

TOP242-250

TOPSwitch®-GX 产品系列



输出功率更大、设计灵活性更强、高效节能的集成离线式开关IC

产品特点

降低系统成本，提高设计灵活性

- 输出功率更大以适应更高功率的应用
- 使用P/G封装时输出功率在34 W以下都无需散热器
- 节约外围元件成本
- 完全集成的缓启动电路降低了器件的应力及输出电压过冲
- 外部电路实现精确的流限编程
- 更宽的占空比实现更高的输出功率，同时可以使用更小尺寸的输入滤波电容
- 在Y/R/F封装具有独立的输入线电压检测及流限编程引脚
- 输入欠压(UV)检测可以防止关机时输出的不良波动
- 输入过压(OV)关断电路提高了对输入浪涌的耐受力
- 具有最大占空比(DC_{MAX})降低特点的线电压前馈抑制了工频纹波并在高输入电压时限制了最大占空比
- 频率调制降低EMI及EMI滤波器成本
- 在零负载时实现输出电压的稳压而无需假负载
- 132 kHz频率调制降低变压器及电源的尺寸
- Y/R/F封装在视频应用时可以选择半频工作
- 迟滞热关断提供自动故障恢复功能
- 热迟滞值较大，防止电路板过热

EcoSmart — 高效节能

- 遥控关机模式下极低的功率消耗（在110 VAC时消耗80 mW；在230 VAC时消耗160 mW）
- 频率随负载减轻而降低，提高待机效率
- 通过网络 / 输入端口实现关机 / 唤醒功能

详述

TOPSwitch-GX采用与TOPSwitch相同的拓扑电路，以高性价比将高压MOSFET、PWM控制器、故障自动保护功能及其它控制电路集成到一个硅片上。TOPSwitch-GX还集成了多项新功能，可以降低系统成本，提高了设计灵活性及效率。

除标准的漏极、源极和控制极外，不同封装的TOPSwitch还另有1至3个引脚，这些引脚根据不同封装形式，可以实现如下功能：线电压检测（过压 / 欠压，电压前馈 / 降低DC_{MAX}）、外部精确设定流限、远程开 / 关控制、与外部较低频率的信号同步及频率选择(132 kHz/66 kHz)。

所有封装形式的器件均具备如下相同特性：软启动、132 kHz开关频率（轻载时自动降低）、可降低EMI的频率调制、更宽的DC_{MAX}、迟滞热关断及更大的爬电距离封装。另外，所有重要参数（例如流限、频率、PWM增益等）的温度容差及绝对容差更小、设计更简化，系统成本更低。

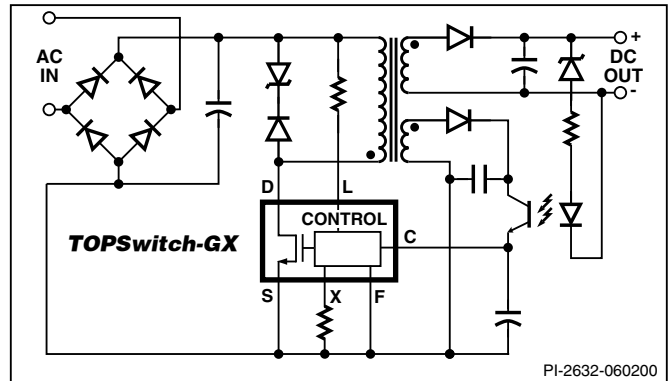


图 1. 典型的反激式应用

输出功率表				
产品 ³	230 VAC ±15% ⁴		85-265 VAC	
	适配器 ¹	开放式 ²	适配器 ¹	开放式 ²
TOP242 P 或 G	9 W	15 W	6.5 W	10 W
TOP242 R	15 W	22 W	11 W	14 W
TOP242 Y 或 F	10 W	22 W	7 W	14 W
TOP243 P 或 G	13 W	25 W	9 W	15 W
TOP243 R	29 W	45 W	17 W	23 W
TOP243 Y 或 F	20 W	45 W	15 W	30 W
TOP244 P 或 G	16 W	28 W	11 W	20 W
TOP244 R	34 W	50 W	20 W	28 W
TOP244 Y 或 F	30 W	65 W	20 W	45 W
TOP245 P 或 G	19 W	30 W	13 W	22 W
TOP245 R	37 W	57 W	23 W	33 W
TOP245 Y 或 F	40 W	85 W	26 W	60 W
TOP246 P 或 G	21 W	34 W	15 W	26 W
TOP246 R	40 W	64 W	26 W	38 W
TOP246 Y 或 F	60 W	125 W	40 W	90 W
TOP247 R	42 W	70 W	28 W	43 W
TOP247 Y 或 F	85 W	165 W	55 W	125 W
TOP248 R	43 W	75 W	30 W	48 W
TOP248 Y 或 F	105 W	205 W	70 W	155 W
TOP249 R	44 W	79 W	31 W	53 W
TOP249 Y 或 F	120 W	250 W	80 W	180 W
TOP250 R	45 W	82 W	32 W	55 W
TOP250 Y 或 F	135 W	290 W	90 W	210 W

表 1. 输出功率表

注释：

1. 环境温度为50 °C的条件下测量得到的。
2. 最大的实际持续输出功率是在敞开式设计、环境温度为50 °C的条件下测量得到的。详情请参考关键应用部分。
3. 关于无铅封装形式，请参考订购信息。
4. 230 VAC或100/115 VAC倍压整流。

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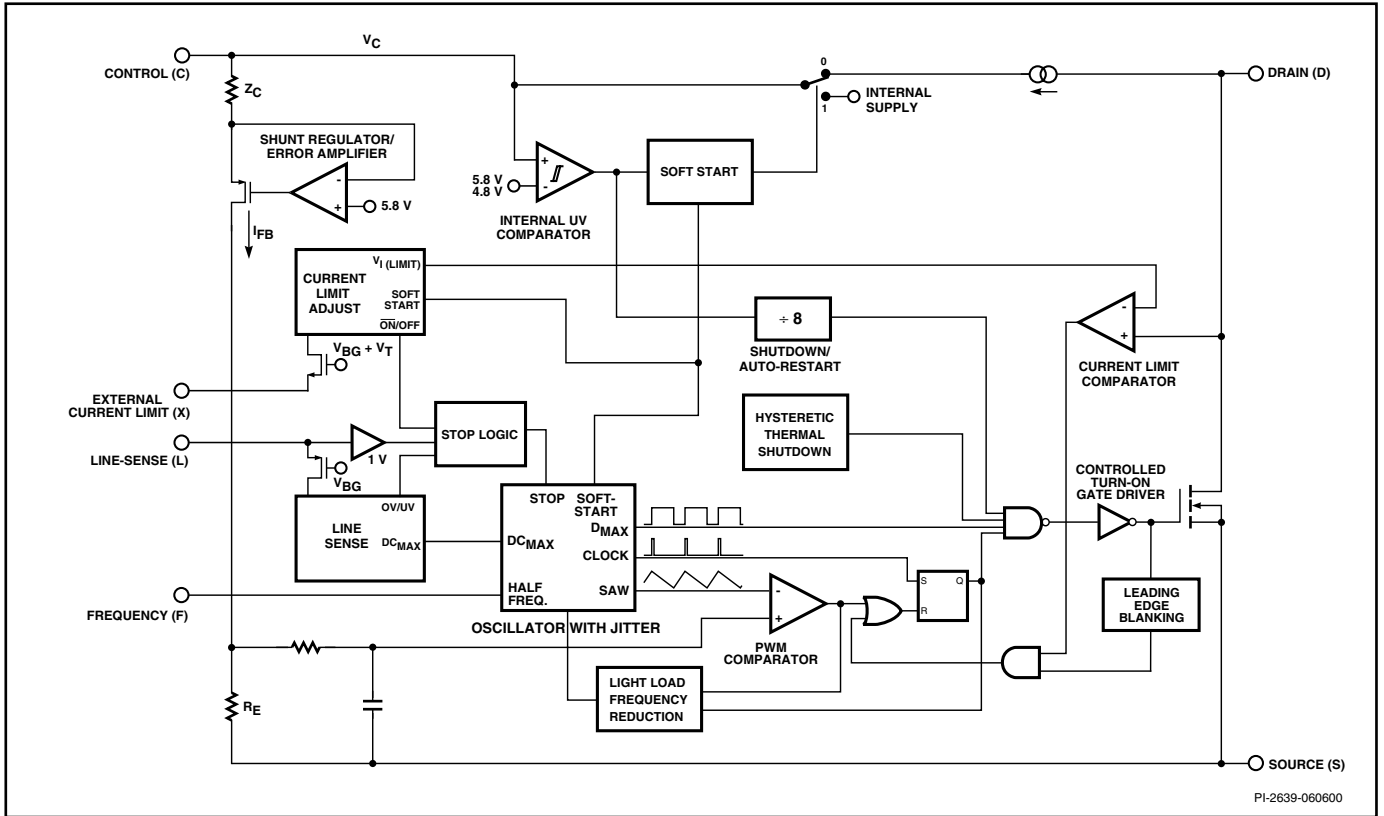


图 2a. 功能结构框图 (Y、R或F封装)

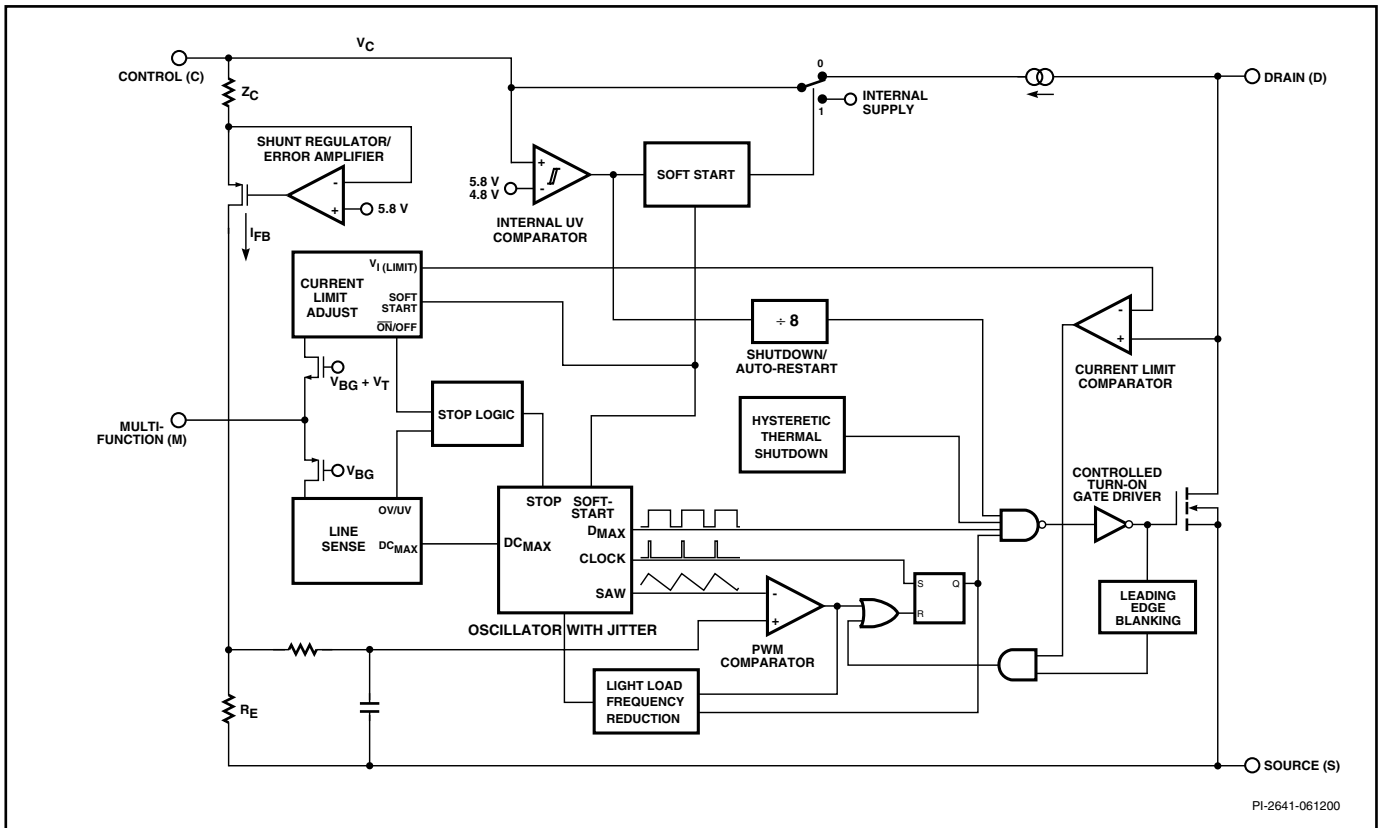


图 2b. 功能结构框图 (P或G封装)

引脚功能描述

漏极 (D) 引脚:

高压功率MOSFET的漏极输出。通过内部的开关高压电流源提供启动偏置电流。漏极电流的内部流限检测点。

控制 (C) 引脚:

误差放大器及反馈电流的输入脚，用于占空比控制。与内部并联调整器相连接，提供正常工作时的内部偏置电流。也用作电源旁路和自动重新启动 / 补偿电容的连接点。

线电压检测 (L) 引脚: (仅限Y、R或F封装)

过压(OV)、欠压(UV)、降低 DC_{MAX} 的线电压前馈、远程开 / 关和同步的输入引脚。连接至源极引脚则禁用此引脚的所有功能。

外部流限 (X) 引脚: (仅限Y、R或F封装)

外部流限调节、远程开 / 关控制和同步的输入引脚。连接至源极引脚则禁用此引脚的所有功能。

多功能 (M) 引脚: (仅限P或G封装)

此引脚集Y封装的线电压检测(L)及外部流限(X)引脚功能于一体。是过压(OV)、欠压(UV)、降低 DC_{MAX} 的线电压前馈、远程开 / 关和同步的输入引脚。连接至源极引脚则禁用此引脚的所有功能并使TOPSwitch-GX以简单的三端模式工作 (如TOPSwitch-II)。

