节 电 王

www.onsemi.com.cn

安森美半导体
ON Semiconductor®

直流-直流电信和网络解决方案

DC-DC Telecom & Networking Solutions

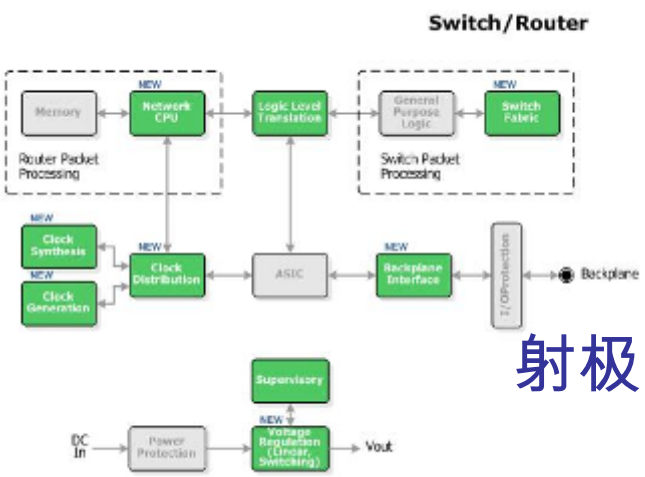
应用/终端产品 Applications / End Products

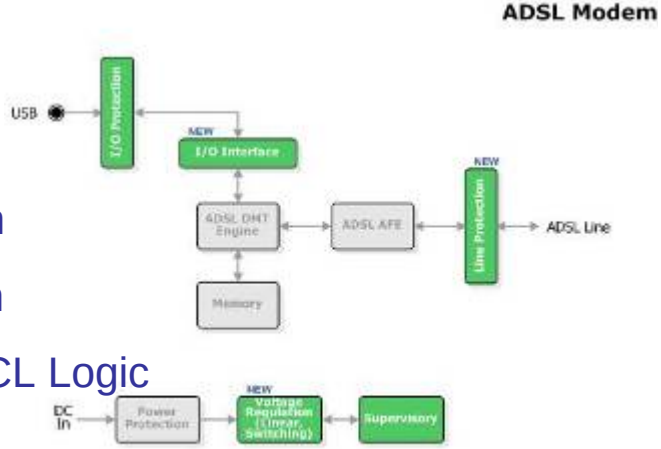
- 扇出缓冲器 Fan Out Buffer
- 时钟开关 Clock Switching
- 数据环回 Data Loopback
- 主时钟信令等级(HCSL)全面缓冲双列直插内存模块(FBDIMM) HCSL FBDIMM
- 同步数字体系/同步光网络 SDH/Sonet
- 高速精密缘 High Speed Precision Edge
- 通用时钟产生 General Purpose Clock Generation
- Infiniband Infiniband
- 万兆位以太网(10GbE) 10G Ethernet
- 千兆位以太网(GbE) 1G Ethernet
- PCI Express PCIe
- iSCSI iSCSI
- 光纤分布式数据接口(FDDI) Fiber Distributed Data Interface
- 光纤信道 Fiber Channel
- 降低系统时钟噪声 Reduction of System Clock Noise
- 通用数据和时钟接口 General Purpose Data & Clock Interface
- 精密时钟同步 Precision Clock Synchronization

- 工作站 Work Stations
- 路由器 Routers
- 交换机 Switches
- 网络 Network
- 电信 Telecom
- 线卡 Line Card
- 基站 Base Station
- 服务器 Servers
- 数据通信 Datacom

安森美半导体提供完整解决方案

ON Semiconductor Offers a Total Solution





时钟分配 Clock Distribution

时钟产生 Clock Generation

射极耦合逻辑(ECL)逻辑 ECL Logic

运算放大器 Op Amp

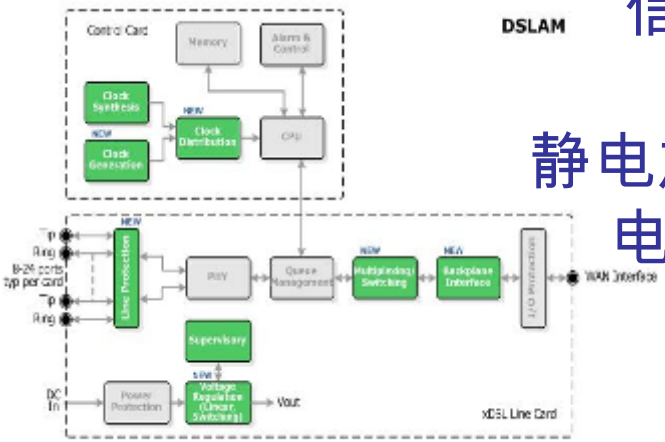
比较器 Comparators

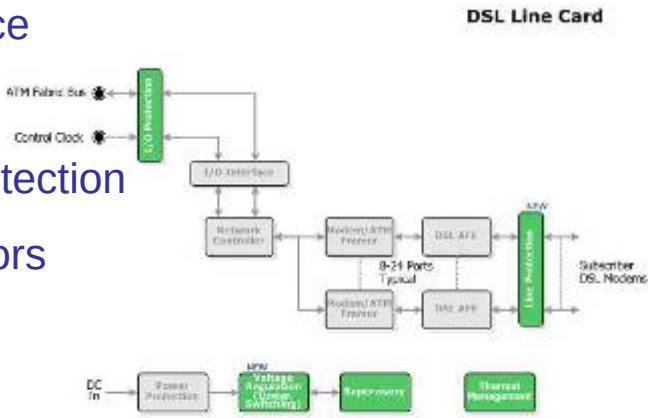
信号和接口 Signal & Interface

浪涌保护 Surge Protection

静电放电(ESD)保护 ESD Protection

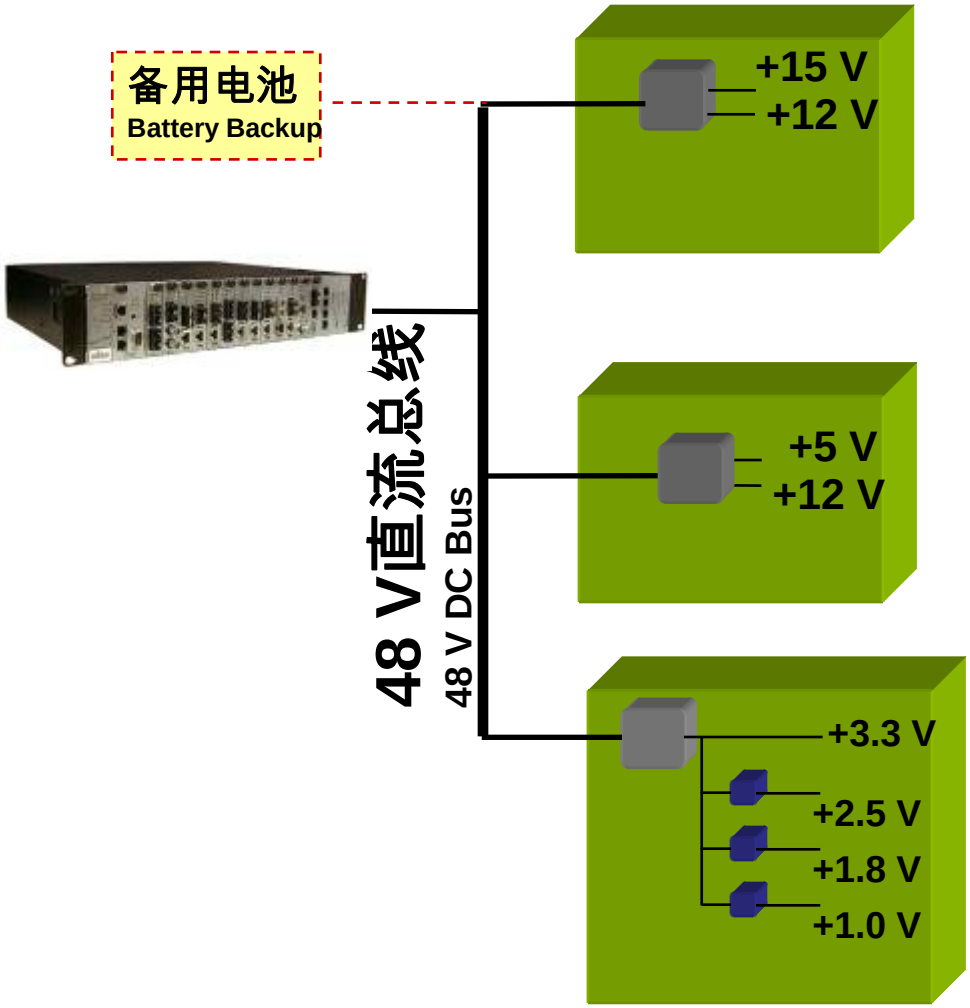
电压转换器 Voltage Translators

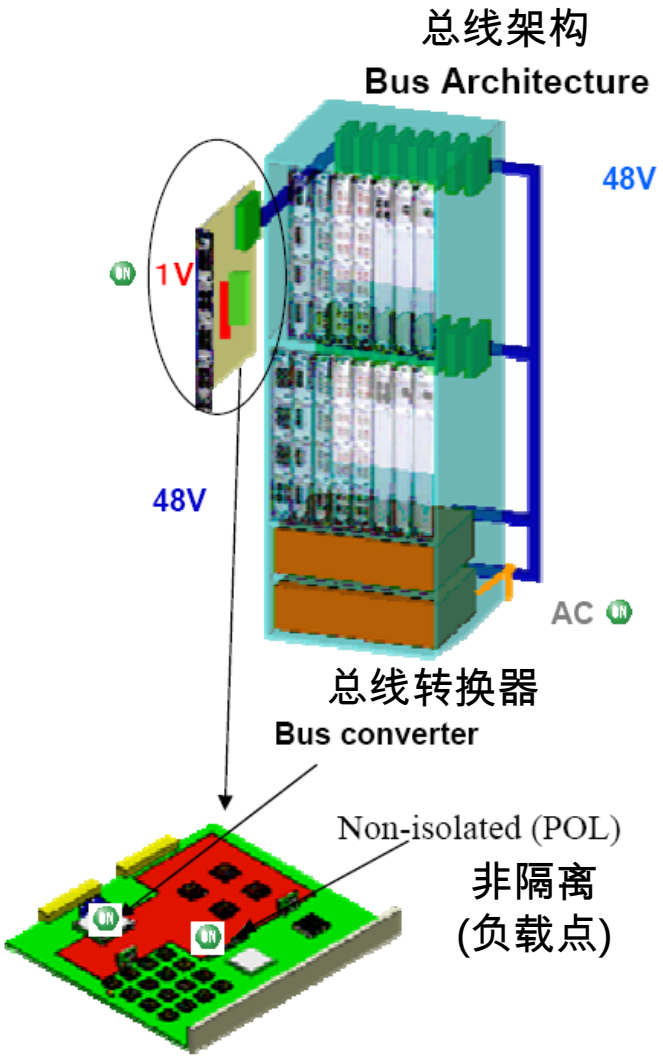




电信和网络设备中的分布式电源架构

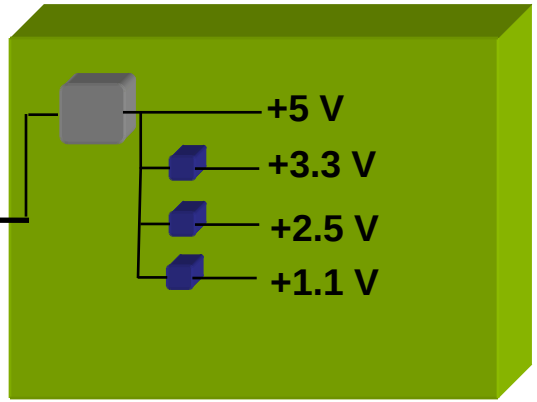
Distributed Power Architecture in Telecom / Networking Equipment



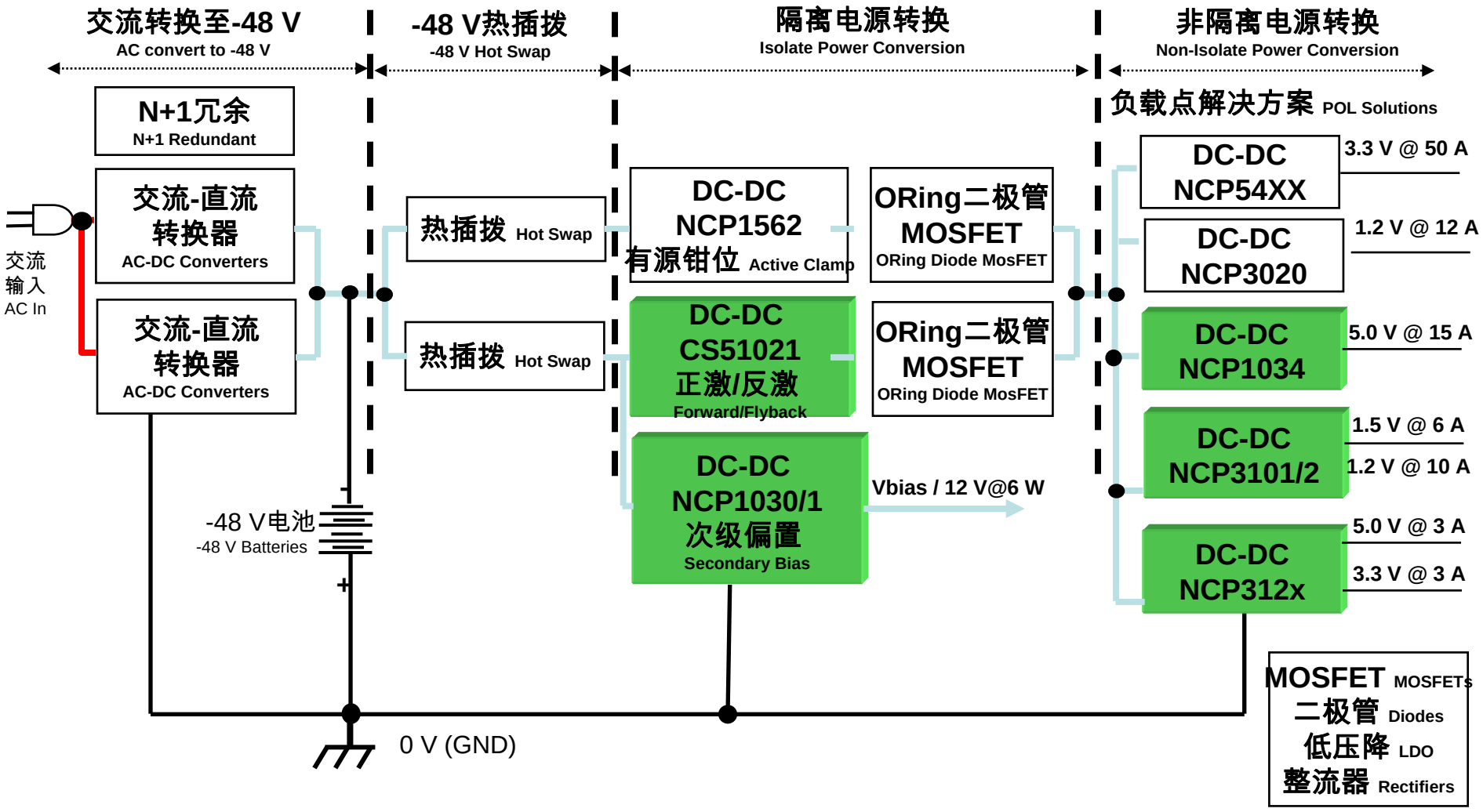


数据通信产品中的电源架构
Power Architecture in Datacom Products

适配器 Adapter
(+12 V / +18 V / +24 V)



