

如何解决设计难点 (第二部分)

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AHEAD OF WHAT'S POSSIBLE™

ADI智库
一站式电子技术宝库

中级第四讲：系统 级低功耗，超低待 机功耗设计



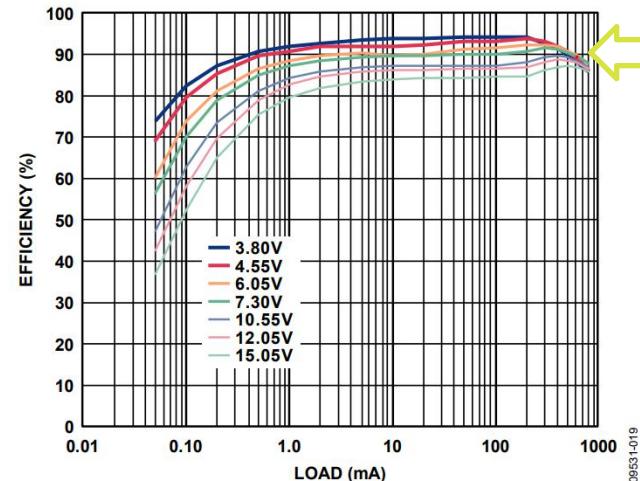
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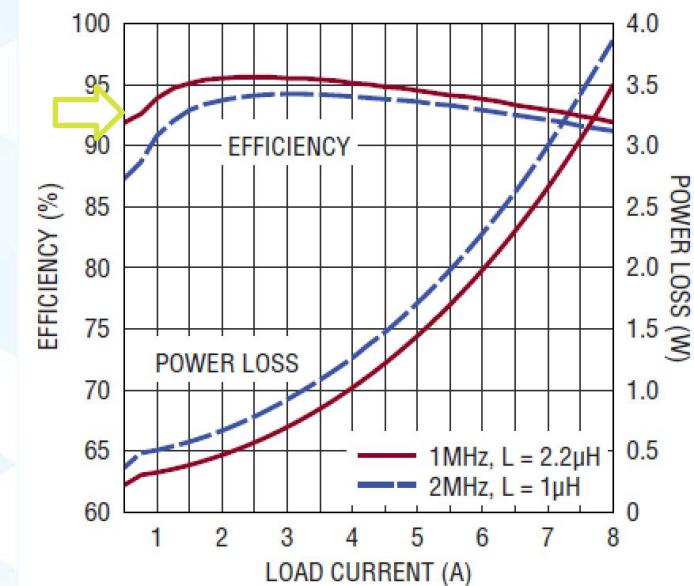
待机时间与系统功耗的关系



负载3.3V系统， 500mA电流
3.8V@3100mAH 电池，能够工作多久？



89% Efficiency DC/DC:
 $I_{bat} = (500 \times 3.3 / 3.8) / 0.89 = 487\text{mA}$
 $3100 / 500 = 6.4\text{小时}$



92% Efficiency DC/DC:
 $I_{bat} = (500 \times 3.3 / 3.8) / 0.92 = 466\text{mA}$
 $3100 / 466 = 6.7\text{小时}$

待机时间与系统功耗的关系

**负载3.3V系统， 100uA待机电流
3.8V@3100mAH 电池， 能够工作多久？**

Ibattery=电源待机电流+系统待机电流

Quiescent Current

LM1117-2.5 $V_{IN} \leq 15 V$	$T_J = 25^\circ C$ over the junction temperature range $0^\circ C$ to $125^\circ C$	5 10	mA
LM1117-3.3 $V_{IN} \leq 15 V$	$T_J = 25^\circ C$ over the junction temperature range $0^\circ C$ to $125^\circ C$	5 10	mA

LDO: $I_{bat}=5mA+0.1mA=5.1mA$

$3100/5.1=607\text{小时}=25\text{天}$

常见的几种工作状态及电流

负载3.3V系统， 100uA待机电流
3.8V@3100mAH 电池，能够工作多久？

Ibattery=电源待机电流+系统待机电流

SYMBOL	PARAMETER	CONDITIONS	MIN	TYP	MAX	UNITS
I _S	Input DC Supply Current (Note 4)					
	Active Mode	V _{SYNC/MODE} = 3.6V, V _{FB} = 0.75V		330	450	µA
	Sleep Mode	V _{SYNC/MODE} = 3.6V, V _{FB} = 0.84V		40	60	µA
	Shutdown	V _{SHDN/RT} = 3.6V		0.1	1	µA

- Burst Mode: Ibat=(0.1x3.3/3.8)/0.55+450uA=158uA+450uA=608uA

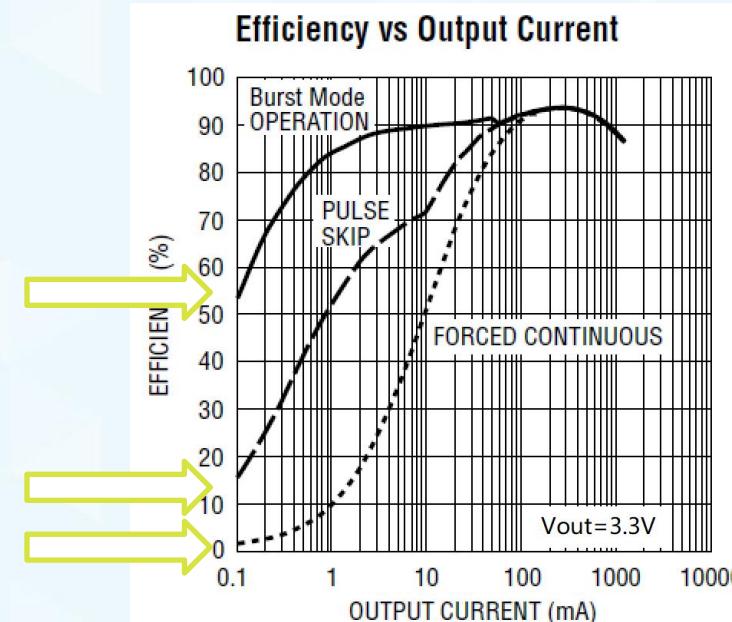
$$3100/0.608=5091\text{小时}=212\text{天}$$

- Pulse Skip: Ibat=(0.1x3.3/3.8)/0.16+450uA=543uA+450uA=993uA

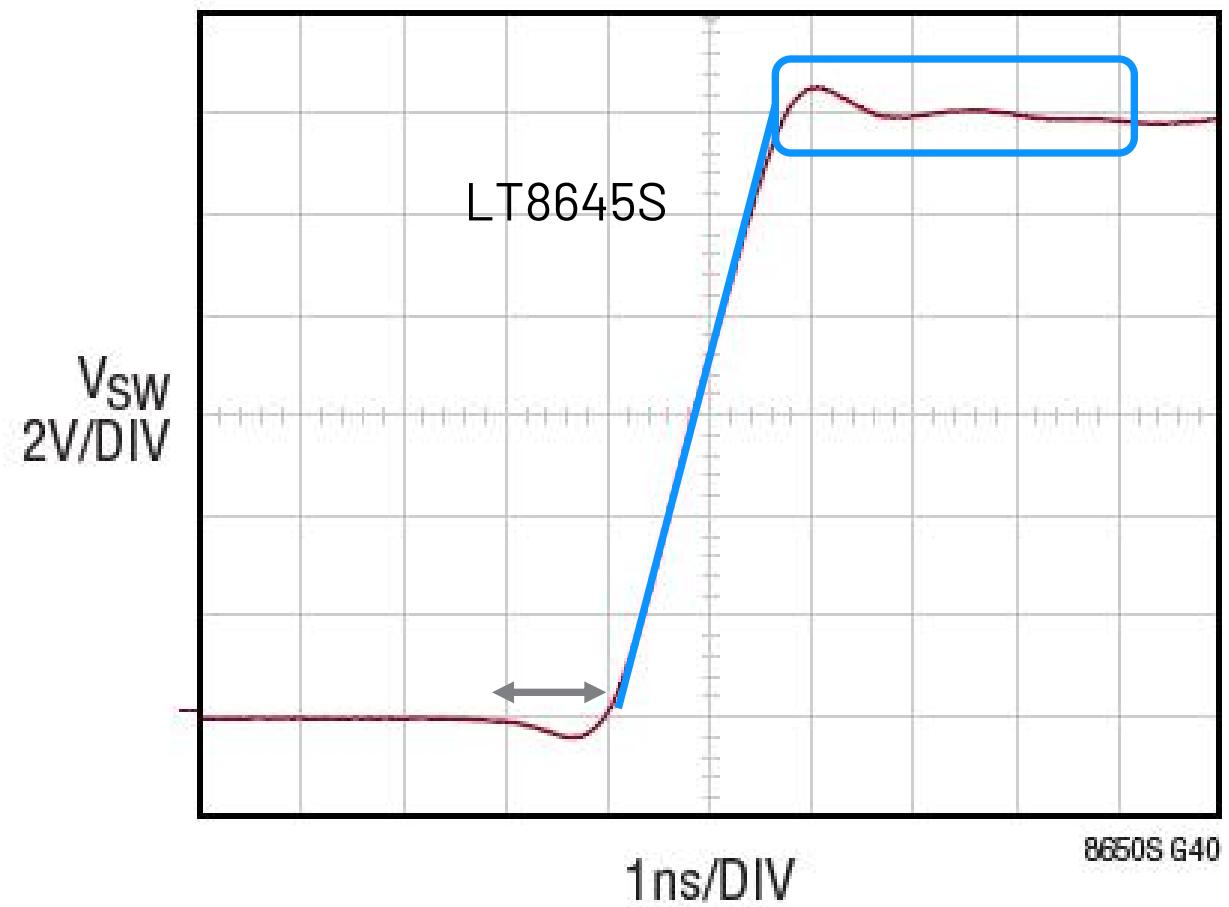
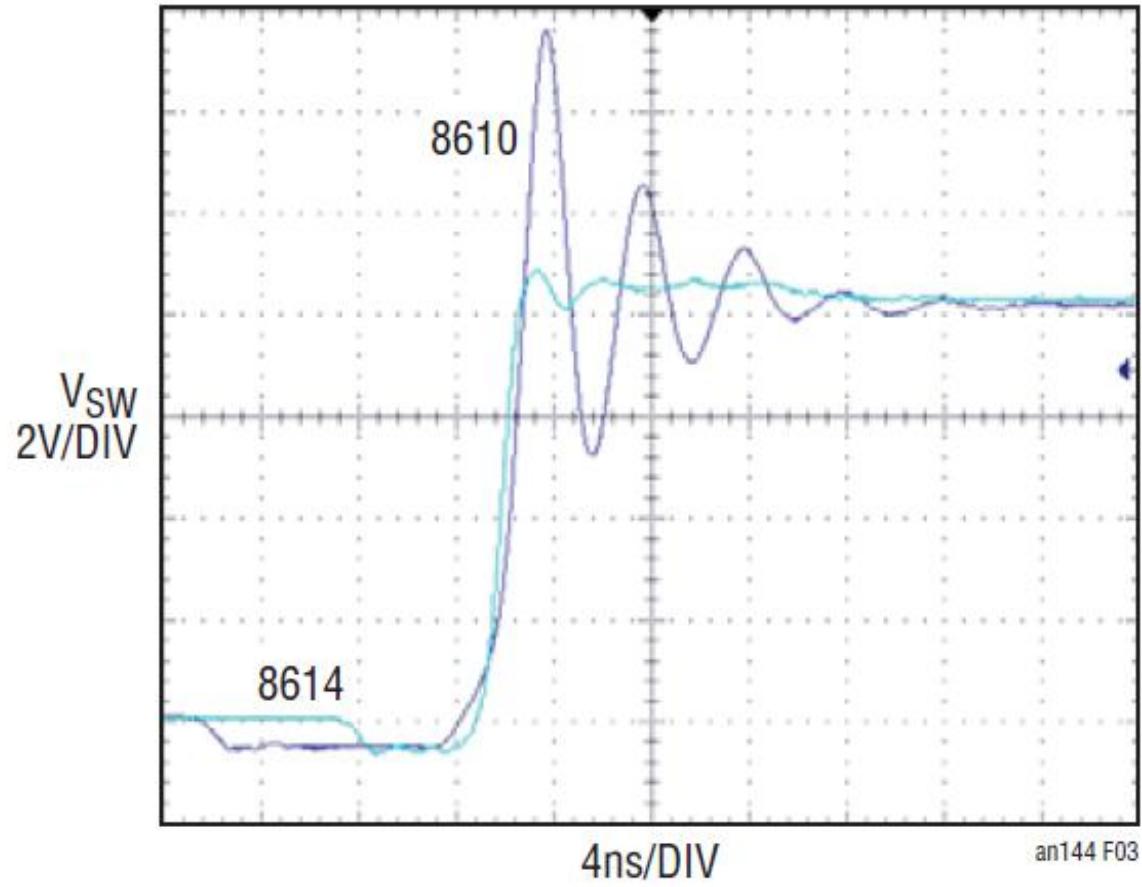
$$3100/0.608=3121\text{小时}=130\text{天}$$

- Forced Continuous: Ibat=(0.1x3.3/3.8)/0.02+450uA=4342uA+450uA=4792uA

$$3100/4.79=647\text{小时}=27\text{天}$$



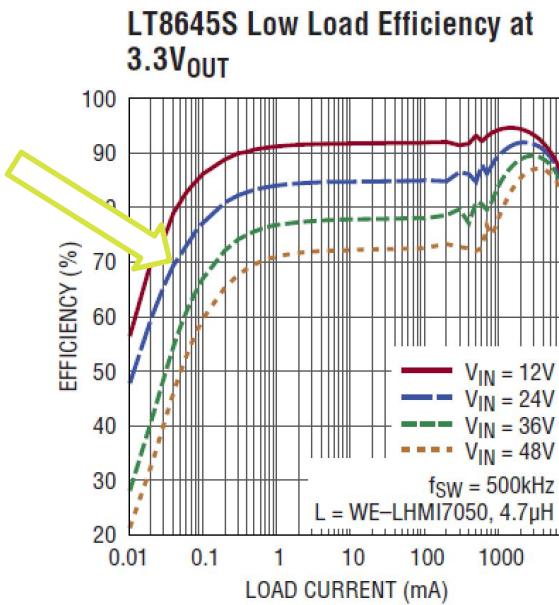
未来性能发展的推动



最新的Silent Switch技术

负载3.3V系统，100uA待机电流
3.8V@3100mAH 电池，能够工作多久？

Ibattery=电源待机电流+系统待机电流



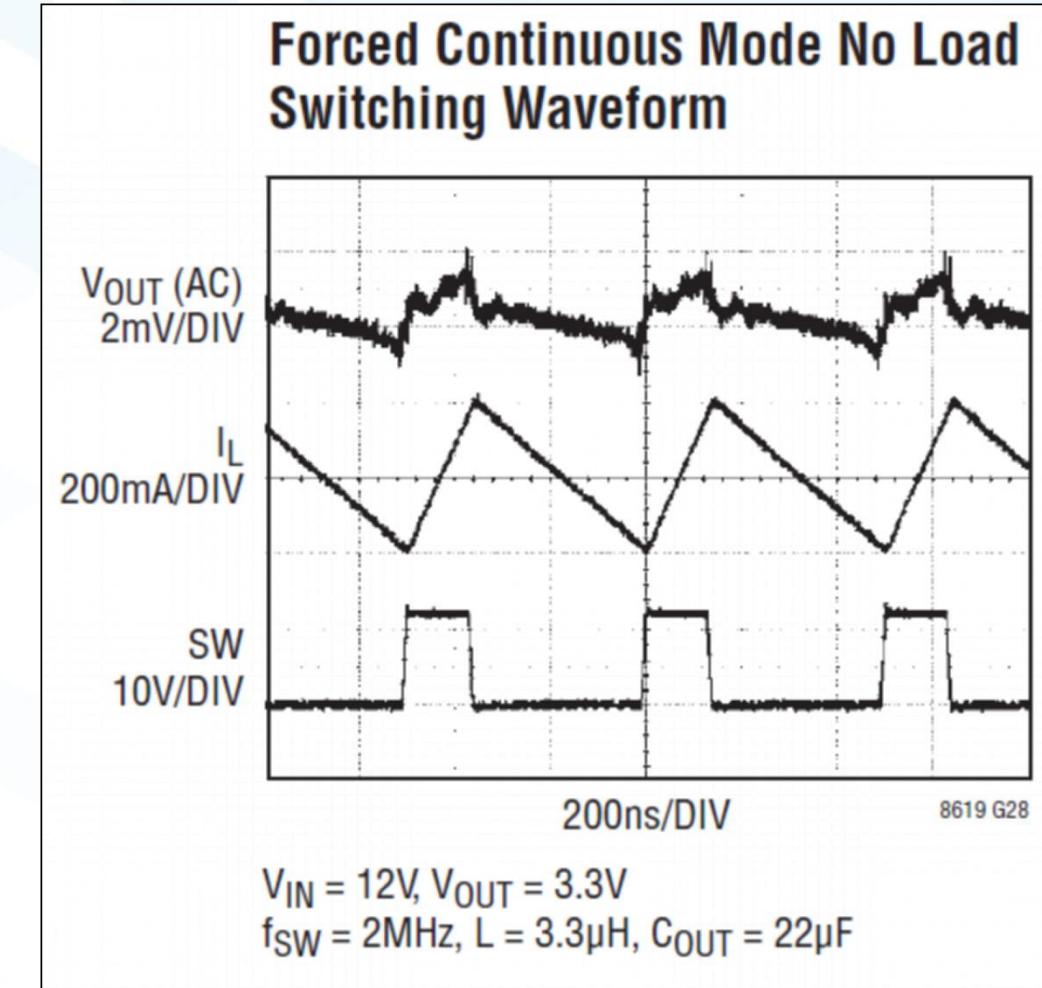
- Ultralow Quiescent Current Burst Mode Operation
 - 2.5 μA I_Q Regulating 12V_{IN} to 3.3V_{OUT} (LT8645S)
 - Output Ripple < 10mV_{P-P}

强制连续运行模式(FCM)

- ▶ Current in inductor is allowed reverse direction during a portion of a cycle
 - Current flowing back and forth through the switches giving away a little more power and efficiency

Benefits to allowing this reverse current flow

- Output ripple voltage and frequency remain constant at all loads easing filtering requirements
- Popular with telecom and other applications where noise interference is a concern

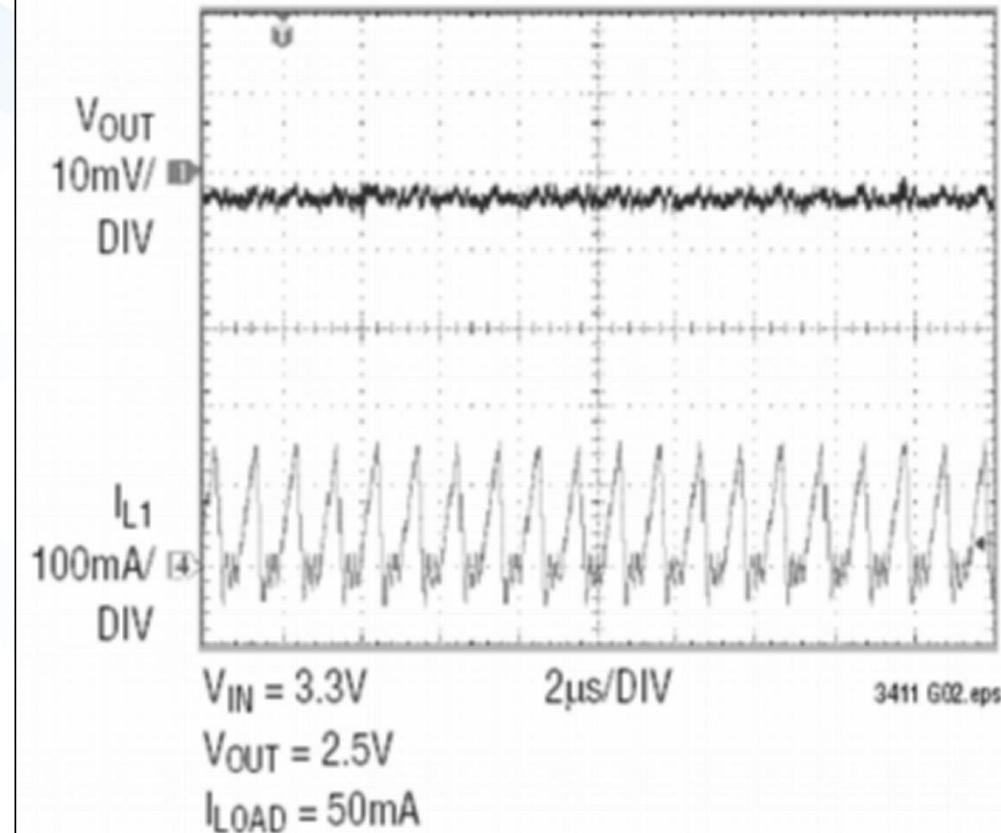


Light Load Operation: 脉冲跳跃 脉冲省略 (PSM)

- ▶ Allows the regulator to skip cycles when they are not needed, which greatly improves efficiency at light loads
 - “One” cycle will charge the output capacitor with enough energy to skip one or more cycles
 - A new cycle is initiated when the output voltage drops below the regulating threshold
- ▶ Output ripple voltage frequency is proportional to the load current

Offers improved light-load efficiencies but at the expense of noise because the switching frequency is not fixed

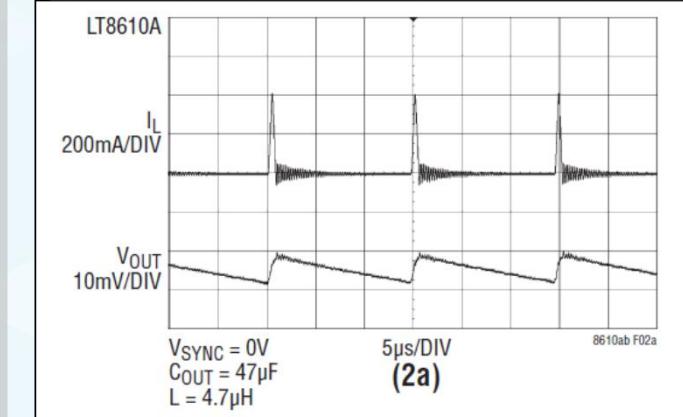
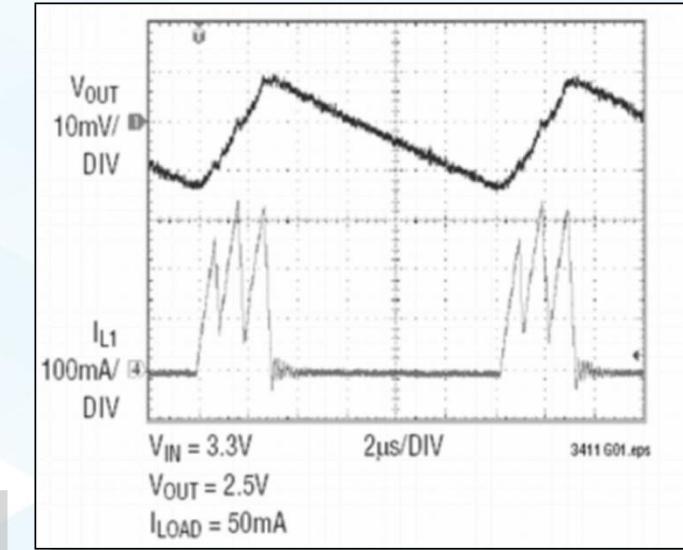
Pulse Skipping Mode



Light Load Operation: 突发模式 (Burst Mode)