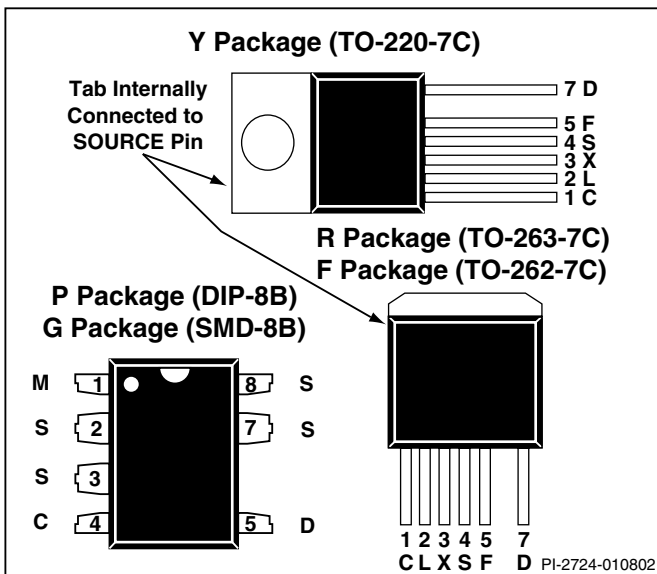


图 3. 引脚布局

频率 (F) 引脚: (仅限Y、R或F封装)

选择开关频率的输入引脚：如果连接到源极引脚则开关频率为132 kHz，连接到控制引脚则开关频率为66 kHz。P和G封装只能以132 kHz开关频率工作。

源极 (S) 引脚:

这个引脚是功率MOSFET的源极连接点，用于高压功率的回路。它也是初级控制电路的公共点及参考点。

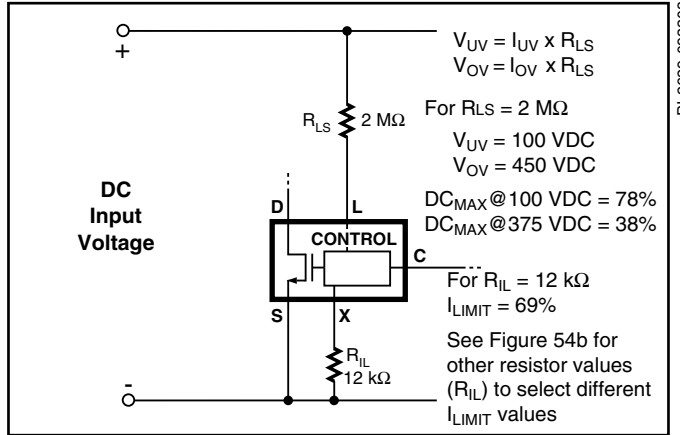


图 4. Y/R/F封装线电压检测及外部流限设置

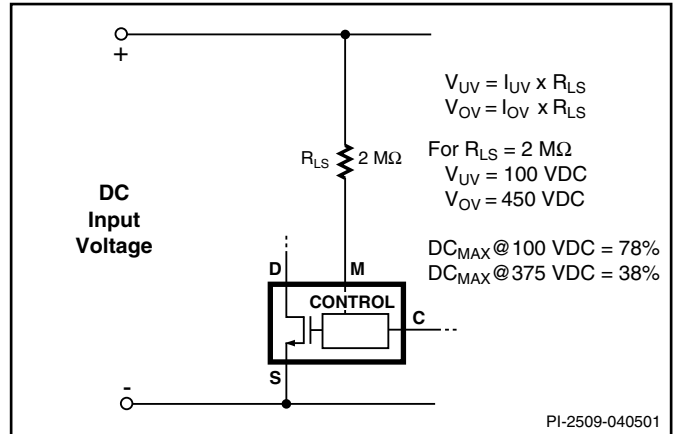


图 5. P/G封装线电压检测

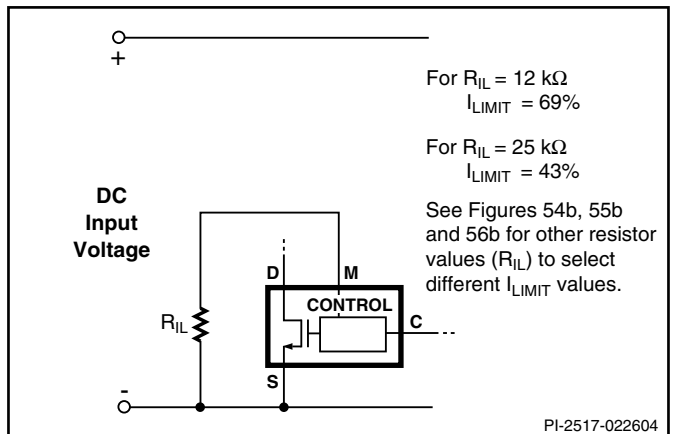


图 6. P/G封装外部流限设置

TOPSwitch-GX 产品系列功能描述

与TOPSwitch类似，TOPSwitch-GX也是一款集成式开关电源芯片，能将控制引脚输入电流转化为高压功率MOSFET开关输出的占空比。在正常工作情况下，功率MOSFET的占空比随控制引脚电流的增加而线性减少，如图7所示。

TOPSwitch-GX除了象三端TOPSwitch一样，具有高压启动、逐周期电流限制、环路补偿电路、自动重启动、热关断等特性，还综合了多项能降低系统成本、提高电源性能和设计灵活性的附加功能。此外，TOPSwitch-GX采用了专利高压CMOS技术，能以高性价比将高压功率MOSFET和所有低压控制电路集成到一片集成电路中。

TOPSwitch-GX增加了频率、线电压检测和外部电流限制（仅限Y、R或F封装）引脚或一个多功能引脚（P或G封装），以实现一些新的功能。将如上引脚与源极引脚连接时，TOPSwitch-GX以类似TOPSwitch的三端模式工作，在此种模式下，TOPSwitch-GX仍能实现如下多项功能而无需其他外围元件：

1. 完全集成的10 ms软启动，限制启动时的峰值电流和电压，显著降低或消除大多数应用中的输出过冲。
2. DC_{MAX} 可达78%，允许使用更小的输入存储电容，所需输入电压更低或具备更大输出功率能力。
3. 轻载时频率降低，降低开关损耗，保持多路输出电源中良好的交叉稳压精度。
4. 采用较高的132 kHz开关频率，可减少变压器尺寸，并对EMI没有显著影响。
5. 频率调制功能可降低EMI。
6. 迟滞过热关断功能确保器件在发生热故障时自动恢复。滞后时间较长可防止电路板过热。
7. 采用缺省引脚及引线的封装，可提供更大的漏极爬电距离。
8. 绝对容差更小，降低温度变化对开关频率、电流限制及PWM增益的影响。

线电压检测(L)引脚通常用于线电压检测，通过一个电阻与经整流的高压直流总线连接，能设定过压(OV) / 欠压(UV)和降低 DC_{MAX} 的线电压前馈。在此模式之下，电阻值

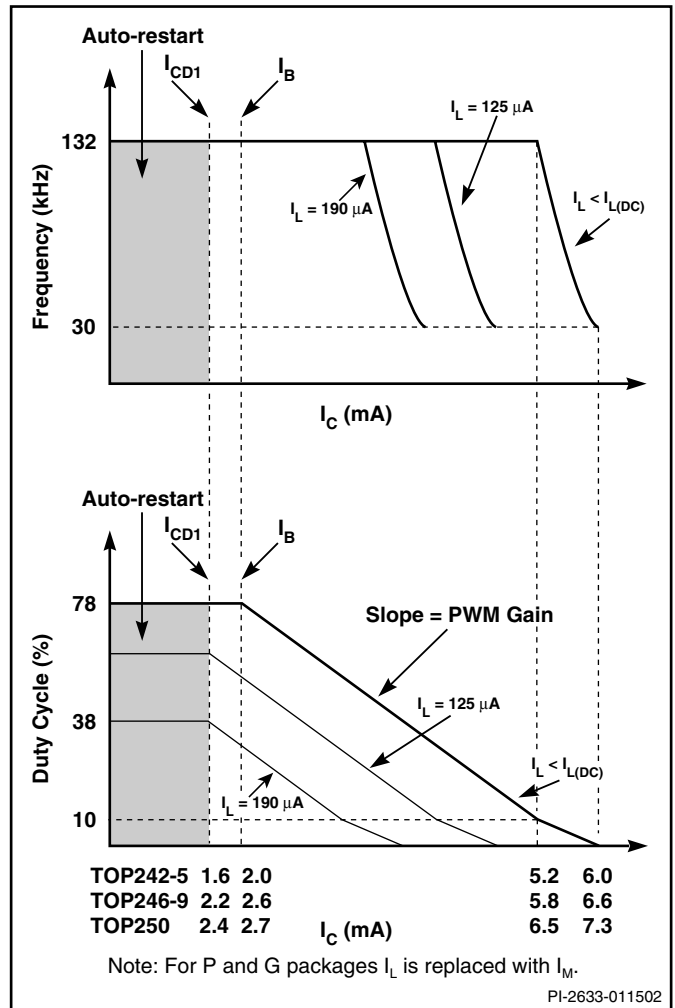


图7. 占空比和频率与控制引脚电流的关系

确定OV/UV的阈值，且 DC_{MAX} 从电路电压超过欠压阈值时开始线性减少。见表2和图11。

此引脚还可用于远程开 / 关控制及同步输入。

外部流限(X)引脚通常通过一个电阻与源极连接，从外部将流限降低到接近工作峰值的电流。此引脚也可用作两种模式下的远程开 / 关控制和同步输入。见表2和图11。

在P和G封装中，多功能引脚组合了线电压检测及外部流限引脚功能，但其中某些功能不能同时实现，如表3所示。

在Y、R和F封装中，频率引脚与源极相连时开关频率设置为132 kHz的缺省值。而与控制引脚连接时，频率减半。此引脚最好不要悬空。

控制 (C) 引脚工作

控制引脚是提供供电和反馈电流的低阻抗节点。在正常工作期间，分流稳压器用来将反馈信号从供电电流中分离出来。控制引脚电压 V_C 是控制电路（包括MOSFET栅极驱动在内）的供电电压。应在控制极及源极引脚间就近放置一个外部旁路电容以提供瞬时栅极驱动电流。连接到控制脚的所有电容也用于设定自动重新启动定时，同时用于环路补偿。

启动时，整流后的直流高压加在漏极引脚上，MOSFET起初处于关断状态，通过连接在漏极和控制引脚间的高压电流源对控制电容充电。当控制引脚电压 V_C 接近5.8 V时，控制电路被激活并开始软启动。在10 ms左右时间内，软启动电路使MOSFET的占空比从零逐渐上升到最大值。在软启动结束时，如果没有外部反馈 / 供电电流流入控制引脚，则内部高压开关电流源关断，控制引脚开始根据控制电路所吸收的供电电流的大小开始放电。如果电源设计正确，而且不存在开环或输出短路等故障时，在控制引脚放电到接近下限阈值电压4.8 V之前时（内部电源欠压锁存阈值），反馈环路将闭合，向控制引脚提供外部电流。当外部流入的电流将控制引脚充电到5.8 V并稳压电压时，超过芯片所消耗的电流将通过电阻 R_e 分流到源极引脚，如图2所示。流经 R_e 的电流控制MOSFET

的占空比，实现闭环调节。在采用初级反馈结构中，并联稳压器很低的输出阻抗 Z_c 决定了误差放大器的增益。控制脚的动态阻抗 Z_c 和外接控制脚的电容一起共同决定控制环路的主极点。

当出现开环或短路等故障而使外部电流无法流入控制引脚时，控制引脚上的电容开始放电，达到4.8 V时激活自动重新启动电路而关断MOSFET输出，使控制电路进入低电流的待机模式。高压电流源再次接通并对外接电容充电。内部带迟滞的电源欠压比较器通过使高压电流源通断来保持 V_C 值处在4.8 V到5.8 V的区域内，如图8所示。自动重新启动电路中有一个除8的计数器，仅在计满(S7)时才接通输出MOSFET，用以防止输出MOSFET在八个放电—充电周期过去前重新导通。通过将自动重新启动的占空比减到典型值4%，可有效地限制TOPSwitch-GX的功耗。自动重新启动模式将不断循环工作直到输出电压稳压通过闭合反馈环路重新进入受控状态为止。

振荡器和开关频率

内部振荡器使内部电容在两个设定的电压值间线性充放电，以产生脉宽调制解调器所需的锯齿波电压。在每个周期的起点，振荡器将脉宽调制解调器 / 电流限制的触发器电路置位。