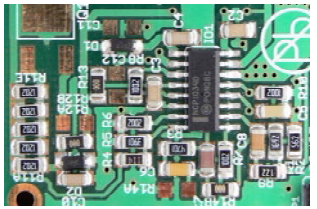
分布式电源解决方案
Distributed Power Solution



网络电源-参考设计 Networking Power – Reference Design

- 解决方案 Solution:
  - NCP1034
  - NTD3055, NTD24N06

- 目标应用 Target Application:
  - 网络电源 Networking power
  - 数据通信 Datacom
  - +24 V/+48 V电源 +24 V / +48 V Power



- 规范 Specification:
  - 输入 Input: +48 V (+/-10%)
  - 输出1 Output-1: 5.0 V @ 8 A
  - 输出2 Output-2: 12 V @ 5 A
  - 保护 Protection: 限流 Current Limit, 欠压锁定 UVLO @ 24 V, 预偏压负载 Pre-Bias Load
  - 目标能效 Efficiency: Target >85%
  - 隔离 Isolated: 无 NO
  - 必须采用陶瓷电容 Must use ceramic capacitors
  - 采用同步输出降低电磁干扰 Synchronize outputs for reduced EMI

元件/拓扑结构理据
Component / Topology Justification

- 需要同步能力以减少电磁干扰(EMI)/电磁兼容性(EMC)问题
  Need synchronization capability to reduce EMI/EMC

- 需要采用优化的外部MOSFET来实现较高能效，并能根据要求调节输出电流 **Need to meet good efficiency with optimized external MOSFETs and scale output current per the requirement**

- 非隔离提供使用较低成本标准降压拓扑结构的能力 **Non-isolated offers ability to use lower cost standard buck**

- **NCP1034提供 NCP1034 offers:**
  - 高达100 V输入和2 A同步门驱动 Up to 100 V input & 2 A synchronous gate drive
  - 同步输入 Synchronization input
  - 输出电压低至1.25 V Output voltage down to 1.25 V
  - 外部可调节欠压锁定(UVLO) Externally adjustable UVLO
  - 具有“启用”引脚，支持低能耗模式 ENABLE with low power mode

NCP1034 – 100 V同步控制器

NCP1034 – 100 V Synchronous Controller

价值主张 Value Proposition

The NCP1034 is a flexible synchronous PWM controller designed to operate from wide input supply voltage range up to 100 V. The NCP1034 provides a 2 A gate drive and is capable of producing output voltages as low as 1.25 V.

独特特性 Unique Features

- Up to 100 V input
- 2 A Drive Capability
- Synchronization

优势 Benefits

- Suitable for +48 V, +60 V, +100 V supplies
- Drive High Efficiency FETs
- Fixed frequency for 1 or more devices

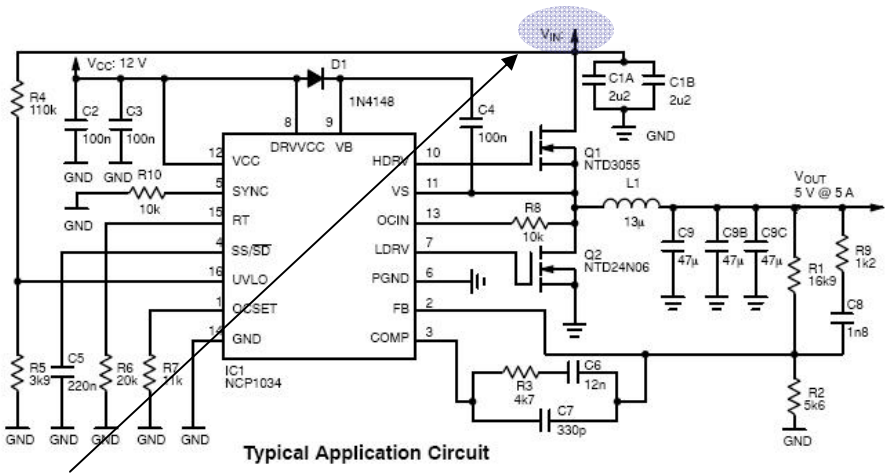
其它特性 Others Features

- External frequency adjustment
- Programmable Soft-Start
- Programmable Over Current Protection
- Hiccup Current Limit Using MOSFET RDS(on)

市场和应用 Market & Applications

- **Consumer Electronics:** xDSL, Modems,
- **Automotive:** CLA, Infotainment, Navigation
- **Computing**: Telecom
- **Industrial:** Power supplies, Process control

典型应用框图和封装信息Typical App. diagram & Package info



Typical Application Circuit

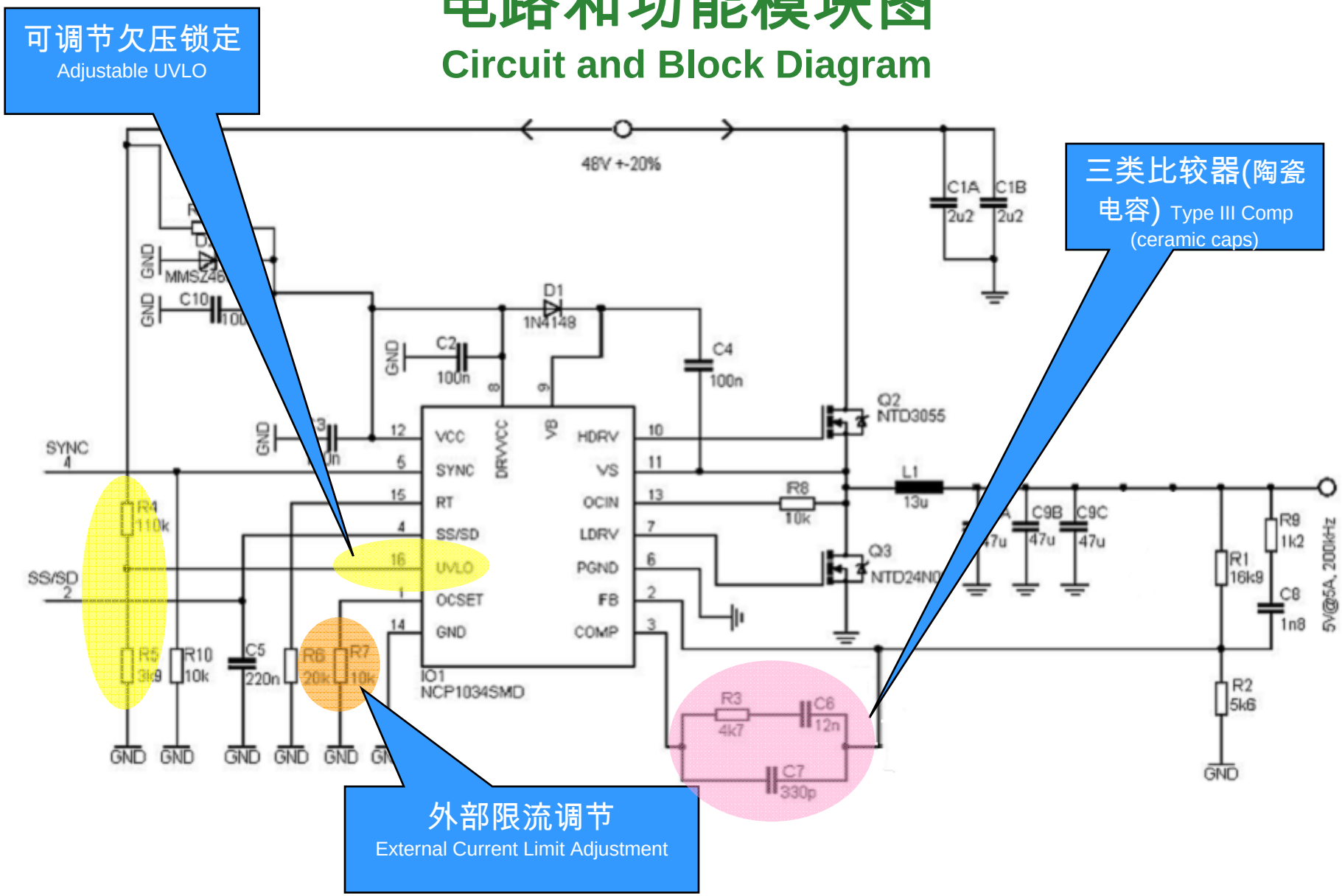
宽输入电压范围
Wide Input Voltage Range

同步输出
Synchronous Output

订购信息和支援 Ordering info & Support

- SOIC-16
- NCP1034DR2G: -40 to +125°C Tj

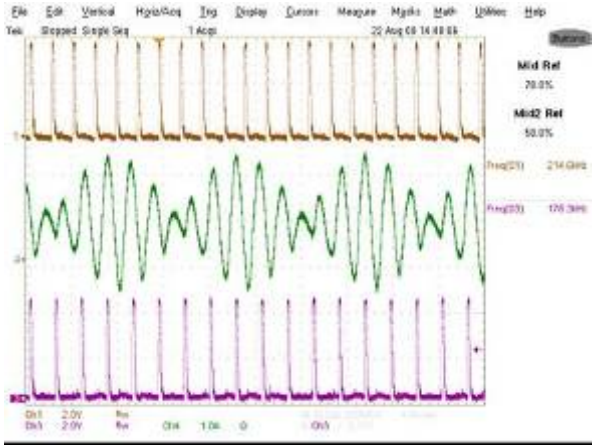
电路和功能模块图
Circuit and Block Diagram



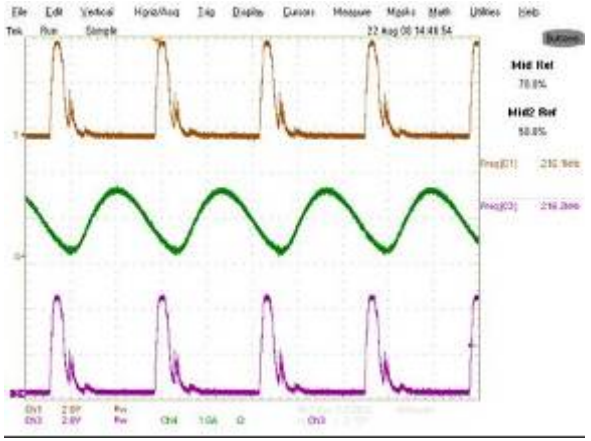
同步 Synchronization

快速傅立叶变换分析
FFT Analysis

无同步 Without Synchronization

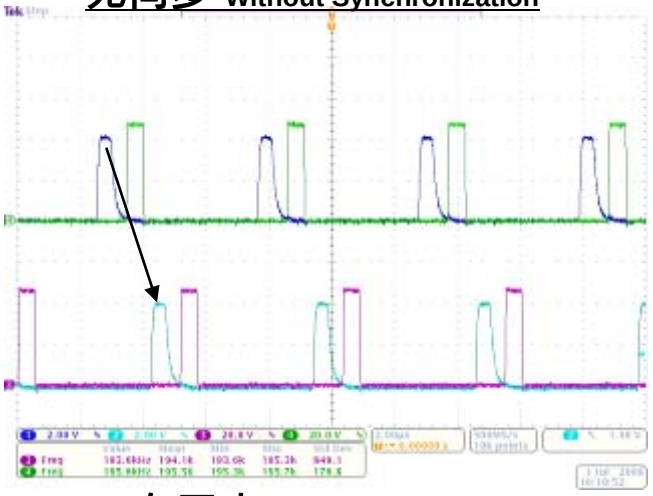


有同步 With Synchronization

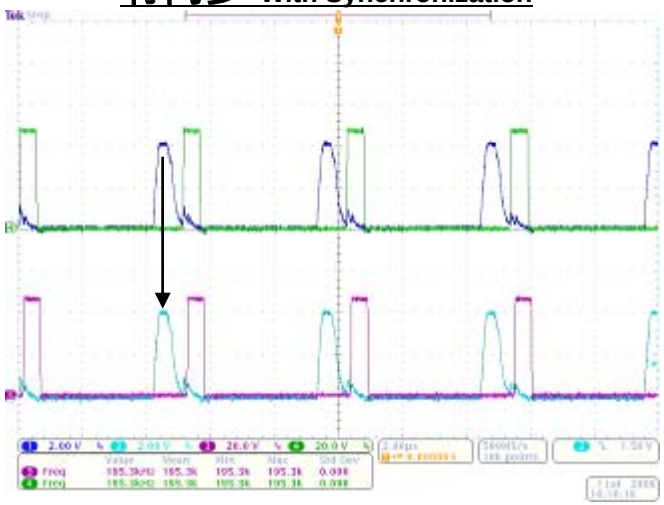


NCP1034被同步至输入信号的上升沿
NCP1034 is synchronized to the rising edge of the input signal

