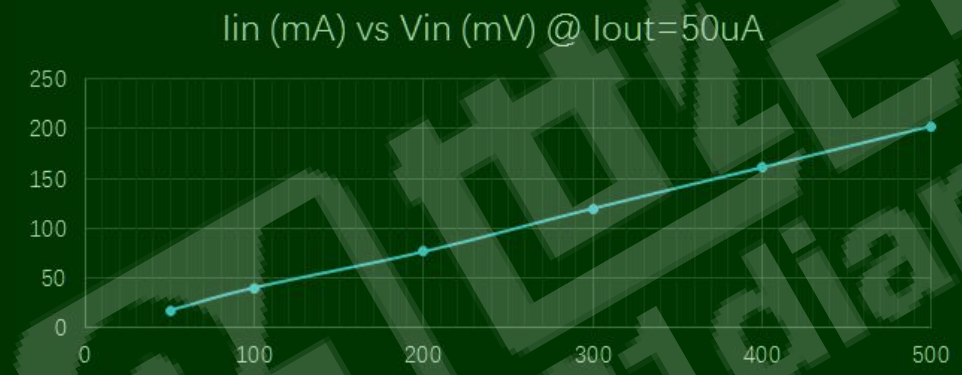
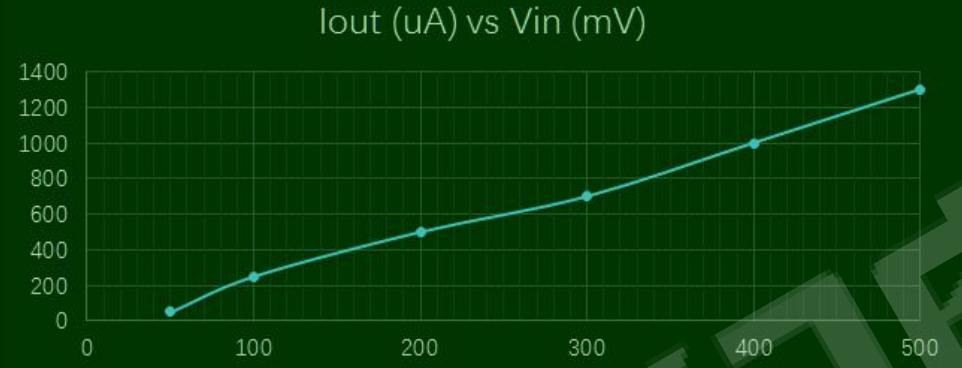


- Vin=50mV
- Vin=100mV
- Vin=200mV
- Vin=300mV
- Vin=400mV
- Vin=500mV



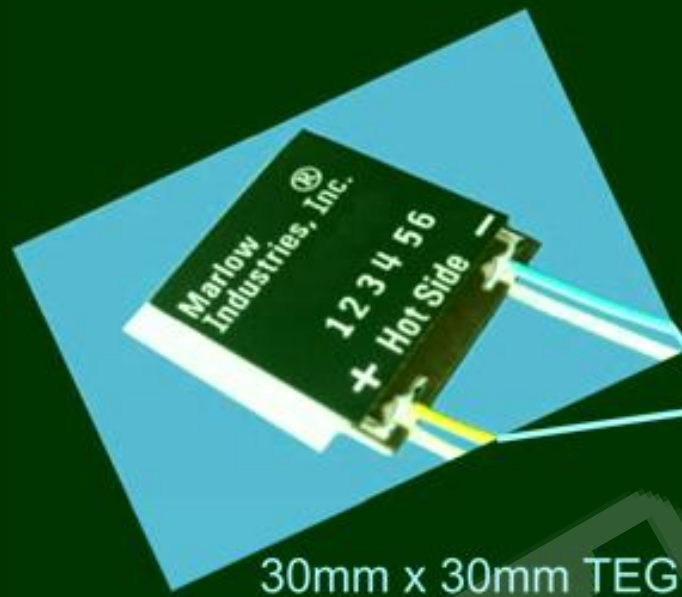
- Vin=50mV
- Vin=100mV
- Vin=200mV
- Vin=300mV
- Vin=400mV
- Vin=500mV