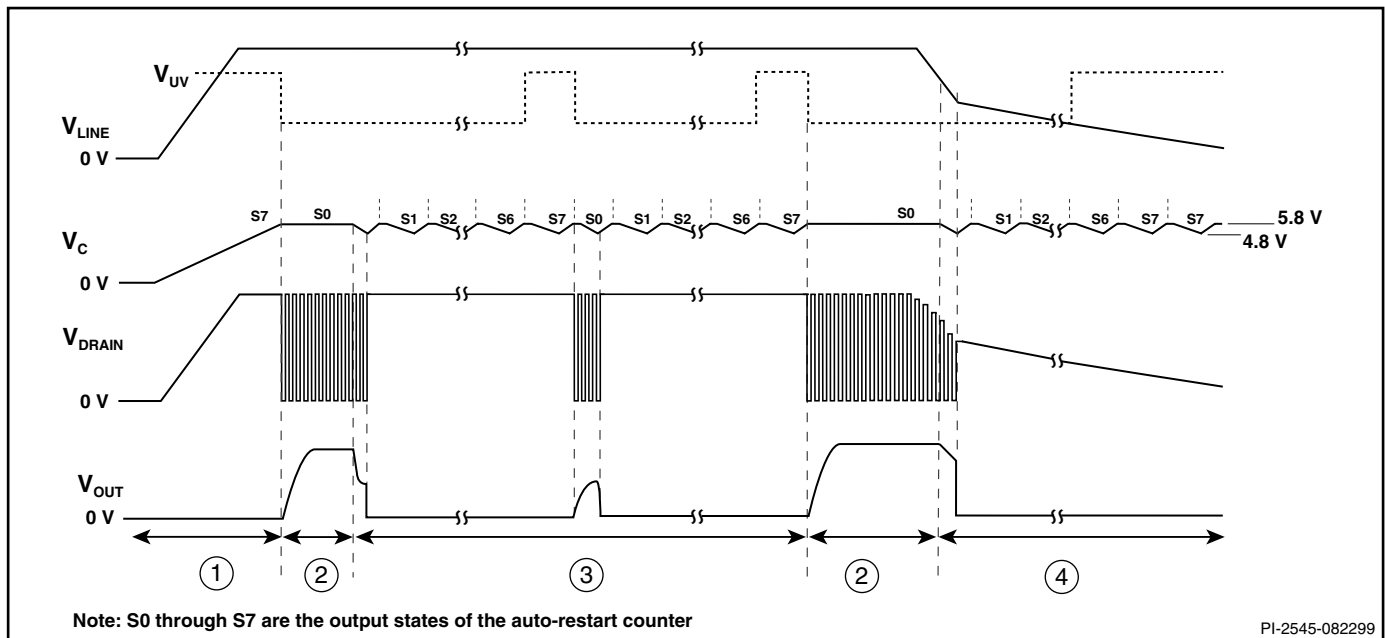


图 8. (1)上电(2)正常工作(3)自动重新启动(4)电源关断时的典型波形

开关频率一般选择为132 kHz，这使变压器尺寸最小且EMI频率低于150 kHz。频率引脚（仅限Y、R及F封装）与控制脚短接时，开关频率降至66 kHz（频率减半），这种特性在对噪声敏感的视频应用或高效率待机模式中非常有用。如果频率引脚与源极引脚相连，则开关频率为缺省值132 kHz。

为使EMI电平更低，开关频率以250 kHz速率（典型值）大约 ± 4 kHz的范围内抖动，如图9所示。图46的测量值显示了增加频率调制后对EMI的改善。

脉宽调制器及最大占空比

脉宽调制器通过驱动输出MOSFET来实现电压模式控制，其占空比与流入控制脚超过芯片内部消耗所需要的电流成反比（如图7）。此部分电流在 R_E 两端产生反馈误差信号（如图2），并由一个转折频率为7 kHz的RC滤波电路进行滤波，以降低芯片电源电流中由MOSFET栅极驱动产生的开关噪音。经滤波的误差信号与内部振荡器产生的锯齿波信号进行比较，产生占空比的波形。控制电流增大时，占空比减少。由振荡器产生的时钟信号置位触发器电路，从而导通输出MOSFET。脉宽调制器使此触发器电路复位而关断输出MOSFET。注意：在占空比开始变化前，必须有最小电流注入控制脚。

最大占空比 DC_{MAX} 按缺省值78%（典型值）设定。但如图11所示，当线电压检测或多功能引脚（根据封装不同）通过恰当的电阻与经整流的直流高压总线相连时，随输入电压的增加，最大占空比可以从78%降至38%（典型值）（参见可降低 DC_{MAX} 线电压前馈）。

轻载频率降低

电源输出负载减少时，脉宽调制器根据流入控制引脚的电流按比例降低占空比。当控制引脚的电流增加时，占空比线性降低到10%。为保持轻载时的高效率，占空比低于10%时，频率开始线性下降，直到占空比为0时达到最低频率（参见图7）。132 kHz和66 kHz工作时，最低频率一般为30 kHz 和15 kHz。

此特性使电源在轻载时可以较低频率工作，降低了开关损耗，同时也能保持良好的交叉调节和低输出纹波。

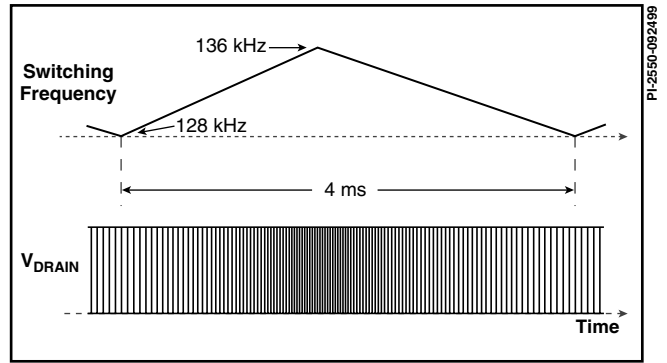


图9. 开关频率调制（理想化的 V_{DRAIN} 波形）

误差放大器

并联调整器也可在初级反馈应用中用作误差放大器。并联调整器的电压由一个具有温度补偿的带隙基准提供。控制脚的动态阻抗设置误差放大器的增益。控制脚将外部电路信号箝位在 V_C 电压的水平。控制脚超出供电电流的部分将被误差放大器隔离，并流经 R_E 作为电压误差的信号。

可外部编程的片内限流

逐周期的峰值漏电流限制电路以MOSFET的导通电阻作为电流采样电阻。流限比较器将输出MOSFET导通状态下的漏-源极电压 $V_{DS(ON)}$ 与一个阈值电压相比较。漏电流太大将使 $V_{DS(ON)}$ 超过阈值电压并在下一个时钟周期开始前关断输出MOSFET。流限比较器的阈值电压采用温度补偿，使输出MOSFET的 $V_{DS(ON)}$ 随温度所产生的变化对流限的影响最小。*TOPSwitch-GX*的缺省流限值已在内部预先设定，但可通过连接在外部流限(X)引脚（仅限Y、R及F封装）或多功能(M)引脚（P或G封装）和源极引脚间的电阻，从外部将流限控制在30%到100%缺省流限值之间。在选择阻值时请参见“典型性能特性”中的图表。由于较大的*TOPSwitch-GX*的 $R_{DS(ON)}$ 值较小，设定较低的流限值时可选择超出所需功率的*TOPSwitch-GX*来获得更高效率 / 减少散热片面积。通过连接在外部流限(X)引脚（仅限Y、R及F封装）或多功能(M)引脚（P或G封装）和经整流的直流高压总线间的电阻，流限随线电压的增高而降低，可实现真正的不受电压变化影响的功率限定工作。使用RCD箝位电路时，这种功率限制技术能降低高压输入时的最大箝位电压，能实现更高反射电压的设计并降低箝位损耗。

输出MOSFET刚导通时，前沿消隐电路将流限比较器抑制片刻。在设置前沿消隐时间后，如果电源设计正确，电源初级侧电容产生的电流尖峰及次级端整流器的反向恢复时间不会引起开关脉冲的提前误关断。

如图52所示，由于MOSFET的动态特性，前沿消隐后的一段时间内，流限会相对更低些。为避免在正常工作时误触发电流限制功能，漏极电流的波形应在图示的封闭区内。

线电压欠压保护 (UV)

在上电时，UV令TOPSwitch-GX在输入电压达到欠压阈值前保持关断；在断电时，UV防止它在输出失调后自动重新启动。在待机电源等应用中，它能防止关断时由输入大容量电容缓慢放电而产生的干扰。上电时，UV阈值由连接在线电压检测（Y、R或F封装）或多功能引脚（P或G封装）和经整流的高压总线间单电阻设定。电源接通后，UV阈值降到初始阈值的40%，使输入电压的工作范围更宽（UV下限阈值）。工作时，如果在电源未失调的情况下达到UV下限，则此器件将保持关断，直到UV达到上限为止。如果电源在达到UV下限前电源失调，则器件将自动重新启动。在每个自动重新启动周期末(S7)，UV比较器会被启动。此时若没有超过UV上限值，则MOSFET在下

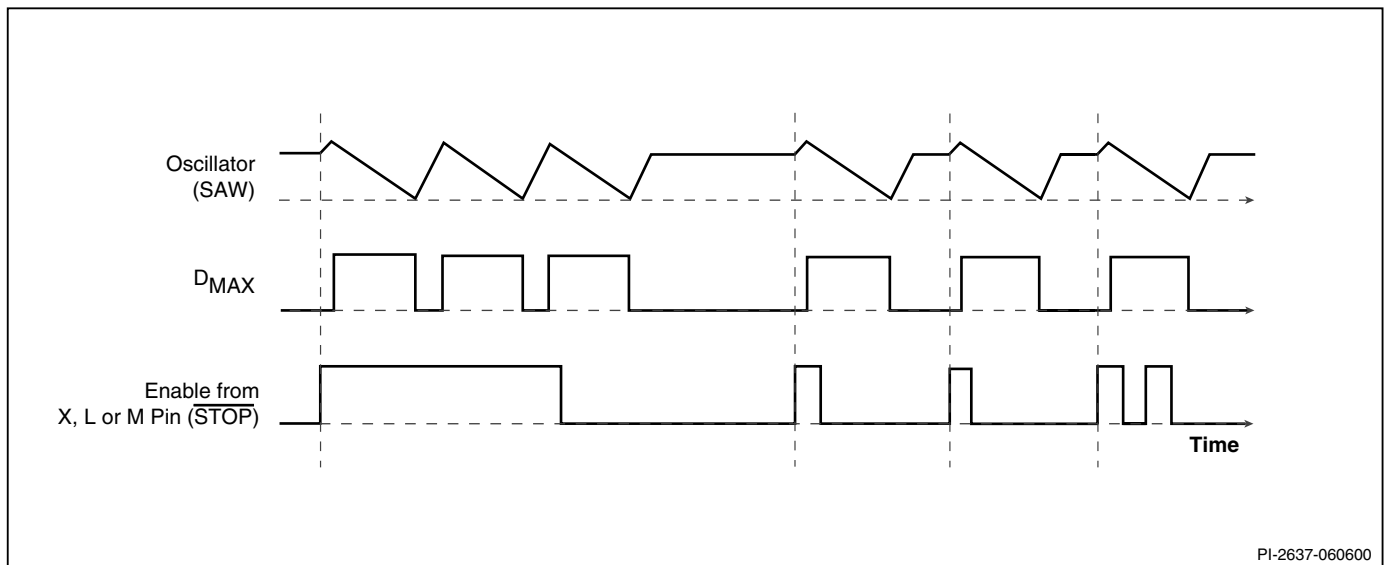
一个周期内关断（见图8）。如图19及23所示，UV特性可单独使用，而与OV特性无关。

线电压过压关断 (OV)

过压阈值和UV的设置采用同一电阻。超过此阈值时即强制TOPSwitch-GX输出关断。从图11可见OV和UV的比率设为4.5。当MOSFET关断时，由于漏极没有反馈电压和漏电感尖峰，经整流的直流高压的抗浪涌冲击的能力增大到MOSFET的额定电压(700 V)。OV阈值有少量迟滞以防止噪声引发关断。如图18和32所示，OV特性可单独禁用，而不影响UV特性。

降低 DC_{MAX} 的线电压前馈

设置UV和OV的电阻同时也用于产生线电压前馈，使输出纹波最小并减小了输入电压瞬态变化时对输出的影响。这种前馈的工作方式在图7中以不同的值 I_L （Y、R或F封装）或 I_M （P或G封装）表示。值得注意的是，对于相同的控制脚电流，更高的线电压会使占空比更小。另外，最大占空比也从略高于UV阈值时的78%（典型值）降至OV阈值时的30%（典型值）（见图11）。在TOP248、TOP249及TOP250正向转换器运用中，在较高线电压时，限定 DC_{MAX} 将有助于防止由大负载瞬态变化引起的变压器饱和。在较高线电压时，选择 DC_{MAX} 为38%可确保TOPSwitch-GX的功率在正常工作时不会受到此特性的限制。



PI-2637-060600

图 10. 同步时序图

远程开 / 关和同步

*TOPSwitch-GX*可通过控制流入线电压检测脚或流出外部流限引脚（Y、R或F封装）以及注入或流出多功能引脚（P或G封装）的电流来接通或关断（见图11）；另外，线电压检测脚上连有1 V的输入阈值比较器，此电压阈值也可用于实现远程开 / 关控制。因此很容易以几种不同方式实现*TOPSwitch-GX*的远程开 / 关控制。把晶体管或光耦的输出连接在外部流限 / 线电压检测引脚（Y、R或F封装）或多功能引脚（P或G封装）和源极引脚之间可以“启动”此功能（如图23、29和36所示）；连接到线电压检测脚（Y、R或F封装）或多功能引脚（P或G封装）和控制脚之间则可“取消”此功能（见图23和图37）。

线电压检测引脚或外部流限（Y、R或F封装）或多功能引脚（P或G封装）接收到OV、UV和远程开 / 关等功能产生的禁止输出信号时，*TOPSwitch-GX*总是在完成当前的开关周期后，才强制关断输出，如图10所示。内部振荡器在当前周期结束前渐渐停止振动，直到禁止信号结束。当上述引脚的信号状态从禁止变为开通时，内部振荡器开始下一个开关周期。采用这种方法，可通过此引脚将*TOPSwitch-GX*与任何外部信号进行同步，其同步频率在内部开关频率与20 kHz之间。

如上所述，远程开 / 关特性使*TOPSwitch-GX*逐周期瞬间接通 / 关断，并具备很小的延迟。此外，此远程开 / 关功能可用作*TOPSwitch-GX*的待机或电源开关，使之长时间处于极低功耗状态。如果处于远程关断状态的时间可使控制引脚内部放电到4.8 V内部欠压阈值（47 μF 的控制引脚电容约需时32 ms），则控制引脚进入迟滞调节模式。在此模式下，控制引脚在4.8 V到5.8 V间进行充放电周期转换（见上述控制脚工作原理一节），并彻底放完高压直流输入，而且功耗很低（230 VAC输入时M或X引脚开路时典型值为160 mW）。进入此模式后，当*TOPSwitch-GX*被远程接通，它在控制脚电压再次达到5.8 V时执行正常的软启动程序。在最差情况下，从远程开启到启动的延迟时间