无同步 Without Synchronization



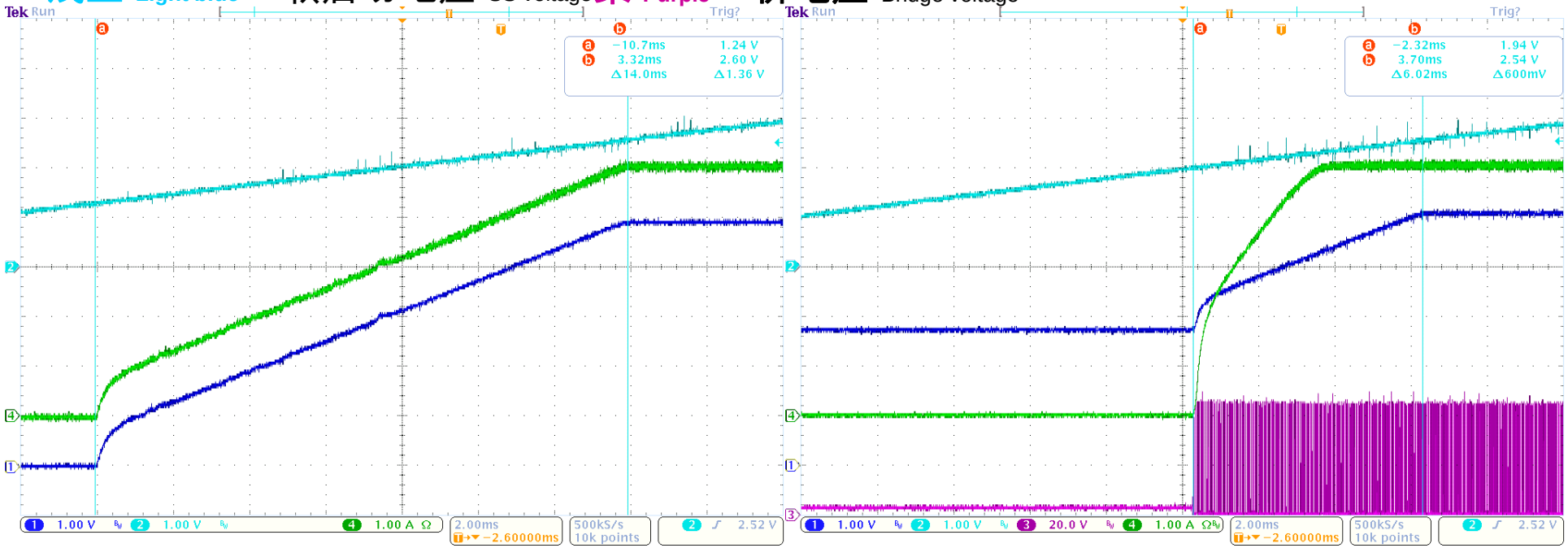
有同步 With Synchronization



启动至预偏置负载 Start-Up into Pre-biased Load

深蓝 Dark blue – 输出电压 Output voltage 绿 Green – 输出电流 Output current

浅蓝 Light blue – 软启动电压 SS voltage 紫 Purple – 桥电压 Bridge voltage

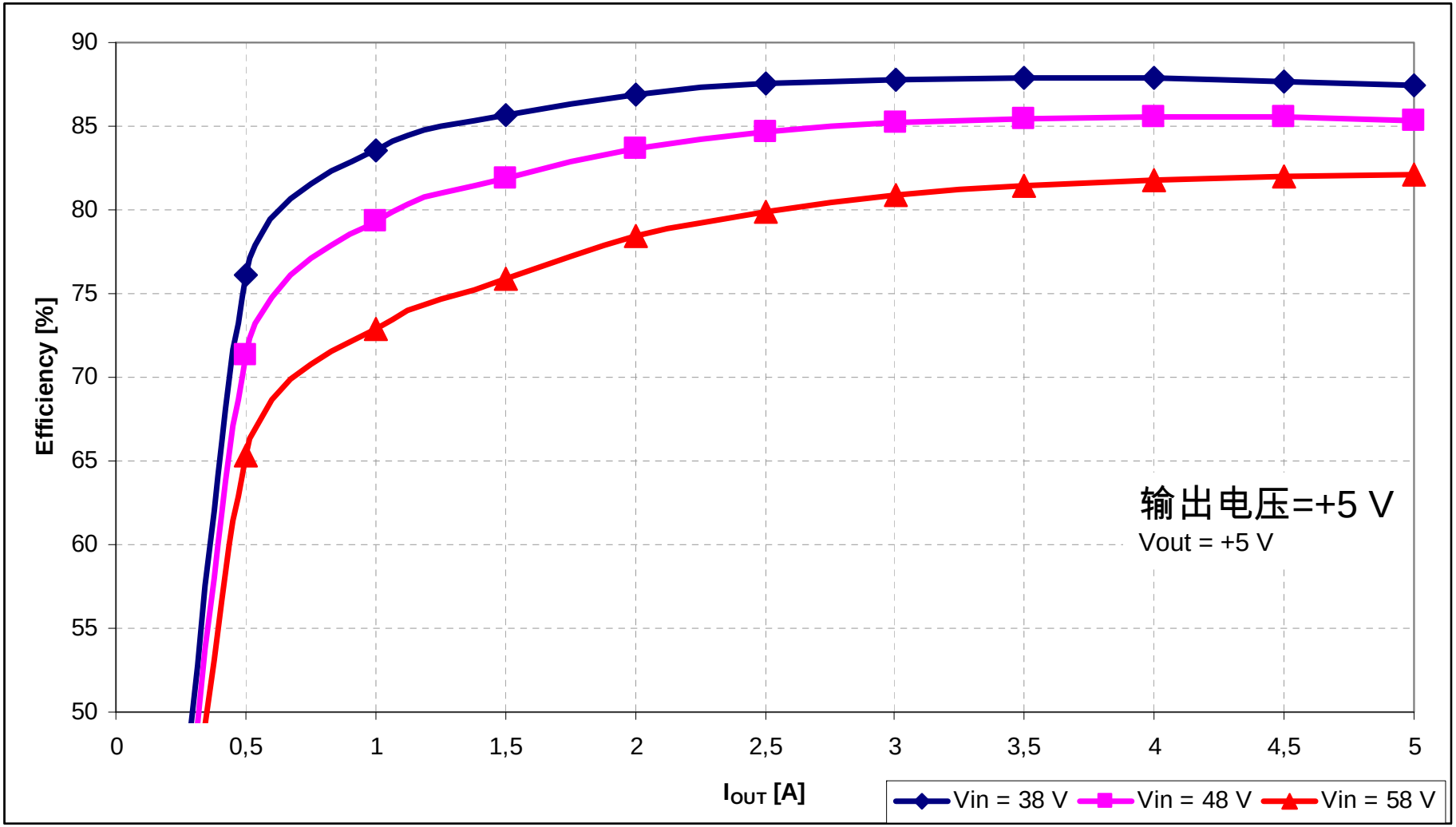


启动至额定负载 Start to Nominal Load

启动至预偏置输出 Start to Pre-biased Output

NCP1034能够启动至预偏置输出电容。高端MOSFET获得第一个导通脉冲之前，低端MOSFET不会导通。在此期间，在软启动序列通过编程输出电压之前，低端MOSFET不会释放能量。The NCP1034 is able to startup into a pre-biased output capacitor. The low−side MOSFET does not turn on before the high−side MOSFET gets the first turn−on pulse. During this time, the energy is not discharged by the low−side MOSFET until the soft−start sequence crosses the programmed output voltage.

能效 Efficiency



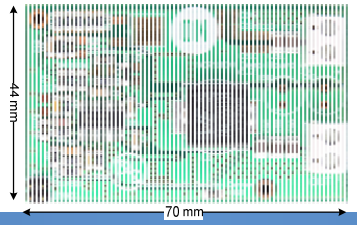
双输出5 A/8 A参考设计

Reference Design Dual Output 5 A/8 A

器件 Device	应用 Application	输入电压 Input Voltage	输出电压 Output Voltage	输出电流 Output Current	拓扑结构 Topology
NCP1034	网络交换机 Network Switch	38 V – 58 V	12 V	5 A	降压 Buck
NCP1034			5 V	8 A	降压 Buck

NCP1034				
Characteristic	Min	Typ	Max	Unit
Output Voltage		5		
Output Current		5		A
Oscillator Frequency		200		kHz
Output Voltage Ripple	16.5		20.5	mV
Load Regulation				
Iout = 0.1 – 5 A Vin = 48V		0.34		mV/A
Line Regulation				
Iout = 0.1A		0.004		%
Iout = 5A		0.011		%

NCP1034				
Characteristic	Min	Typ	Max	Unit
Output Voltage		12		V
Output Current		8		A
Oscillator Frequency		200		
Output Voltage Ripple	16.5		20.6	mV
Load Regulation				
Iout = 0.1 – 5 A Vin = 48V		.035		mV/A
Line Regulation				
Iout = 0.1A		.004		%
Iout = 5A		.012		%



网络电源参考设计
Networking Power – Reference Design

- 解决方案 Solution :
  - CS51021

- 目标应用 Target Application :
  - 以太网供电 (PoE)
  - 数据通信 Datacom
  - +48 V电源 +48 V Power

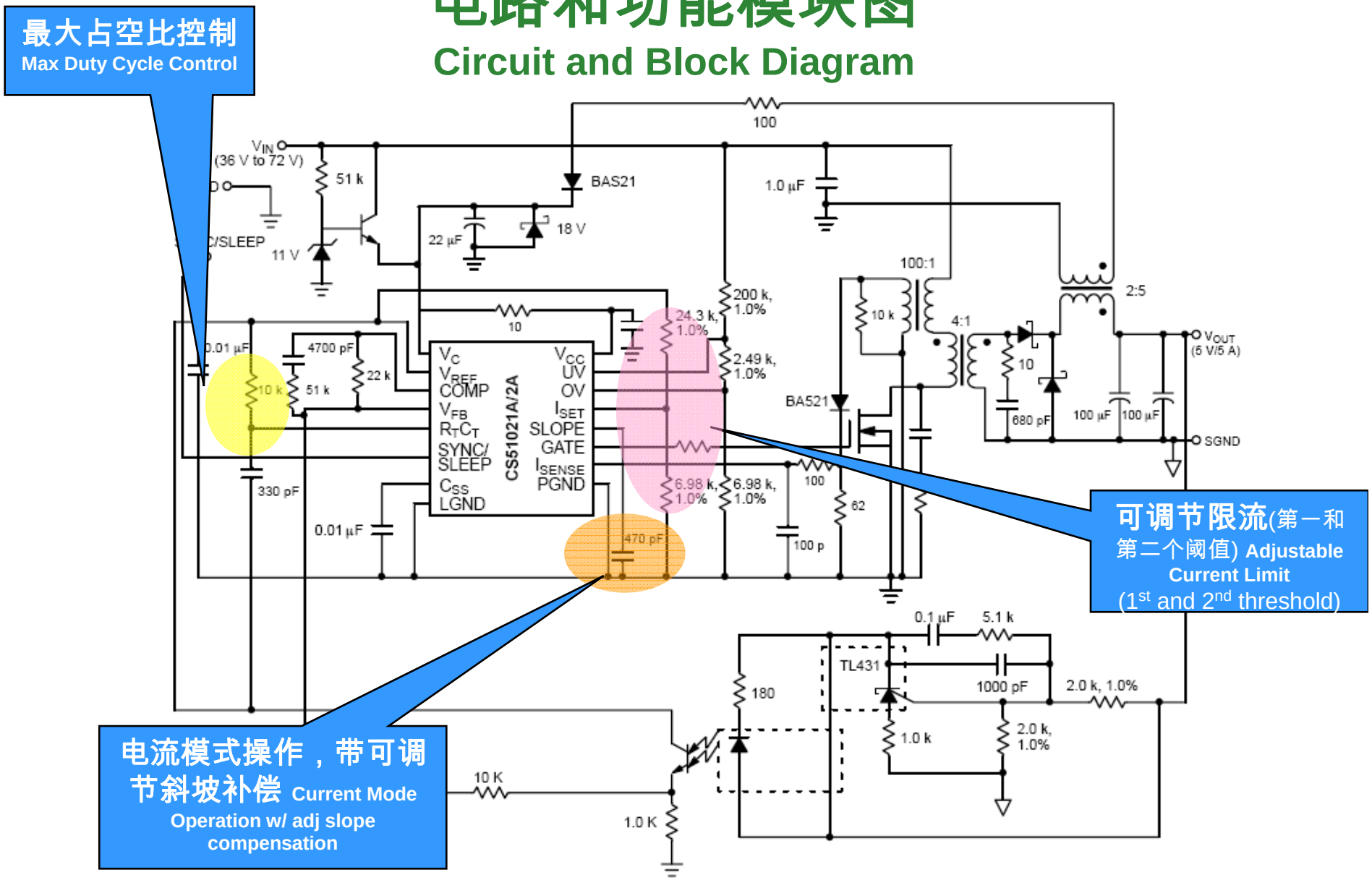
- 规范 Specification :
  - 输入 Input：+48 V (+/-20%)
  - 输出 Output：5 V @ 5 A
  - 保护：限流、欠压、过压保护 Protection: Current Limit, Undervoltage, Overvoltage
  - 能效：目标为高于85% Efficiency: Target >85%
  - 隔离：有 Isolated: YES
  - 必须使用陶瓷电容 Must use ceramic capacitors

元件/拓扑结构理据
Component / Topology Justification

- **正激转换器 Forward Converter**
  - 高能效，小尺寸输出滤波器，低输出纹波 High efficiency, small output filter, low output ripple
  - 高密度板设计 High density board design
  - 输入和输出之间隔离 Isolation between input and output

- **CS51021提供 CS51021 offers:**
  - 1 MHz频率能力 1 MHz Frequency Capability
  - 提供具有可编程迟滞的过压保护 Over Voltage Protection with Programmable Hysteresis
  - 可编程逐脉冲过流保护 Programmable Pulse-by-Pulse Over Current Protection
  - 带有前沿消隐的电流模式控制 Current mode control with leading edge blanking

电路和功能模块图
Circuit and Block Diagram



CS51021 – 电流模式脉宽调制控制器

CS51021 -- Current Mode PWM Controller

价值主张 Value Proposition

The CS51021A Fixed Frequency PWM Current Mode Controller family provides all the necessary features required for AC−DC or DC−DC primary side control. Several features are integrated eliminating the additional components needed to implement them externally.