Curves of Test Data





LTC3108 Application

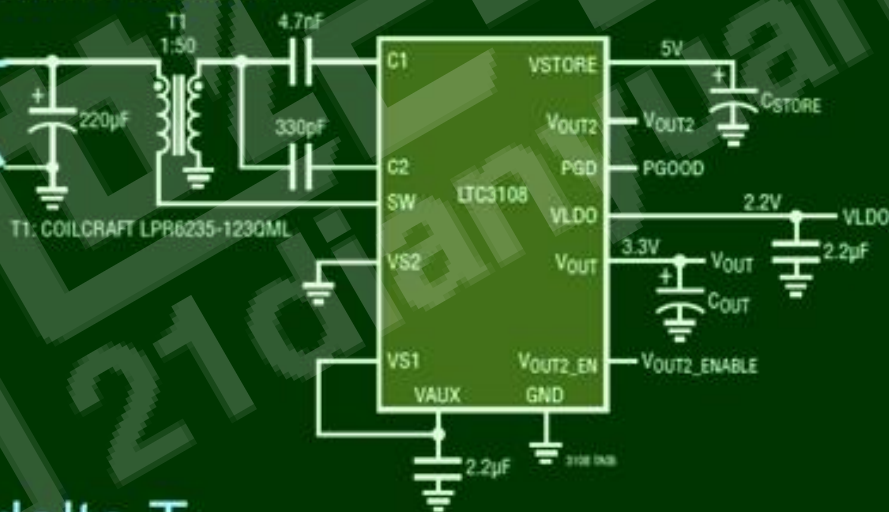


30mm x 30mm TEG

LTC3108

Ultralow Voltage Step-Up Converter
And Power Manager
(min $V_{IN} = 20mV$)

$V_{IN} \sim 20mV - 500mV$



LTC3108 Output:

$$V_{OUT} = 3.3V$$

$$I_{OUT} = 60\mu A \quad @ \quad 10^{\circ}C \text{ delta } T$$

$$I_{OUT} = 400\mu A \quad @ \quad 30^{\circ}C \text{ delta } T$$



LTC3588

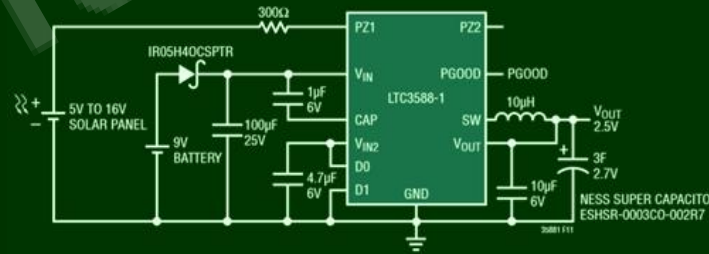
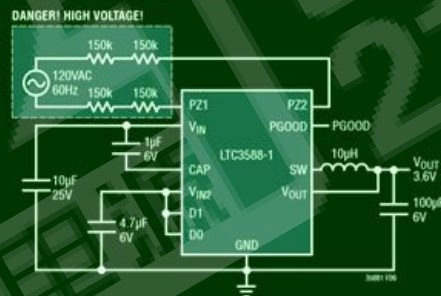
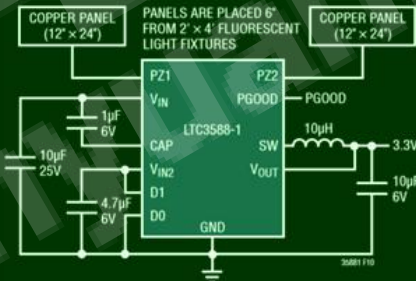
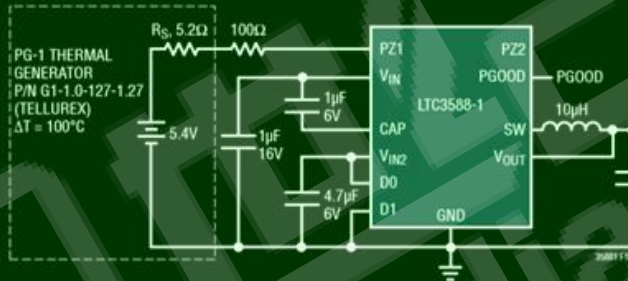
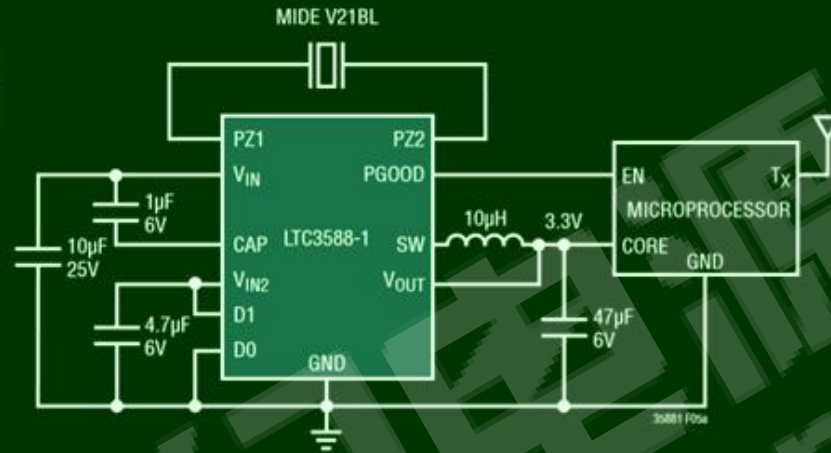