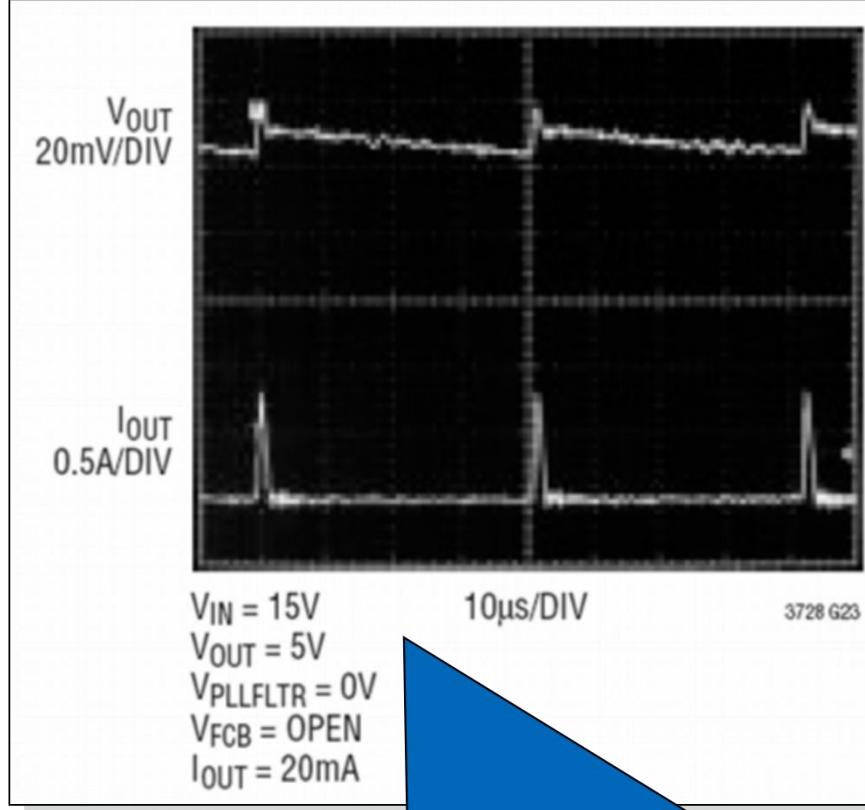
- Short active-mode intervals with extended system time in standby
 - Lowers I_q losses
- Quasi-disabled until a lower threshold on the output is reached
 - Hysteretic control
- "Pumps up" the output with a burst of pulses until a upper threshold on the output is reached

- Current sense is used to detect when the required output current drops below an internally set threshold
- The part shuts down the internal oscillator and goes into a low current operating state
- Remain in the low current operating state until the output voltage has dropped enough to require another burst of current

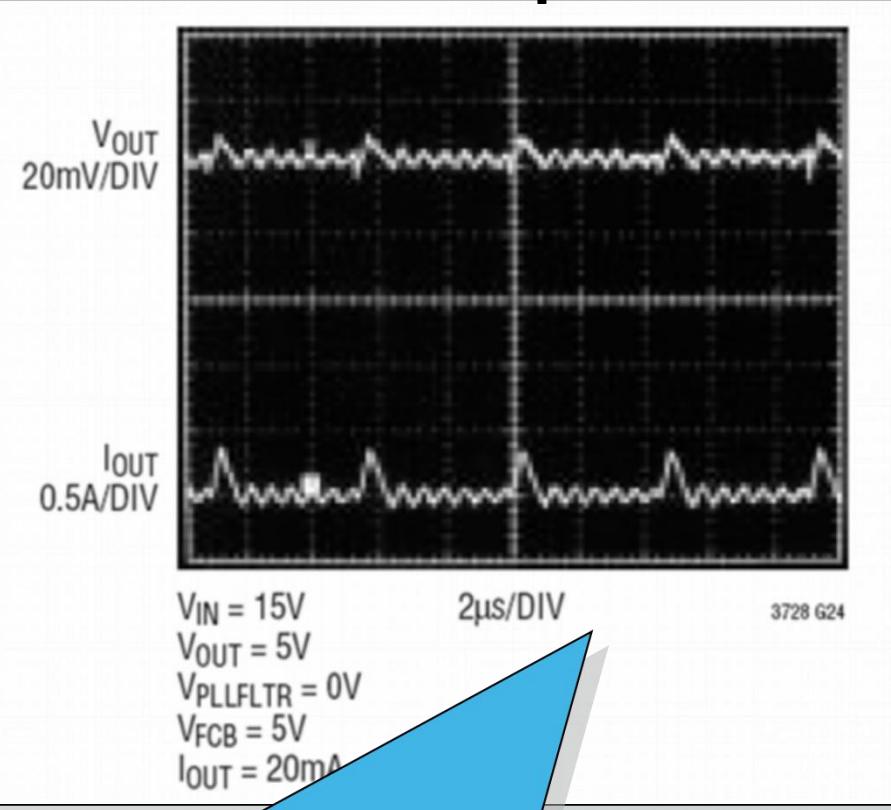


Burst Mode vs. Pulse Skipping

Burst mode



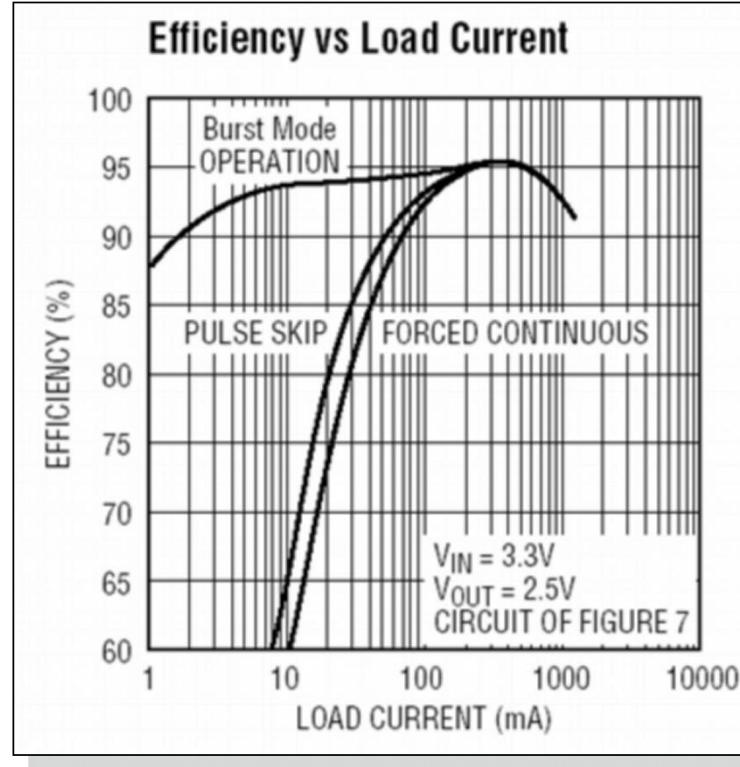
Pulse skip mode



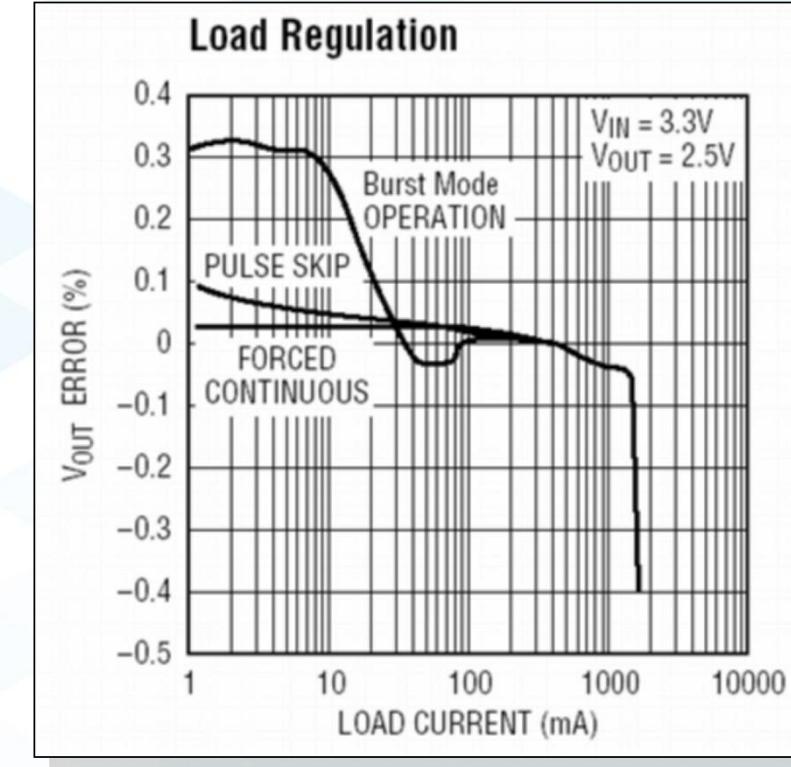
Provides the best low current efficiency at the cost of a higher output voltage ripple

Provides lower output voltage and current ripple at the cost of low current efficiency

Efficiency and Load Regulation for Different Modes



Burst mode has highest light load efficiency, followed by pulse skip mode and then forced continuous mode



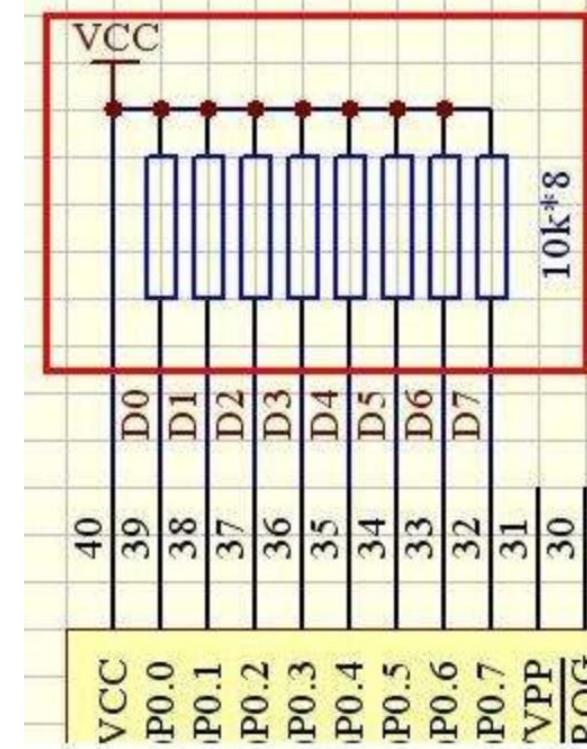
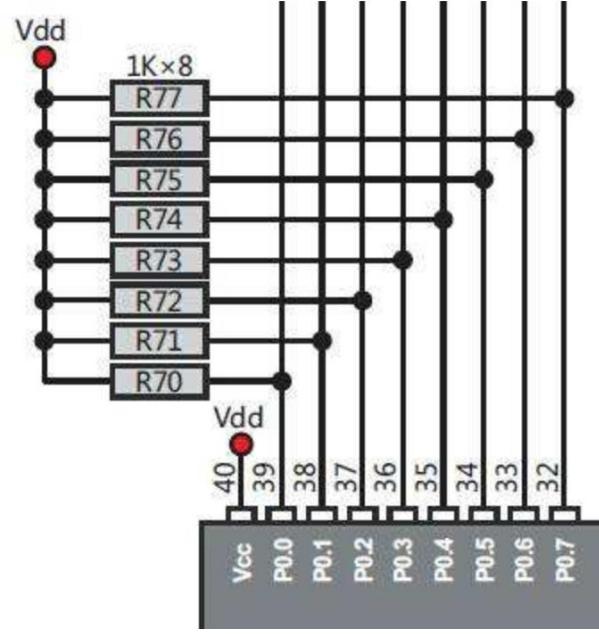
Forced continuous mode has best light load regulation, followed by pulse skip mode and then burst mode

Operation Mode Summary

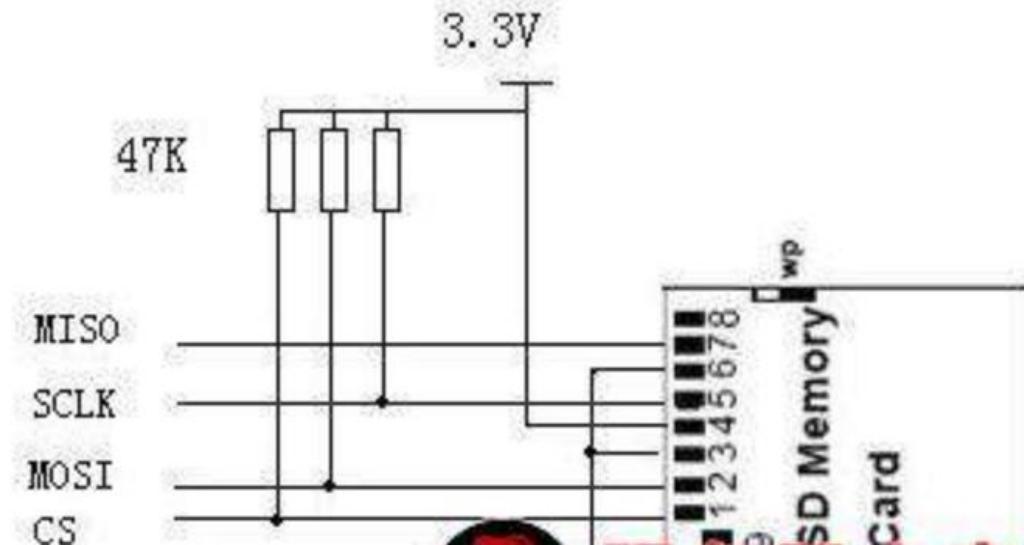
	Forced Continuous Mode	Pulse Skipping Mode	Burst Mode
Light Load Efficiency	Okay	Good	Best
Load Regulation	Best	Good	Okay
Noise	Best	Good	Okay

Many Power-by-Linear products offer selectable light load modes of operation.

系统电流的优化 - I/O电流及漏电问题



SD Card SPI Model



系统电流的优化 - 如何进一步降低待机功耗

I_{IL}	逻辑0输入电流 (Ports 1,2,3)	$V_{IN} = 0.45V$	$V_{IN} = V_{CC}$	-50	μA
I_{IL}	逻辑1到0转换电流 (Ports 1,2,3)	$V_{IN} = 2V, V_{CC} = 5V \pm 10\%$		-650	μA
I_U	输入漏电流 (Port 0, \bar{EA})	$0.45 < V_{IN} < V_{CC}$		± 10	μA

上拉电阻极限状况下电流

$$5V/1K=5mA$$

$$5V/10K=0.5mA$$

$$5V/100K=0.05mA=50\mu A$$

$$5V/470K=0.01mA=10\mu A$$

20个上拉电阻合计电流

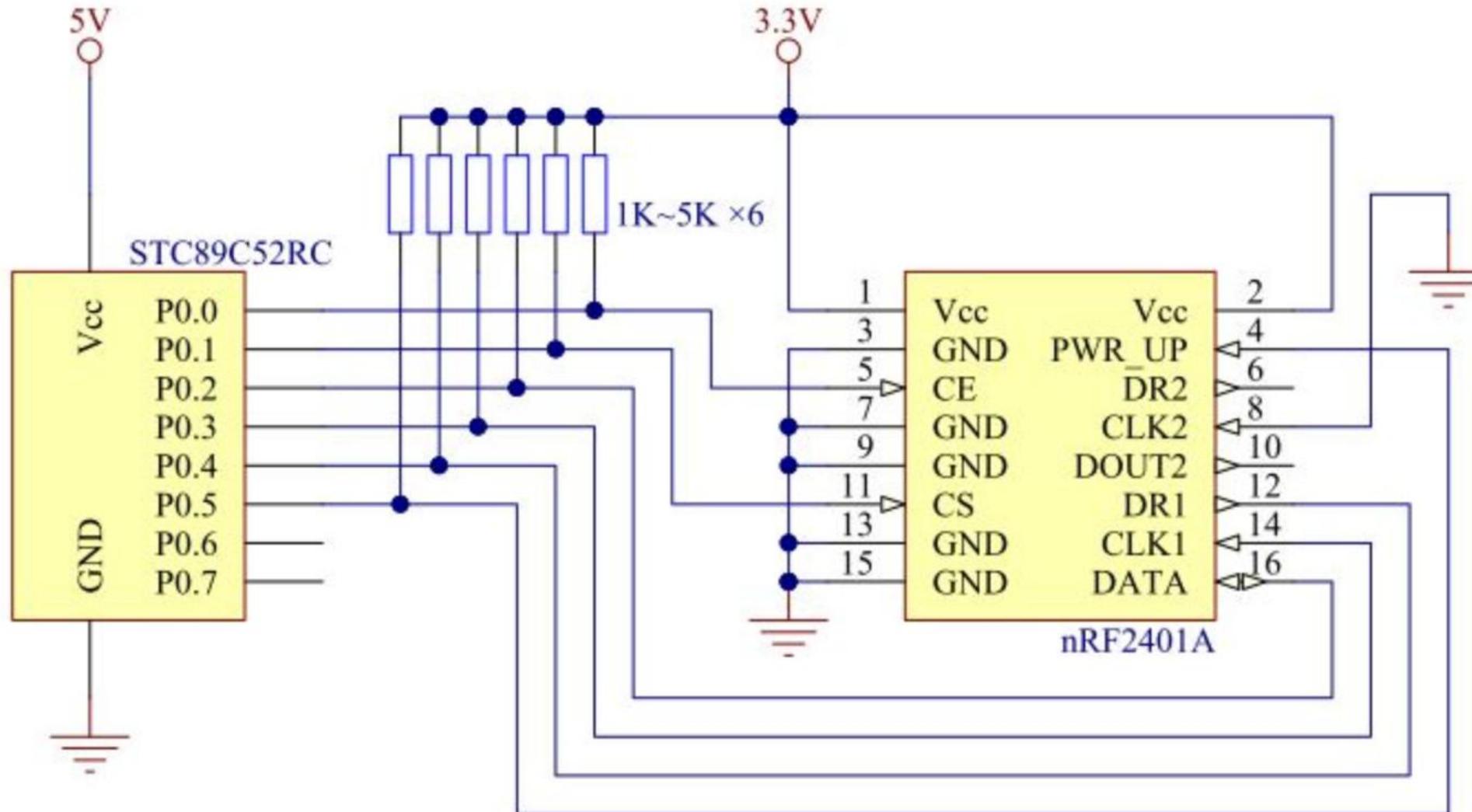
$$20*5mA=100mA$$

$$20*0.5mA=10mA$$

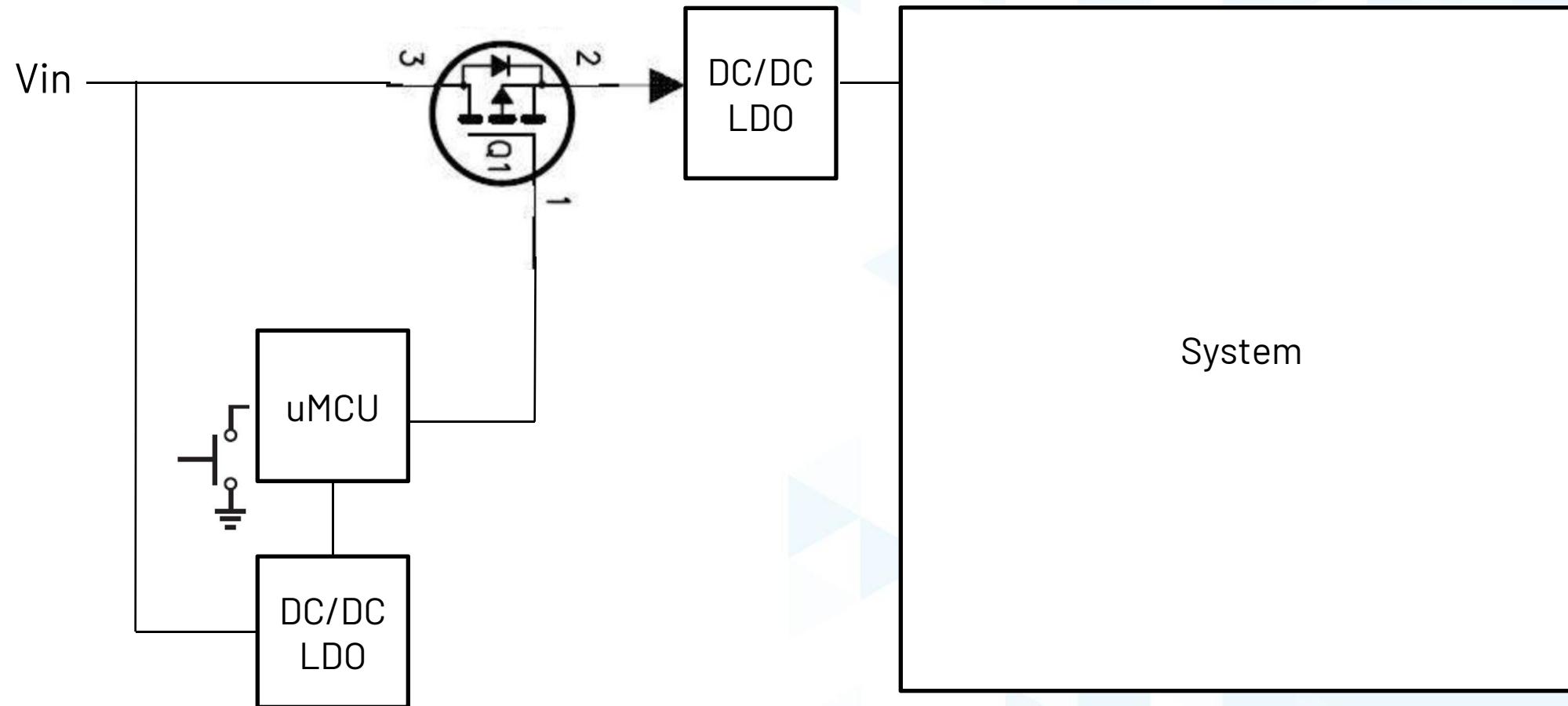
$$20*0.05mA=1mA$$

$$20*0.01mA=0.2mA$$

系统电流的优化 - I/O电流及漏电问题



系统开关机管理



Push-Button的工作原理

TYPICAL APPLICATION

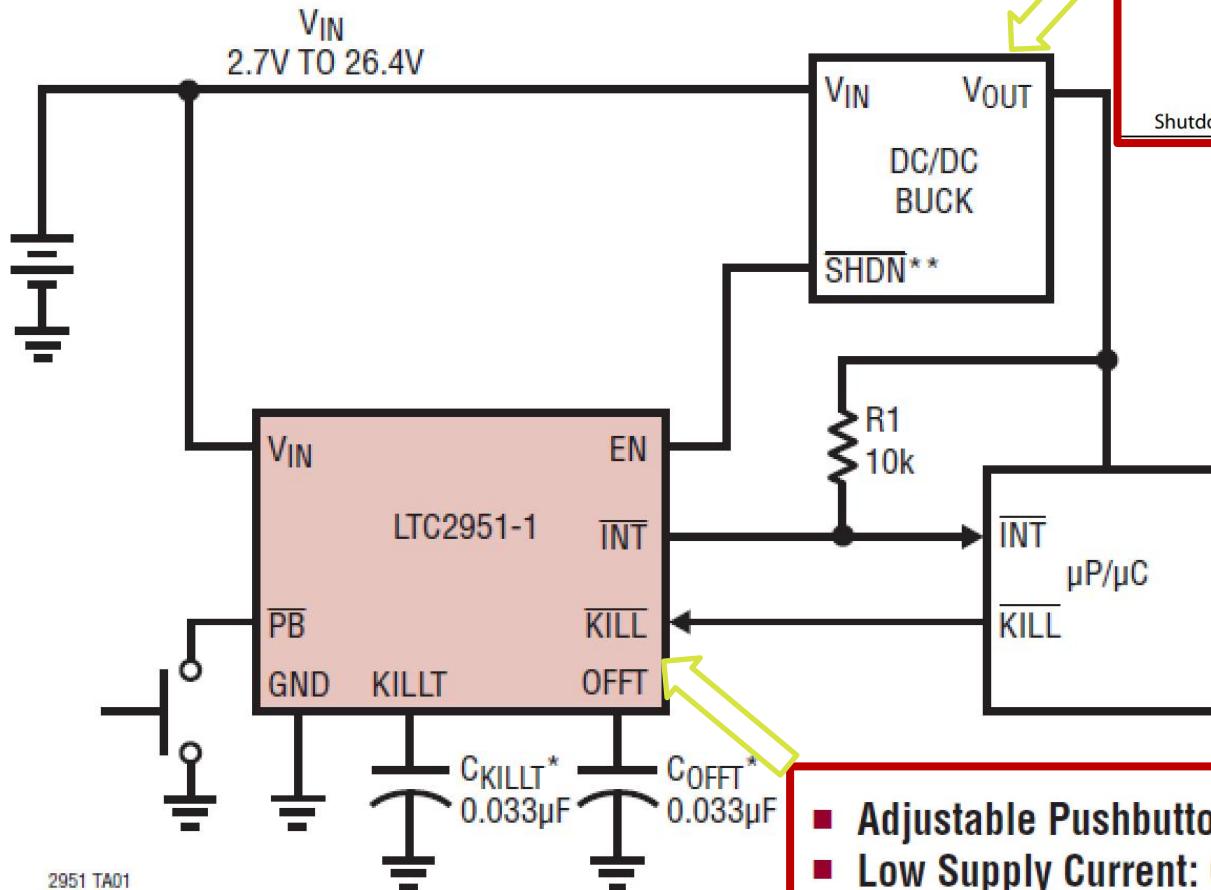
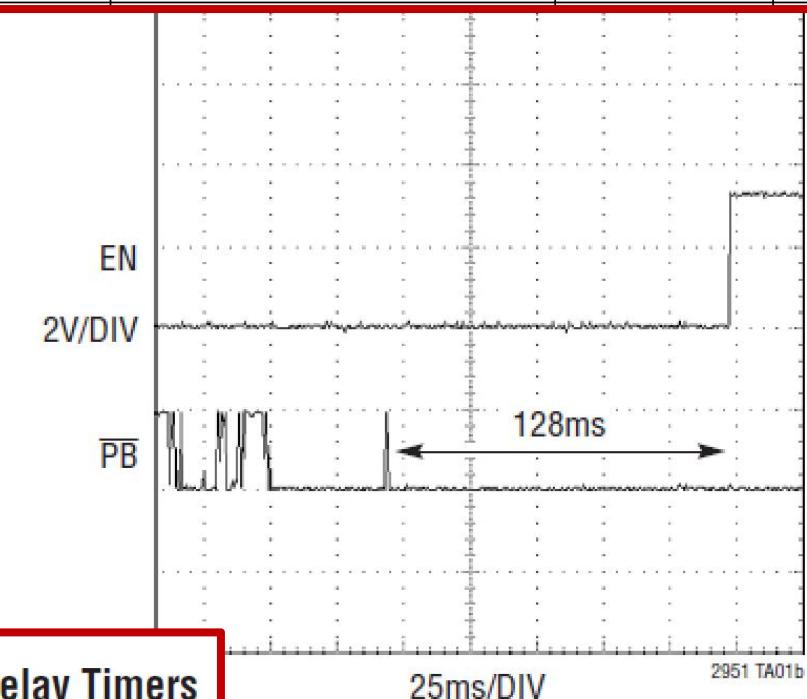


Table 1.