独特特性 Unique Features

- 1 A sink/source gate drive
- Up to 1 MHz Fsw
- Programmable slope compensation

优势 Benefits

- High efficiency operation
- Optimize for size or efficiency
- Increased stability

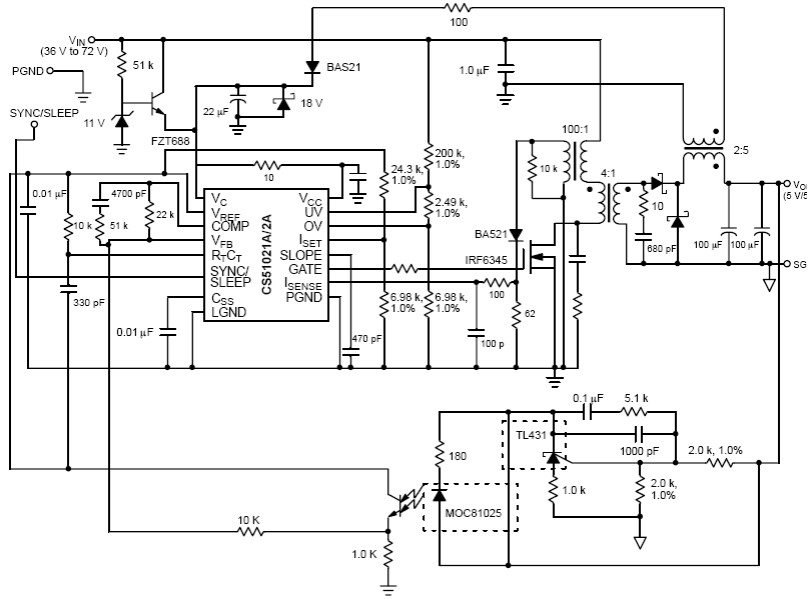
其它特性 Others Features

- Programmable Max Duty Cycle Limit
- Programmable Pulse−By−Pulse Overcurrent Protection
- Overvoltage Protection with Programmable Hysteresis
- Bidirectional Synchronization

市场和应用 Market & Applications

- **Consumer Electronics:** PoE PD, …
- **Automotive:** Body electronics, Navigation, …
- **Computing**: Power supply, …
- **Industrial:** Power supplies, Process control, PoE PD, Solar Power Charger…

应用数据 Application Data

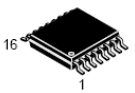


能够配置为正激、反激或升压拓扑结构

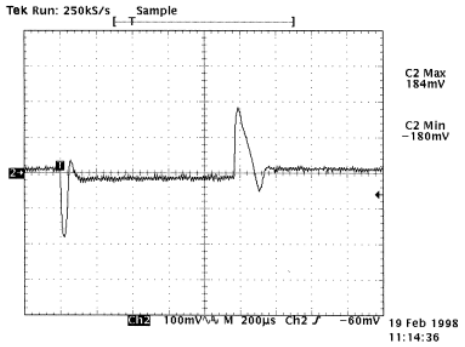
Capable of being configured as Forward, Flyback or Boost

订购和封装信息 Ordering & Package Information

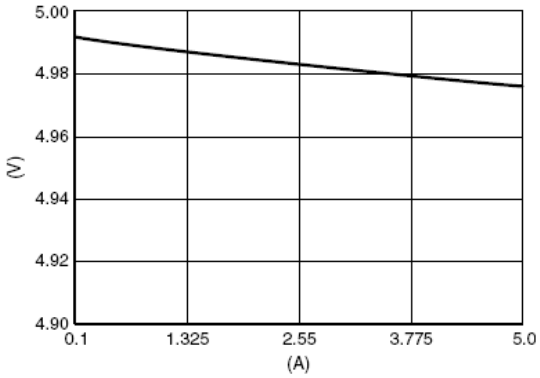
- SOIC-16 & TSSOP-16
- CS51021: -40 to +125°C



测量数据 Measurement Data

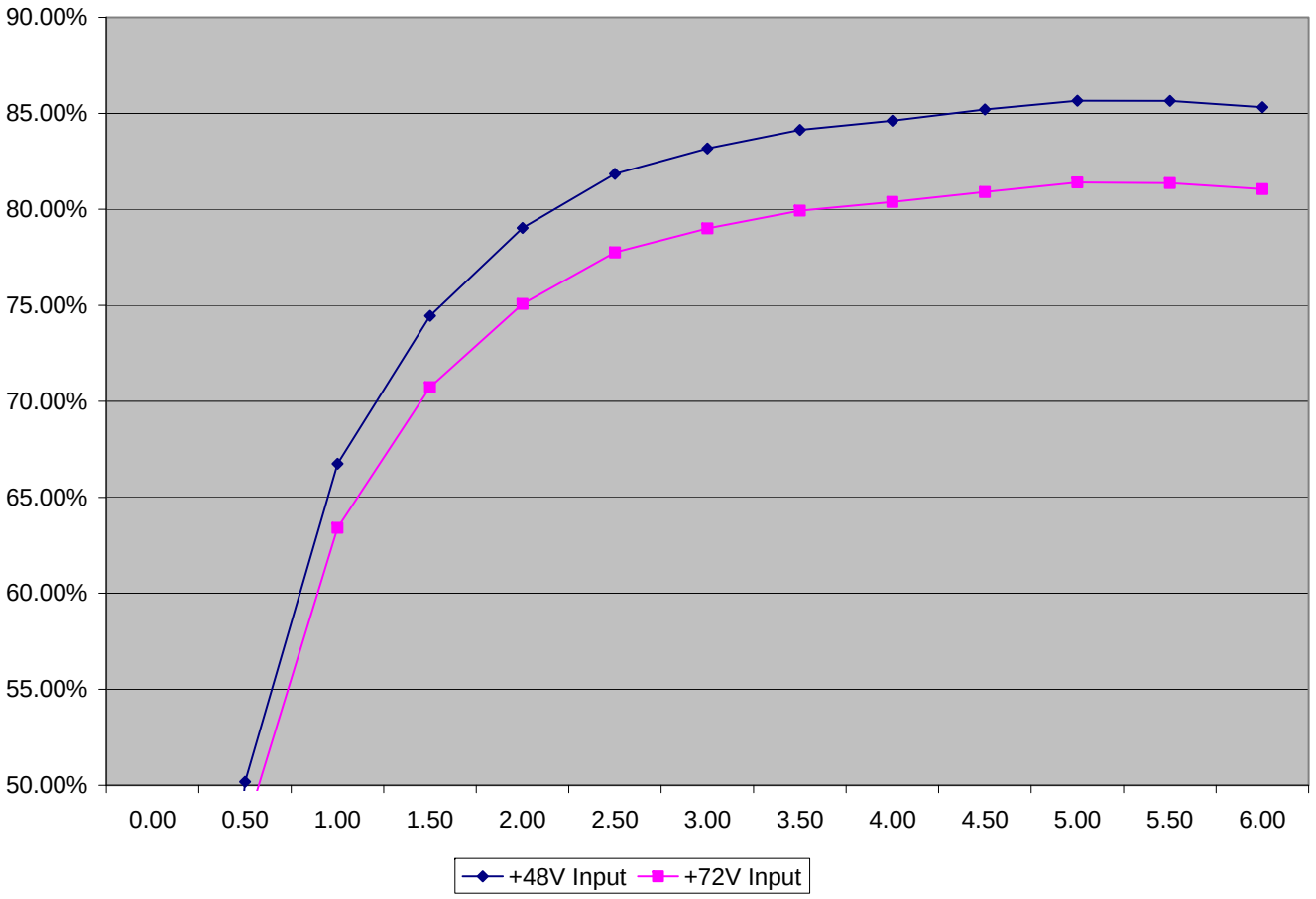


瞬态响应 Transient Response



负载稳压 Load Regulation

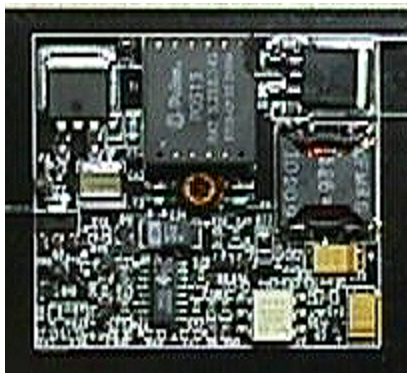
能效 Efficiency



隔离5 A输出参考设计 Reference Design – Isolated 5 A Output

器件 Device	应用 Application	输入电压 Input Voltage	输出电压 Output Voltage	输出电流 Output Current	拓扑结构 Topology
CS51021	网络交换机 Network Switch	36 V – 72 V	5 V	8 A	正激 Forward

CS51021				
Characteristic	Min	Typ	Max	Unit
Output Voltage	4.75		5.05	V
Output Current	0		5	A
Oscillator Frequency		330		kHz
Output Voltage Ripple			50	mV
Load Regulation	4.99		4.59	V



50 x 53mm

基站电源参考设计
Basestation Power – Reference Design

- 解决方案 Solution :
  - NCP3102

- 目标应用 Target Application :
  - 基站，电信 Basestation, Telecom
  - +18 V电源 +18 V Power

- 规范 Specification :
  - 输入 Input : +12 V (+/-20%)
  - 输出 Output : 1.0 V @ 10 A
  - 保护：限流保护 Protection: Current Limit
  - 能效：目标高于75% Efficiency: Target >75% @ 18 V输入电压至1.0 V输出电压 18 Vin to 1.0 Vout
  - 隔离：无 Isolated: No
  - 必须使用陶瓷电容 Must use ceramic capacitors
  - 必须能够能高达18 V输入电压进行稳压 Must be able to regulate up to 18 V input
  - 小尺寸/高功率密度 Small size / High power density

元件/拓扑结构理据
Component / Topology Justification

- **应用需求 Application needs:**
  - 宽输入范围降压稳压器，能够提供低占空比，及输出大于1.25 V的高能效电源转换 Wide input voltage range buck regulator capable of low duty cycle and high efficiency conversion to >1.25 V
  - 小尺寸/高功率密度 Small size / High power density
  - 在高温环境中能够保持输出电压精度 Maintain output voltage accuracy in high temp environment
  - 比分立直流-直流(DC-DC)模块相比更低的成本 Lower cost compared to discrete dc-dc module

- **NCP310x提供 NCP310x offers:**
  - 采用高能效场应管(~8 mΩ)的集成降压稳压器 Integrated buck regulator with highly efficient FET (~8 mohm)
  - 支持宽温度范围的精密内部参考 Precision internal reference across wide temp range
  - 改善散热的QFN封装 Thermally enhanced QFN package
  - 输出电压低至0.8 V Output voltage down to 0.8 V
  - 方便系统集成，简化嵌入式系统设计 Easy system integration simplifying embedded system design

NCP3102 – 10 A同步转换器

NCP3102 – 10 A Synchronous Converter

价值主张 Value Proposition

The NCP3102 is an integrated wide input voltage high-output current synchronous PWM buck converter. The 10 A output in a small QFN package makes the part ideal for high power density designs.