FEATURES

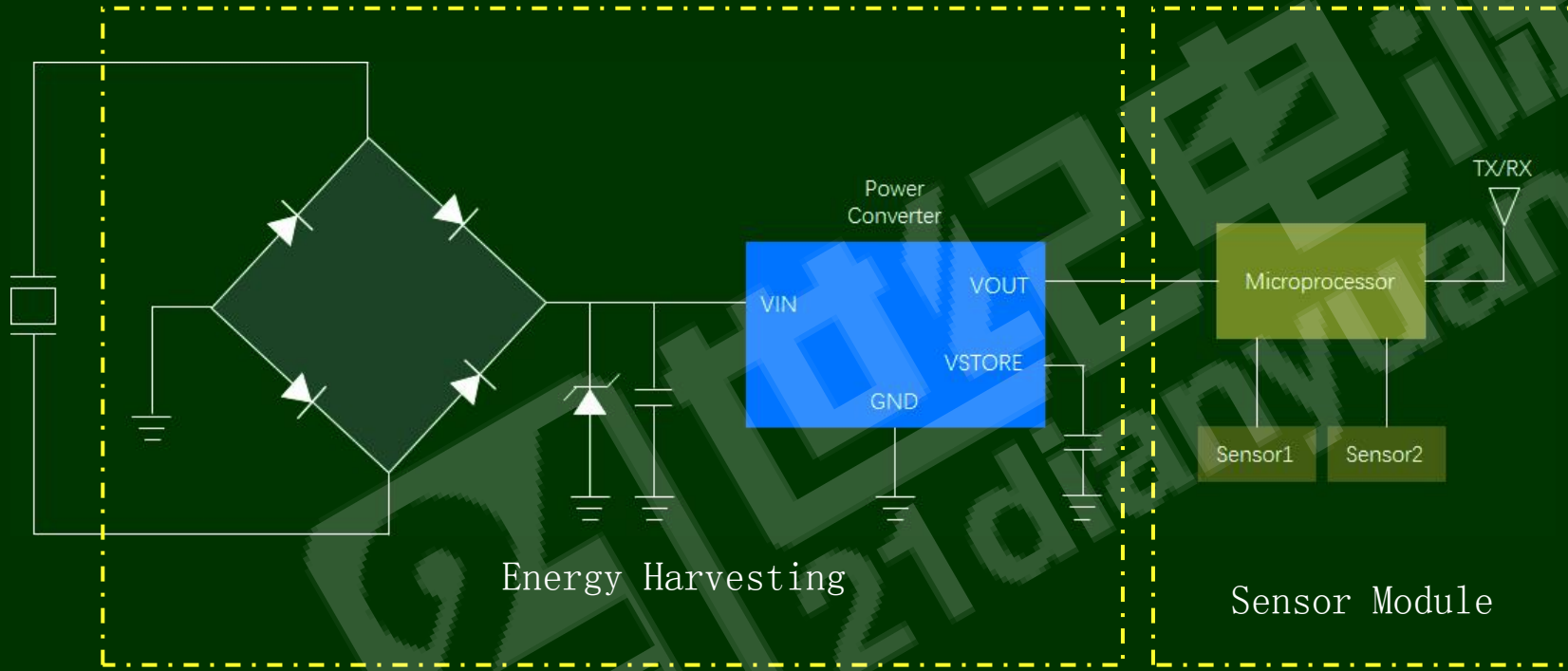
- 950nA Input Quiescent Current (Output in Regulation – No Load)
- 450nA Input Quiescent Current in UVLO
- 2.7V to 20V Input Operating Range
- Integrated Low-Loss Full-Wave Bridge Rectifier
- Up to 100mA of Output Current
- Selectable Output Voltages of 1.8V, 2.5V, 3.3V, 3.6V
- High Efficiency Integrated Hysteretic Buck DC/DC
- Input Protective Shunt – Up to 25mA Pull-Down at $V_{IN} \geq 20V$
- Wide Input Undervoltage Lockout (UVLO) Range
- Available in 10-Lead MSE and 3mm x 3mm DFN Packages