Parameter	Symbol	Test Conditions/Comments	Min	Typ	Max	Unit
SUPPLY						
Input Voltage Range	V_{IN}		3.2	13.5	15	V
Quiescent Current	I_{Q-PSM}	$FSEL = V_{IN}, SYNC = 0\text{ V}$, no load, device not switching				μA
	I_{Q-PWM}	$FSEL = V_{IN}, SYNC = V_{IN}$, no load, device not switching	725			μA
Shutdown Current	I_{SW-PWM}	$FSEL = V_{IN}, SYNC = V_{IN}$, no load, device switching	5.7			mA
	I_{SHUT}	$EN = \text{GND}, T_J = -40^\circ\text{C}$ to $+85^\circ\text{C}$	1.2	3.5		μA

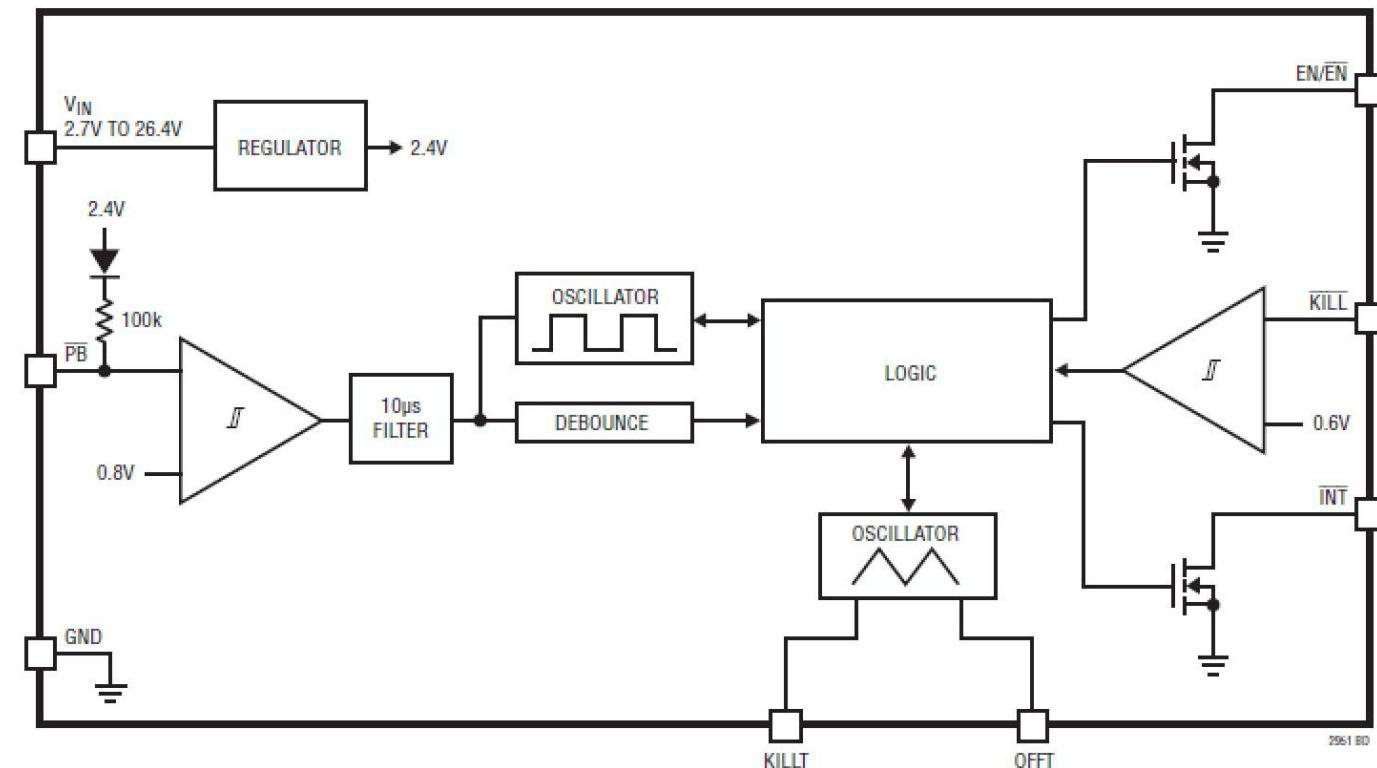


- Adjustable Pushbutton Debounce and Delay Timers
- Low Supply Current: 6 μ A

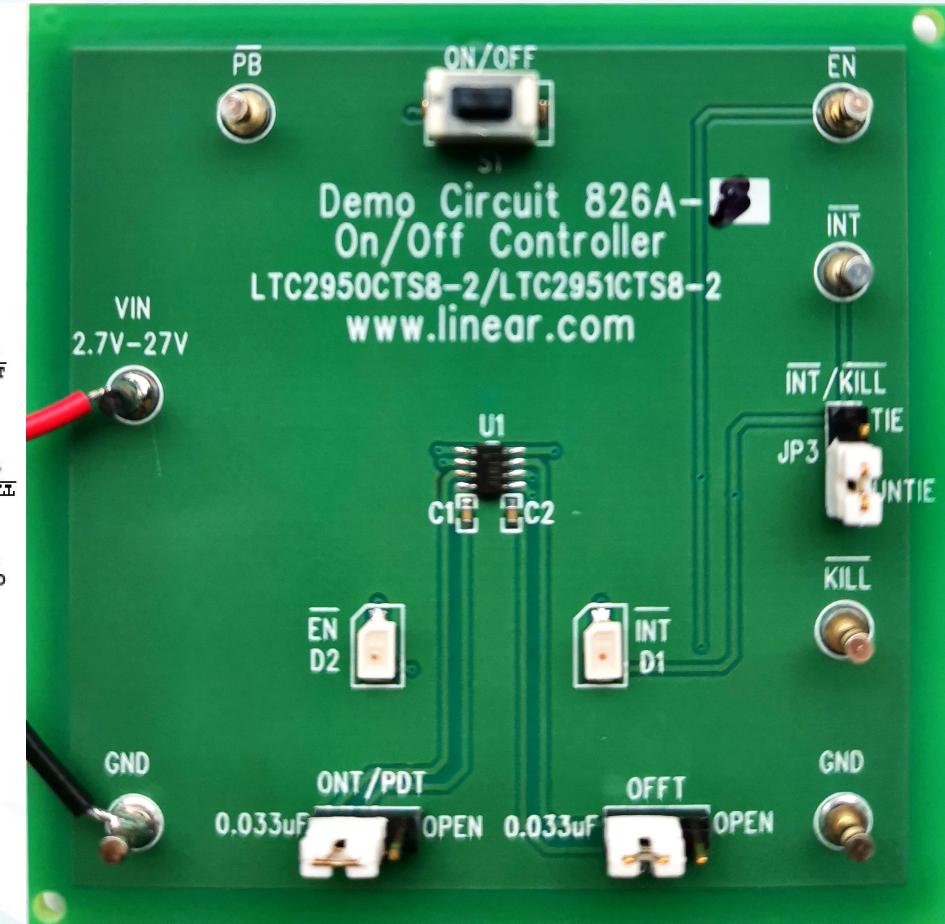
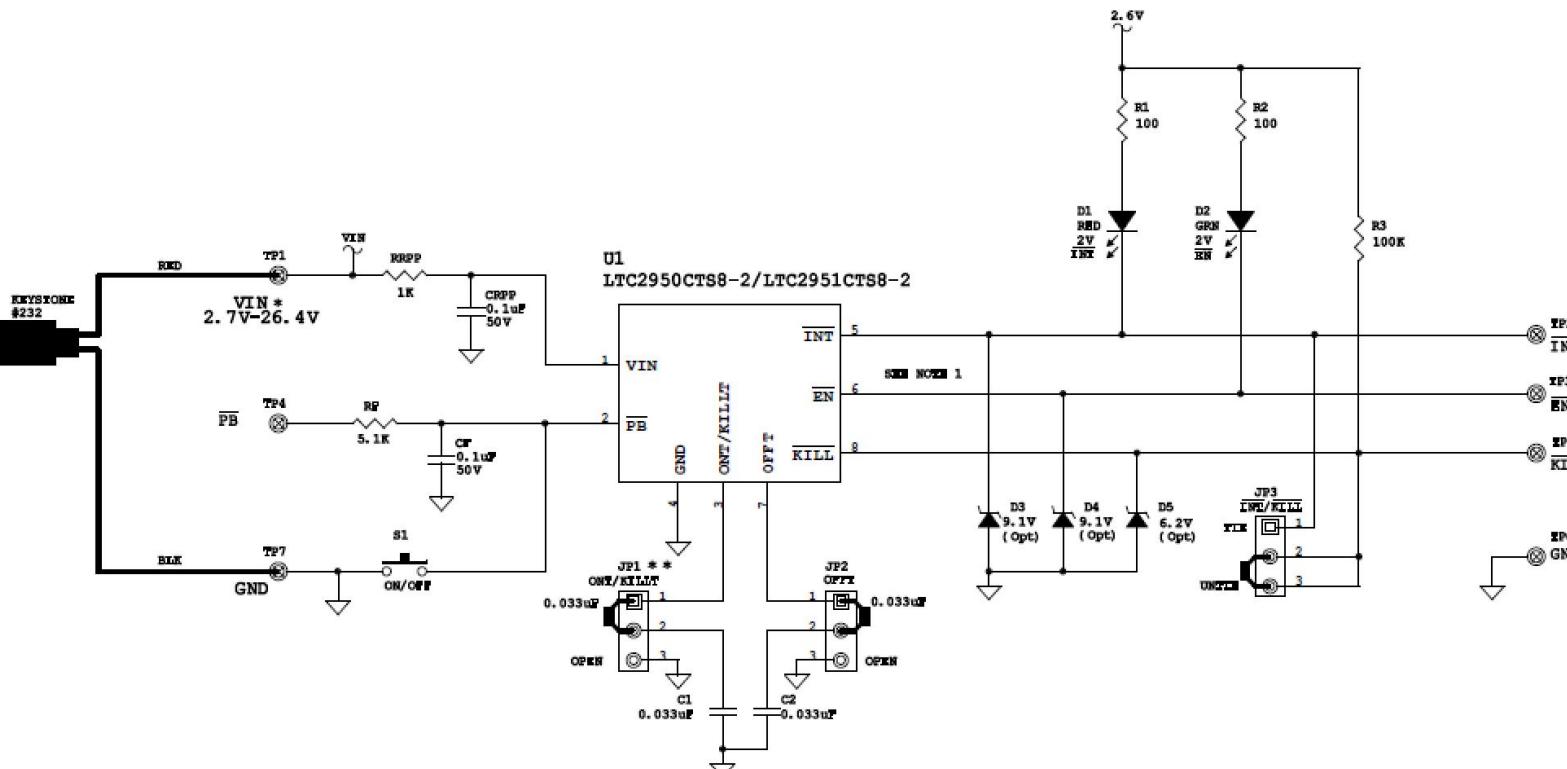
Push-Button的工作原理

FEATURES

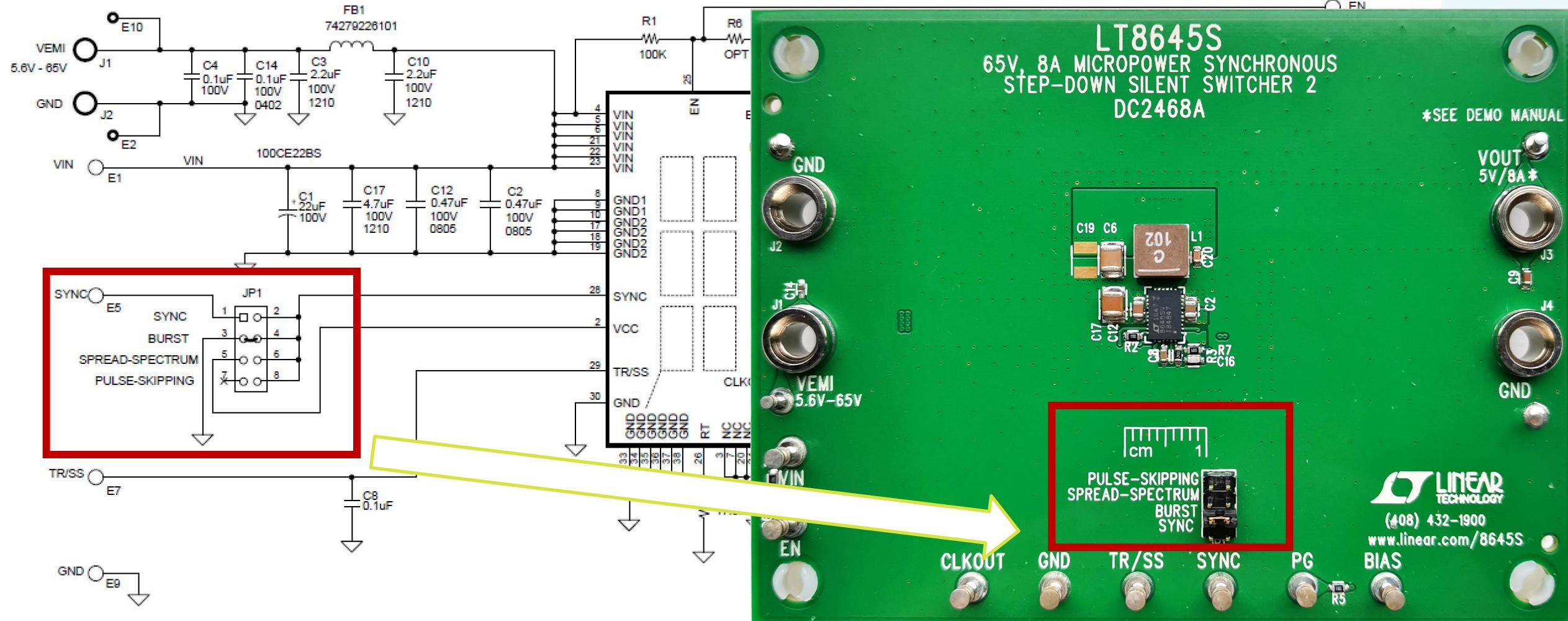
- Adjustable Pushbutton Debounce and Delay Timers
- Low Supply Current: $6\mu A$
- Wide Operating Voltage Range: 2.7V to 26.4V
- EN Output (LTC2951-1) Allows DC/DC Converter Control
- \overline{EN} Output (LTC2951-2) Allows Circuit Breaker Control
- Simple Interface Allows Graceful μP Shutdown
- High Input Voltage \overline{PB} Pin with Internal Pull-Up Resistor
- $\pm 10kV$ ESD HBM on \overline{PB} Input
- Accurate 0.6V Threshold on KILL Comparator Input
- 8-Pin 3mm \times 2mm DFN and ThinSOT™ Packages



实验：Push Button



实验：DC/DC 不同工作模式波形测试



中级第五讲：板级 小功率隔离电源设 计



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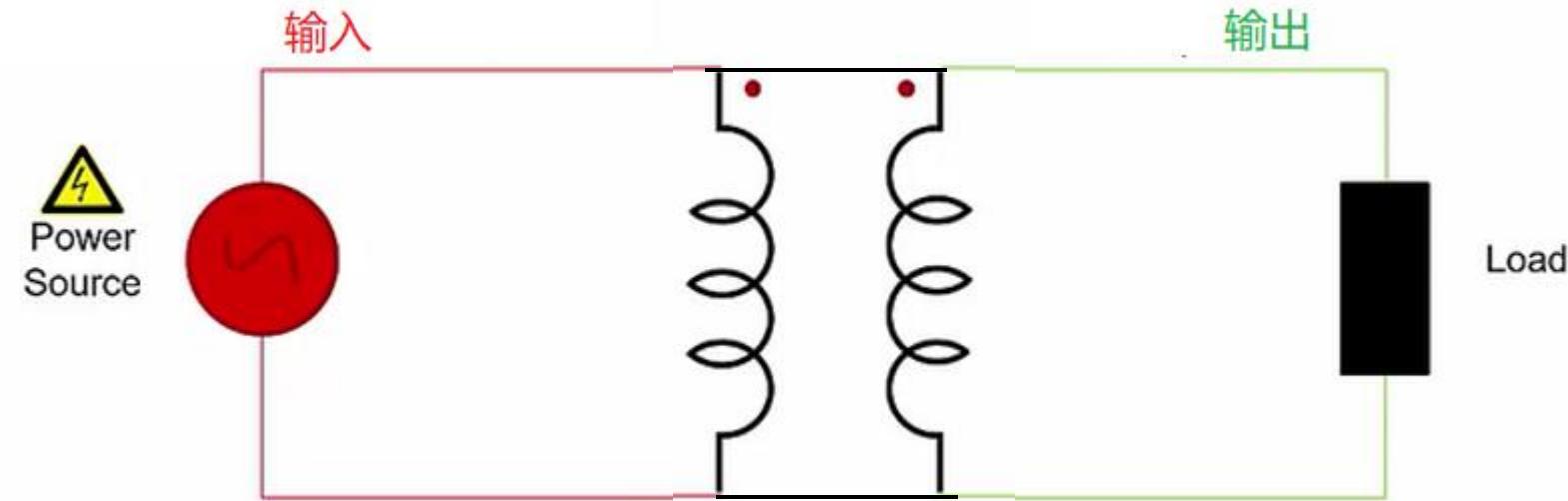
什么是隔离电源

输入：高输入，宽输入，高能量

输出：低输出，用户可接触

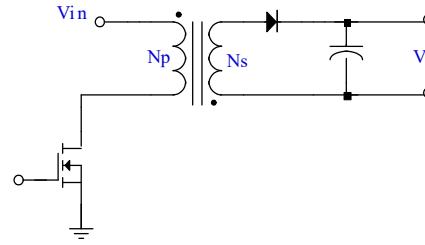
问题：占空比极低，危险

如何解决：隔离，变压



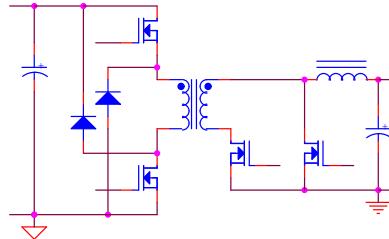
隔离电源种类

反激变换器



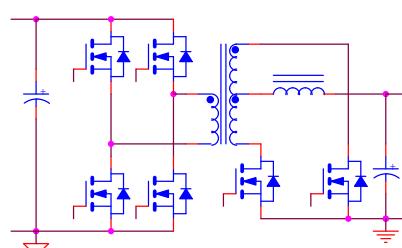
- 最简单的隔离拓扑 (1个开关管, 1个整流管, 1个变压器)
- 电压可升可降, 电压可正可负
- 可多路输出
- 小于60W
- 高电压应力