可与控制脚的整个充放电时间相同，即47 μF 控制脚电容需时约为125 ms。这种降低功耗的远程关断模式可以取消即贵又不可靠的线上机械开关。接通和关断序列也可用微处理器来控制，正如喷墨和激光打印机等应用中所要求的那样。

软启动

两种片内集成的软启动功能通常在启动时开始工作，10 ms（典型值）后停止。在此10 ms期间，最大占空比从0%并线性增加到缺省最大值78%，流限从约85%线性增长到100%。除启动时外，软启动在每次自动重新启动时也会被激活，包括在远程关断或热关断后的自动重新启动和控制引脚电压(V_c)进入滞后调节的重新启动。这不仅有效地将输出MOSFET、箝位电路和输出整流器在启动时的电流和电压压力降至最低，还有助于使输出过冲最小，防止启动期间的变压器饱和。

关断 / 自动重新启动

为使*TOPSwitch-GX*在故障情况下的功耗最小，关断 / 自动重新启动电路在输出失调情况下，一般按4%的自动重新启动占空比接通和断开电源。失调中断外部电流流入控制脚， V_c 调节也从分流模式进入迟滞自动重新启动模式，在控制脚工作一节中有所介绍。当故障情况去除，电源输出变为可调， V_c 调节也进入分流模式，电源又恢复正常工作。

迟滞过热保护

*TOPSwitch-GX*由精密的模拟电路提供温度保护，当结温超过热关断温度（典型值140 $^{\circ}\text{C}$ ）时，该电路就关断输出MOSFET，当结温冷却到迟滞温度以下时，自动恢复并重新正常工作。此芯片采用70 $^{\circ}\text{C}$ 的较大迟滞值，可以防止连续故障情况下PCB板过热。当电源过热关断后， V_c 的调节进入迟滞模式，控制脚上的波形为4.8 V到5.8 V间（典型值）的锯齿波。

带隙基准

*TOPSwitch-GX*内部所有的关键电压均来自于一个具有温度补偿的带隙基准。此基准电压还用于产生一个具有温度补偿特性的电流基准，经调整此电流基准能精确设定开关频率、MOSFET栅极驱动电流、流限和线路过压 / 欠压阈值。*TOPSwitch-GX*改善了电路性能，使以上这些重要参数的绝对容差更严格，且相对于温度的变化更小。

高压偏置电流源

在启动或迟滞模式工作时，高压电流源从漏极引脚输入，为*TOPSwitch-GX*器件提供偏置，并对控制脚的外接电容充电。在自动重新启动、远程关断和过热关断时，器件进入迟滞工作模式。此时电流源通断的有效占空比约为35%，此占空比由控制脚充电(I_{C1})、放电电流和 I_{CD2} 的比率决定。正常工作情况下，输出MOSFET接通，此电流源关断。电流源开关可以在漏极电压波形上产生小干扰，但这属于正常情况。

特色引脚的使用

运用频率(F)引脚

频率引脚是一个数字输入引脚，限Y、R或F封装。频率引脚与源极引脚短路时选择132 kHz的额定开关频率（图13），此方式适合于大多数应用。另外一些应用可能希望开关频率较低，如对噪声敏感的视频应用，这时可通过将频率引脚与控制引脚短接来选择减半的66 kHz开

关频率（图14）。此外，图15所示电路实例可将待机模式的开关频率从正常工作时的132 kHz降为66 kHz，这使待机电源功耗较低。

运用线电压检测(L)引脚(Y、R或F封装)

当线电压检测引脚有电流注入时，它相当于最大电流为+400 μ A（典型值）的2.6 V左右的电压源。在+400 μ A时，这个引脚为一个恒定的电流源，请参见图12a。另外此引脚上还连接了一个阈值为1 V的比较器，可以检测此引脚是否与源极引脚短接。

线电压检测引脚可提供四种功能：OV、UV、降低 DC_{MAX} 的线电压前馈和远程开 / 关。将此引脚和源极引脚短接可禁用这四种功能。通常通过连接到线电压检测引脚和经整流的高压直流总线间的电阻来检测输入电压，并实现OV、UV、降低 DC_{MAX} 的线电压前馈功能。在此模式下，电阻值确定OV/UV电压阈值，而且 DC_{MAX} 在整流直流高压刚超过UV阈值时开始线性降低。此引脚也可用作远程开 / 关和同步输入。表2是这些功能可能的组合，图16至图40是电路举例。线电压检测引脚I/V曲线的具体功能描述如图11所示（右手侧），横轴正极方向代表注入线电压检测引脚的电流，纵轴的涵义根据功能不同而不同。对于控制输出开 / 关的UV、OV和远程开关，纵轴代表输出的使能 / 禁止状态。电流 I_{UV} （典型值+50 μ A，30 μ A的迟滞）时触发UV，达到 I_{OV} （典型值+225 μ A，8 μ A迟

线电压检测及外部电流流限引脚表*

插图编号 ▶	16	17	18	19	20	21	22	23	24	25	26	27	28	29
三端工作	✓													
欠压		✓	✓								✓	✓	✓	
过压		✓		✓							✓	✓	✓	
线电压正向反馈 (DC_{MAX})		✓									✓	✓	✓	
过载功率限制						✓								
外部流限					✓	✓			✓	✓		✓	✓	
远程开 / 关							✓	✓	✓	✓	✓	✓		✓

*此表格仅仅列举了部分线电压检测和外部R流限引脚可能采用配置。

表 2. 典型的线电压检测和外部流限引脚配置

滞)时触发OV,在UV和OV阈值之间允许输出使能。对于降低 DC_{MAX} 的电压前馈,纵轴代表占空比的幅度,此前馈将最大占空比从 $I_{L(DC)}$ (典型值+60 μA)时的78%降低为 I_{OV} (+225 μA)时的38%。

运用外部流限(X)引脚(Y、R或F封装)

电流从外部流限引脚流出时,它相当于最大电流-240 μA (典型值)的1.3 V左右的电压源。在-240 μA 时,此引脚转化为恒流电流源(请参见图12a)。

使用外部流限引脚可获得两种功能:外部流限和远程开/关。将外部流限引脚与源极引脚短接可禁用这两种功能。在高效应用中,将此引脚通过一个电阻和源极引脚相连,可从外部将流限降到接近峰值电流。表2是此引脚的几种可能的组合。在图11所示的功能描述中,横轴(左手侧)代表外部流限引脚的电流,纵轴的涵义根据功能不同而不同。对于远程开关等控制输出开/状态的功能,纵轴代表输出的允许/禁止状态;对于外部流限功能,纵轴代表 I_{LIMIT} 的幅度。**流限编程范围和如何选择恰当的阻值请参见典型特性章节中的图示。**

运用多功能(M)引脚(P和G封装)

P和G封装的多功能引脚集线电压检测和外部流限引脚的功能于一身,但没有线电压检测引脚所需的1 V阈值比较器,如图2b所示。所有其它功能均保留,但由于某些功能需要负极性的输入电流(多功能引脚),它们之间会相互

排斥。比如,线电压检测特性就无法和外部流限设定同时使用。电流注入多功能引脚时,它相当于最大电流为+400 μA (典型值)的2.6 V左右的电压源。在+400 μA 时,此引脚为电流的恒定电流源。电流从多功能引脚流出时,它相当于最大电流为-240 μA (典型值)的1.3 V左右的电压源。在-240 μA 时,它转换为恒流电流源。请参见图12b。

多功能引脚可提供五种功能:OV、UV、降低 DC_{MAX} 的线电压前馈、外部流限和远程开/关。短路多功能引脚和源极引脚可以禁用这五种功能,迫使TOPSwitch-GX与TOPSwitch-II一样以三端模式工作。通常在多功能引脚和整流的高压直流总线间连接一个电阻来检测电压,以实现OV、UV和降低 DC_{MAX} 的前馈功能。在此模式下,电阻值确定OV/UV电压阈值,并且 DC_{MAX} 在整流直流高压刚超过UV阈值时开始线性降低。通过一个电阻连接多功能引脚和源极引脚,可从外部对流限编程。但在多数应用中都不需要此功能,因为与Y、R和F封装器件相比,P和G封装器件减少了内部限流电路,以达到散热要求。因此建议将多功能引脚用于如上所述的线电压检测,而非降低外部限流。此引脚还可用于远程开/关和同步的输入。表3是这些功能可能的组合,图30到图40是电路举例。多功能引脚I/V特性曲线的具体功能描述如图11所示。横轴正极方向显示注入功能引脚的电流,纵轴根据不同功能代表不同的涵义。对于控制输出开/关的UV、OV和远程

多功能引脚列表*											
插图编号 ▶	30	31	32	33	34	35	36	37	38	39	40
三端工作	✓										
欠压		✓	✓								✓
过压		✓		✓							✓
线电压前馈 (DC_{MAX})		✓									✓
过载功率限制						✓					
外部流限					✓	✓			✓	✓	
远程开/关							✓	✓	✓	✓	✓

*此表仅列出多功能引脚的部分配置。

表3. 典型的多功能引脚配置

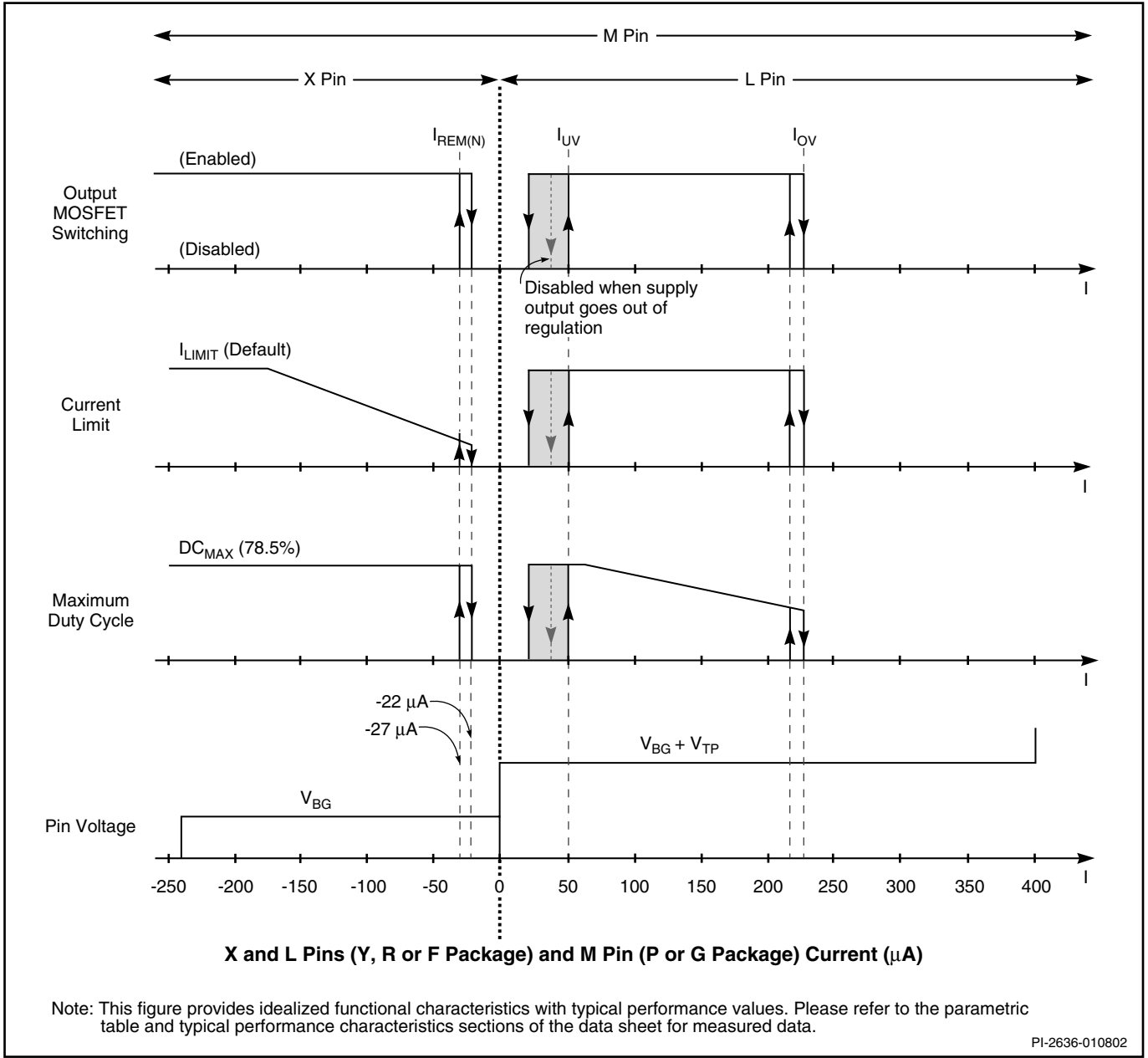


图 11. 多功能引脚（P或G封装）、线电压检测及外部流限引脚（Y、R或F封装）的特性曲线

开 / 关，纵轴代表输出的允许 / 禁止状态。电流 I_{UV} （典型值+50 μA ）时触发UV， I_{OV} （典型值 +225 μA 带30 μA 的迟滞）时触发OV。在UV和OV阈值之间输出导通。对于外部电流限制、降低 DC_{MAX} 的线电压前馈功能，纵轴代表 I_{LIMIT} 和 DC_{MAX} 的幅度。降低 DC_{MAX} 的线电压前馈将

最大占空比从 $I_{M(DC)}$ （典型值+60 μA ）时的78%降低为 I_{OV} （典型值+225 μA ）时的38%。只有当多功能引脚电流为负值时才能用外部流限功能。流限编程范围和如何选择恰当的阻值请参见典型特性章节中的图示。