APPLICATIONS

- Piezoelectric Energy Harvesting
- Electro-Mechanical Energy Harvesting
- Wireless HVAC Sensors
- Mobile Asset Tracking
- Tire Pressure Sensors
- Battery Replacement for Industrial Sensors
- Remote Light Switches
- Standalone Nanopower Buck Regulator

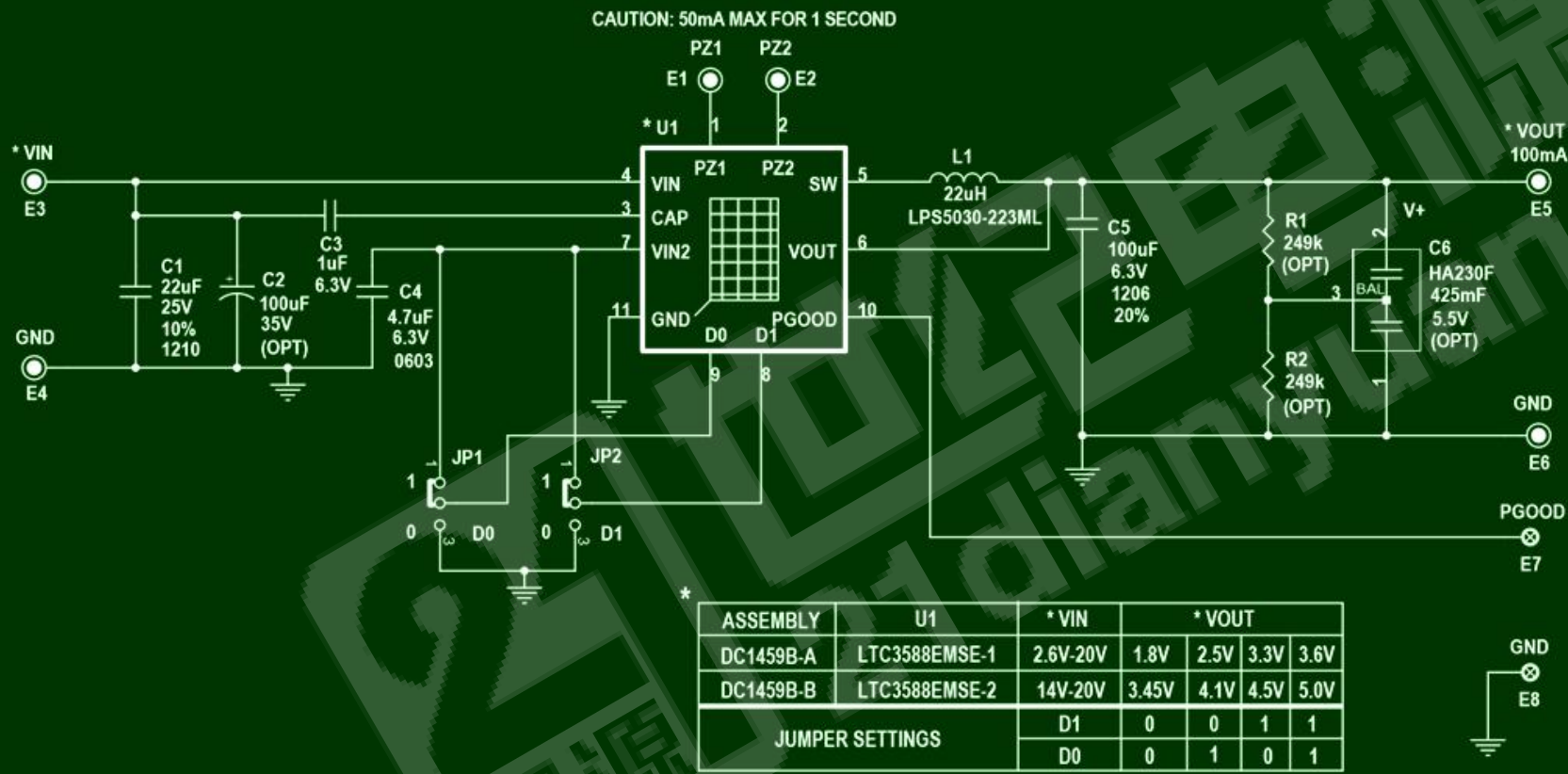


AC Input Energy Harvesting

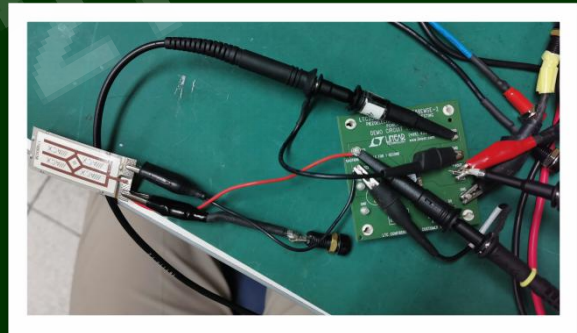
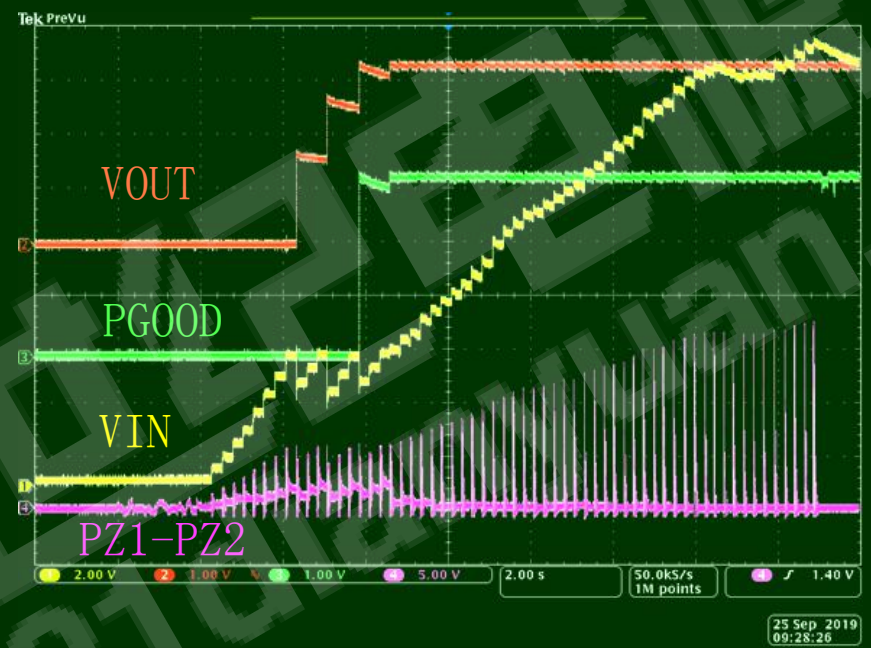
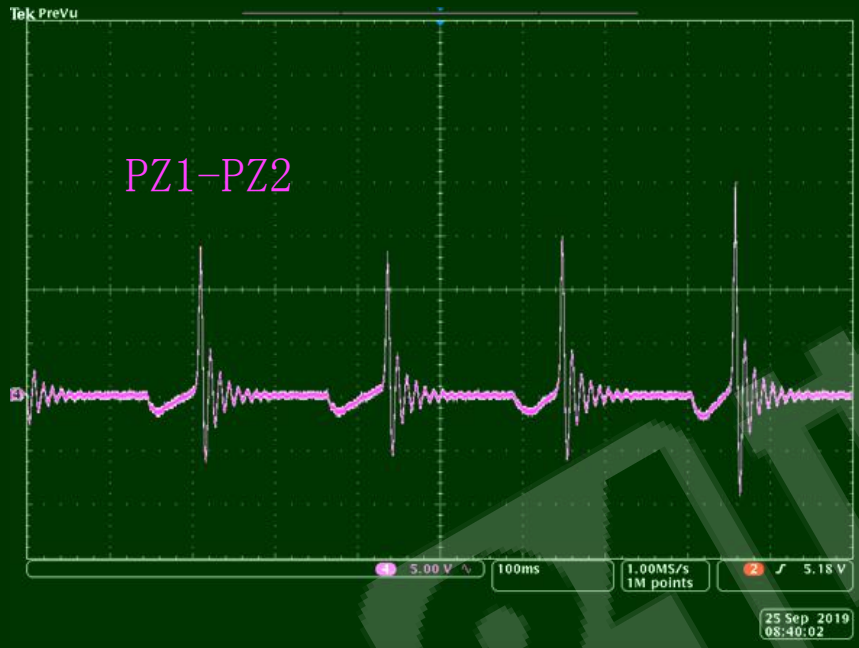