独特特性 Unique Features

- Highly integrated 10 A solution
- Integrated FET (10 mΩ HS & LS)

优势 Benefits

- High Power Density ; Reduced Board Space
- Highly Efficient System (>92% max efficiency)

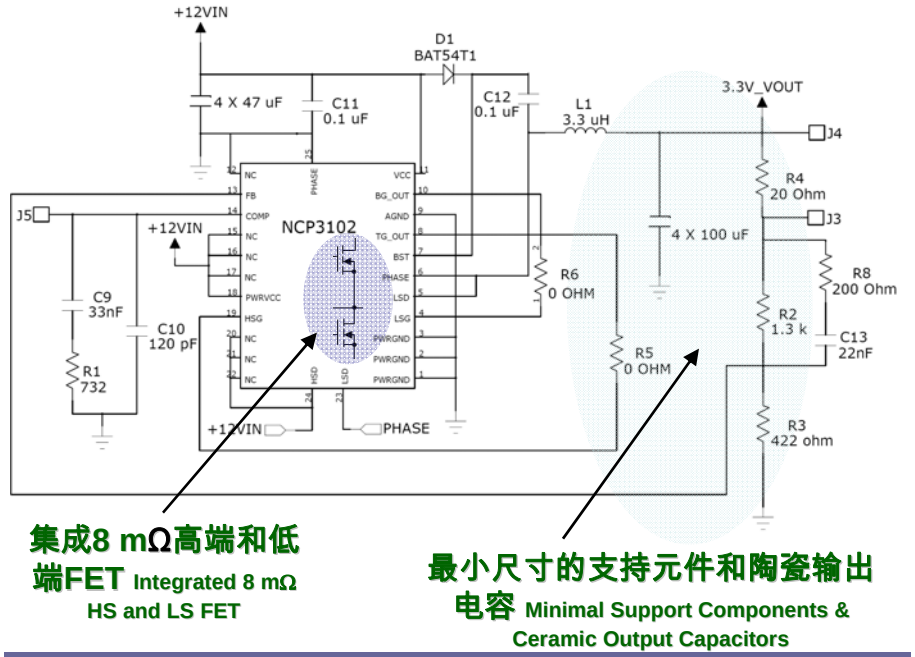
其它特性 Others Features

- 275 kHz Switching frequency
- Programmable current limit
- 0.8 V +/-1% accurate internal reference

市场和应用 Market & Applications

- **Consumer Electronics:** CRT, LCD TVs, STB, DVD, …
- **Computing**: Power supply
- **Industrial:** Power supplies, Base Station, Broadband & Optical Communication Infrastructure

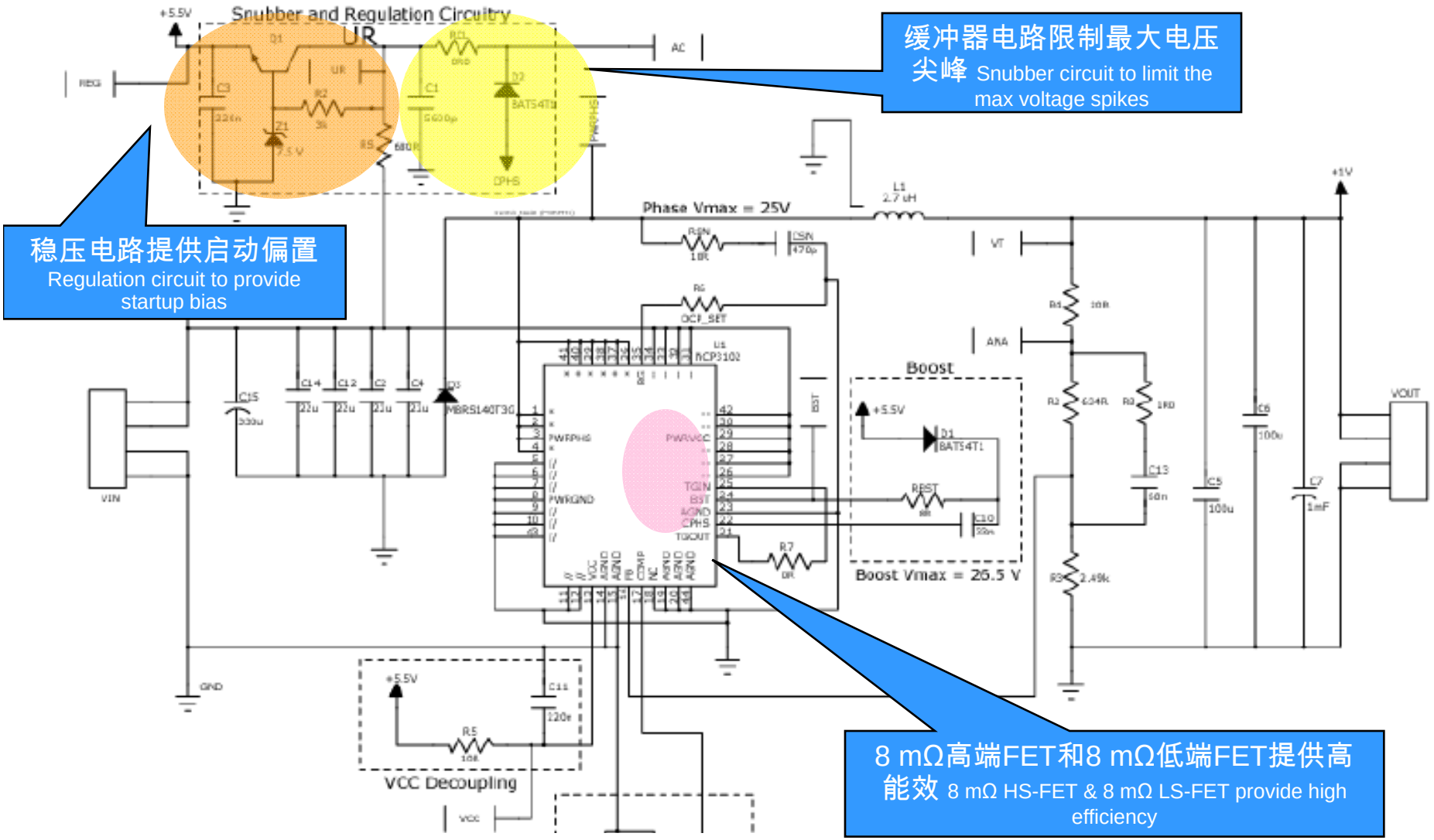
应用数据 Application Data



订购和封装信息 Ordering & Package Information

- QFN-40
- NCP3102: 0 to +85°C
- NCP3102B: -40 to +85°C

电路和功能框图 Circuit and Block Diagram



外部偏置电路 External Bias Circuit

- NCP3102采用简单的外部电路来将输入电压能力从13.2 V扩展至19 V。NCP3102的内部脉宽调制(PWM)控制部分使用与功率场效应管(FET)不同的电源输入端。因此，图4中显示的缓冲器和稳压电路能够单独为低压控制部分供电。 A simple external circuit was used to extend the input voltage capability of the NCP3102 from 13.2 V to 19 V. The internal PWM control section of the NCP3102 uses a different power rail than the power FET's. Therefore, the snubber and regulation circuitry shown in Figure 4 can power the low voltage control section separately.

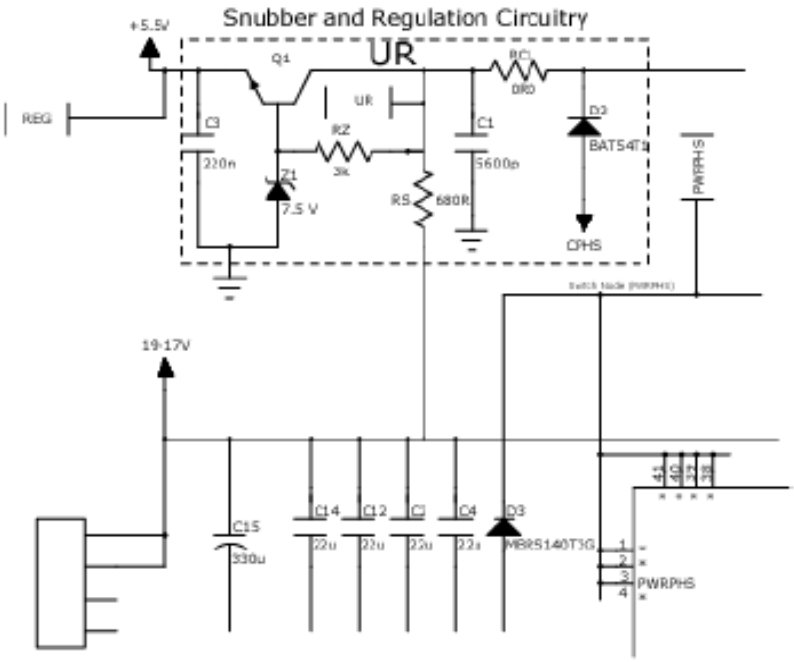


Figure 4 - Reference Schematic for 17V-19V Input

缓冲器电路
Snubber Circuitry

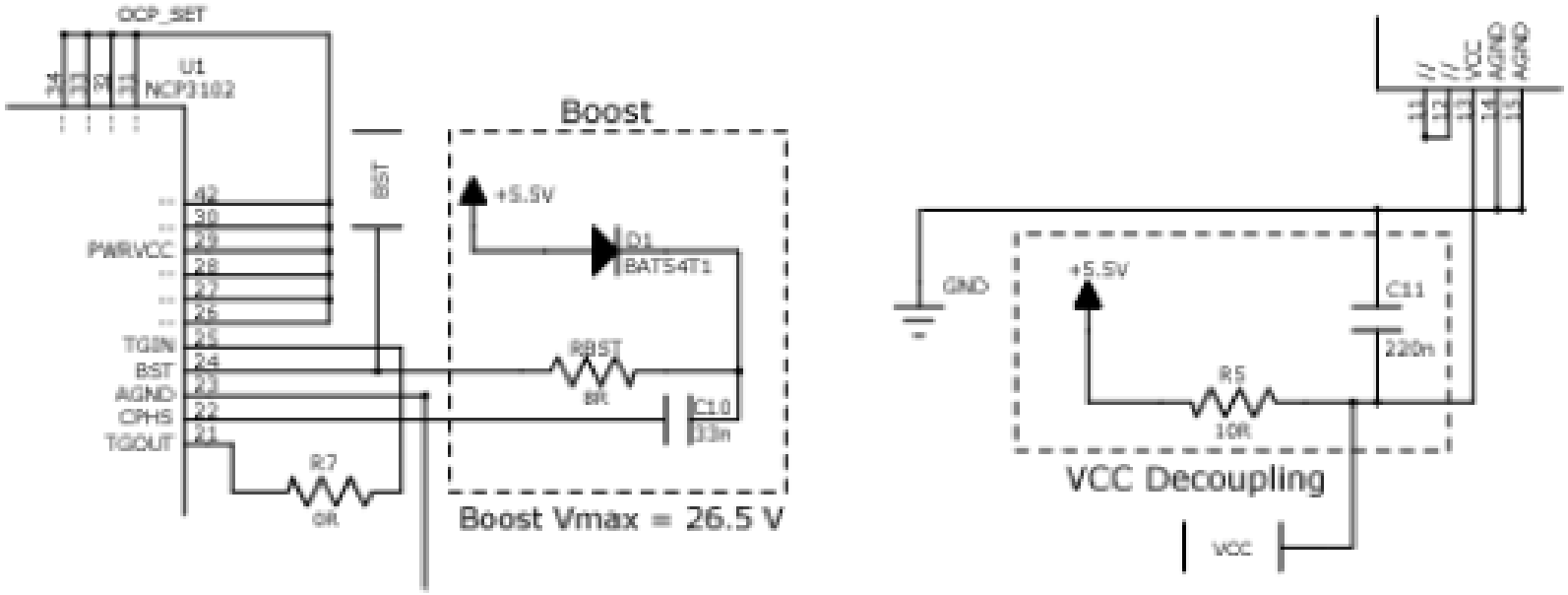
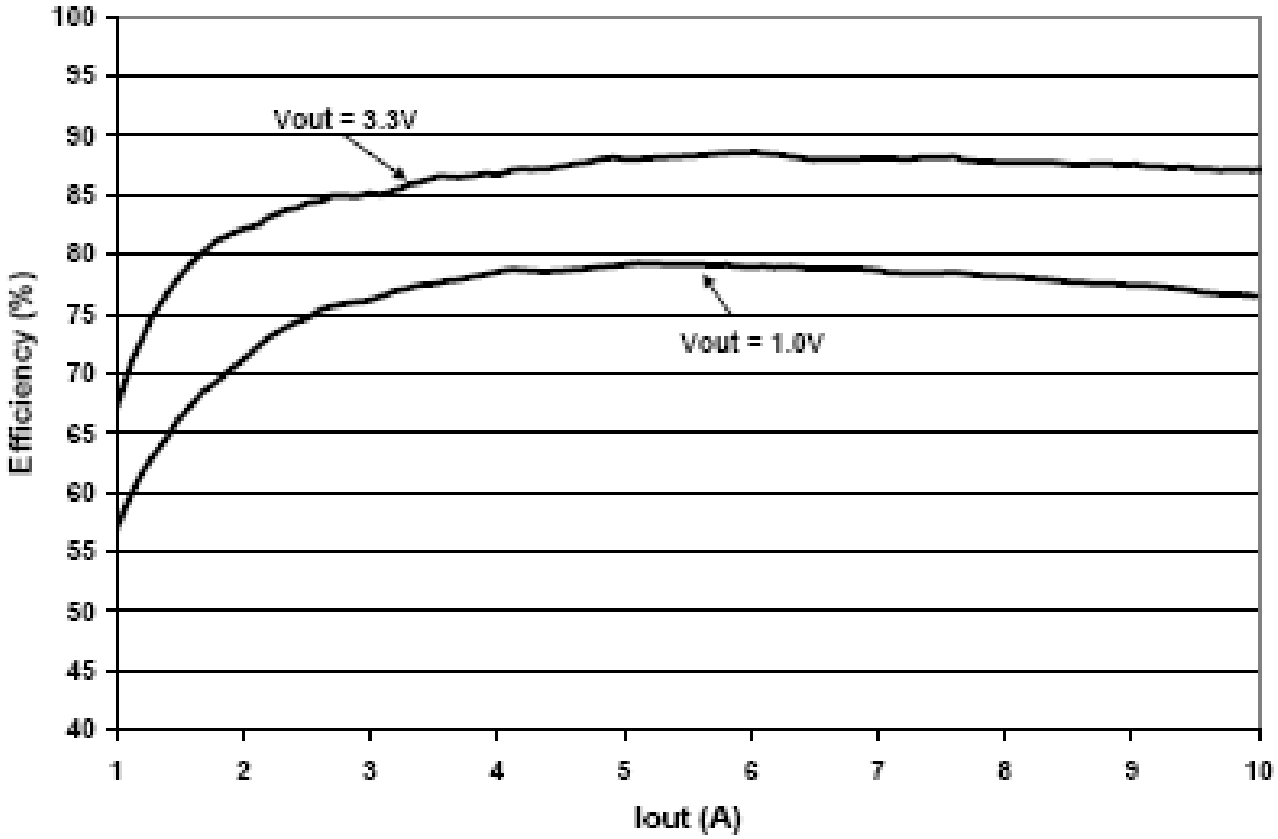


Figure 5- Modification for Extended Voltage Range

- 图4和5中所显示的电路提供的作用是稳压器、启动延迟和缓冲器/电磁干扰(EMI)抑制器。 The circuit shown in Figure 4 and 5 serves as a regulator, startup delay, and snubber / EMI suppressor.