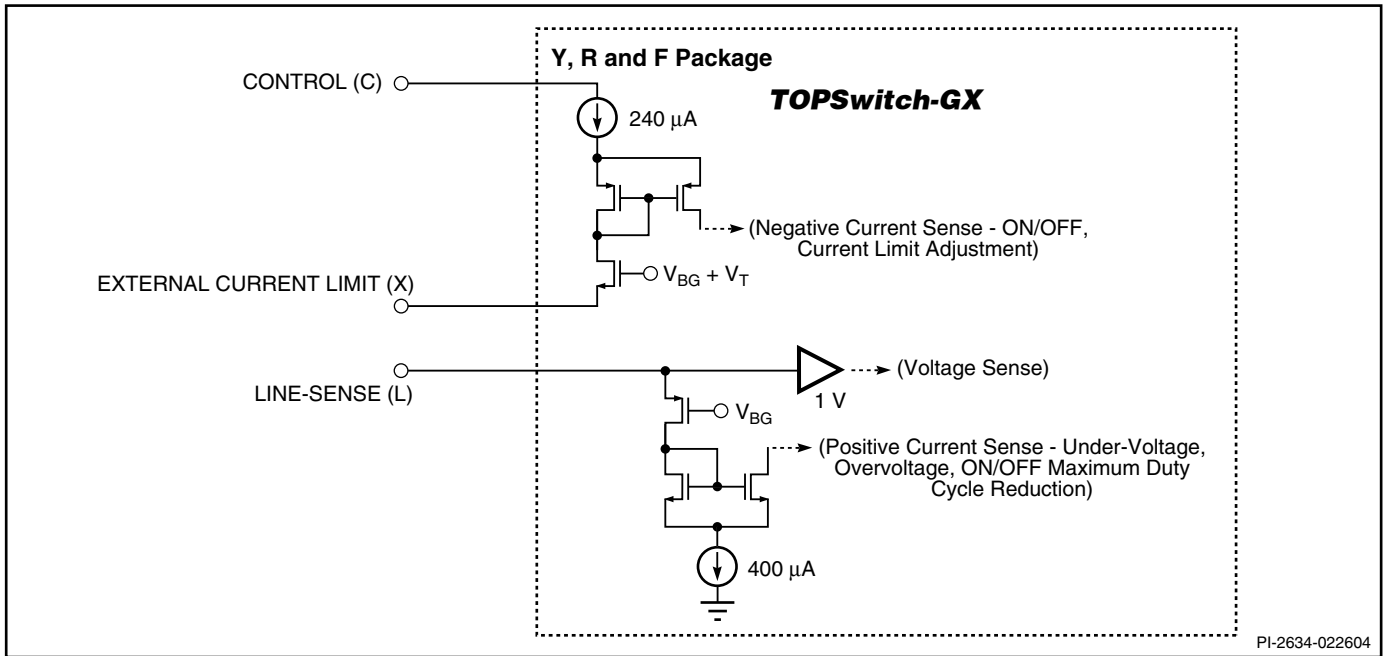


图 12a. 线电压检测(L)和外部流限(X)引脚输入简图

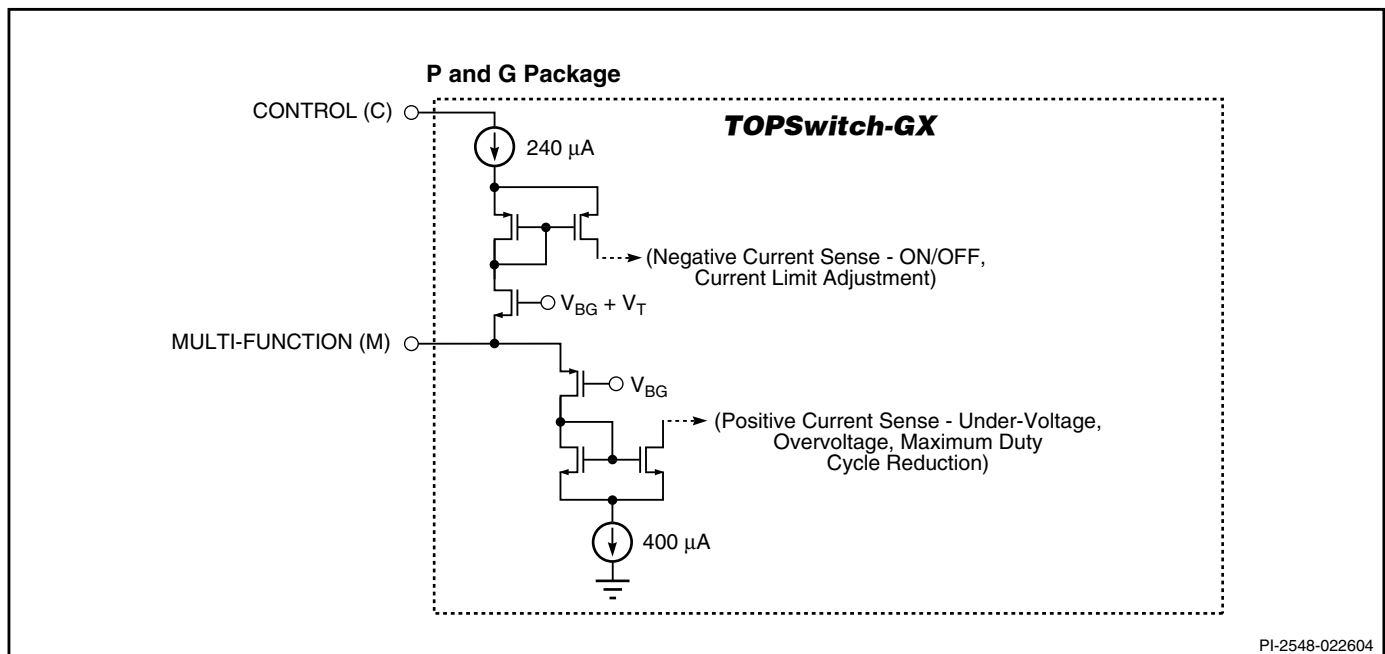


图 12b. 多功能引脚(M)输入简图

频率 (F) 引脚的典型使用方法

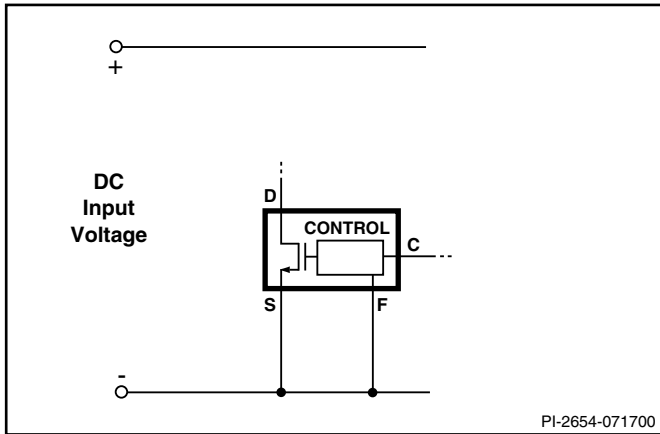


图 13. 全频率工作 (132 kHz)

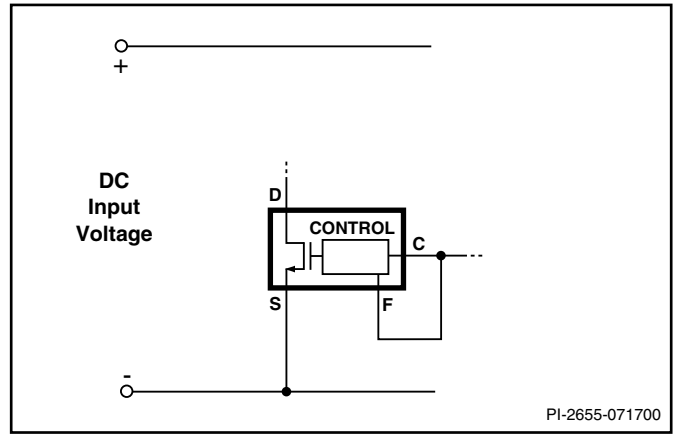


图 14. 半频率工作 (66 kHz)

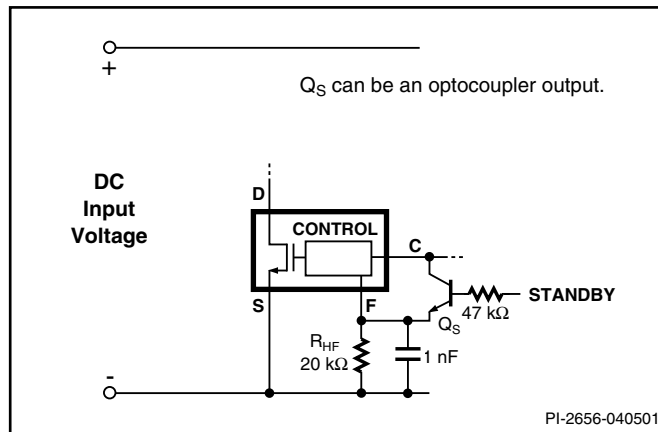


图15. 半频率待机模式 (更高待机效率)

线电压检测 (L) 和外部流限 (X) 引脚的典型使用方法

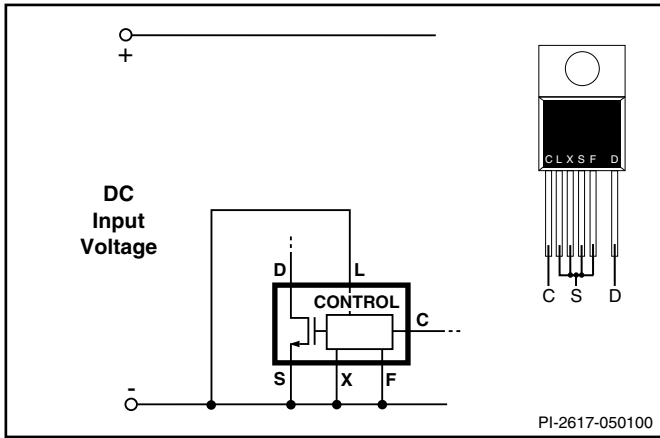


图 16. 三端工作 (禁止线电压检测和外部流限特性。频率引脚与源极或控制引脚相连。)

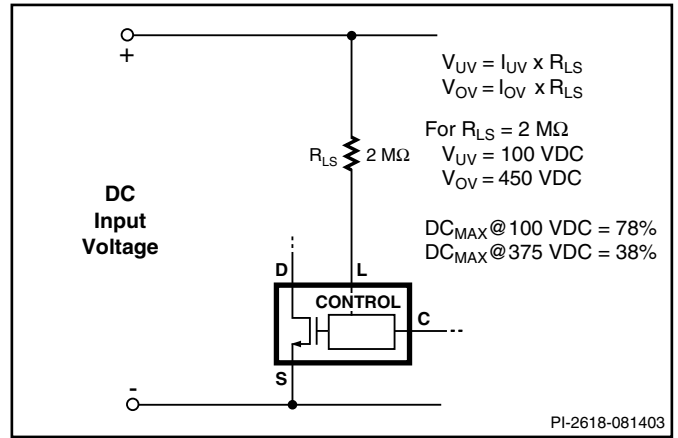


图 17. 实现欠压、过压和线电压前馈的线电压检测

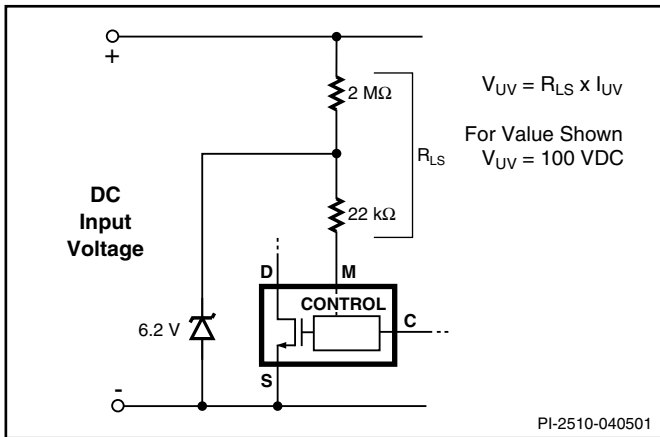


图 18. 仅实现欠压的线电压检测 (禁止过压)

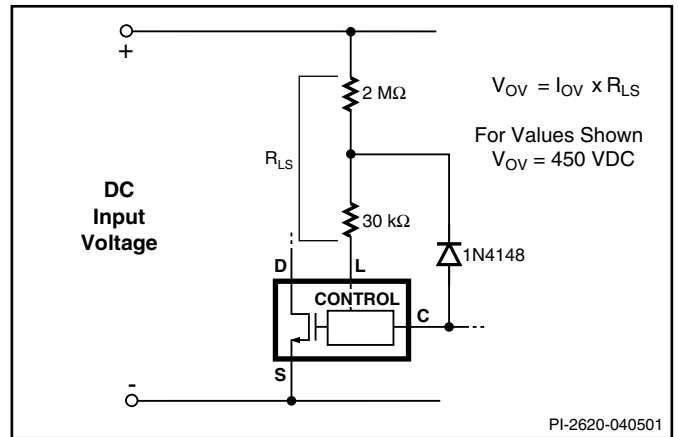


图 19. 仅实现过压的线路检测 (禁止欠压)。低压时会降低最大占空比, 线电压增高时最大占空比进一步降低

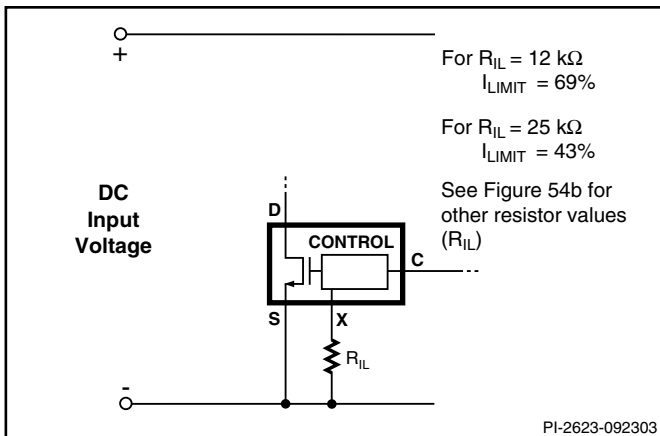


图 20. 外部设定流限

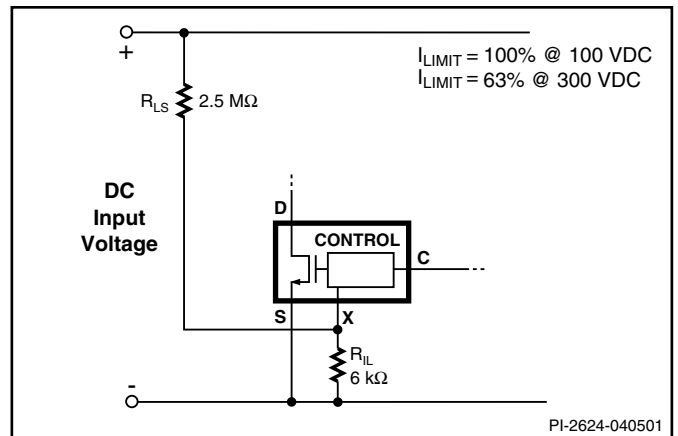


图 21. 流限随电压降低而降低

线电压检测 (L) 和外部流限 (X) 引脚的典型使用方法 (继上)