双管正激变换器



- 适中的隔离拓扑 (2个开关管, 2个整流管, 1个变压器, 1个电感)
- 小于300W
- 原边需要浮地驱动
- 不适合多路输出

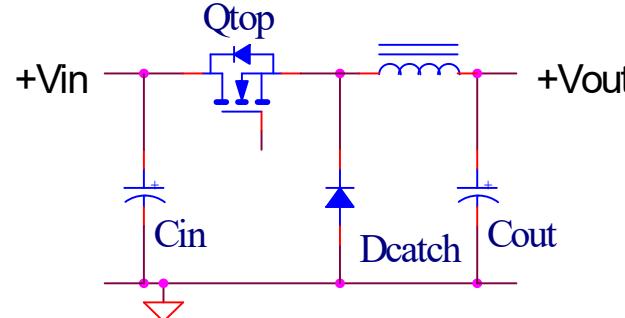
全桥变换器



- 适中的隔离拓扑 (2个开关管, 2个整流管, 1个变压器, 1个电感)
- 大于300W
- 原边需要浮地驱动
- 不适合多路输出

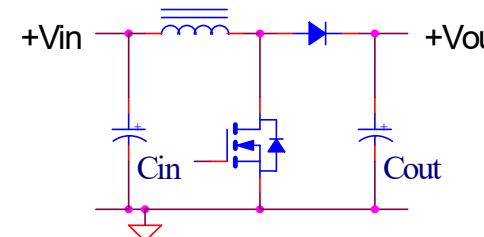
隔离拓扑起源

Buck



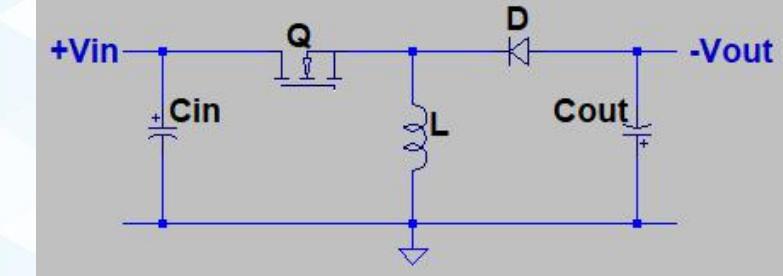
$$V_{OUT} = V_{IN} \cdot D$$

Boost



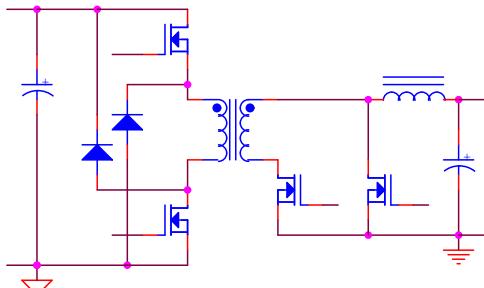
$$V_{OUT} = V_{IN}/(1 - D)$$

Inverting "Buck-Boost"



$$V_{OUT} = V_{IN} \cdot D/(1 - D)$$

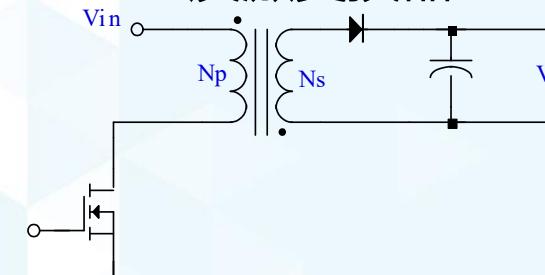
正激变换器，桥式变换器



$$V_{OUT} = (V_{IN}/n) \cdot D$$

$$n=N_p/N_s$$

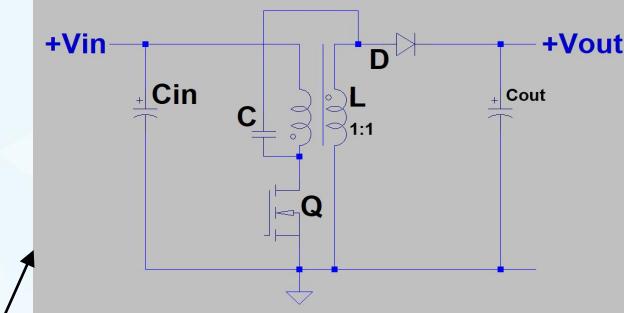
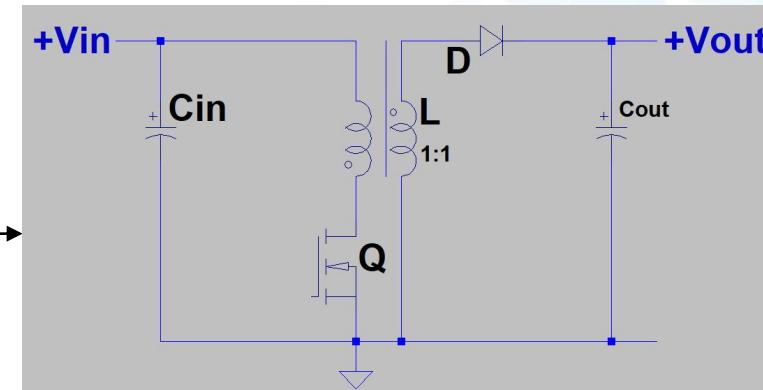
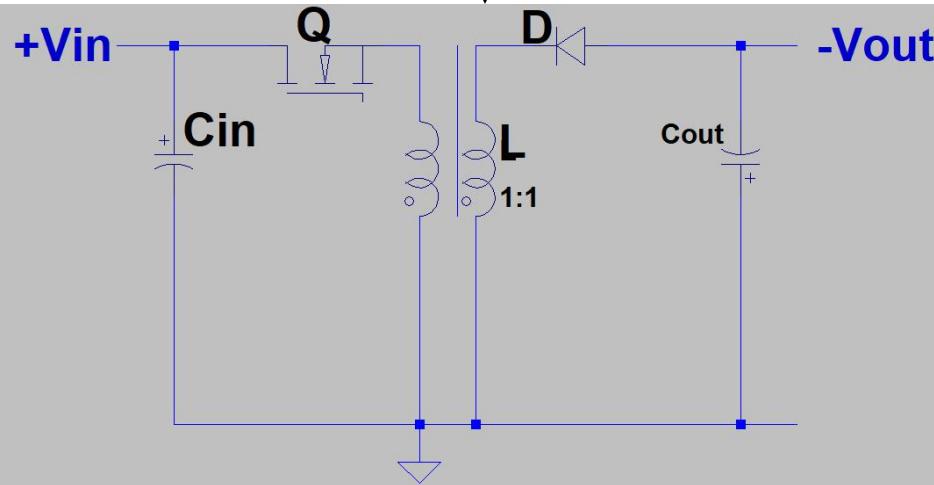
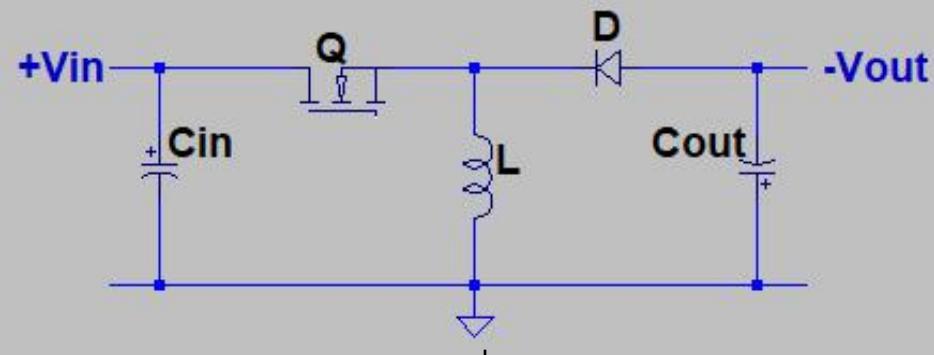
反激变换器



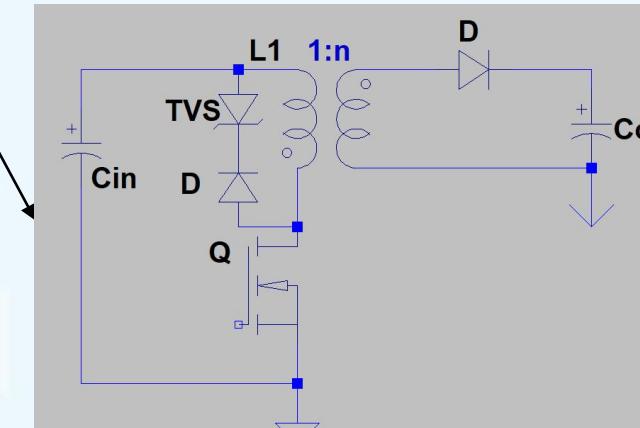
$$V_{OUT} = (V_{IN}/n) \cdot D/(1 - D)$$

反激变换器的由来

Inverting "Buck-Boost"



SEPIC

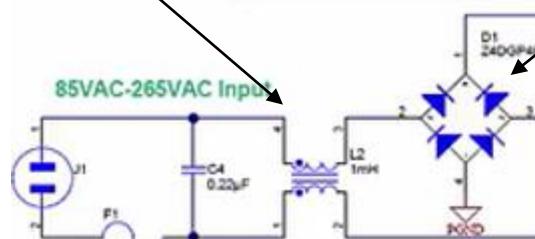


Flyback

典型的AC/DC反激构成

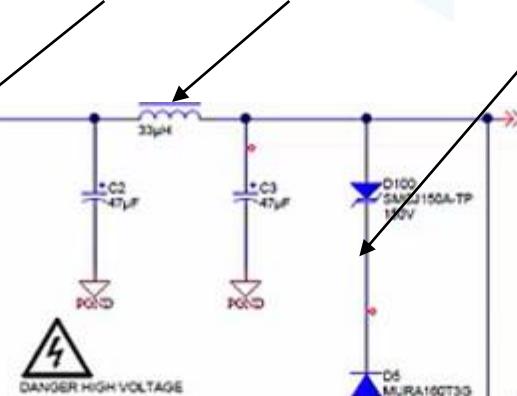
1.输入防护

(保险, NTC, MOV, EMC滤波等)



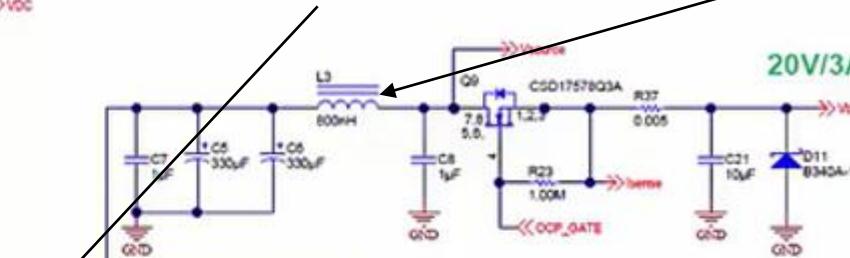
2.整流桥

3.滤波 4.漏感钳位电路

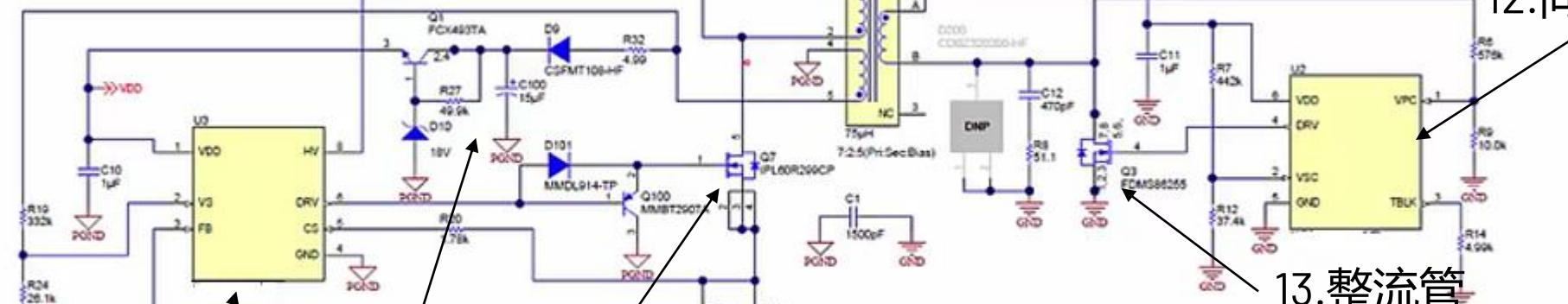


8.变压器 (耦合电感)

11.后级LC滤波



12.同步整流控制器



5.控制器

6.辅助电源

7.开关管

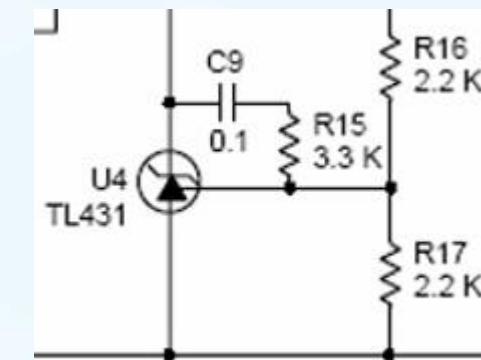
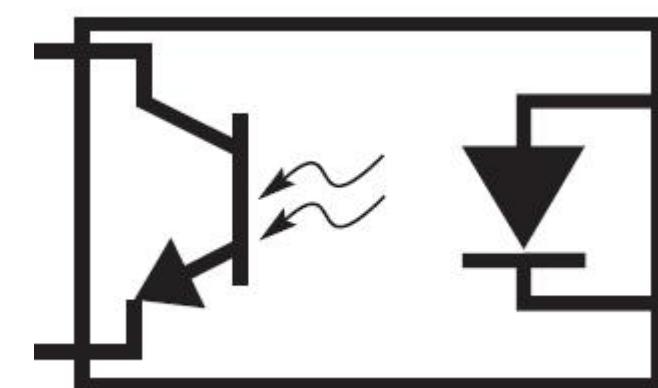
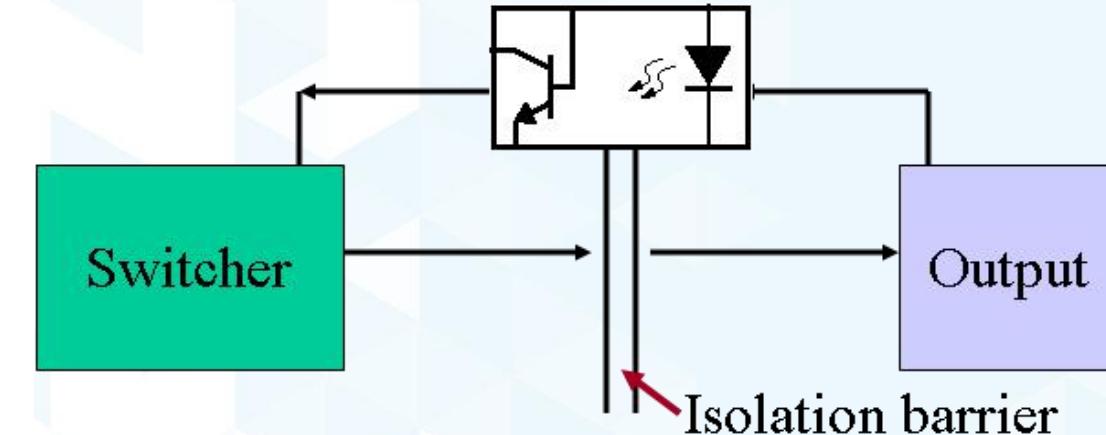
13.整流管

9.光耦

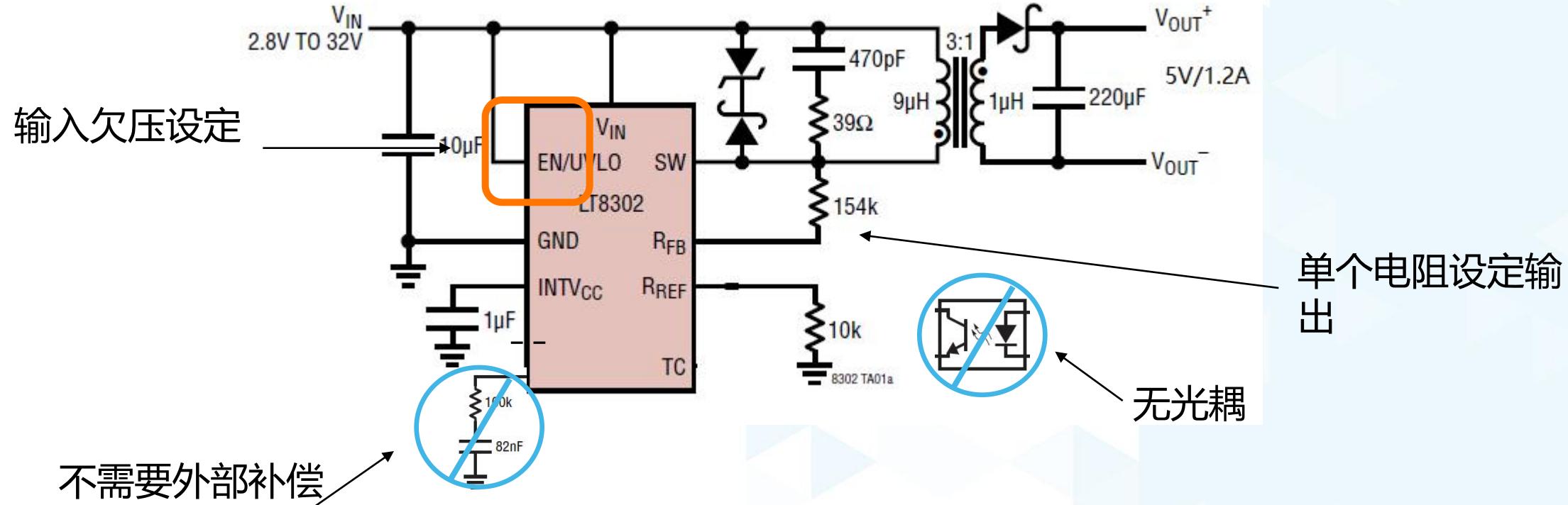
10.TL431反馈

常见的反馈方式和光耦

- 传统的反馈方式：TL431+光耦
- 传统方式的问题：电路复杂，光耦问题
- 光耦问题：
 - 低速
 - 光耦寿命问题
 - 大尺寸
 - 成本
- ADI推出无光耦反激电路



ADI无光耦反激电路



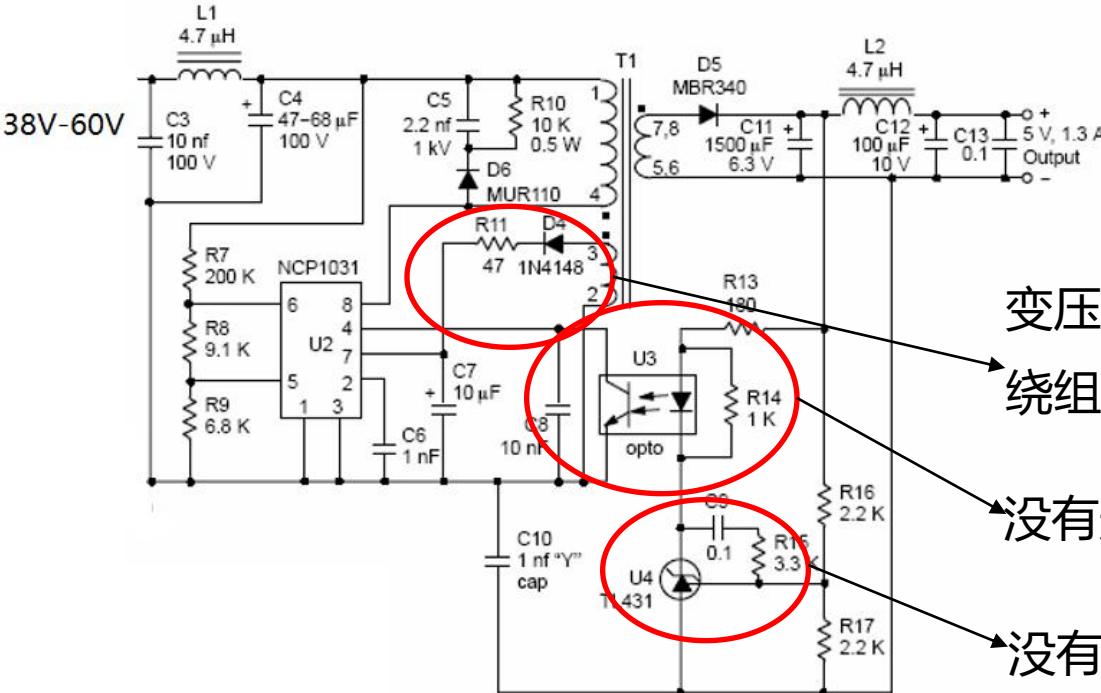
ADI集成MOS无光耦反激系列



Part	VIN	IQ (Sw On/ Sw Off)	Power Switch	POUT	Package
LT8301	2.8V-42V	350uA/100uA	1.2A/65V DMOS	up to 6W	SOT23-5
LT8302	2.8V-42V	380uA/106uA	3.6A/65V DMOS	up to 18W	SO-8E
LT8300	6V-100V	330uA/70uA	260mA/150V DMOS	up to 2.5W	SOT23-5
LT8303	5.5V-100V	280uA/70uA	450mA/150V DMOS	Up to 5W	SOT-23-5
LT8304	3V-100V	390uA/116uA	2A/150V DMOS	Up to 24W	SO-8E
LT8315	18V-560V	470uA/70uA	300mA/630V	Up to 15W	TSSOP

方案对比1-复杂度对比

POE应用：PD设备54V输入/5V/1.5A输出

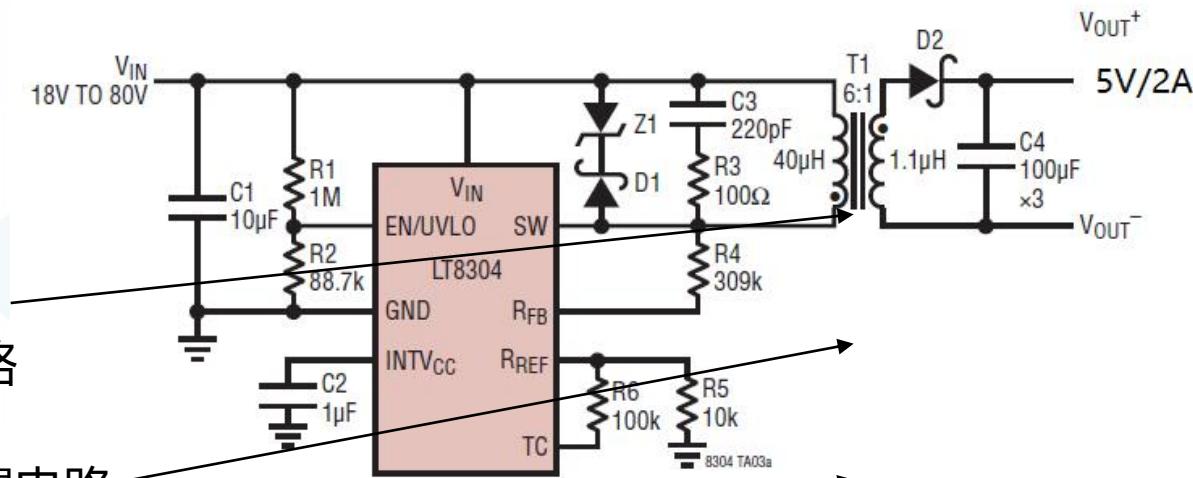


变压器没有第3绕组和整流电路

没有光耦和偏置电路

没有TL431和环路补偿

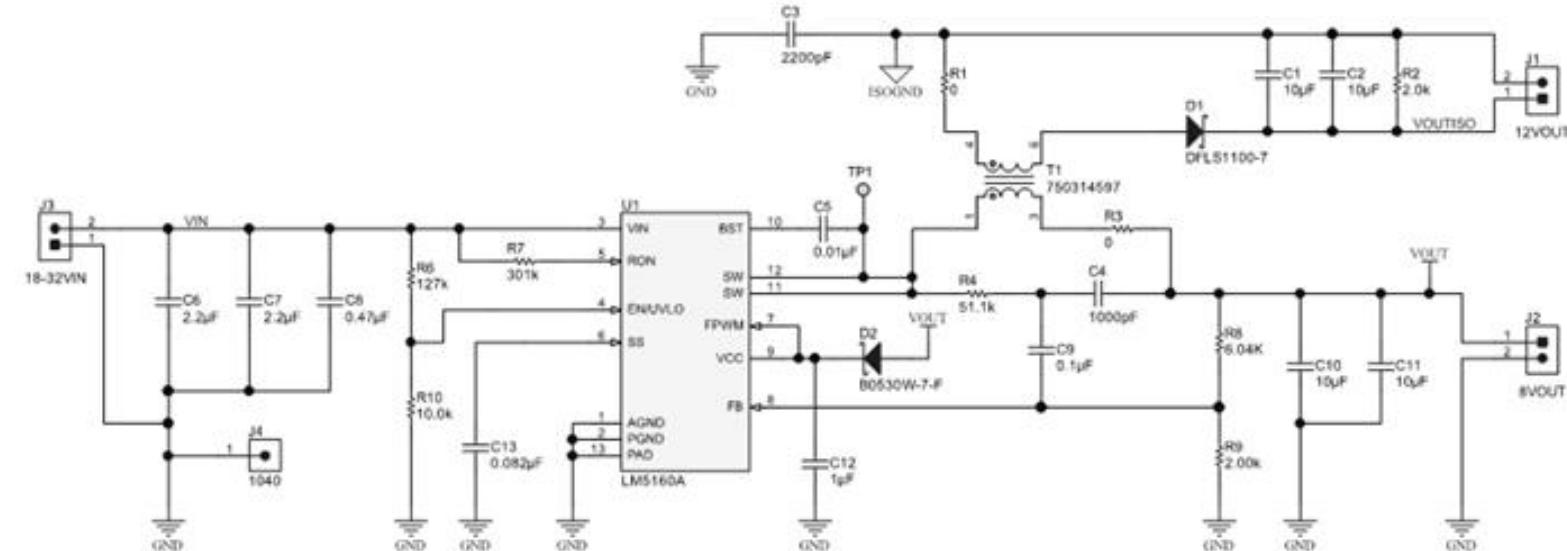
来自ON网站



方案对比2-复杂度对比

工业应用：输入18V-32V/输出12V/0.4A

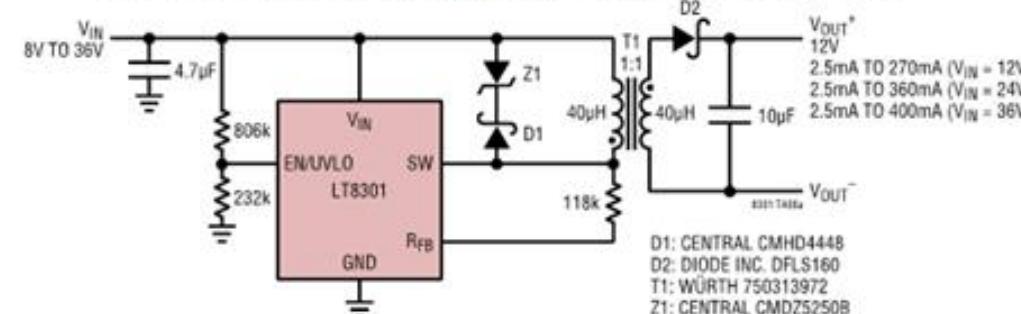
18V to 32V_{IN}/12V_{OUT} Fly-Buck with LM5160A