LTC3588 Demo Board Schematic

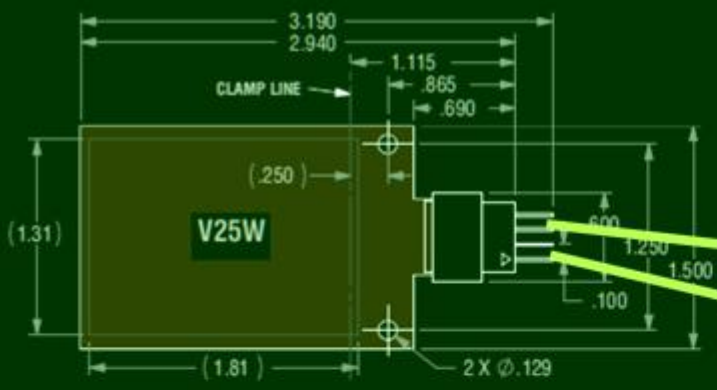


Piezoelectric Energy Harvesting Demo Board Test Waveforms



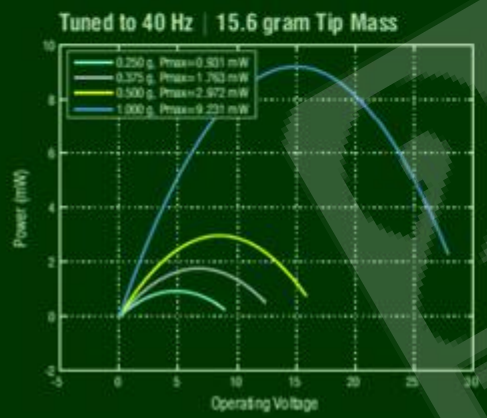
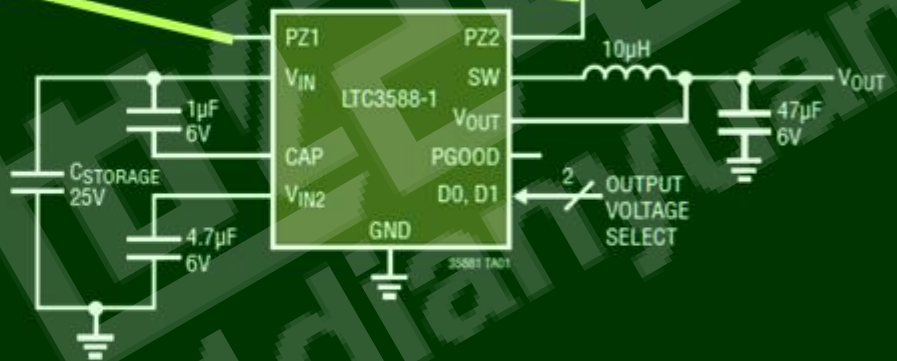