能效
Efficiency



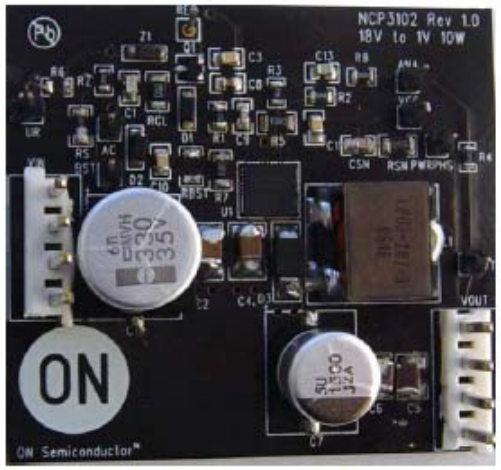
NCP3102 Efficiency (+18IN+ to +1.0V or +3.3V Output at 10A)

10 A稳压器参考设计

Reference Design – 10 A Regulator

器件 Device	应用 Application	输入电压 Input Voltage	输出电压 Output Voltage	输出电流 Output Current	拓扑结构 Topology
NCP3102	基站 Base Station	9.6-14.4 V (18 V)	1.0 V	10 A	降压 Buck

NCP3102				
Characteristic	Min	Typ	Max	Unit
Output Voltage		1.0		
Output Current		10		A
Oscillator Frequency		275		kHz
Output Voltage Ripple		10		mV
Load Regulation				
Iout = 0.5 – 10A Vin = 18V		0.27		mV/A



物理尺寸为55 x 50 mm

55 x 50mm Physical Size

电信负载点(POL)电源参考设计

Telecom Point-of-Load Power – Reference Design

- 解决方案 Solution :
  - NCP3121

- 目标应用 Target Application :
  - 电信，数据通信 Telecom, Datacom
  - 无线局域网、线缆调制解调器，xDSL WLAN, Cable Modem, xDSL

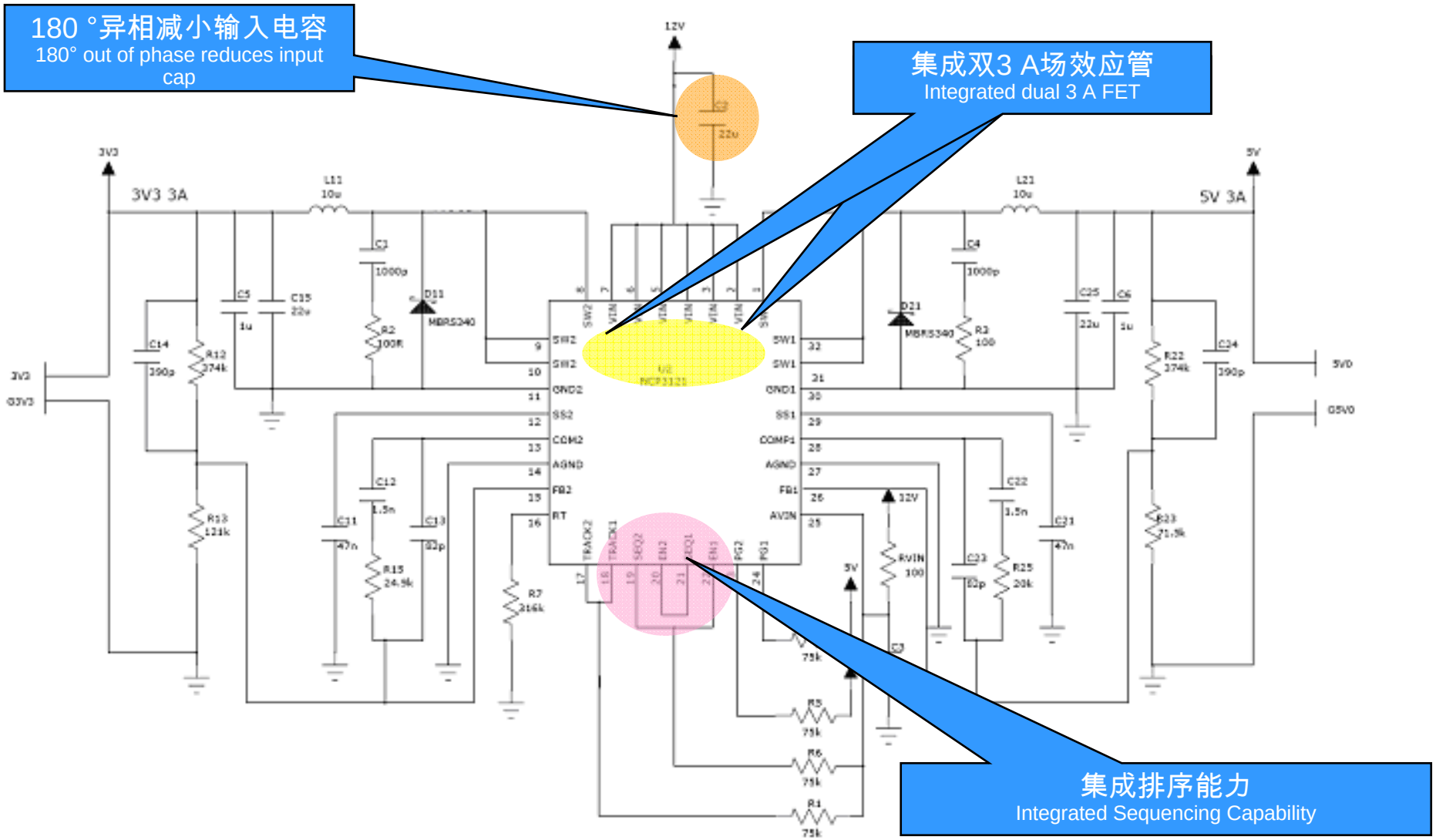
- 规范 Specification :
  - 输入 Input : +12 V (+/-10%)
  - 输出1 Output-1 : 5.0 V @ 3 A
  - 输出2 Output-2 : 3.3 V @ 3 A
  - 保护：限流保护 Protection: Current Limit
  - 能效：目标高于80% Efficiency: Target >80%
  - 隔离：无 Isolated: No
  - 必须使用陶瓷电容 Must use ceramic capacitors
  - 小尺寸/高功率密度 Small size / High power density

元件/拓扑结构理据
Component / Topology Justification

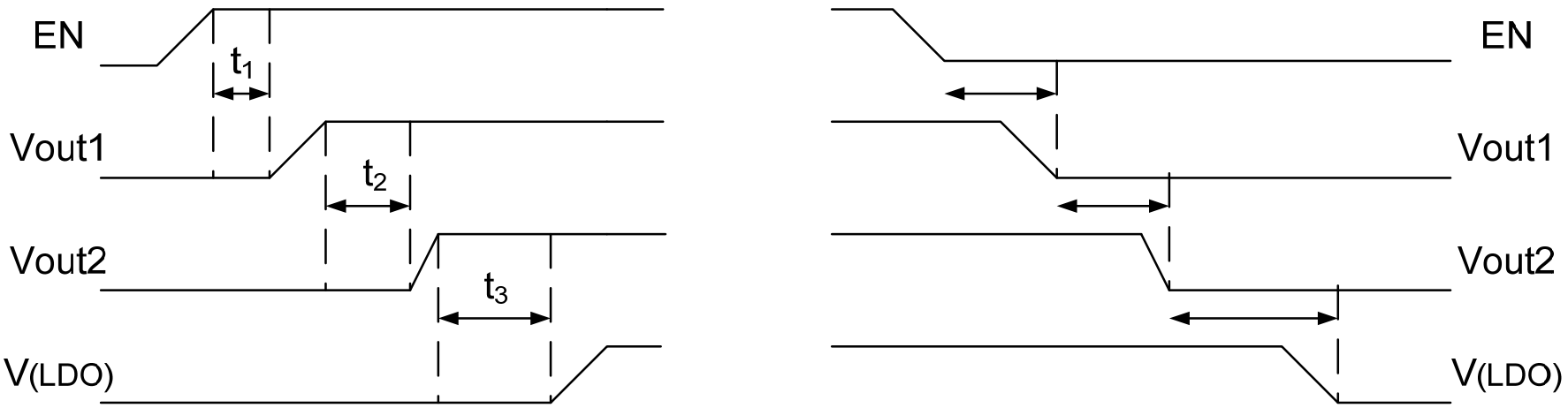
- **应用要求 Application needs:**
  - 具有上电和掉电排序能力，满足新的芯片组(FPGA、ASIC等)要求 Sequencing capability for power-up and power-down to meet new chipset requirements (FPGA, ASIC, etc.)
  - 小尺寸/高功率密度 Small size / High power density
  - 大批量/低成本解决方案 High volume / Low cost solution

- **NCP3121提供 NCP3121 offers:**
  - 集成双3 A降压稳压器 Integrated dual 3 A buck regulator
  - 支持宽温度范围的精密内部参考 Precision internal reference across wide temp range
  - 改善散热性能的QFN封装 Thermally enhanced QFN package
  - 内置自动追踪和排序特性 Auto-Tracking and Sequencing feature built-in

电路和功能框图 Circuit and Block Diagram



排序要求 Sequencing Requirements

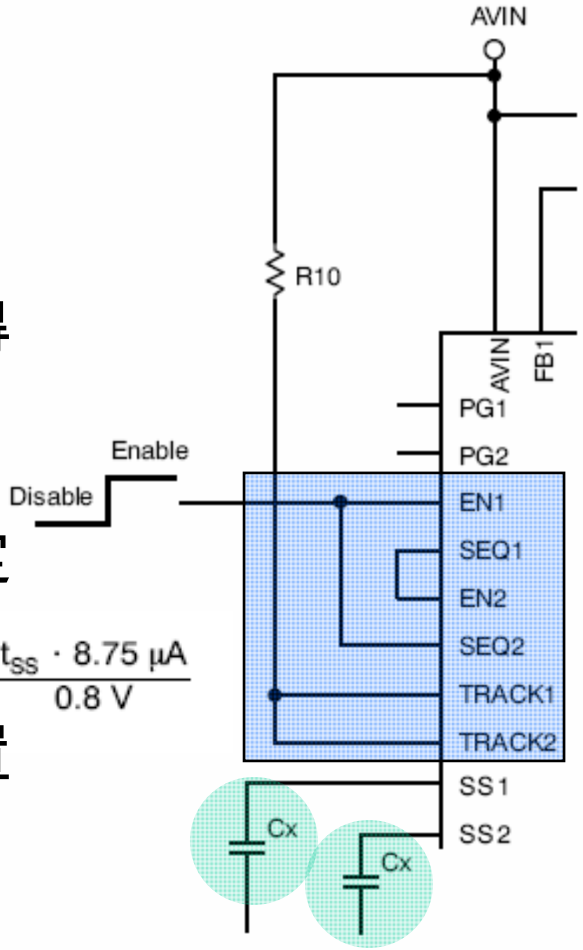


保证上电和掉电的排序 Sequencing guaranteed on power-up and power-down

- 防止错误数据加载至输入/输出(I/O)缓冲器 Prevent false data from being loaded in I/O buffers
- 时序要求必须也满足(t_1,t_2,t_3) Timing requirement must also be meet (t_1, t_2, t_3)
- 保护专用集成电路(ASIC)免受损伤(反向偏置ESD结构) Protect the ASIC from damage (reverse bias ESD structure)

自动追踪和排序 Auto-Tracking & Sequencing

- NCP3120能够作为独立开关转换器操作，或者也能支持自动追踪和排序 The NCP3120 can operate as a standalone switching converter or it can support auto-tracking and sequencing
- 软启动电容调节使得上电和掉电操作得到保证Adjustment of the soft-start capacitors allows guaranteed power-up and power-down operation
- 提供“启用”、“排序”和“追踪”引脚来设定配置 Enable, Sequence and Track set the configuration
- 也能够采用菊花链形式将数款器件配置在一起，从而管理多路输出 Several devices are also capable of being daisy chained together to manage multiple outputs

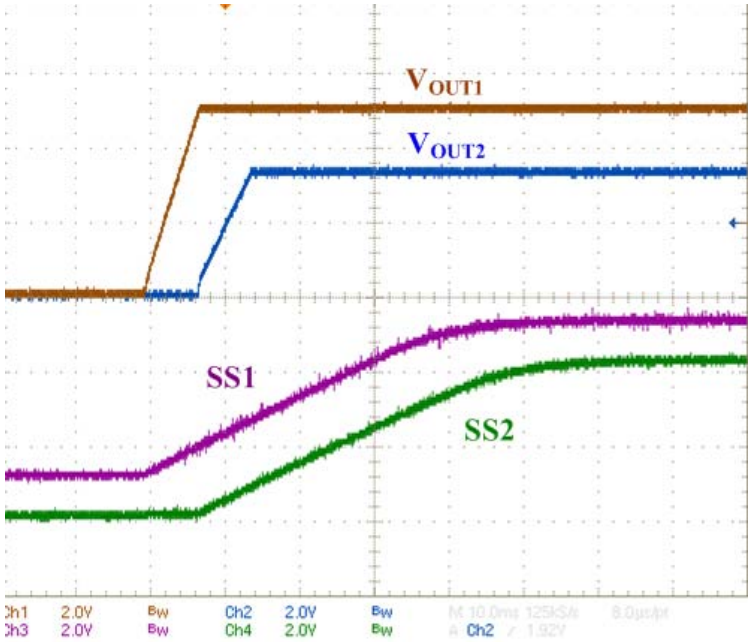


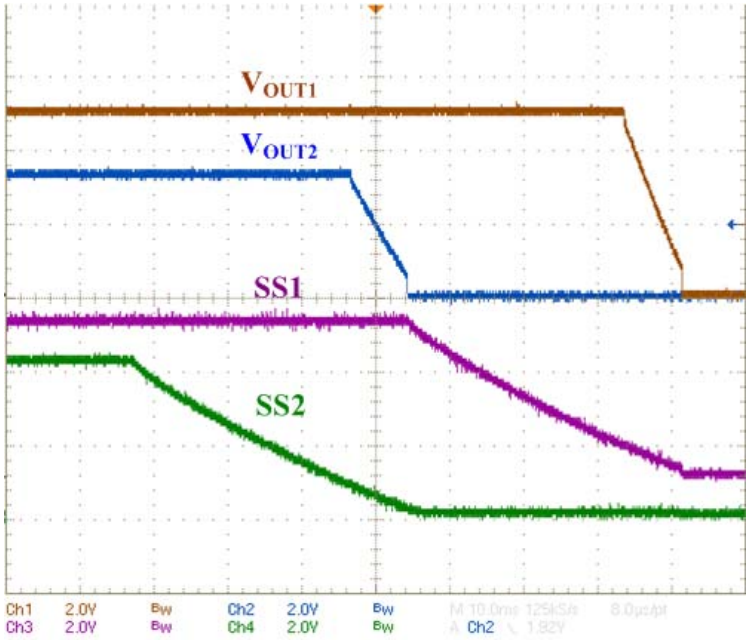
$$C_{SS} \approx \frac{t_{SS} \cdot 8.75\ \mu A}{0.8\ V}$$