同样都是没有光耦的方案，
LT8301外围电路更简洁

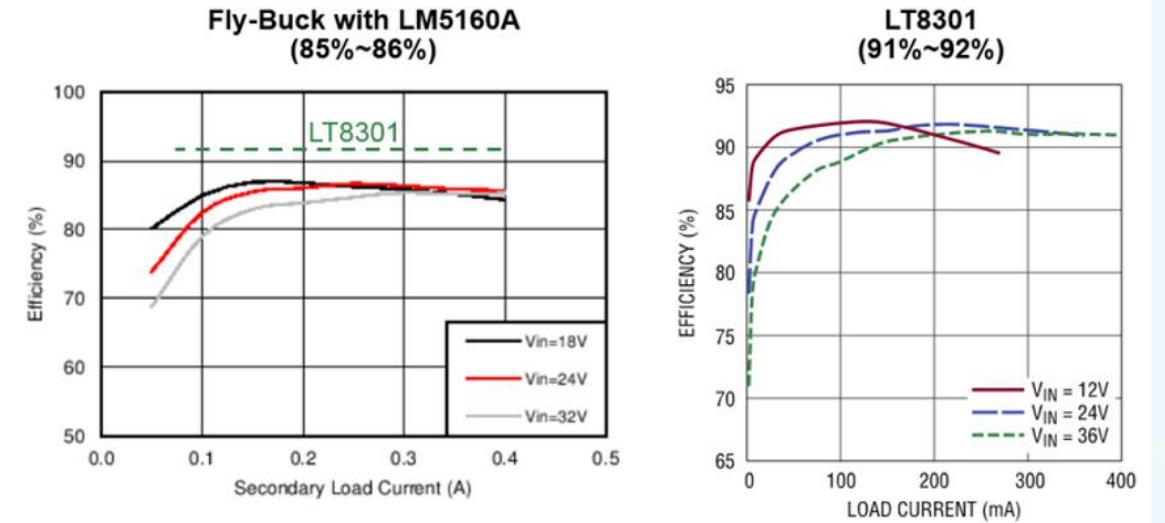
LM5160A图纸来自TI网站

8V to 36V_{IN}/12V_{OUT} Flyback with LT8301

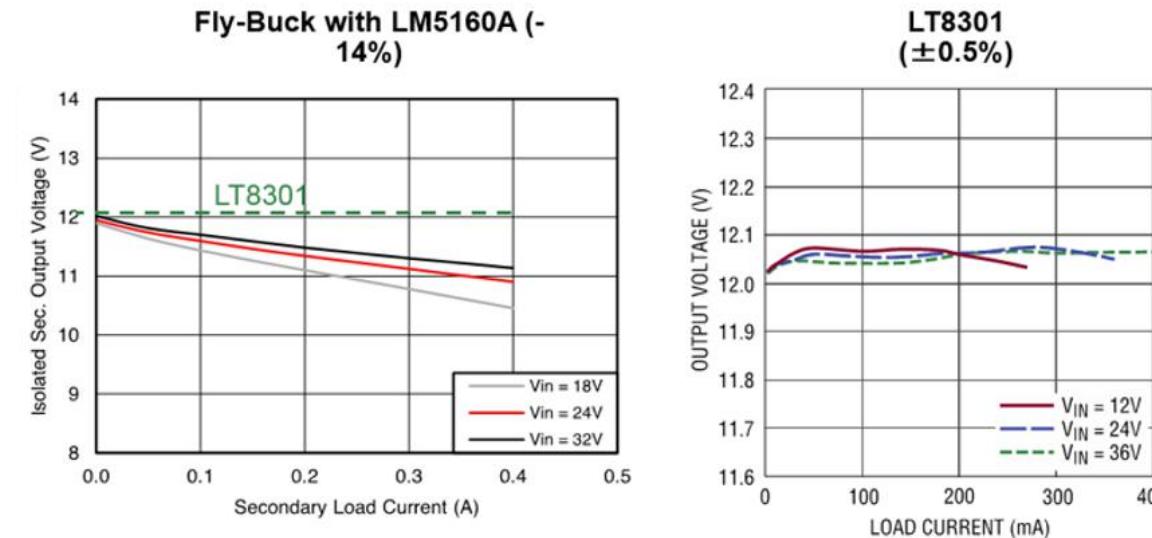


方案对比2-性能对比

效率对比，LT8301比LM5160A高6%



输出稳压精度对比，LT8301比LM5160A更高



LM5160A数据来自TI网站

方案对比3-交叉调整率对比

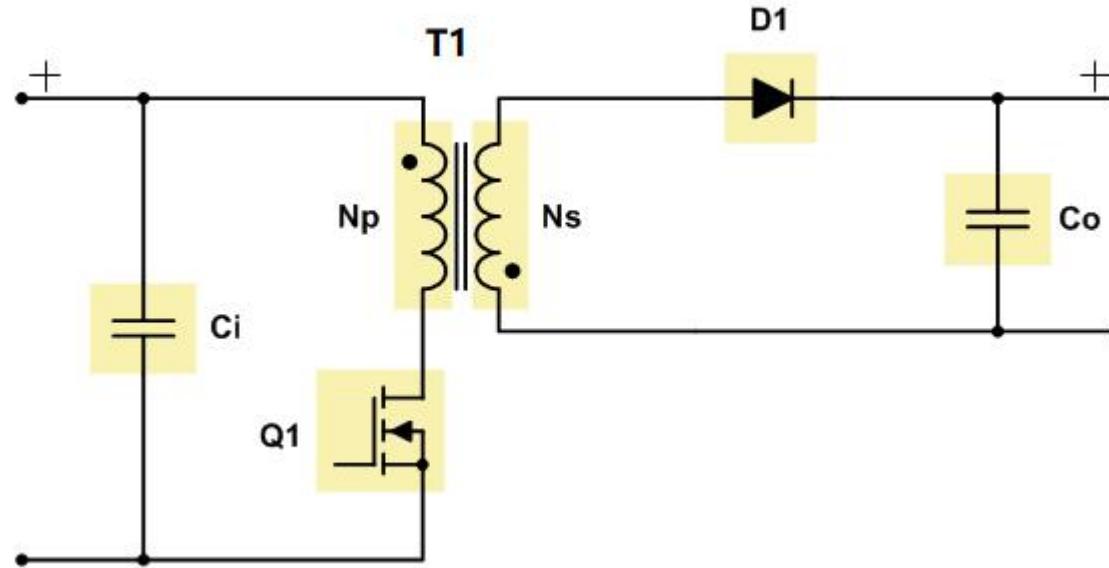
URA2412ZP-6WR3 vs LT8304
测试数据

24V input Test condition	+12V/-12V Competitor	+12V/-12V ADI	Comments
+0.25A/-0A	12.03/ -14.33	12.08/-12.36	竞争对手的模块输出有主从之分，当两路负载出现不平衡时，从路的稳压精度差
+0.25A/-0.025A	12.02/-12.33	12.09/-12.31	
+0.25A/-0.25A	12.03/-12.0	12.28/-12.14	
+0.025A/-0.25A	12.03/-11.67	12.39/-12.08	
+0A/-0.25A	12.03/ -3.0	12.42/-12.08	

URA2405ZP-6WR3 vs LT8304
测试数据

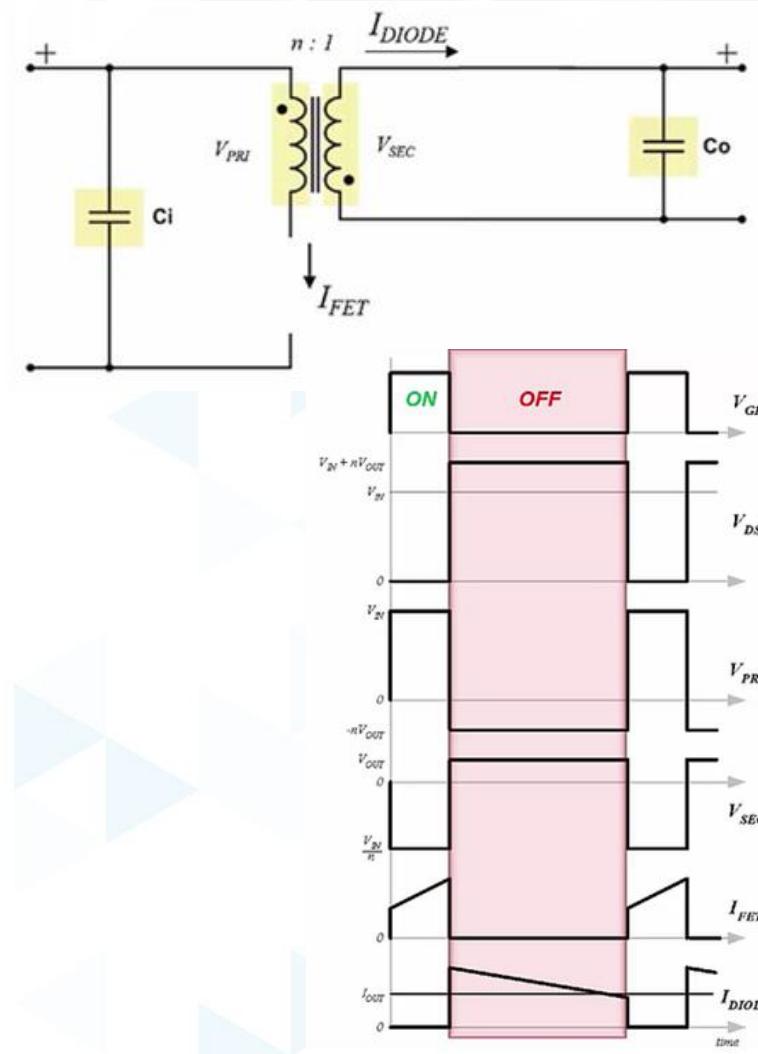
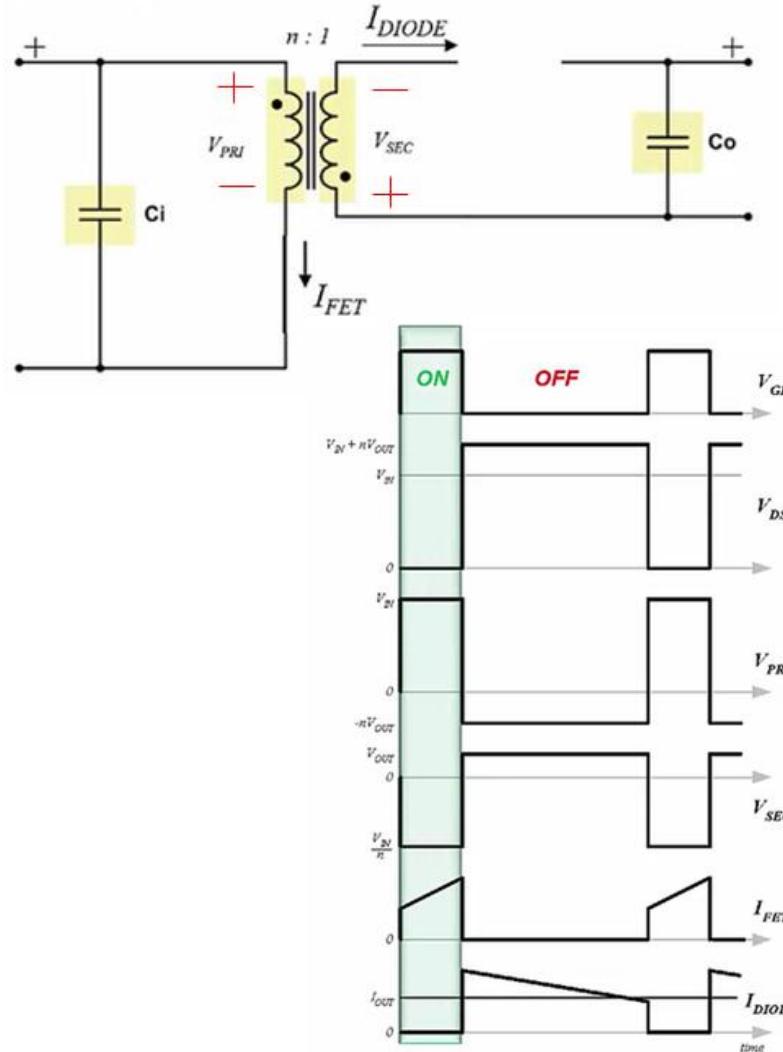
24V input Test condition	+5V/-5V Competitor	+5V/-5V ADI	Comments
+0.6A/-0A	4.99/ -8.09	5.05/-5.75	竞争对手的模块输出有主从之分，当两路负载出现不平衡时，从路的稳压精度差
+0.6A/-0.06A	4.99/-5.33	5.05/-5.3	
+0.6A/-0.6A	4.99/-4.99	5.09/-5.09	
+0.06A/-0.6A	5.02/-4.75	5.37/-5.06	
+0A/-0.6A	5.03/ -3.39	5.81/-5.07	

反激变换器

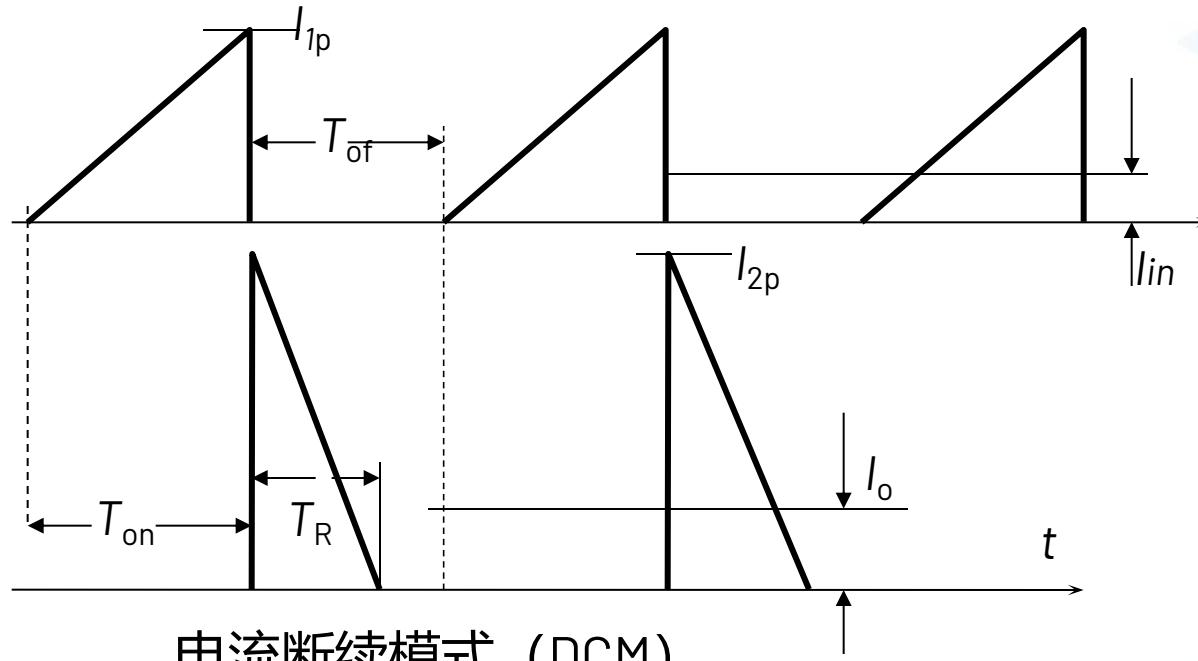


3个元件 (Q_1, T_1, D_1)=低成本，小体积
 Q_1 导通存储能量
 Q_2 截止传送能量

Isolated Topology



电流连续模式和电流断续模式



电流断续模式 (DCM)

功率晶体管零电流开通，开通损耗小

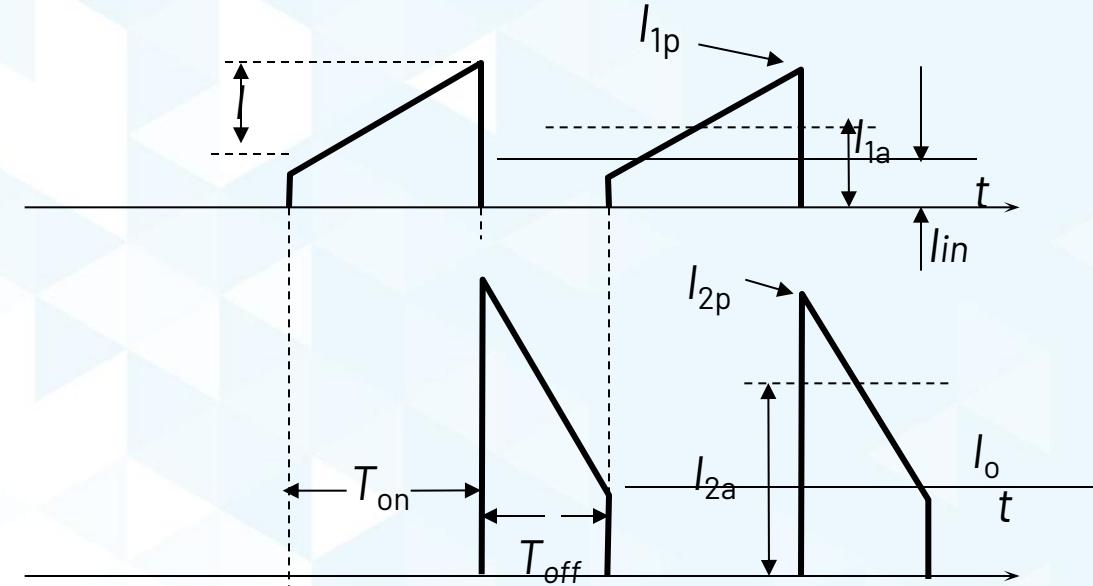
而二极管零电流关断，可以不考虑反向恢复问题

电感量小，尺寸小

次级峰值电流 I_{2p} 高，输出电容压力大

初级峰值电流 I_{1p} 大（如果 $D=0.5$ ， $I_i=I_{1p}/4$ ）

关断损耗很大，漏感对效率影响大



电流连续模式 (CCM)

次级峰值电流 I_{2p} 小，适合大一点的电流输出

初级峰值电流 I_{1p} 小，（如果 $D=0.5$ ， $I_i=I_{1p}/2$ ）

关断损耗小，漏感对效率影响小

功率晶体管开通有电流尖峰，需要屏蔽掉

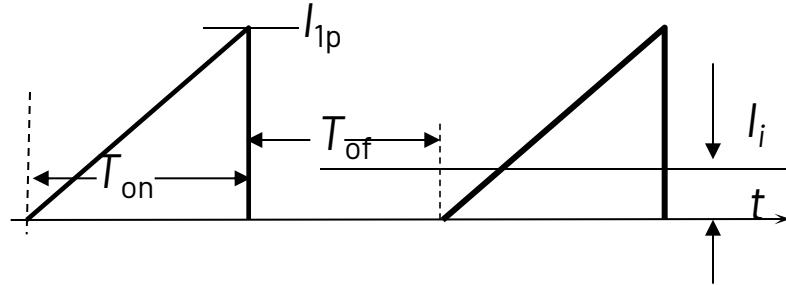
二极管强迫关断，有反向恢复，电压应力大

电感量大，尺寸大

电流断续模式(DCM)

如何让电路工作在电流断续模式?

取决于变压器的电感量，最大是负载如果是断续，那么基本都是断续工作。



$$I_{1p} = \frac{U_i T_{on}}{L_1} = \frac{U_i D}{L_1 f} \quad \text{导通期间存储能量} \quad W = \frac{L_1 I_{1p}^2}{2}$$

稳态输入功率 $P_i = Wf = \frac{L_1 f I_{1p}^2}{2} = \frac{P_o}{\eta}$

$$P_o = \frac{(U_i D)^2 \eta}{2 f L_1} \quad L_1 = \frac{(U'_{i min} D_{max})^2 \eta_T}{2 f P'_o}$$

V_{in} : 24V, $D=0.5, f=100\text{KHZ}, P_o=20\text{W}$

$L=31\mu\text{H}$

电流连续模式(CCM)

如何让电路工作在电流连续模式?

取决于变压器的电感量，重载连续，允许轻载进入断续工作。

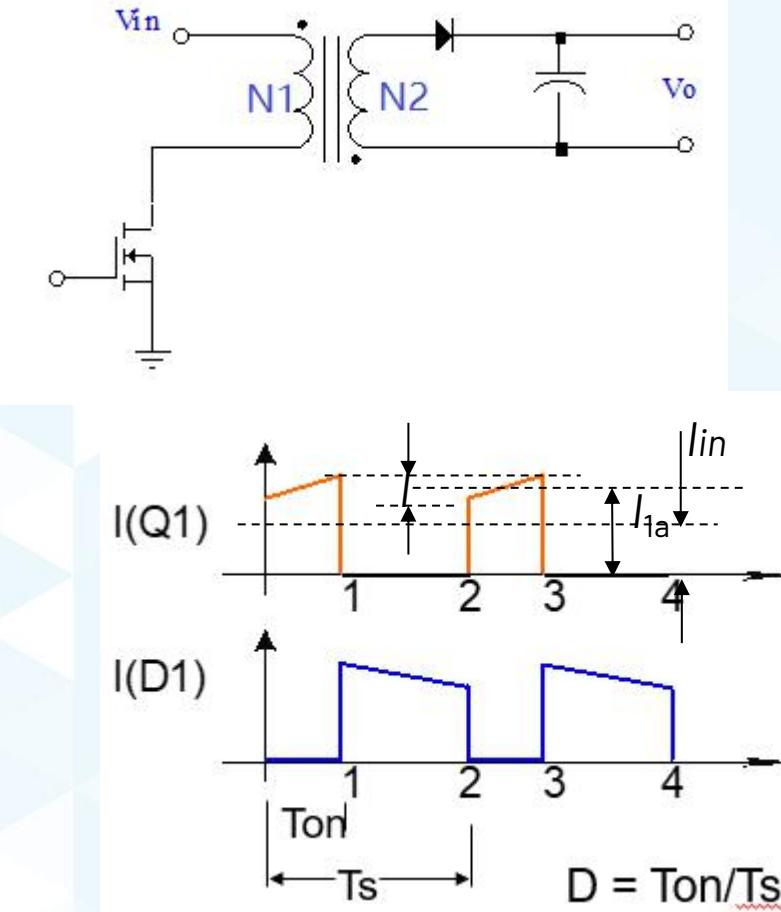
$$U_o = \frac{U_i N_2 T_{on}}{N_1 T_{off}} = \frac{U_i D}{n(1 - D)}$$

$$I_{1a} = \frac{P_o}{V_{in} * D * \eta} \quad \Delta I_1 = k * I_{1a} \quad \text{选取} \quad I/I_a = 0.2$$

$$L_1 \geq \frac{U'_i D}{\Delta I_1 f} = \frac{\eta (U'_{i min} D_{max})^2}{0.2 P'_o f}$$