LTC3588 Application



LTC3588

Piezoelectric Energy Harvesting
Power Supply
($I_{CC} = 900nA$)



LTC3588 Output:

$$V_{OUT} = 3.3V$$

$$I_{OUT} = 200\mu A @ 0.25g / 40Hz$$

Energy Harvesting ICs Selection Guide

Part Number	Description	Output Power Level	Number of Outputs	Energy Source	Packages	Topology	I_0	$V_{IN\ MIN}$ (V)	$V_{IN\ MAX}$ (V)
LTC3330	Nanopower Buck-Boost DC/DC with Energy Harvesting Battery Life Extender	0.1mW to 50mW	2	Vibration, Solar (AC or DC)	5mm × 5mm QFN-32	Full Bridge Rectifier, Buck	750nA	3.0V(EH) 1.8V(V_{BATT})	19V(EH) 5V(V_{BATT})
LTC3331	Nanopower Buck-Boost DC/DC with Energy Harvesting Battery Charger	0.1mW to 50mW	1	Vibration, Solar (AC or DC)	5mm × 5mm QFN-32	Full Bridge Rectifier, Buck	950nA	3.0V	19V
LTC3107	Ultralow Voltage Energy Harvester and Primary Battery Life Extender	0.01mW to 5mW	2	Thermal	3mm × 3mm DFN-10	Boost	80nA	20mV	500mV
LTC3106	300mA Ultralow I_0 Step-Up Converter and Power Manager with MPPC	0.1mW to 160mW	2	Solar	3mm × 4mm QFN-20, TSSOP-20E	Buck-Boost	1.5 μ A	330mV	5.5V



Energy Harvesting ICs Selection Guide

Part Number	Description	Output Power Level	Number of Outputs	Energy Source	Packages	Topology	I_o	$V_{IN\ MIN}$ (V)	$V_{IN\ MAX}$ (V)
LTC4071	Li-Ion/Polymer Shunt Battery Charger System with Low Battery Disconnect	0.1mW to 250mW	1	-	DFN-8, MSOP-8	Shunt Battery Charger	550nA		None
LTC4070	Li-Ion/Polymer Shunt Battery Charger System	0.1mW to 250mW	1	-	DFN-8, MSOP-8E	Shunt Battery Charger	450nA		None
LTC3588-1/ LTC3588-2/ LTC3588-3	Piezoelectric Energy Harvesting Power Supply	0.1mW to 50mW	1	Piezoelectric	MS-10, DFN-10	Buck	450nA	14	20
LTC3388-1/ LTC3388-3	20V, High Efficiency Nano Step-Down Regulator	0.1mW to 250mW	1	All	DFN-10, MS-10	Buck	400nA	2.7	20
LTC3526L	550mA 1MHz Synchronous Step-Up DC/DC Converters in 2mm x 2mm DFN	0.1mW to 650mW	1	Solar	DFN-6	Boost	9μA	0.5	5
LTC3109	Auto-Polarity, Ultralow Voltage Step-Up Converter and Power Manager	0.1mW to 50mW	3	Thermoelectric	QFN-20, SSOP-20	Boost	200nA	0.02	0.5
LTC3108/ LTC3108-1	Ultralow Voltage Step-Up Converter and Power Manager	0.1mW to 50mW	3	Thermoelectric	DFN-12, SSOP-16	Boost	200nA	0.02	0.5
LTC3105	400mA Step-Up DC/DC Converter with Maximum Power Point Control and 250mV Start-Up	0.1mW to 1100mW	1	Solar	DFN-10, MS-12	Boost	24μA	0.2	5
LT3652HV	Power Tracking 2A Battery Charger	1W to 30W	1	Solar	DFN-12, MS-12	Buck	19μA	4.95	34
LT3652	Power Tracking 2A Battery Charger for Solar Power	1W to 30W	1	Solar	DFN-12, MS-12	Battery Charger	19μA	4.95	32

Thank you!

21世纪电源网
21dianyuan.com