消除使用另外外部元件来保证电源管理的需要

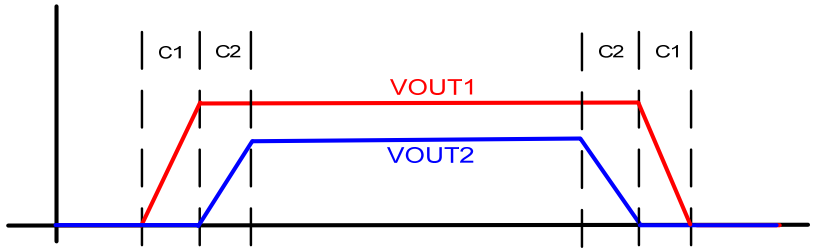
Eliminates the Need for Additional External Components to Guarantee Power Management

排序 Sequencing



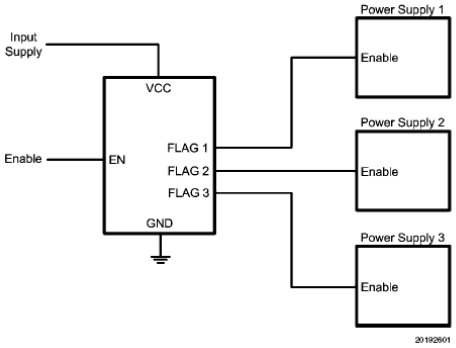


排序：第一路输出电压稳定后第二路输出电压开始上升 **Sequencing:** The second output voltage starts ramping when the first output voltage is already settled.

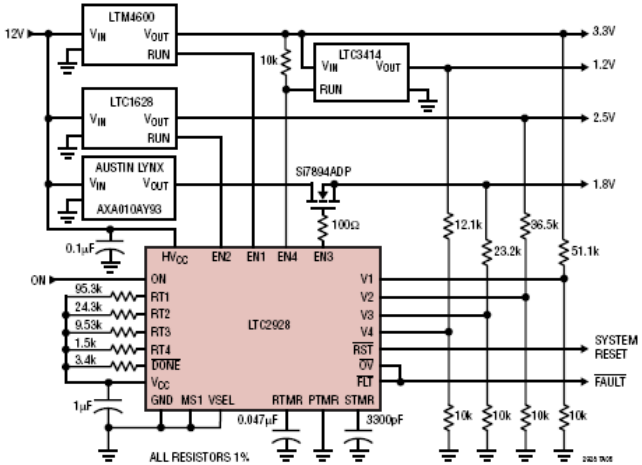


无须使用外部排序芯片
Eliminates External Sequence Chip

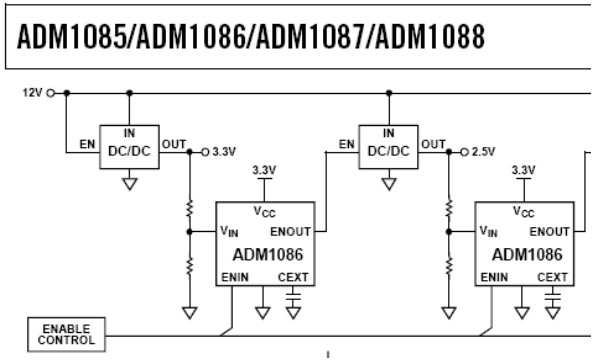
LM3880 – 电源排序器 Power Sequencer



LT2928 – 电源排序器 Power Supply Sequencer



ADM1086 – 电压排序器 Voltage Sequencer



- NCP3121内置自动追踪和排序能力，消除了使用外部芯片来管理这项功能并保证性能的需要 Built-in auto-tracking and sequencing capability eliminates the need to use an external chip to manage this function and guarantee performance

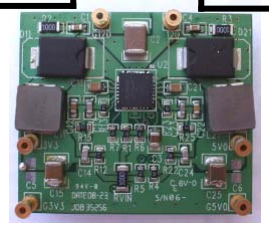
双输出3 A/3 A参考设计

Reference Design Dual Output 3 A / 3 A

器件 Device	应用 Application	输入电压 Input Voltage	输出电压 Output Voltage	输出电流 Output Current	拓扑结构 Topology
NCP3121	xDSL	10.8 – 13.2 V	5 V	3 A	降压 Buck
			3.3 V	3 A	降压 Buck

NCP3121 (output-1)				
Characteristic	Min	Typ	Max	Unit
Output Voltage	2.274	3.28	3.298	V
Output Current	0		3	A
Oscillator Frequency		300		kHz
Output Voltage Ripple	5	69	98	mV
Load Regulation				
Iout = 0.1 – 3A Vin = 12V		2.97		mV/A
Line Regulation				
Iout = 0.1A	.35	.47	.64	%
Iout = 3A	.64	.70	.76	%

NCP3121 (output-2)				
Characteristic	Min	Typ	Max	Unit
Output Voltage	4.982	5.00	5.019	V
Output Current		3		A
Oscillator Frequency		300		
Output Voltage Ripple	5	73	156	mV
Load Regulation				
Iout = 0.1 – 3 A Vin = 12V		4.63		mV/A
Line Regulation				
Iout = 0.1A	-.01	.00	.11	%
Iout = 3A	-.36	-.28	-.20	%



电信偏置电源参考设计

Telecom Bias Supply – Reference Design

- 解决方案 Solution :
  - NCP1031

- 目标应用 Target Application :
  - 基站，网络 Basestation, Networking

- 规范 Specification :
  - 输入 Input : +35 V to +76 V (+48 V)
  - 输出1 Output-1 : 12 V
  - 功率 Power: 2 W
  - 保护：限流保护、欠压/过压保护 Protection: Current Limit, UV/OV
  - 能效：目标高于80% Efficiency: Target >80%
  - 隔离：有 Isolated: Yes
  - 必须使用陶瓷电容 Must use ceramic capacitors
  - 小尺寸/高功率密度 Small size / High power density

元件/拓扑结构理据
Component / Topology Justification

- **应用要求 Application needs:**
  - 小尺寸/高功率密度。最小数量的支持元件。 Small size / High power density. Minimal number of support components.
  - 宽输入范围，覆盖+48 V电信应用 Wide input voltage range to cover +48 V Telecom

- **NCP1030提供 NCP1030 offers:**
  - 集成电源开关 Integrated power switch
  - 内部启动稳压器；直接采用输入电压供电 Internal start-up regulator ; direct power from input voltage
  - 采用SENSEFET™提升能效 Improved efficiency with SENSEFET™
  - 采用集成门驱动和电源开关降低电磁干扰(EMI) Reduced EMI with integrated gate drive and power switch

NCP1030/31 – PWM控制器及电源开关

NCP1030/31 - PWM Controller & Power Switch

价值主张 Value Proposition

The NCP1030 and NCP1031 are a family of miniature high-voltage monolithic switching regulators with on-chip Power Switch and Startup Circuits. The NCP103x can be configured in any single-ended topology such as forward or flyback.

独特特性 Unique Features

- 200 V Switch
- Up to 1 MHz Fsw
- Synchronization

优势 Benefits

- Suitable for +48 V, +60 V, +100 V supplies
- Reduced size
- Fixed frequency for 1 or more devices

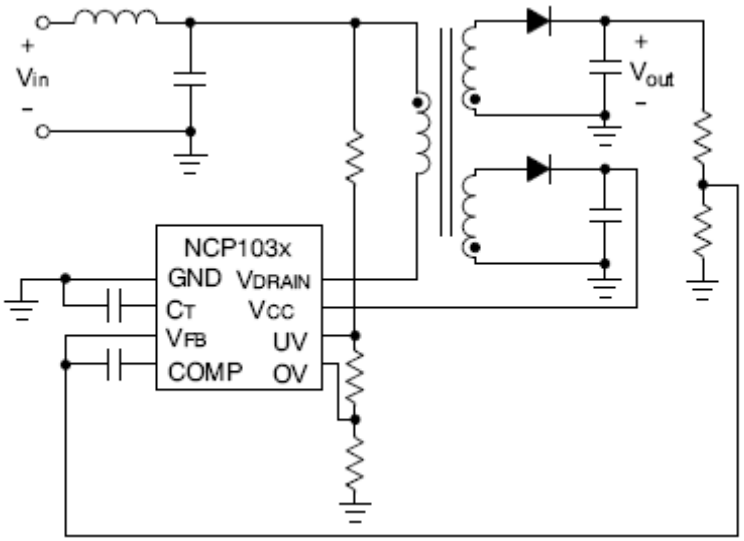
其它特性 Others Features

- Internal Start-up Circuit with aux winding override
- External frequency synchronization
- Trimmed +/-2% internal reference
- Active Leading Edge Blanking (LEB) Circuit

市场和应用 Market & Applications

- **Consumer Electronics:** xDSL, Modems
- **Computing**: Telecom
- **Industrial:** Power supplies, Process control, Low Power Bias supply, 2nd Side Bias w/ isolated dc-dc

典型应用图和封装信息 Typical App. diagram & Package info

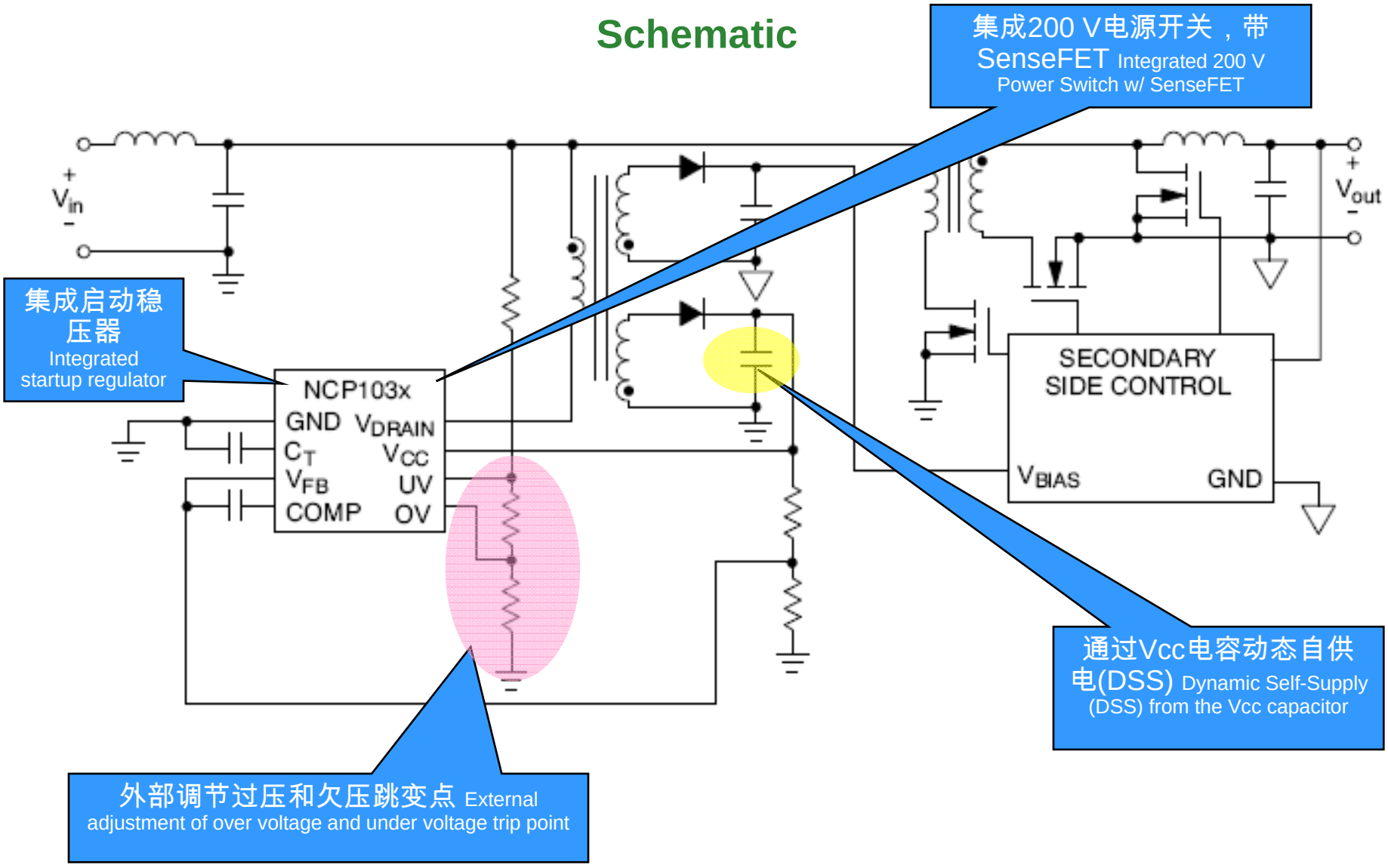


外部元件数量最小 Minimal Number of External Components

订购信息和支援 Ordering info & Support

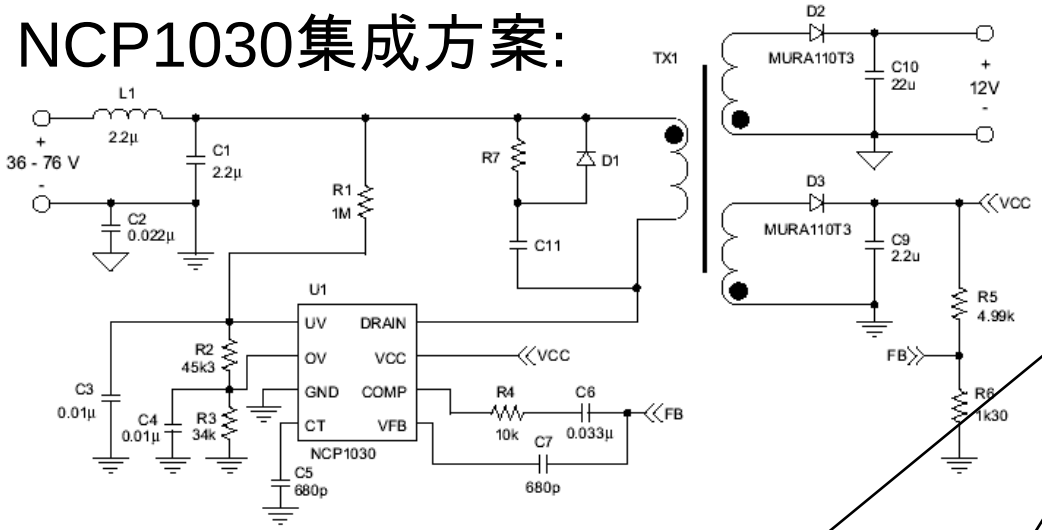
- NCP1030: Micro-8
- NCP1031: SOIC-8 & DFN-8