V_{in} : 24V, $D=0.5$, $f=100\text{KHZ}$, $P_o=20\text{W}$,

$L=306\mu\text{H}$, 连续模式电感量会大很多



变压器设计流程

1. 确定频率和 ΔB

2. 确定 V_{inmin} 和 D_{max}

3. 计算变压器匝比

4. 选择合适的磁芯

5. 计算原边电感量

6. 计算线圈匝数

7. 计算磁芯气隙

Parameter/Equation	Value	Unit	Comment
$F_s/\Delta B$	50-300/0.1-0.2	KHZ/Tesla	取决于频率和散热条件
V_{inmin}/D_{max}	<0.8		
Parameter/Equation	Value	Unit	Comment
$F_s/\Delta B$	50-300/0.1-0.2	KHZ/Tesla	取决于频率和散热条件
V_{inmin}/D_{max}	<0.8		根据控制器规格书
$N_{ps} < \frac{V_{ds}-V_{inmin}-V_{leakage}}{V_{out}}$			根据最大占空比限制以及器件耐压限制，结果尽量取整方便后面匝数选择
$N_{ps} < \frac{V_{inmin}-D_{max}}{V_{out}*(1-D_{max})}$			
L_e/A_e	>10	mm/mm²	根据经验选一个差不多大小尺寸
DCM		uH	固定频率的DCM或CCM公式
CCM			
$N_p = \frac{L_{pri} + L_{swmax}}{\Delta B * A_e}$	$N_p = \frac{V_{in} + D + T}{\Delta B * A_e}$		取整数匝
$N_s = N_p / N_{ps}$			
$L = N_p^2 * u_0 * A_e / l_g$		mm	$R_m = \frac{l_g}{u_0 * A_e} + \frac{l_c}{U_o + U_r * A_e} \approx \frac{l_g}{U_o * A_e}$ $AL = \frac{2\pi m}{l_g} = \frac{l_g}{U_o * A_e}$ $L_{pri} = N_p^2 * AL$
Parameter/Equation	Value	Unit	Comment
$F_s/\Delta B$	50-300/0.1-0.2	KHZ/Tesla	取决于频率和散热条件
V_{inmin}/D_{max}	<0.8		根据控制器规格书
$N_{ps} < \frac{V_{ds}-V_{inmin}-V_{leakage}}{V_{out}}$			根据最大占空比限制以及器件耐压限制，结果尽量取整方便后面匝数选择
$N_{ps} < \frac{V_{inmin}-D_{max}}{V_{out}*(1-D_{max})}$			
L_e/A_e	>10	mm/mm²	根据经验选一个差不多大小尺寸
DCM		uH	固定频率的DCM或CCM公式
CCM			
$N_p = \frac{L_{pri} + L_{swmax}}{\Delta B * A_e}$	$N_p = \frac{V_{in} + D + T}{\Delta B * A_e}$		取整数匝
$N_s = N_p / N_{ps}$			
$L = N_p^2 * u_0 * A_e / l_g$		mm	$R_m = \frac{l_g}{u_0 * A_e} + \frac{l_c}{U_o + U_r * A_e} \approx \frac{l_g}{U_o * A_e}$ $AL = \frac{2\pi m}{l_g} = \frac{l_g}{U_o * A_e}$ $L_{pri} = N_p^2 * AL$
Parameter/Equation	Value	Unit	Comment
$F_s/\Delta B$	50-300/0.1-0.2	KHZ/Tesla	取决于频率和散热条件
V_{inmin}/D_{max}	<0.8		根据控制器规格书
$N_{ps} < \frac{V_{ds}-V_{inmin}-V_{leakage}}{V_{out}}$			根据最大占空比限制以及器件耐压限制，结果尽量取整方便后面匝数选择
$N_{ps} < \frac{V_{inmin}-D_{max}}{V_{out}*(1-D_{max})}$			
L_e/A_e	>10	mm/mm²	根据经验选一个差不多大小尺寸
DCM		uH	固定频率的DCM或CCM公式
CCM			
$N_p = \frac{L_{pri} + L_{swmax}}{\Delta B * A_e}$	$N_p = \frac{V_{in} + D + T}{\Delta B * A_e}$		取整数匝
$N_s = N_p / N_{ps}$			
$L = N_p^2 * u_0 * A_e / l_g$		mm	$R_m = \frac{l_g}{u_0 * A_e} + \frac{l_c}{U_o + U_r * A_e} \approx \frac{l_g}{U_o * A_e}$ $AL = \frac{2\pi m}{l_g} = \frac{l_g}{U_o * A_e}$ $L_{pri} = N_p^2 * AL$

反激变压器气隙

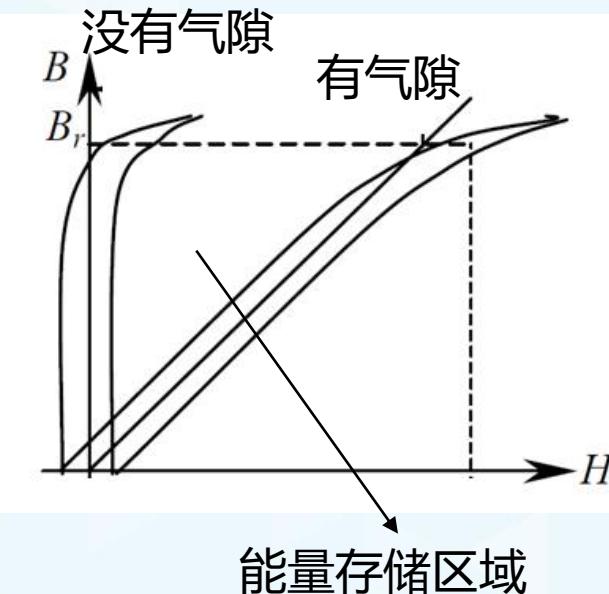
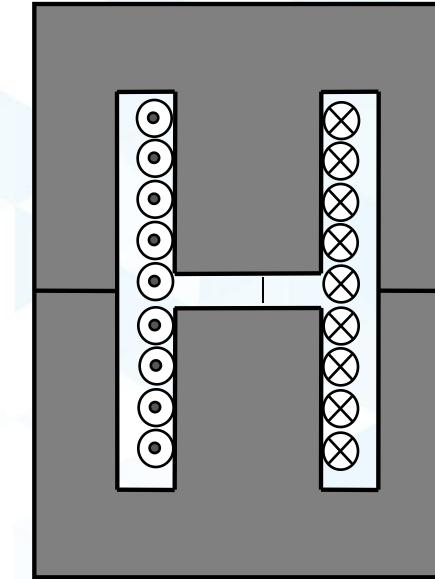
反激变压器实际是个电感(耦合电感). 需要能量存储过程，磁芯是存储不了多少能量的，容易饱和，能量主要存储在气隙中。

$$E_{\text{core}} = \frac{B^2 \times V_e}{2 \times \mu_0 \times \mu_e} \quad E_{\text{gap}} = \frac{B^2 \times V_e}{2 \times \mu_0}$$

引入磁阻概念 $R_m = l_e / (\mu_0 * u_r * A_e)$

$$L = N^2 * 1/R_m = N^2 * \mu_0 * u_r * A_e / l_e,$$

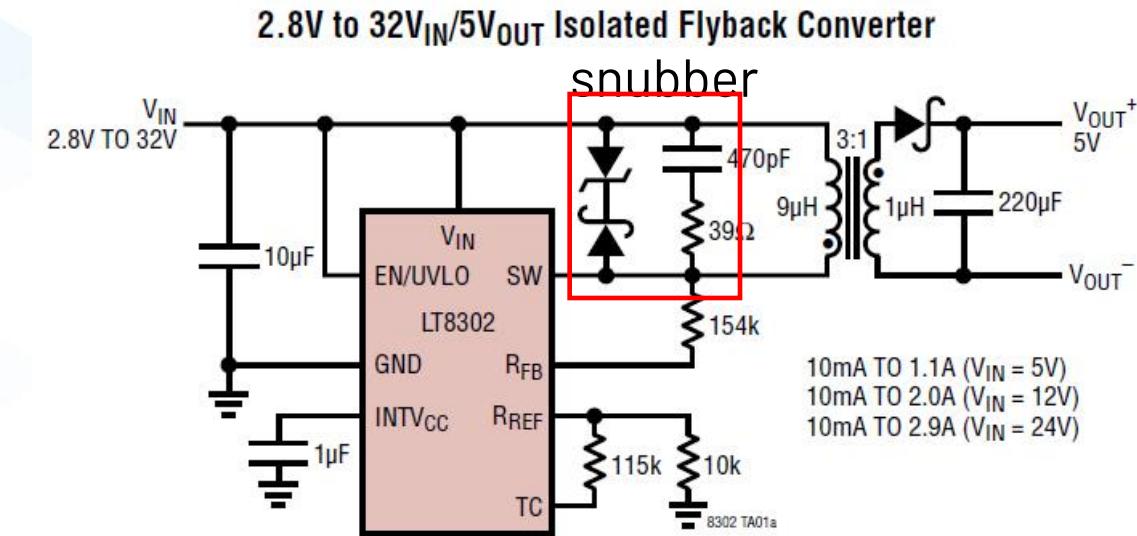
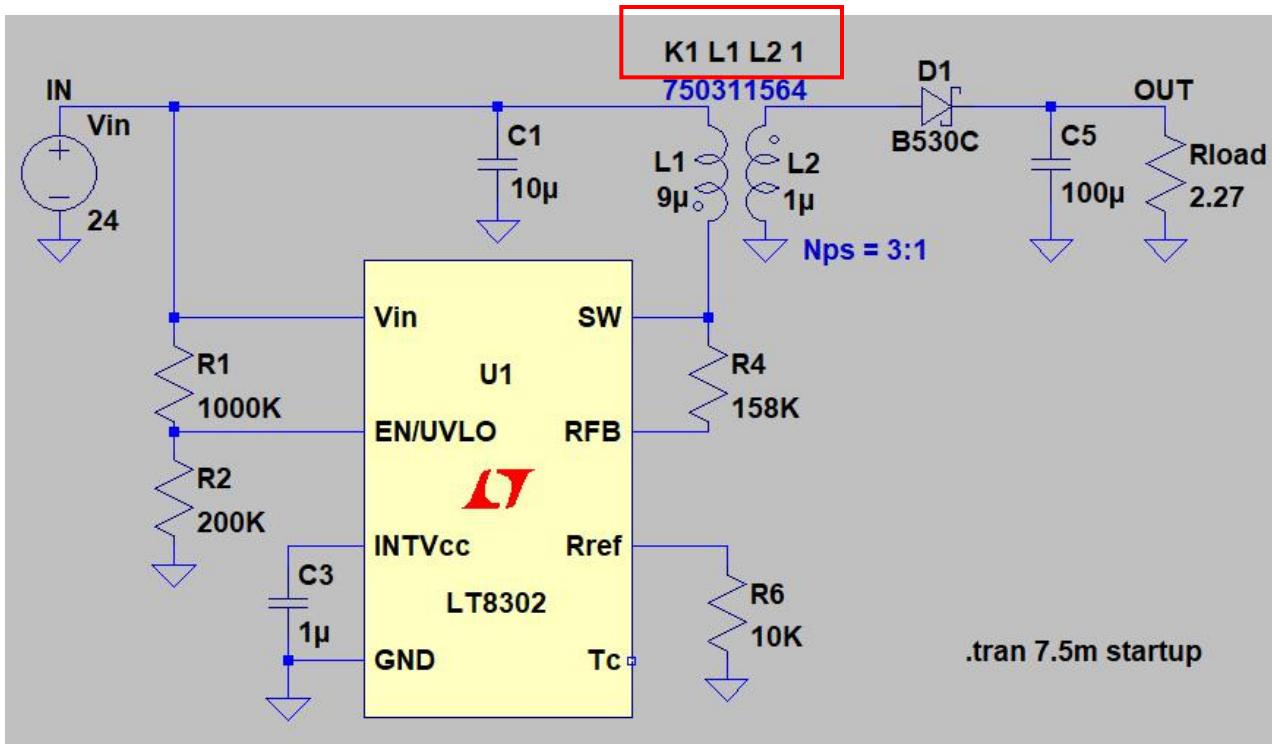
$L_g = N^2 * \mu_0 * A_e / l_g$ (铁氧体磁芯开气隙电感量)



$$E = \int v * i * dt = \int N dB * A_e * H * l_e / N = V_e * \int H * dB = V_e * \int B / U * dB$$

变压器漏感

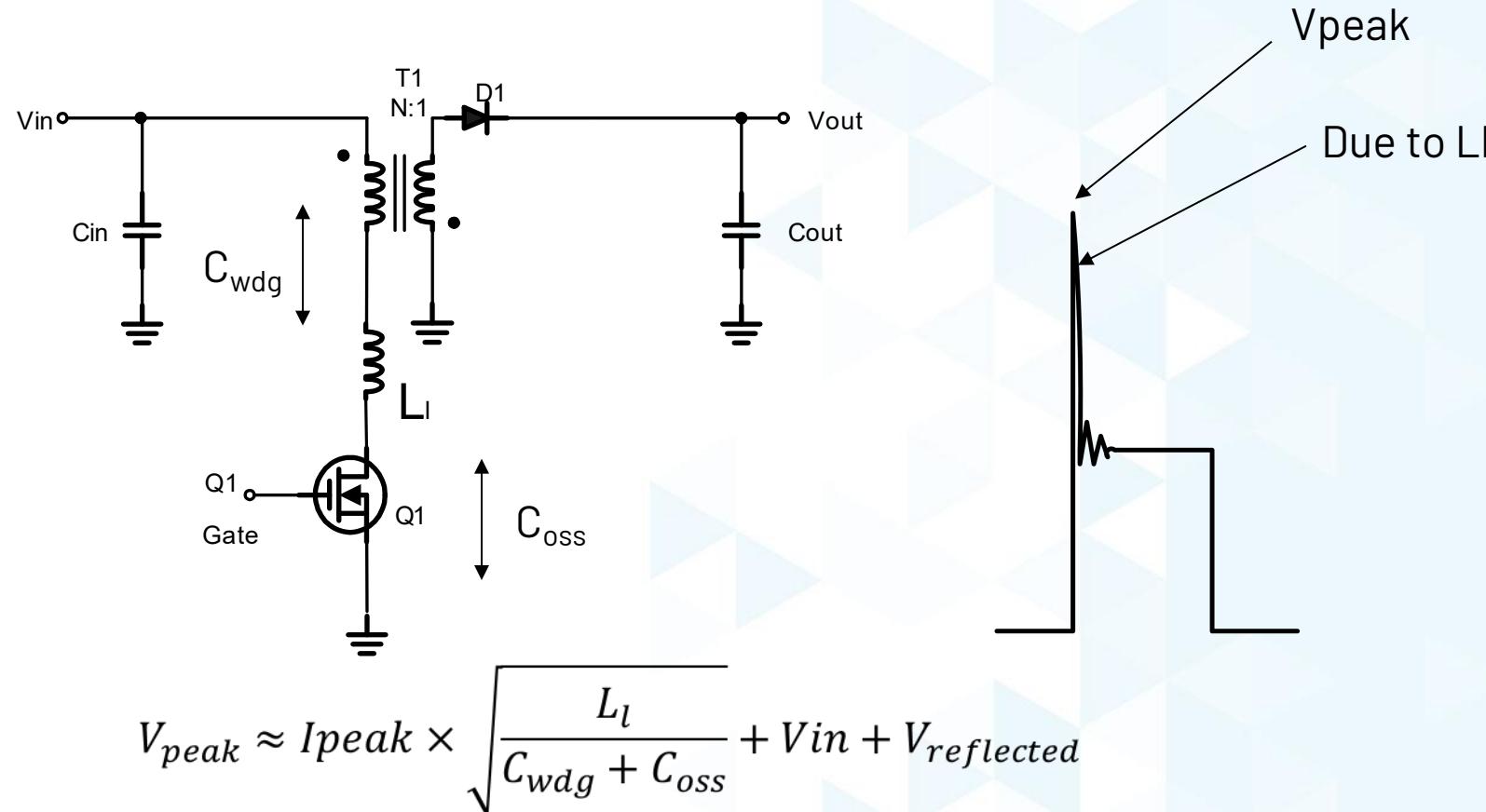
以下电路实际能正常工作吗？



没有漏感的理想变压器并不存在，我们不得不面对！

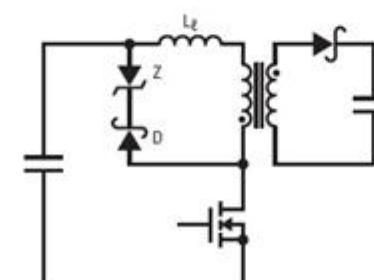
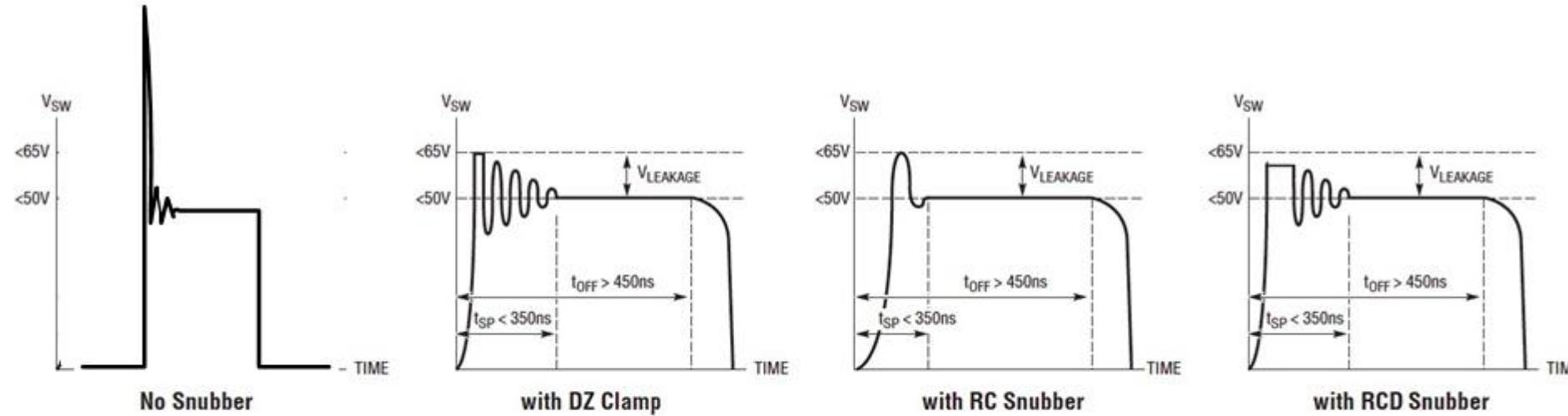
漏感问题1-尖峰问题

如果没有钳位电路，实际会出现什么情况？

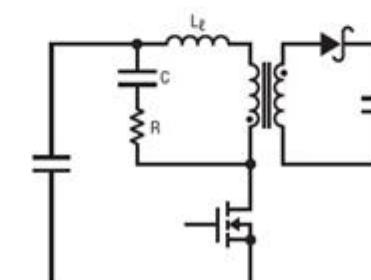


钳位吸收电路

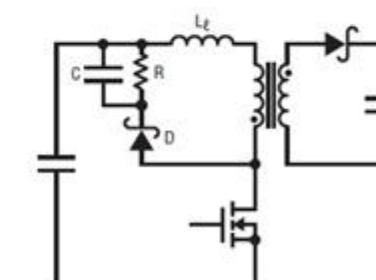
为了减少漏感引起的电压尖峰，可在变压器初级并联稳压管或RCD电路吸收漏感能量。以稳压管箝位电路为例来说明漏感对损耗的影响。



DZ Clamp



RC Snubber



RCD Snubber

钳位吸收电路

$V_{BR} > V_{in} + V_c$

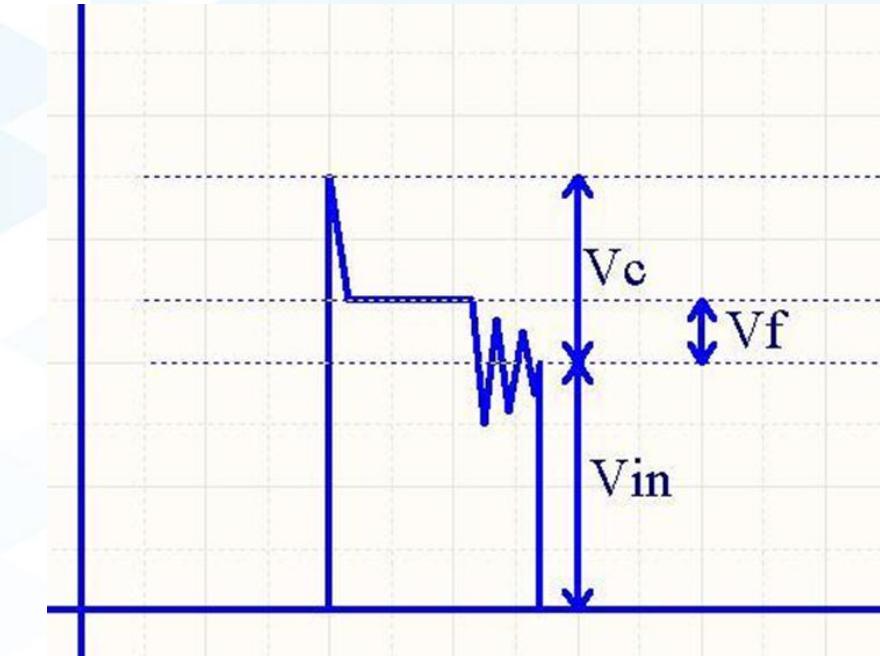
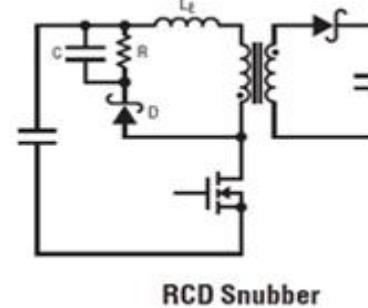
V_f -反射电压

$$P = \frac{1}{2} L_{lk} * I_p^2 * \frac{V_c}{V_c - V_f} * f_s$$

$V_c > 2 * V_f$

$$R = \frac{V_c^2}{P}$$

$RC = 10-20 * T_s$

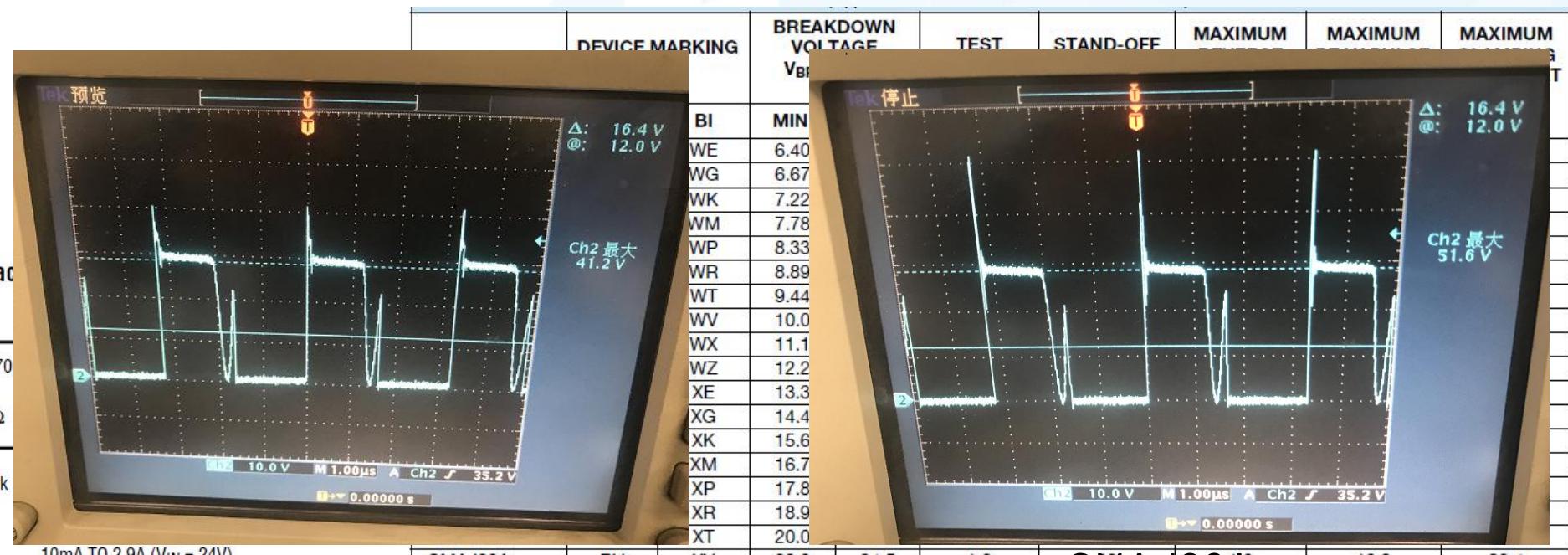
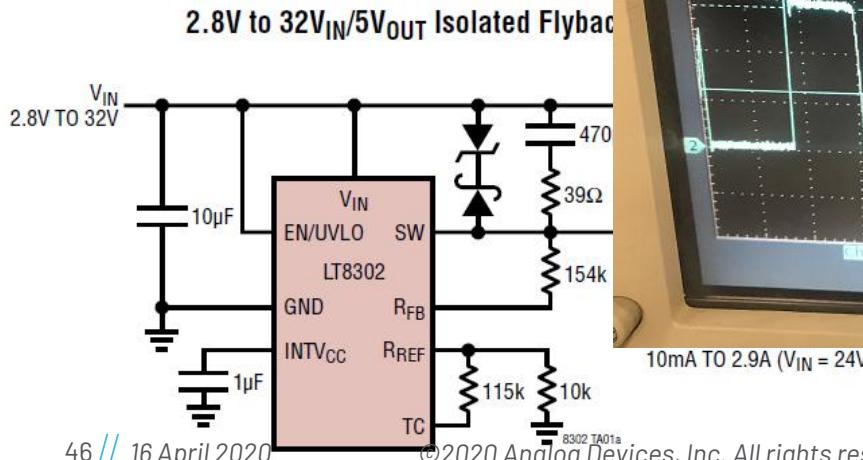