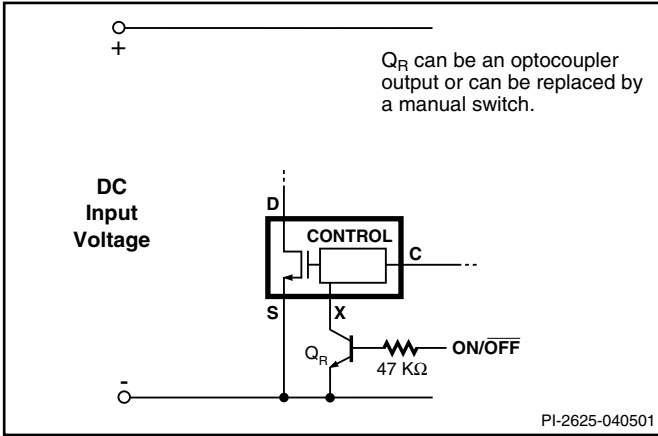


图 22. 控制信号为高电平时开机的远程开 / 关控制电路

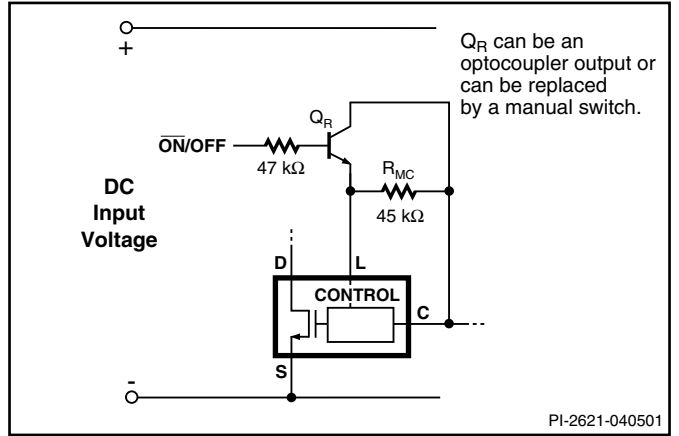


图 23. 控制信号为高电平时关机的远程开 / 关控制电路。
最大占空比会降低

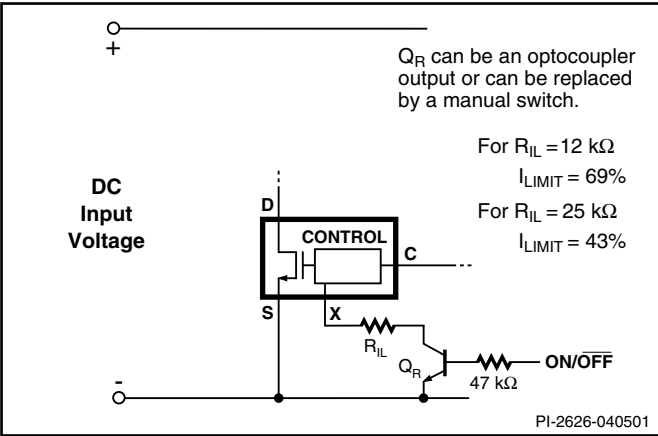


图 24. 使用外部流限设定功能实现的控制信号为高电平时开机的远程开 / 关控制电路

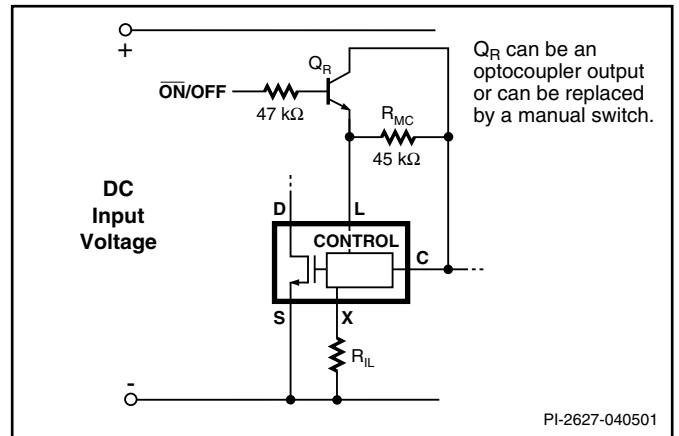


图 25. 用外部设定流限来取消远程开 / 关

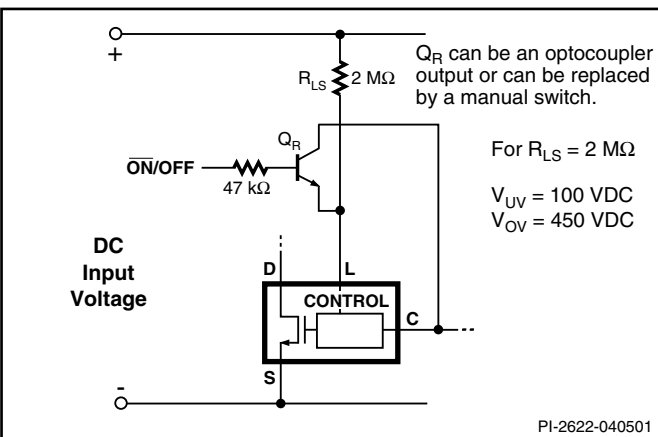


图 26. 用线电压检测来取消远程开 / 关

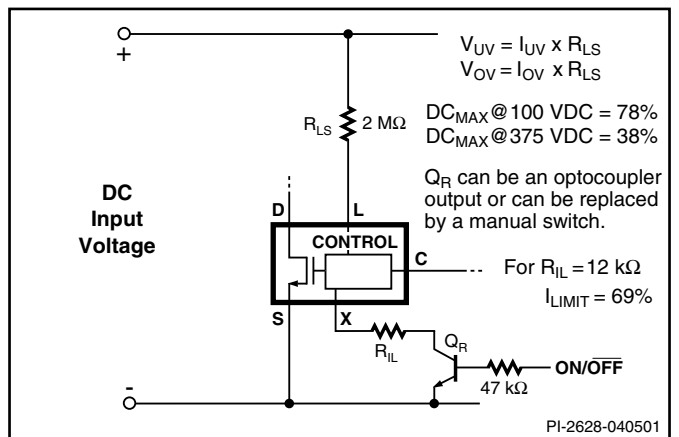


图 27. 用线电压检测和外部设定流限来启动远程开 / 关

线电压检测 (L) 和外部流限 (X) 引脚的典型使用方法 (继上)

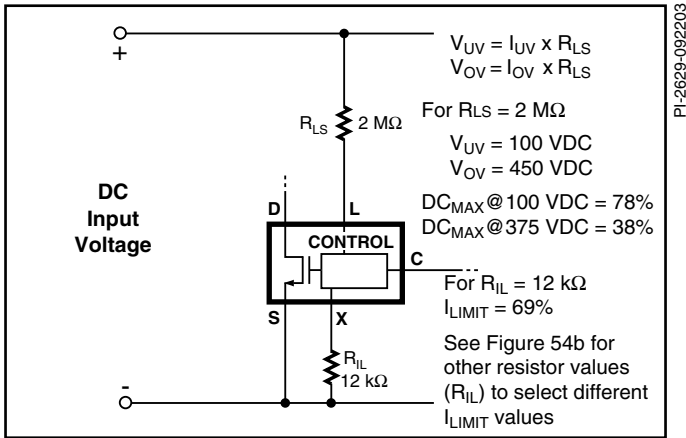


图 28. 线电压检测和外部设定流限

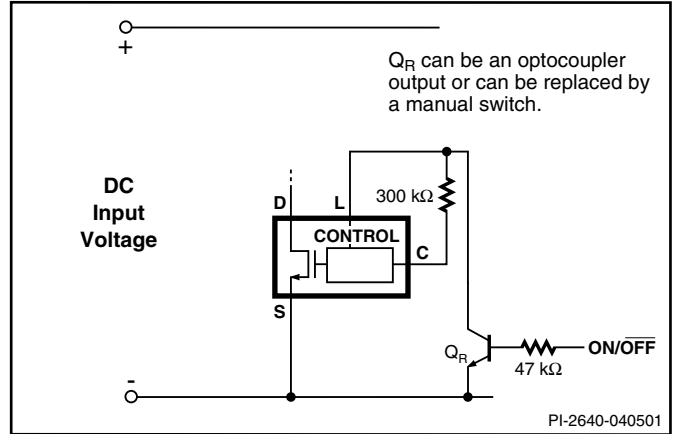


图 29. 启动远程开 / 关

多功能 (M) 引脚的典型使用方法

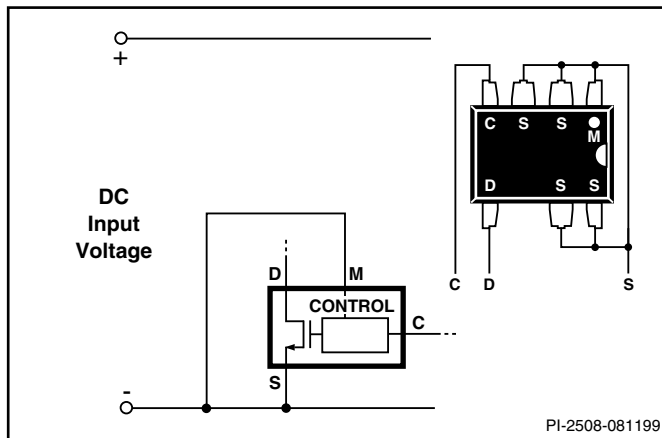


图 30. 三端工作 (禁止多功能特性)

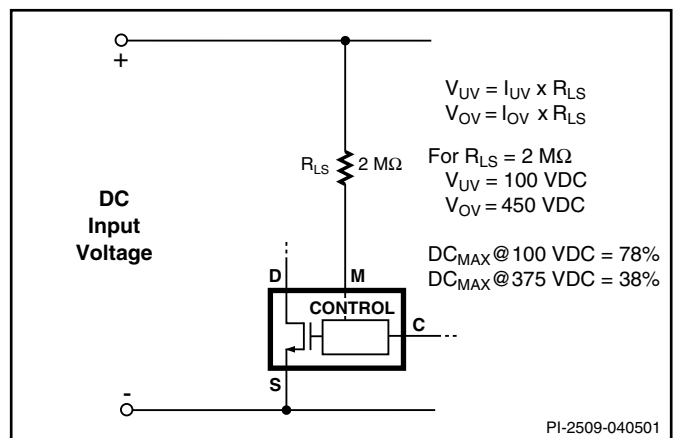


图 31. 欠压、过压和线电压前馈的线电压检测

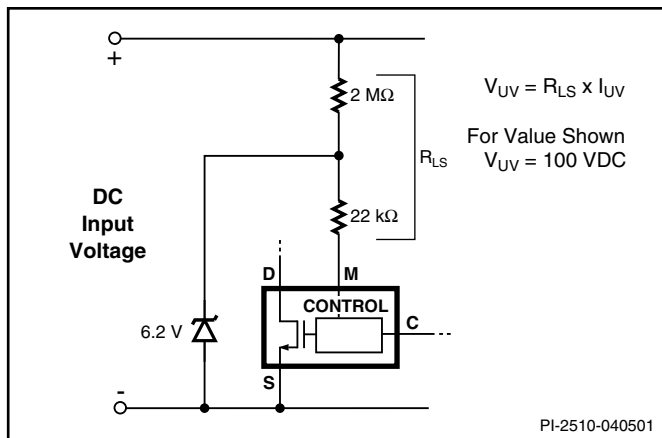


图 32. 仅实现欠压的线电压检测

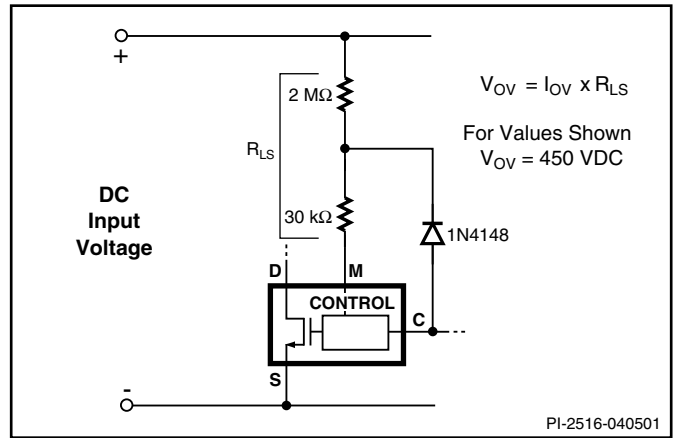


图 33. 仅实现过压的线电压检测 (禁止欠压)。低压时会降低最大占空比, 线电压增高时最大占空比进一步降低

多功能 (M) 引脚的典型使用方法 (继上)