原理图
Schematic

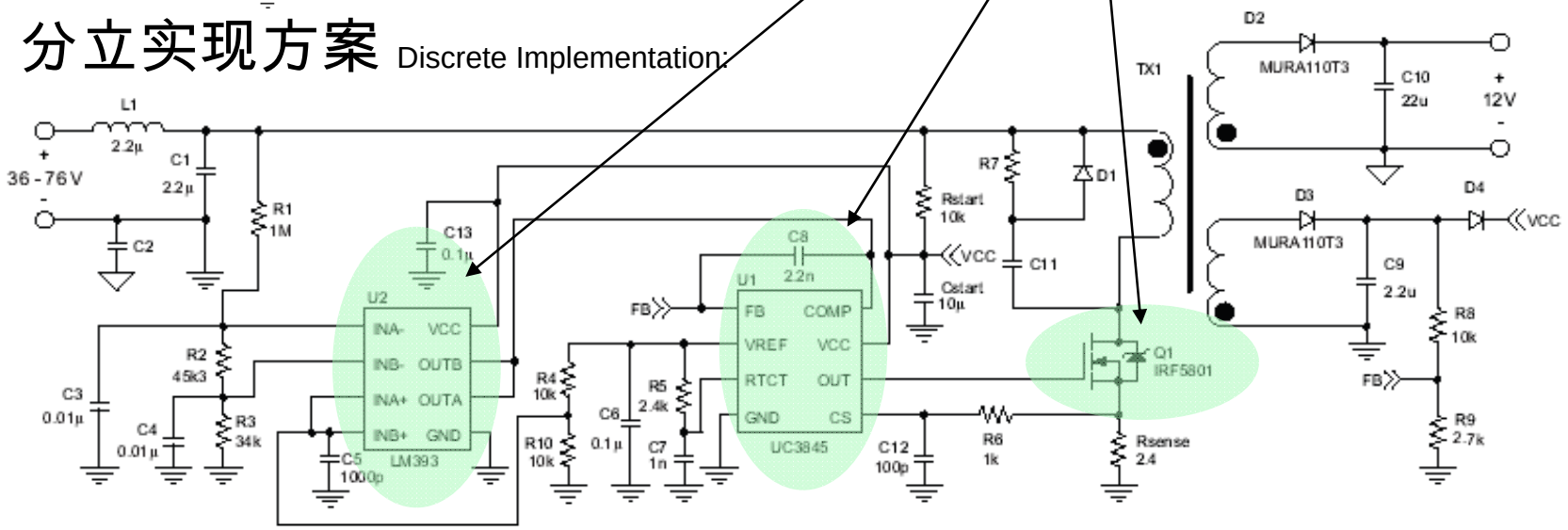


集成关键功能 Integrate Key Function

- NCP1030集成方案:



- 分立实现方案 Discrete Implementation:



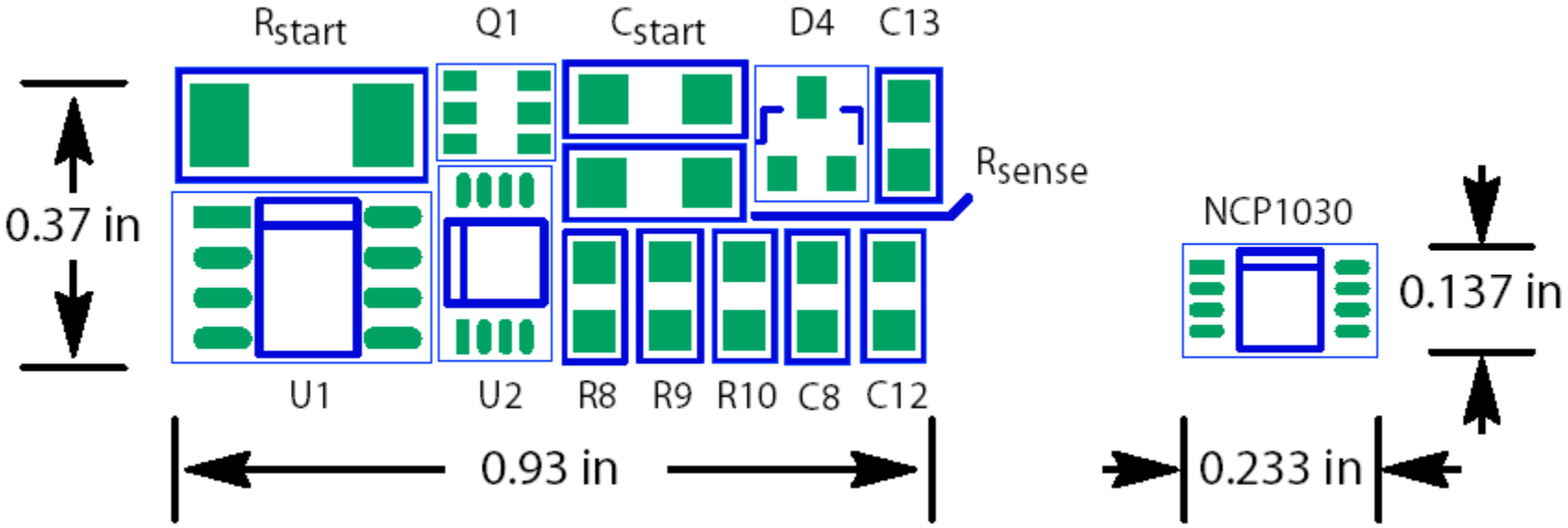
集成 Integrates

- 监控 Supervisory
- PWM控制器PWM Controller
- 电源开关 Power Switch

减少电路板占用空间/提供更高密度

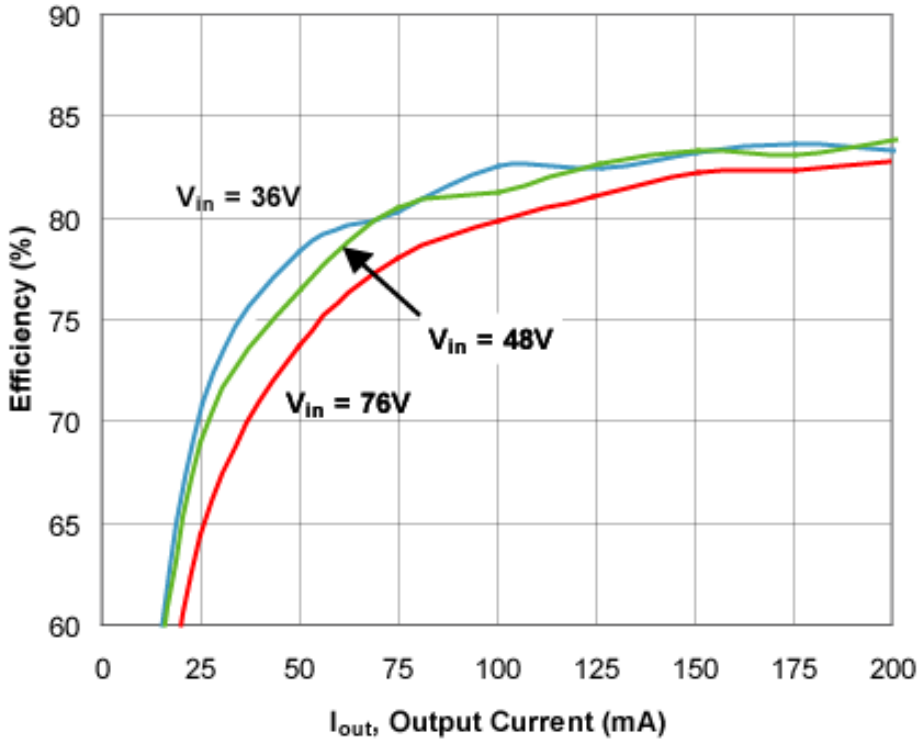
Reduced PCB Space / Higher Density

- 与TL384x和MAX6457A解决方案相比，采用NCP1030实现的偏置电源节省多达**91%**的占位面积！ Bias supply implemented using the NCP1030 compared to a TL384x and MAX6457 solution results in a footprint area saving of **91%!!!!**



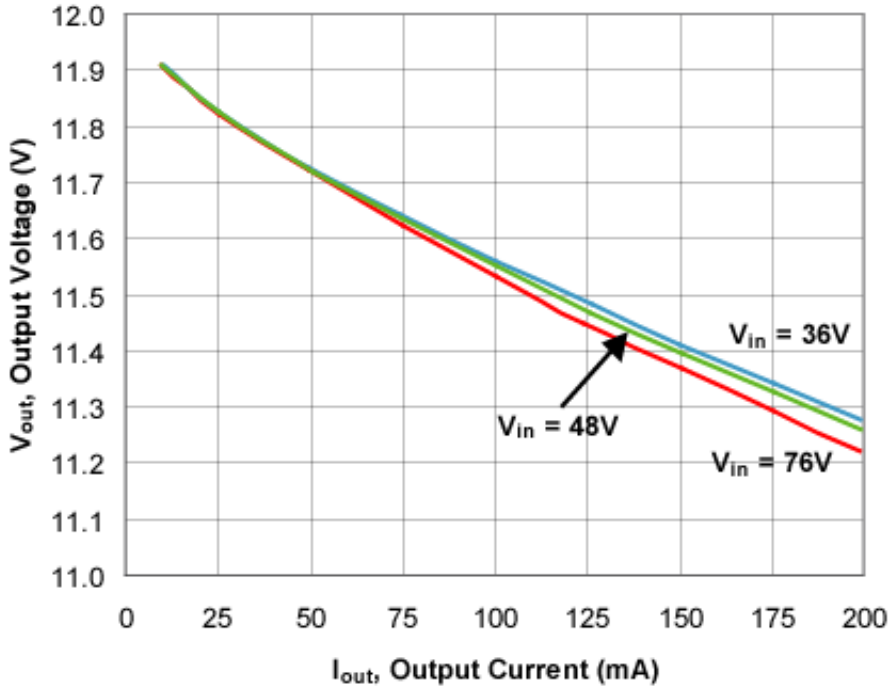
性能数据 Performance Data

能效
Efficiency



能效低于80%
<80% Efficiency

线路和负载稳压
Line & Load Regulation



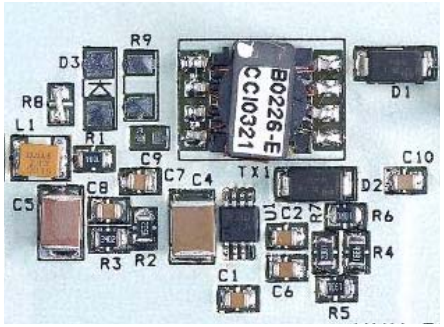
线路稳压精度=0.5%
负载稳压精度=8%
Line Regulation = 0.5%
Load Regulation = 8%

2 W偏置电源参考设计

Reference Design – 2 W Bias Supply

器件 Device	应用 Application	输入电压 Input Voltage	输出电压 Output Voltage	输出功率 Output Power	拓扑结构 Topology
NCP1030	基站 Base Station	48 V (36-72 V)	12 V	2 W	反激 Flyback

NCP1030				
Characteristic	Min	Typ	Max	Unit
Output Voltage	10.8		13.2	V
Output Current	0.017		0.17	A
Oscillator Frequency	250	275	300	kHz
Output Voltage Ripple		50		mV
Load Regulation		0.8		%
Output Power	2.0			W



物理尺寸20 x 35 mm
20 x 35mm Physical Size

提供完整解决方案
Delivering Total Solutions

时钟分配 Clock Distribution
时钟产生 Clock Generation
射极耦合逻辑逻辑 ECL Logic
运算放大器 Op Amp
比较器 Comparators
信号和接口 Signal & Interface
浪涌保护 Surge Protection
静电放电保护 ESD Protection
电压转换 Voltage Translators

高电源能效解决方案
Power Efficient Solutions

产品参考设计 Product Reference Designs

供应链和制造
Supply Chain and Manufacturing

直流-直流控制器 DC-DC Controllers
直流-直流稳压器 DC-DC Regulators

For More Information

- View the extensive portfolio of power management products from ON Semiconductor at www.onsemi.com
- View reference designs, design notes, and other material supporting the design of highly efficient power supplies at www.onsemi.com/powersupplies