钳位吸收电路

看不同VC对效率的影响？

	Vin	lin	Vo	Io	Effi	Vspike	Vc
SMAJ16A	12.07	0.504	5.05	0.998	82.84%	41.2	29.13
SMAJ28A	12.08	0.491	5.05	0.998	84.97%	51.6	39.52

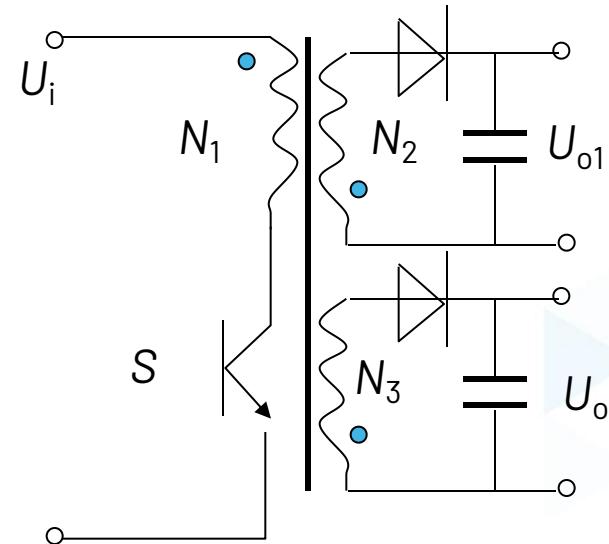
$$V_f := 5.4 \cdot 3 = 16.2 \text{ V}$$



(IV) SMAJ16A

漏感问题2-交叉调整率问题

虽然理论上反激变换器没有输出滤波电感，只有输出电容，相当于电压源，只要一路稳定，多路输出的其余各路基本上（除二极管压降）按匝比稳定输出，但由于漏感存在，产生交叉调节问题。



$$U_{o2} = \frac{N_3}{N_2} U_{o1}$$

中级第六讲：系统 备份电源方案及能 量监控

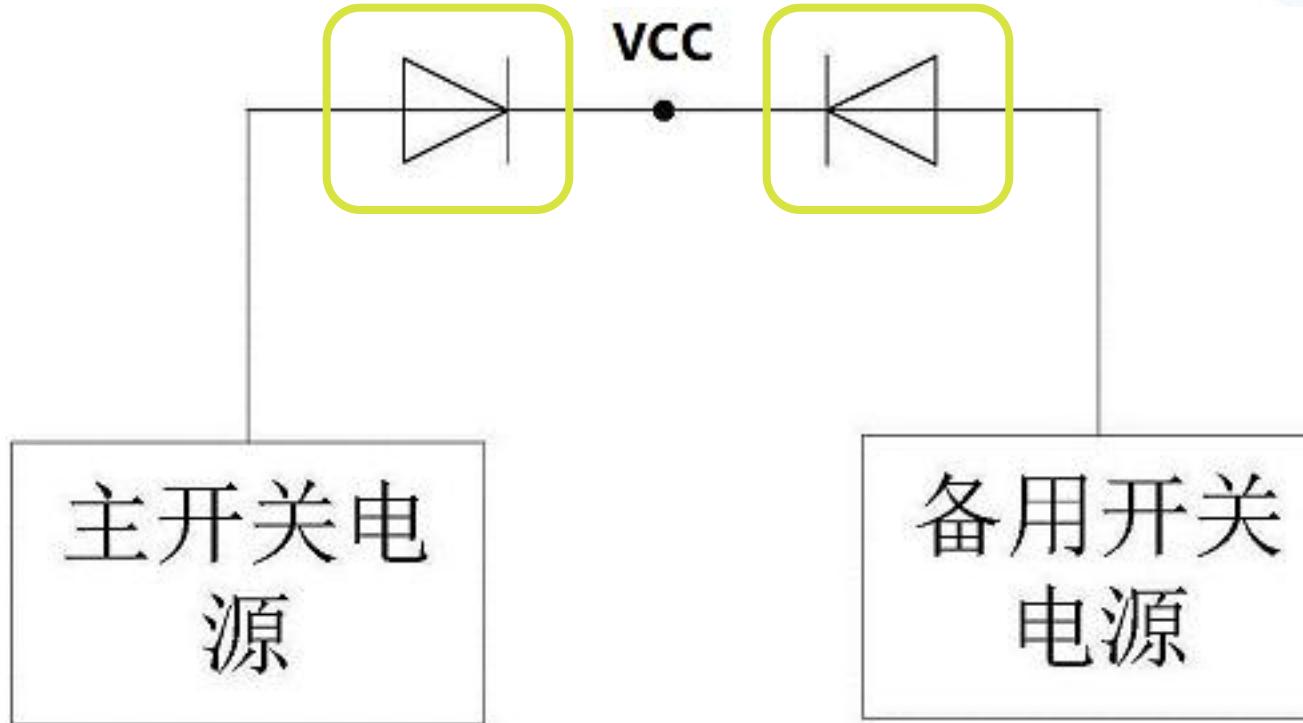


微信扫描二维码

获取课程观看链接

为什么需要系统备份电源

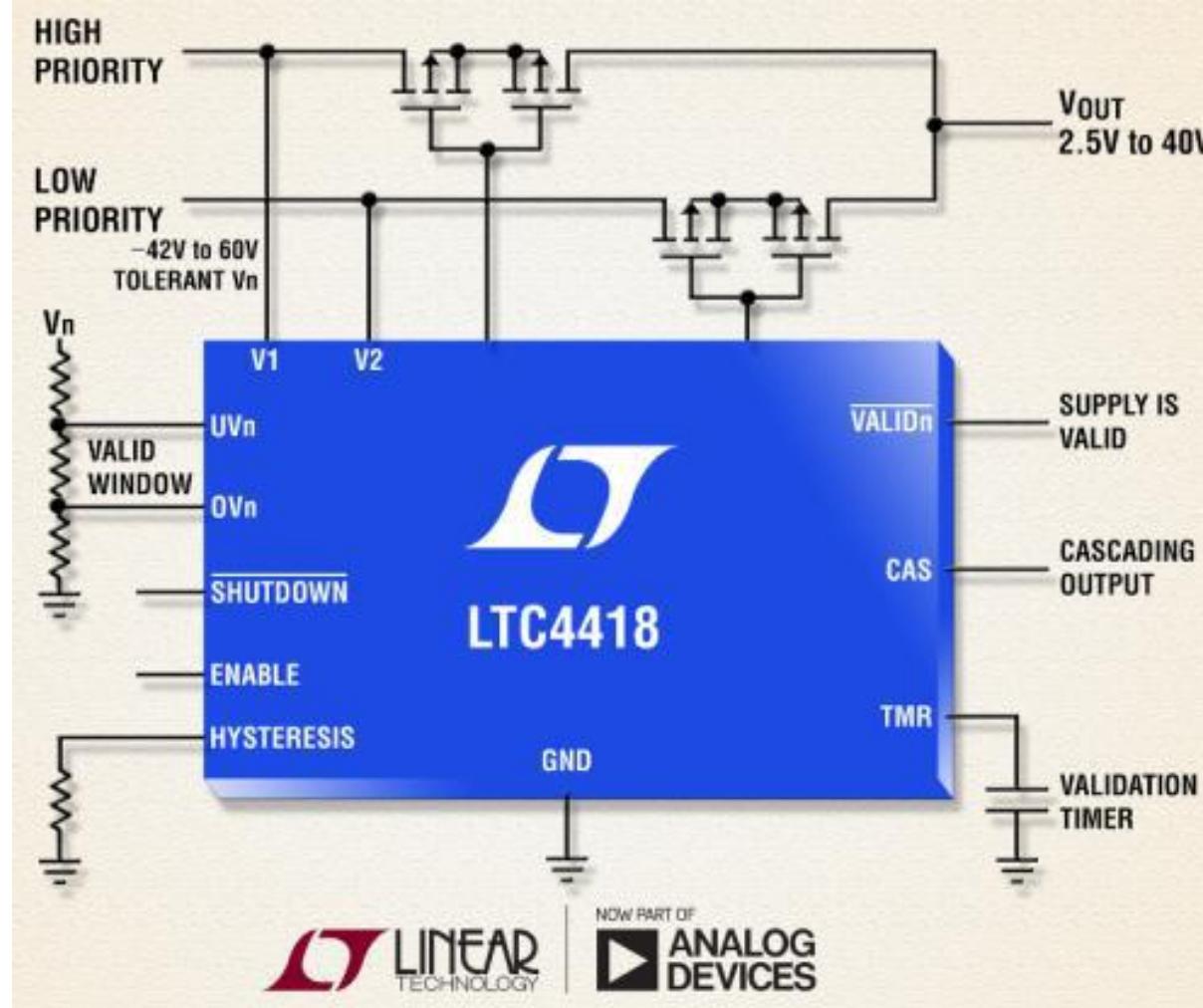
- 冗余电源电路的设计
- 当系统供电发生故障时，如何确保系统能够正常运行？



优点：
实时冗余备份
系统持续工作

缺点：
二极管压降大
双倍开关电源
总体成本较高

合路电路的优化



优点：
低压差高效率
过压欠压保护

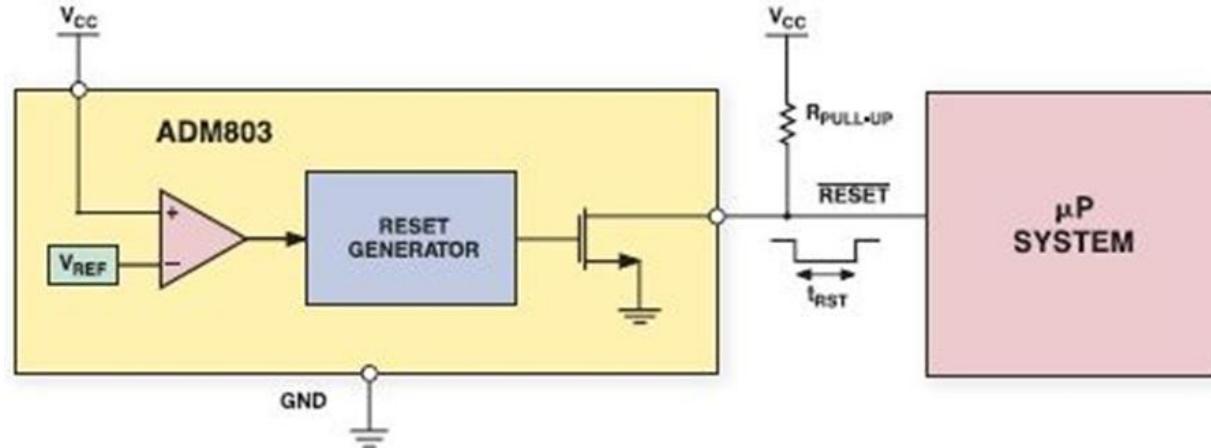
缺点：
双倍开关电源
额外合路电路
总体成本较高

问题与思考

- 所有系统都需要备份电源供电么？
- 系统到底需要保护什么？

如何保护系统的重要数据

如何通知系统掉电?



如何处理系统掉电? 处理时间及电力供应

中断响应
数据处理
数据存储
准备掉电

处理时间
掉电: 几十-几百毫秒
电源故障: 几毫秒
电能维持: 电容, 电池

后备锂电池VS法拉超级电容

计算焦耳能力：

后备系统能源需求= 平均功率 × 备份支持时间

$$E = P_{AVG} \times t_{BACKUP}$$

► 超级电容 vs 后备电池：

	双 2.5V, 10F 超级电容	3.7V, 450mAh 锂电池
能量	60J	6000J
体积	4700mm ³	4800mm ³
备份支持时间：15mW	1小时	100 小时
备份支持时间：1W	1分钟	100 分钟
备份支持时间：20W	1-2 秒	或许不能工作



Summary

- 超级电容：短时间，大电流，高可靠性
- 后备电池：长时间，小电流，温度特性取决于电池种类

后备锂电池VS法拉超级电容



VS



Specifications

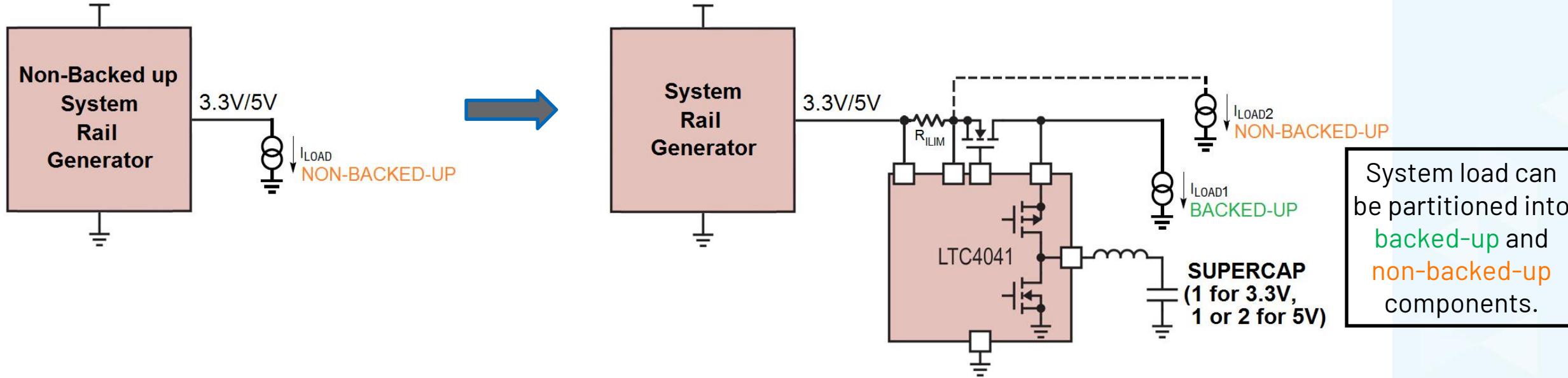
Category temp. range	-25 °C to +85 °C	
Maximum operating voltage	5.5 V.DC	
Nominal cap.range	0.1 F to 1.0 F	
Characteristics at low temperature	Capacitance change	±30 % of initial measured value at +20 °C (at -25 °C)
	Internal resistance	≤5 times of initial measured value at +20 °C (at -25 °C)
Endurance	After 1000 hours application of 5.5 V.DC at +85 °C, the capacitor shall meet the following limits.	
	Capacitance change	±30 % of initial measured value
	Internal resistance	≤4 times of initial specified value
Shelf Life	After 1000 hours storage at +85 °C without load, the capacitor shall meet the specified limits for Endurance.	

产品属性/PRODUCT ATTRIBUTE

- ▶ 品牌: 麦克赛尔 / **maxell** ▶ 电压: 3.6V
- ▶ 名称: ER17/33 ▶ 型号: ER17/33
- ▶ 规格: 3.6V 1600mAh ▶ 产品参数: 35*17 (mm)
- ▶ 标准放电电流 (μA): 75 ▶ 重量 (g) : 13
- ▶ 使用温度范围 (摄氏度 °C): -55到+85

LTC4041 备份电源典型应用

Think of the LTC4041 as a “mini-UPS” for a 3.3V or 5V system rail.



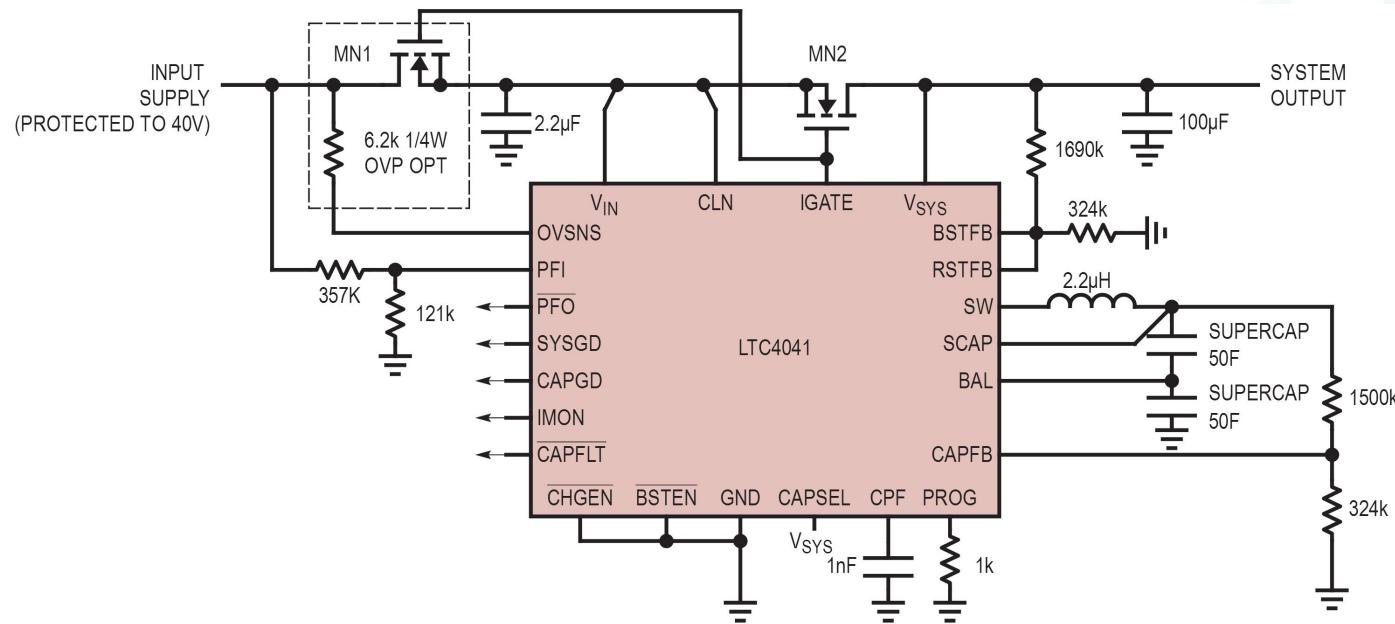
APPLICATIONS

- Ride-Through “Dying Gasp” Supplies
- High Current Ride-Through 3V-5V UPS
- Power Meters/Industrial Alarms
- Servers/Solid State Drives

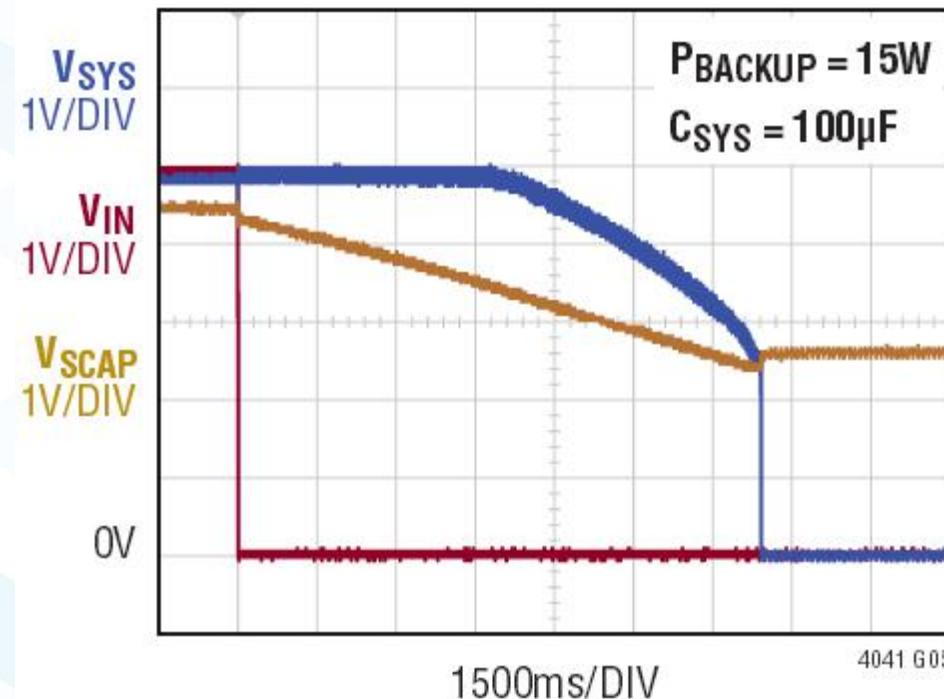


LTC4041备份电源典型应用(可选OVP过压保护)

→ Input Overvoltage Protection (OVP) Power Application with two 50F Supercapacitors in series backup 5V/3A system load for about 4.5 seconds.