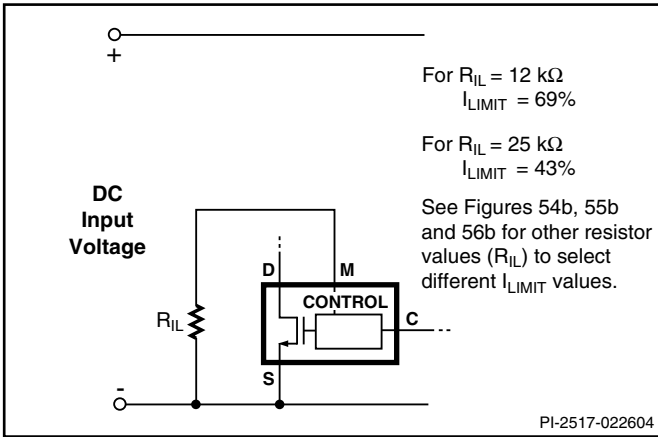


图 34. 外部设定流限 (通常无必要 — 参考M引脚工作描述)

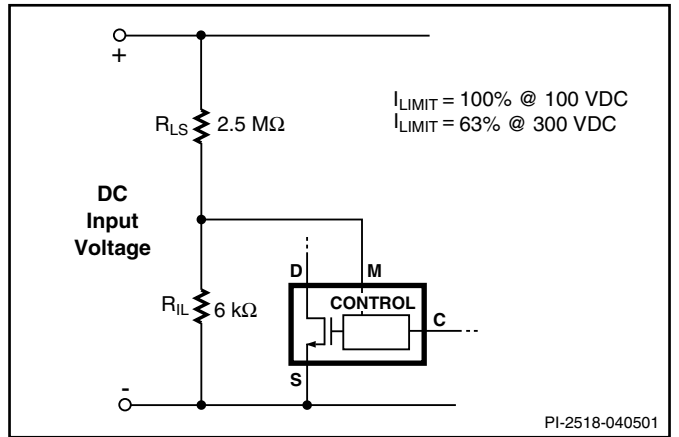


图 35. 流限随电压降低而降低 (通常无必要 — 参考M引脚工作描述)

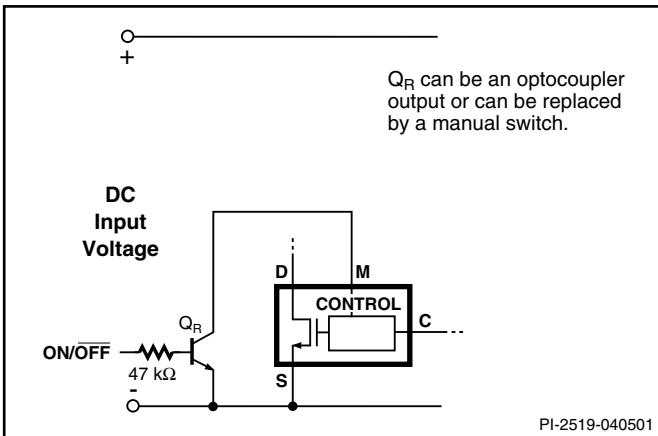


图 36. 启动远程开 / 关

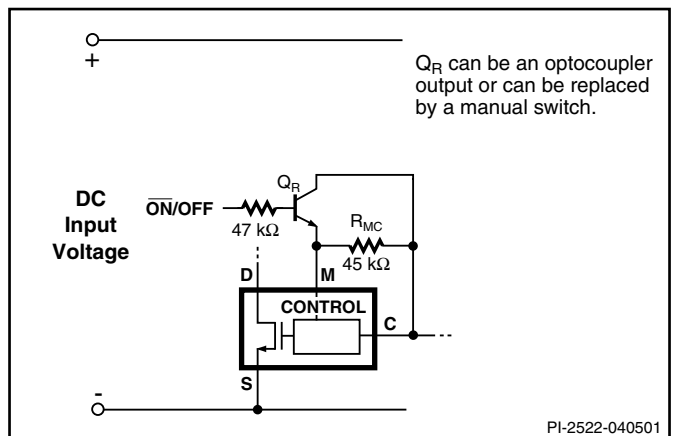


图 37. 取消远程开 / 关。降低最大占空比

多功能 (M) 引脚的典型使用方法 (继上)

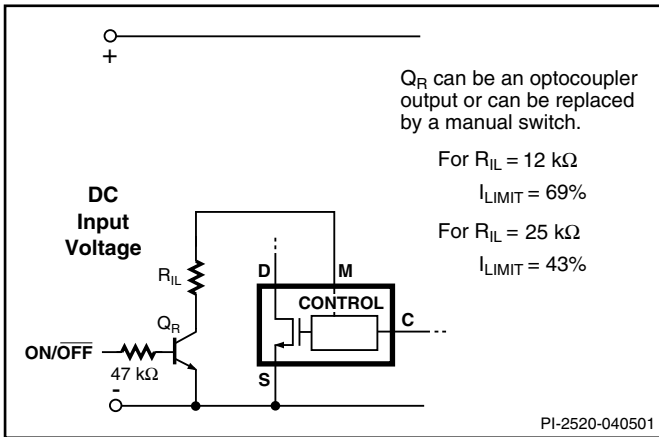


图 38. 用外部设定流限来启动远程开 / 关 (参考M引脚工作描述)

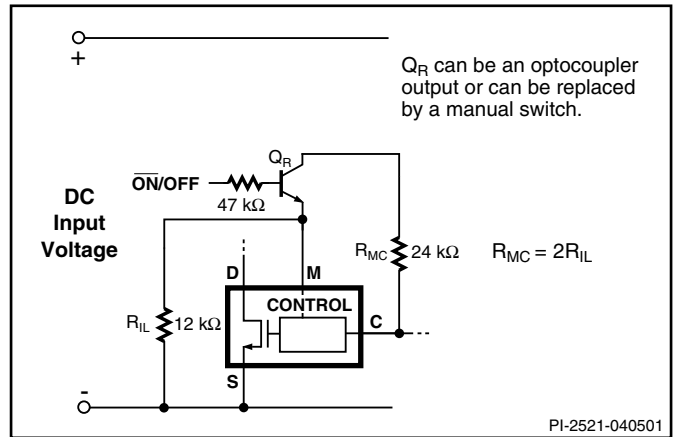


图 39. 用外部设定流限来关闭远程开 / 关 (参考M引脚工作描述)

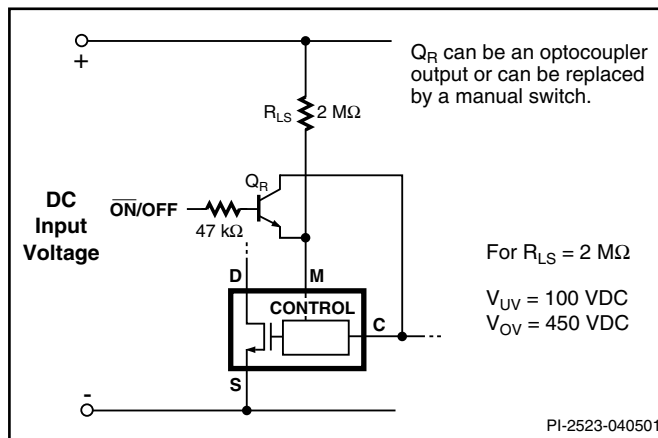


图 40. 用线电压检测来关闭远程开 / 关

应用范例

高效率的30 W宽范围输入电源

图41所示电路利用了TOPSwitch-GX的一些特性来降低系统成本、减小电源尺寸、提高效率。此设计提供12 V、30 W输出，采用通用的85 V到265 V交流输入，在50 °C环境下以开放式模式工作。使用TOP244Y时满载额定效率可达80%。

通过电阻R1和R2从外部设置TOPSwitch-GX的流限值，使其仅略高于低电压工作时的漏极峰值电流，约为缺省流限值的70%。因此，对设定的输出电压，可以采用更小的变压器磁芯和 / 或更高的变压器初级电感，降低TOPSwitch-GX功耗，同时避免启动和输出瞬态情况下变压器磁芯出现饱和。电阻R1和R2提供电压前馈信号，使流限可随电压而降低，从而限定在高输入电压时的最大过载功率。前馈功能与内置的软启动功能相结合，可以使用反射电压较高、低成本的RCD箝位电路（R3、C3和D1）在最差条件下将TOPSwitch-GX的漏极电压限定在留有足够空间的安全范围内。电阻R4实现线电压检测，将UV设定为

100 VDC，OV设定为450 VDC。TOPSwitch-GX增大了最大占空比（确保至少75%，而TOPSwitch-II为64%），因而可以使用更小的输入电容(C1)。TOPSwitch-GX采用RCD箝位，最大占空比更大，反射电压更高，因而T1可以使用较高的初次级匝数比，以降低次级整流管D8上的峰值反向电压。因此，15 V以下输出可使用肖特基二极管整流器，能极大地改善电源效率。TOPSwitch-GX的频率降低特性使电源在空载调节时无需假负载，降低了电源的空载 / 待机功耗。频率调制特性能更好地使传导EMI符合CISPR 22(FCC B)标准。

电路采用简单的齐纳检测电路来降低成本。输出电压稳压由齐纳二极管 (VR2) 电压及光耦合器 (U2) 和电阻R6上的压降决定。电阻 R8 提供进入齐纳二极管的偏置电流，产生对12 V输出电平、过压过载和元件变化时± 5%的稳定度。

高效的 70 W 封闭式通用适配器电源

图42所示电路利用TOPSwitch-GX的某些特性来降低系统成本、减小电源尺寸，提高效率。此设计提供19 V、70 W

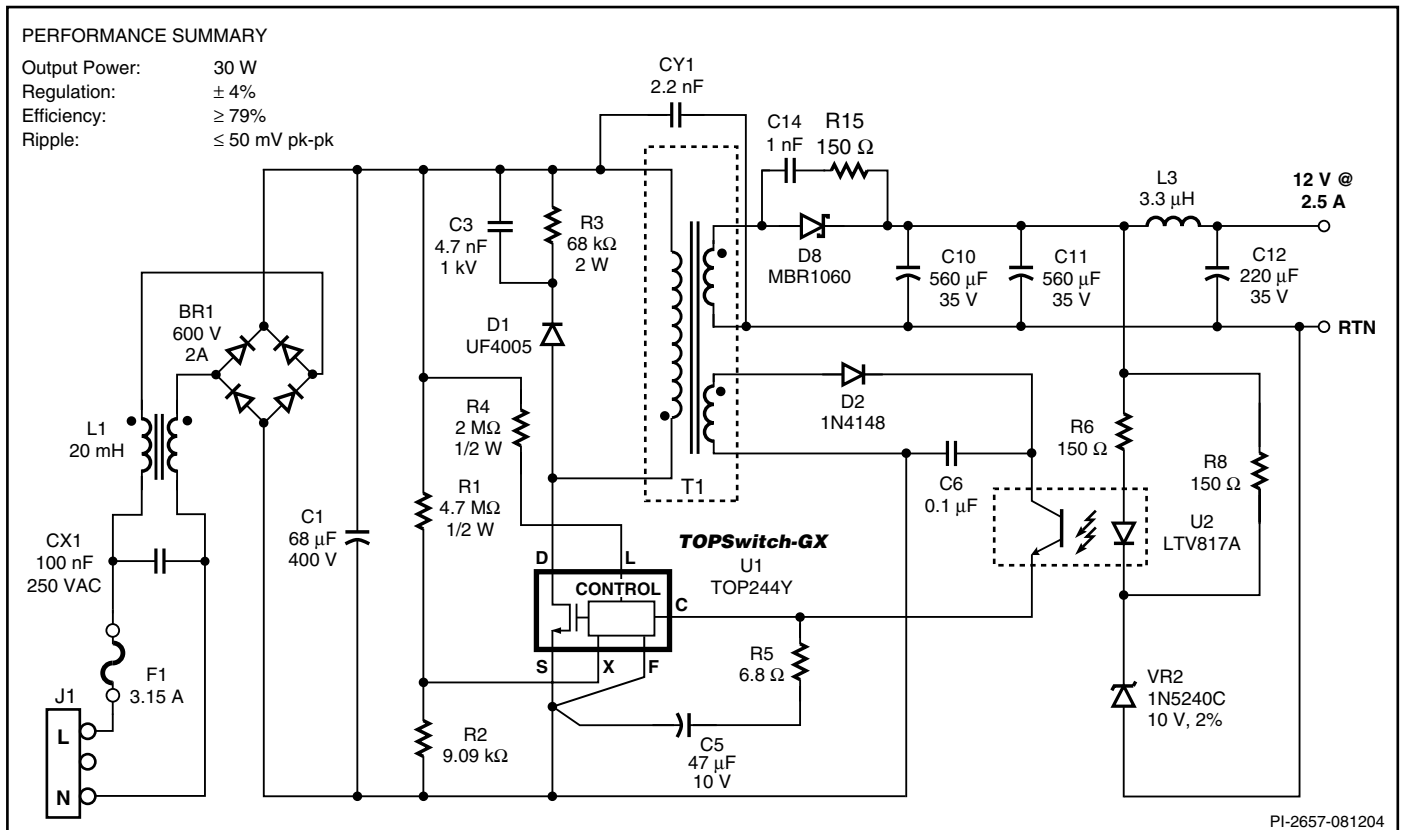


图 41. 使用外部流限编程及线路检测欠压及过压的30 W电源

输出, 采用通用的85 V到265 V交流输入, 在40 °C环境下小型密封适配器盒内(4" x 2.15" x 1")工作。85 VAC时满载效率为85%, 而230 VAC输入时可达90%。