Complete Backup Event with Two 50F Supercapacitors in Series



LTC4041 backup system DEMO

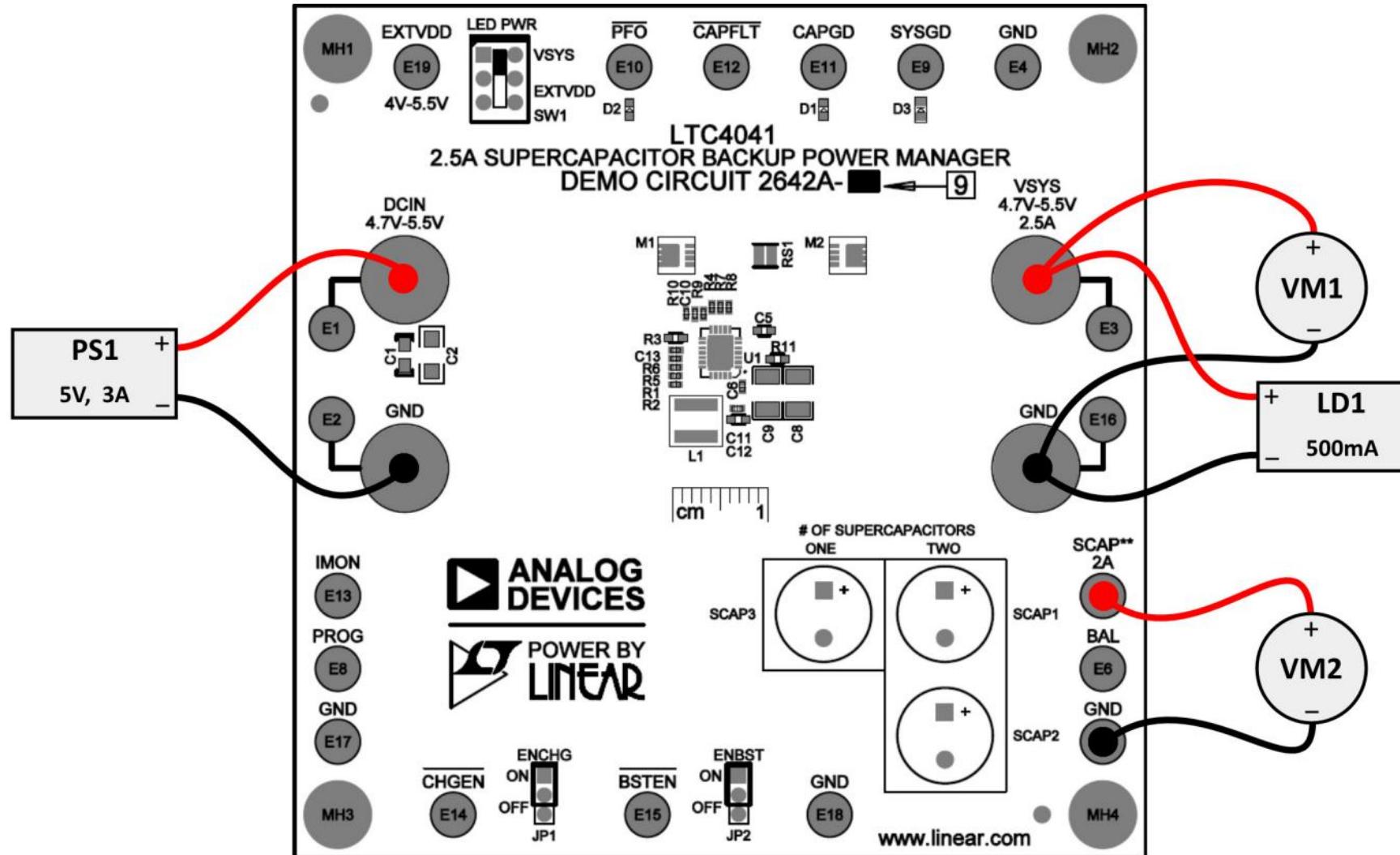
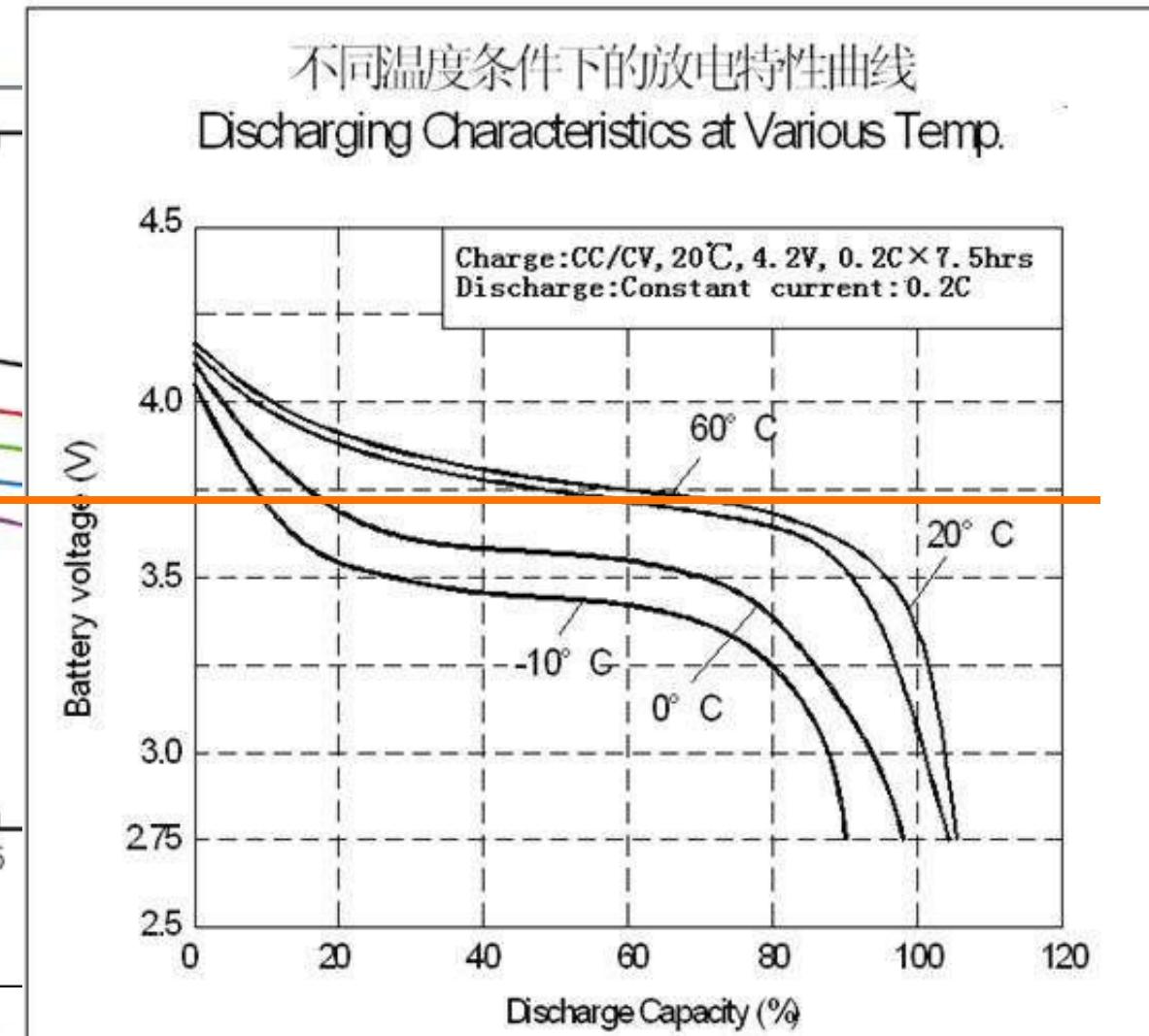
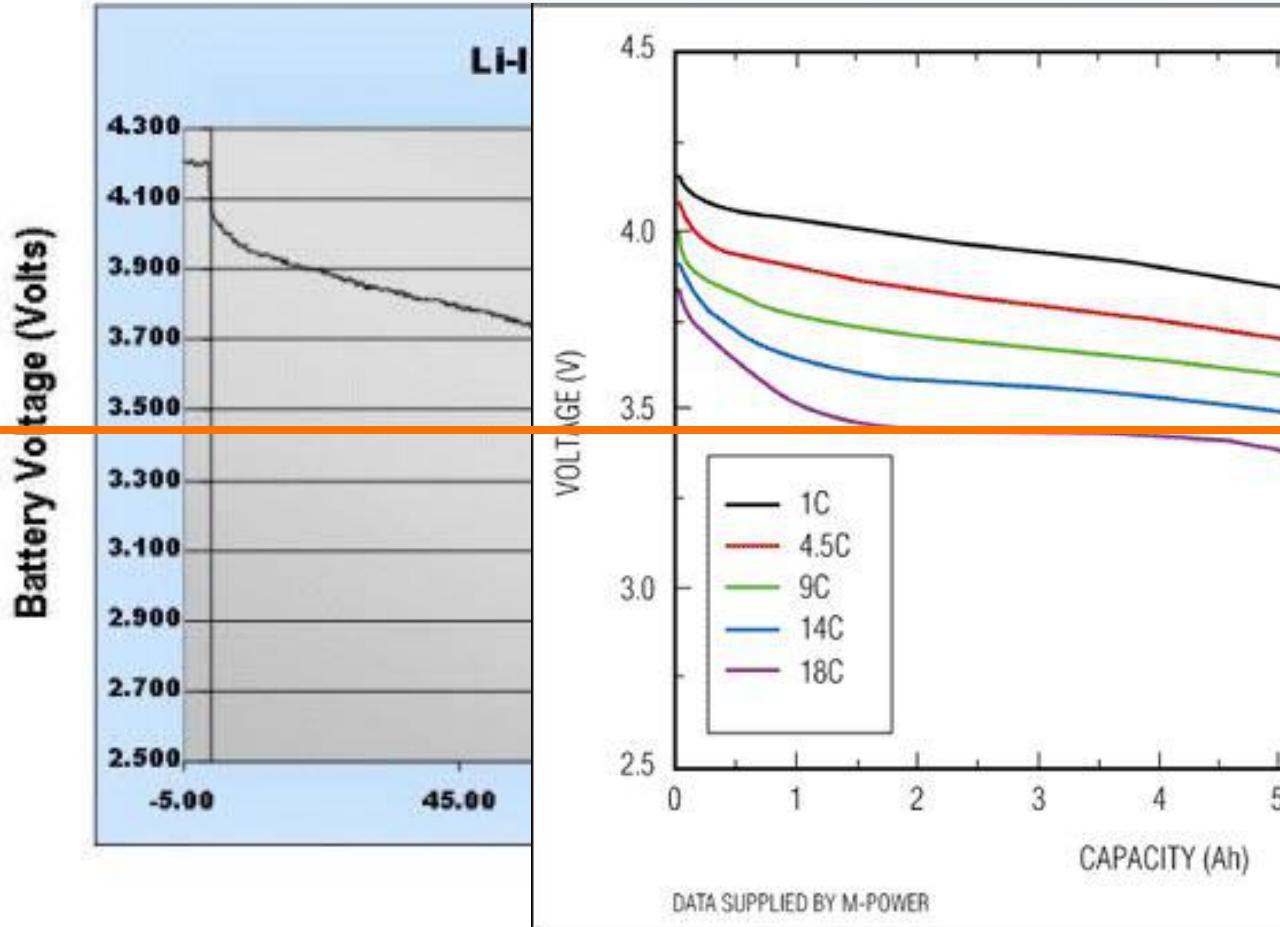


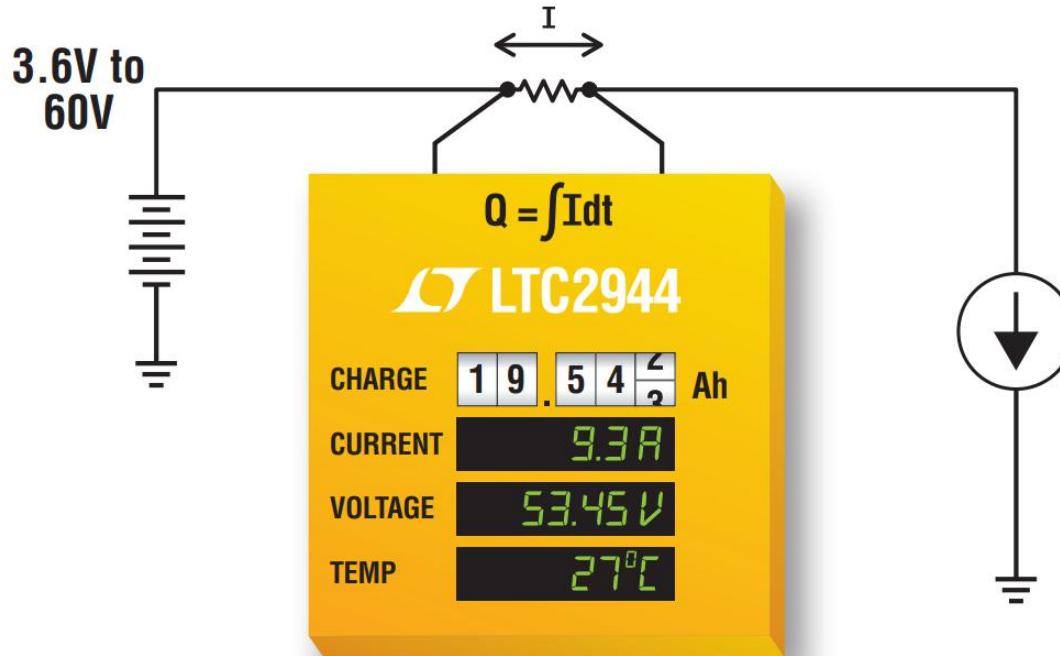
Figure 1. Quick Start Procedure Setup for DC2642A

能量监控应用背景

- 通过电压来检测电池电量和工作状态，真的准确么？
- 3.7V 对应的电池容量是多少？？？



High Voltage Battery Monitor

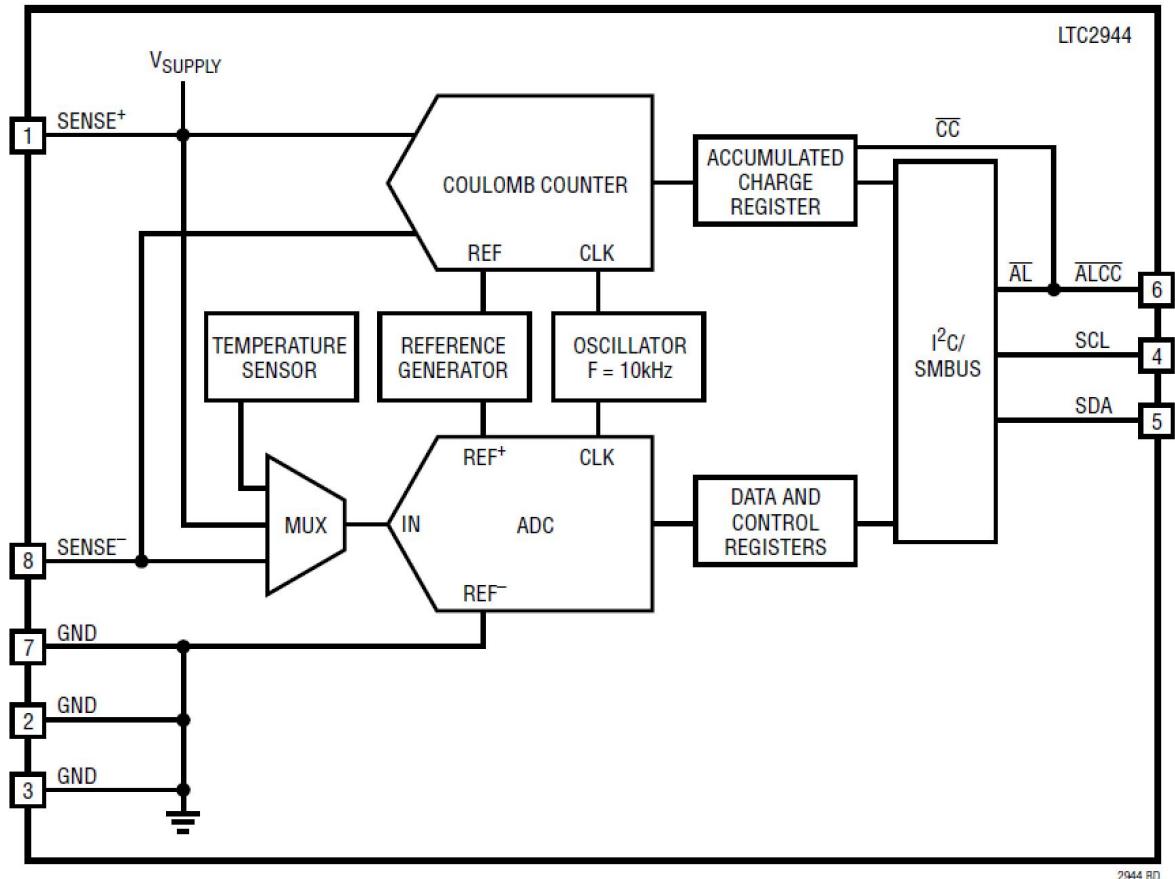


▼ Battery Monitors

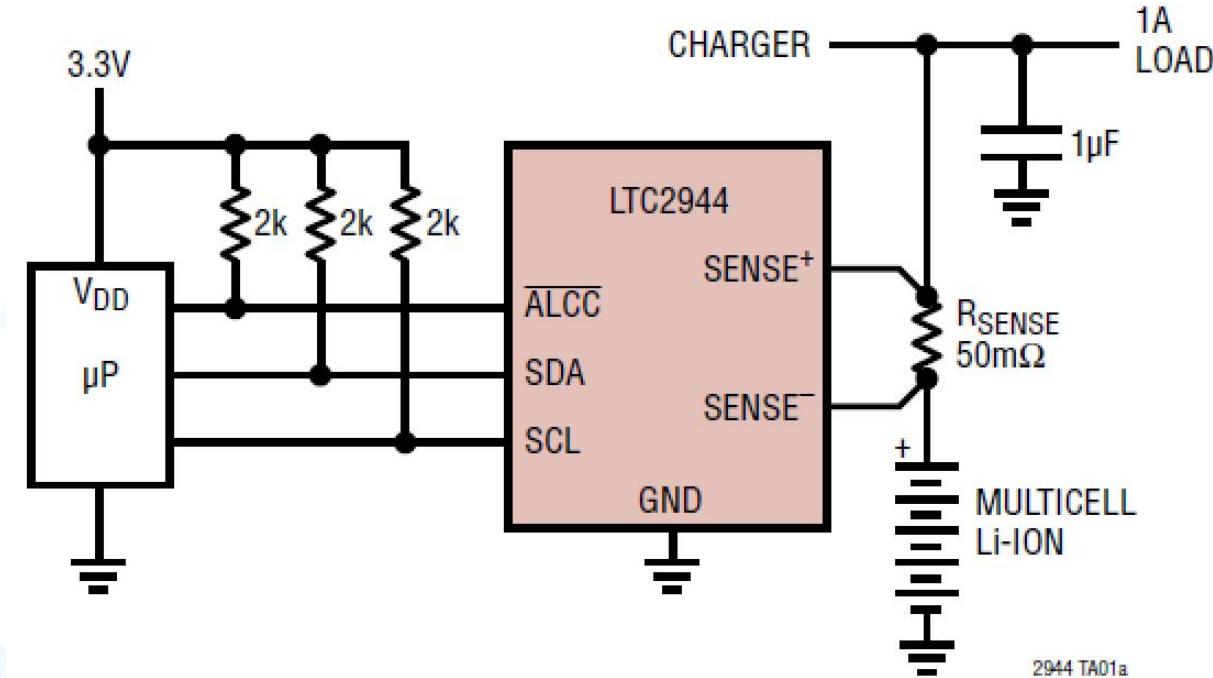
Part Number	Operating Range	Internal Sense Resistor	Measures:				Package
			Q	V	I	T	
LTC2941	2.7V to 5.5V		•				2mm x 3mm DFN-6
LTC2941-1	2.7V to 5.5V	1A	•				2mm x 3mm DFN-6
LTC2942	2.7V to 5.5V		•	•		•	2mm x 3mm DFN-6
LTC2942-1	2.7V to 5.5V	1A	•	•		•	2mm x 3mm DFN-6
LTC2943	3.6V to 20V		•	•	•	•	3mm x 3mm DFN-8
LTC2943-1	3.6V to 20V	1A	•	•	•	•	3mm x 3mm DFN-8
LTC2944	3.6V to 60V		•	•	•	•	3mm x 3mm DFN-8
LTC4150	2.7V to 8.5V		•				MSOP-10

Measure Charge, Voltage, Current and Temperature with 1% Accuracy

LTC2944 原理及应用图



2944 BD



LTC2944 应用图

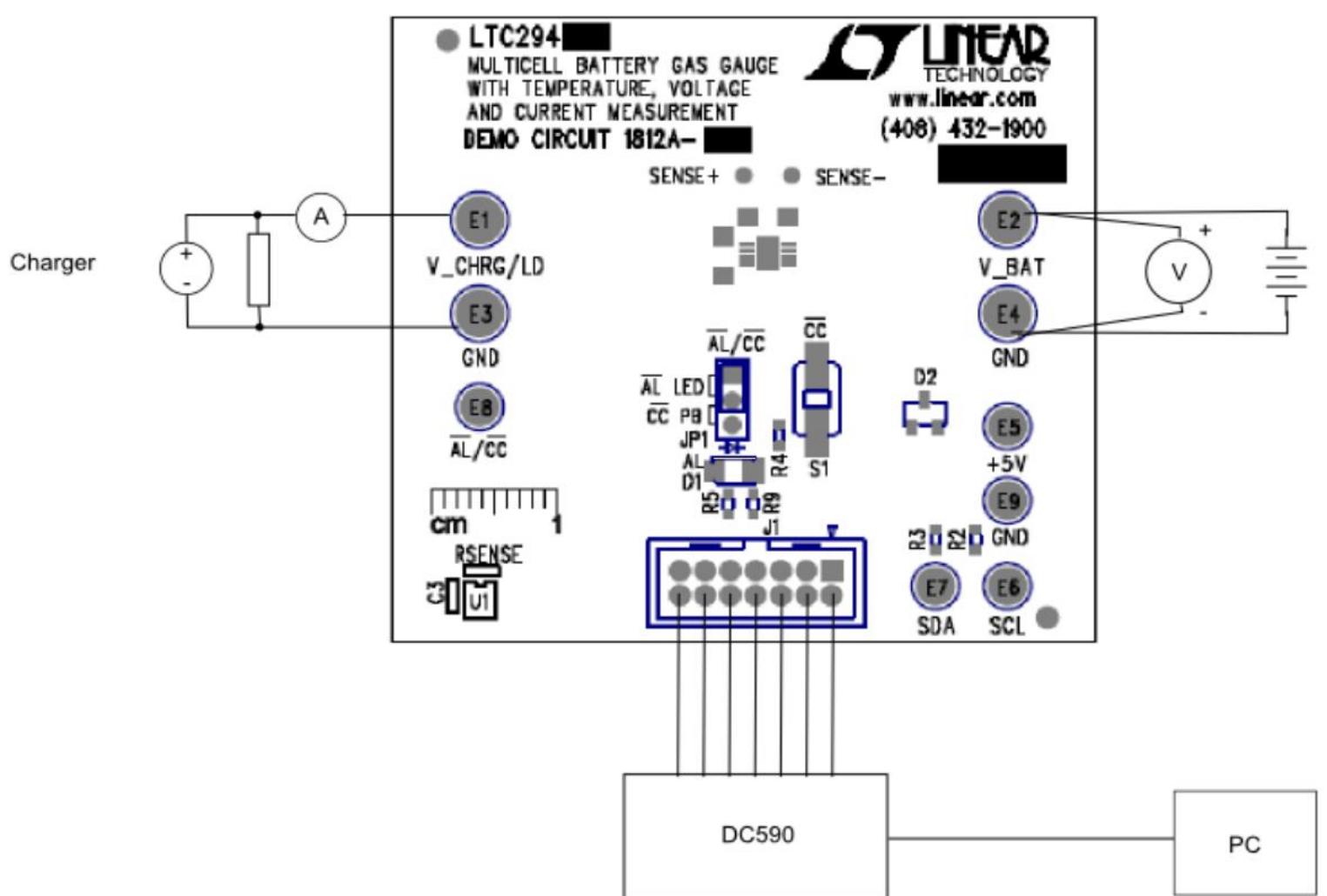
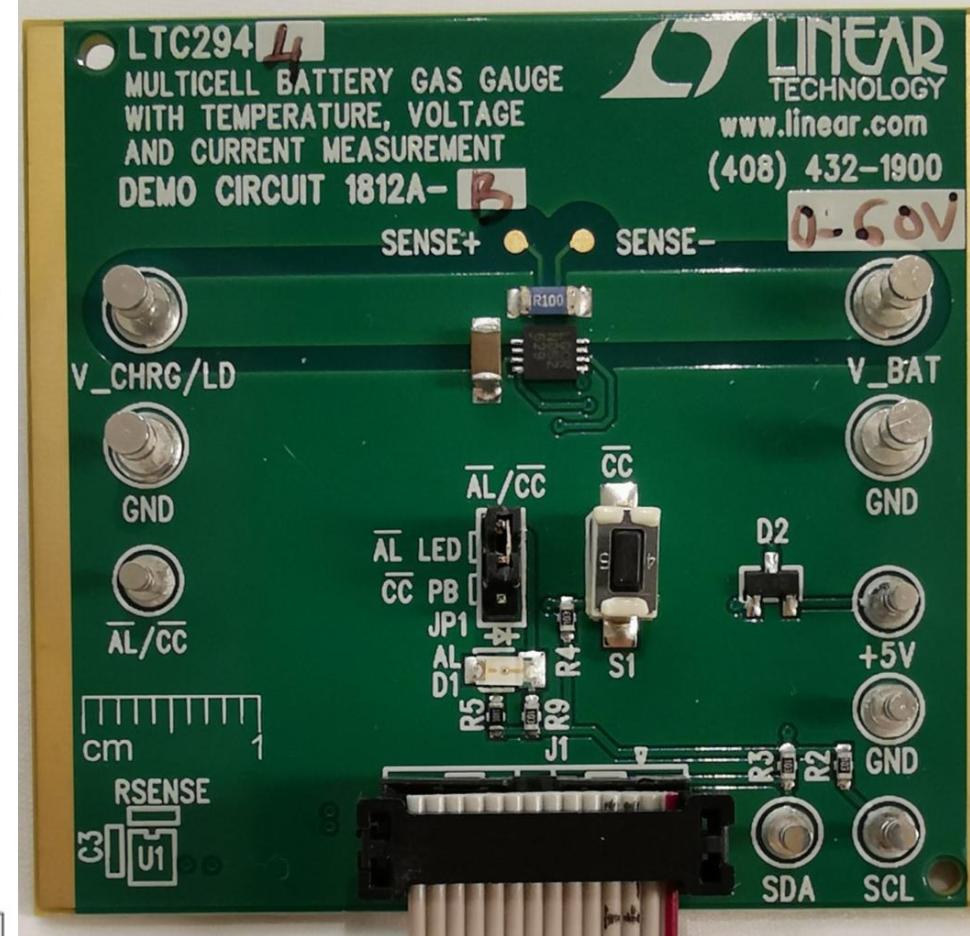


Figure 2. DC1812A Basic Setup



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