考虑到密封适配器的工作热环境, 我们选用器件热耗散最小的TOP249Y。电阻R9和R10从外部将流限值设定为仅略高于低电压工作时的满载峰值电流, 从而允许使用更小的变压器磁芯, 同时避免启动和输出负载瞬态的磁芯饱和。电阻R9和R10还能使流限随电压升高而降低, 从而限制高输入电压时的最大过载功率, 并使次级无需任何保护电路。电阻R11实现欠压和过压检测, 同时提供降低输出电压频率纹波的电压前馈。使用2 M Ω 的电阻值, 电源在DC幅值电压达到100 VDC之后才开始工作。在关断交流输入时, UV检测防止CI放电时的输出干扰, 并在输出失调或输入电压降至40 V以下时关断TOPSwitch-GX。相同的R11电阻值将OV阈值设定为450 V。如果超过OV值, 比如发生电涌时, TOPSwitch-GX在电涌期间停止转换, 从而使器件可以经受住700 V高压的冲击。电容C11与VR1并联以降低齐纳箝位的损耗。开关频率为132 kHz时, 可以用PQ26/20磁芯提供70 W的功率。为降低绕组损耗,

使效率最高, 此电路均为带双100 V肖特基二极管(D2和D3)的两组输出绕组。TOPSwitch-GX的频率降低特性使电源在空载调节时无需假载, 使230 VAC输入时的电源空载功耗降低到仅520 mW。使用简单的滤波元件(C7、L2、L3和C6), 甚至将输出接地, TOPSwitch-GX的频率调制特性仍能使传导EMI符合CISPR22(FCCB)/EN55022B标准。

为调节输出, 将光耦(U2)和次级基准一起使用, 通过电阻分压网络(U3、R4、R5及R6)检测输出电压。D4和C15对偏置绕组的输出进行平滑和滤波。1 μ F的C15防止空载到满载的瞬态期间偏置电压下降。电阻R8实现漏感尖峰滤波, 使偏置电压在输出负载变化很大时仍能保持恒定。R7、C9、C10和C5、R3一起提供环路补偿。

由于初级电流很大, 所有小信号控制元件均连接到一个独立的源节点上, 即以Kelvin方式连接到TOPSwitch-GX的源极引脚。为改善抵抗共模电涌的能力, 偏置绕组的共模回路直接与直流大电容(C1)相连。

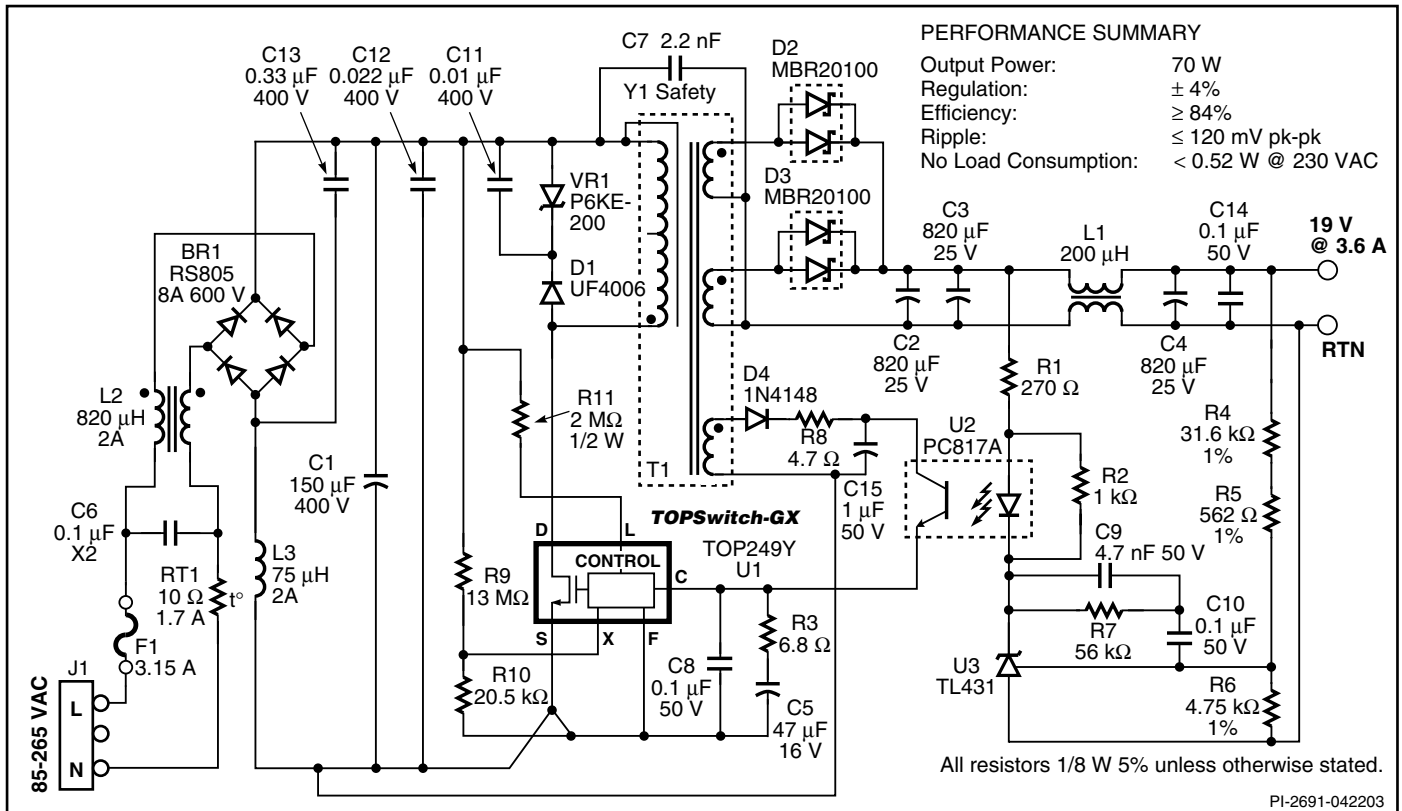


图 42. 具备限流点随输入电压降低及输入过欠压检测功能的70 W电源

250-380 VDC输入、250 W输出的高效电源

图43所示为输入电压250 V到380 VDC的电路，用TOP249提供250 W(48 V@5.2 A)输出功率，效率高达84%。此图只表示了直流输入。一般来讲，在此输出功率的应用中通常都需要一个PFC升压电路在前端来提供直流输入（C1用来提供局部去耦）。此功率级仍可采用反激式拓扑结构，因为输出电压高，而使得次级峰值电流足够低，从而可以合理选择大小适当的输出二极管和电容。

由于我们使用TOP249的上限功率，应通过将X引脚连至源极引脚来使流限设为内部最大值。然而，可通过在L引脚与直流电压间连接一个2 MΩ的电阻来实现线电压检测。如果直流输入电压升至450 V以上，在电压恢复正常值前TOPSwitch-GX将停止工作，以防止器件的损坏。

由于初级电流较高，变压器必需低漏感，因此它通常使用三明治绕法，次级使用铜箔绕组。即使使用了这种技术，漏感能量仍是简单的齐纳箝位所无法负荷的。因此增加了与VR1并联的R2、R3和C6。由于这些器件的选值能使正

常工作期间VR1的低功耗，漏感能量反而由R2和R3消耗。但VR1仍非常重要，它能将启动和过载情况下的峰值漏电压限制在TOPSwitch-GX的MOSFET额定值700 V以下。

次级通过D2 和C9、C10和C11来整流和平滑，这三个电容用于满足次级纹波电流的要求。电感L2和C12对开关噪声进行滤波。

输出电压以简单的齐纳检测链进行调节。VR2、VR3和VR4上的压降以及U2上LED的压降之和即为所需的输出电压。电阻R6控制LED电流并设置整体控制环路的直流增益。二极管D4及C14实现次级软启动，在输出整流前将电流送入控制引脚，确保输出电压在满载条件下及低电压启动时保持稳定。电阻R9为C14提供放电通路。由于与增益相关的输出电压很高，电容C13和R8提供控制环路补偿。

注意散热能力必须足以使TOPSwitch-GX的温度在满载、低压和最高环境温度条件下，保持低于110 °C。如果无法提供足够的散热面积，就需要通过气流来强制冷却。

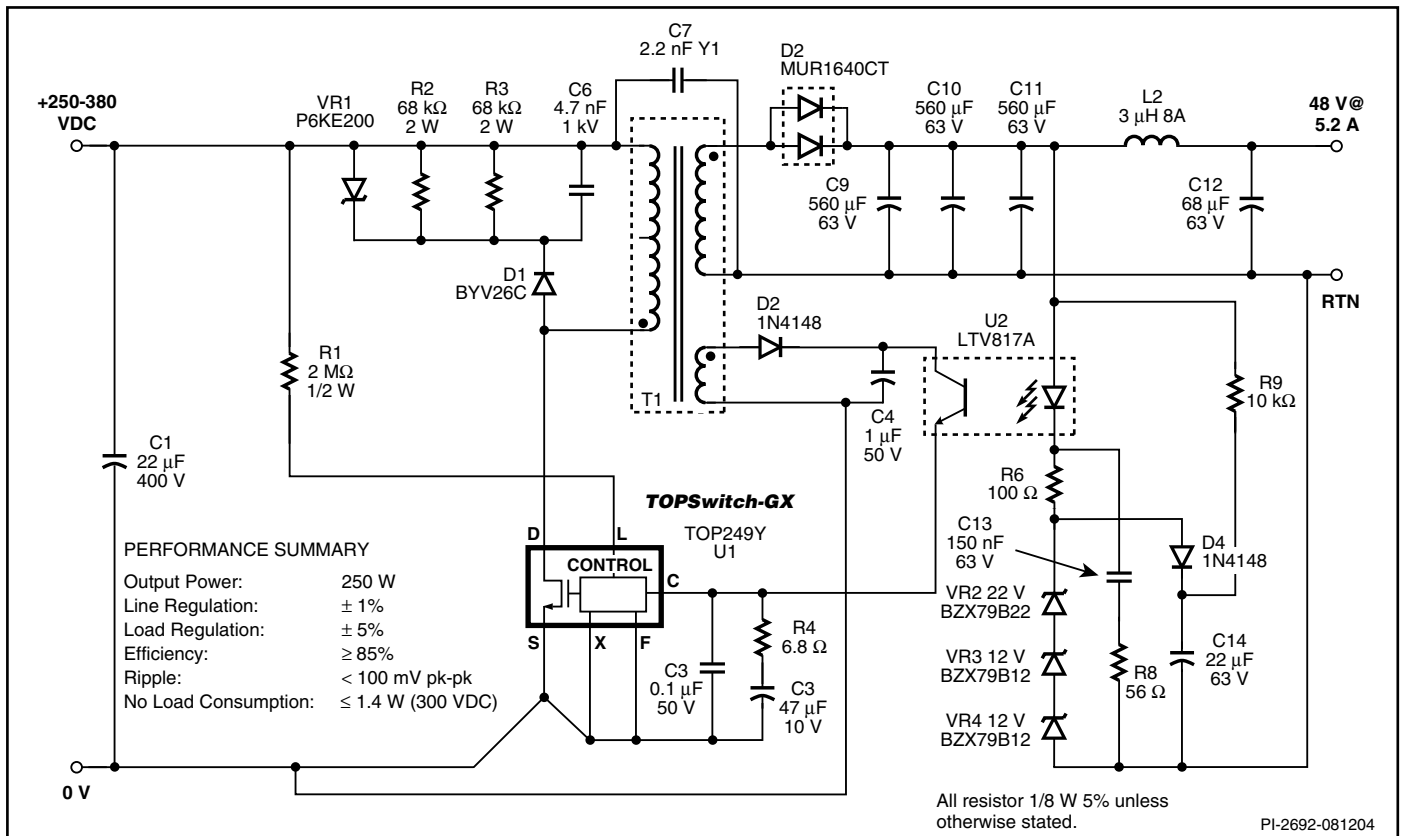


图 43. 使用TOP249的250 W、48 V电源

185-265 VDC输入、60 W多路输出电源

图 44 所示的多输出电源电路常用于使用了大容量记录硬盘的高档机顶盒和有线电视解码器等应用。在输入电压范围为185到265 VAC时，电源提供 45 W（连续）/ 60 W（峰值）（限热）的输出功率。185 VAC电压45 W输出时，效率高于75%。

3.3 V和5 V输出无需次级线性调节器即可实现 $\pm 5\%$ 调节。电路中使用直流叠加（其它输出电压的次级绕组基准连接在D10的负极而非正极）来消除电压误差，获得更高的电压输出。

由于机顶盒所处的工作环境温度通常较高(60 °C)，使用TOP246Y能降低传导损耗，使散热片面积最小。电阻R2将电流设置为典型值的80%，以对过载功率加以限制。线路检测电阻(R1)检测直流电压何时超过450 V，来保护TOPSwitch-GX不受电涌和瞬态电压变化的影响。此时TOPSwitch-GX停止开关，将耐输入电压能力提高到496 VAC。此特性尤其适合于电力状况差的地区。热敏电阻(RT1)限制此功率级所需的大电容C2的涌入电流，防止

保险丝过早地熔断。可选的MOV(RV1)将特定的浪涌保护从4 kV扩大到6 kV。

VR1、R5和C5提供漏电感箝位，使漏极电压在任何情况下都保持在700 V以下。选择电阻R5和电容C5时应使VR1在未过载的情况下耗散极低功率。TOPSwitch-GX的频率调制特性使所示电路可满足CISPR22B标准，具备简单的EMI滤波器（C1、L1和C6）并将输出接地。

次级经D7到D11、C7、C9、C11、C13、C14、C16和C17进行平滑和整流。3.3 V输出的肖特基二极管D11可使效率最高。5 V输出的PN二极管D10使输出电压中心点在5 V。使用两只并联电容可使3.3 V和5 V输出符合纹波电流要求。L2到L5和C8、C10、C12、C15及C18构成开关噪声滤波器。电阻R6限制轻载时30 V输出的峰值充电。输出受次级基准(U3)调节。3.3 V和5 V输出均通过R11和R10检测。R8为U3提供偏置，R7设置总的DC增益。电阻R9、C19、R3和C5提供环路补偿。软启动电容(C20)防止输出过冲。

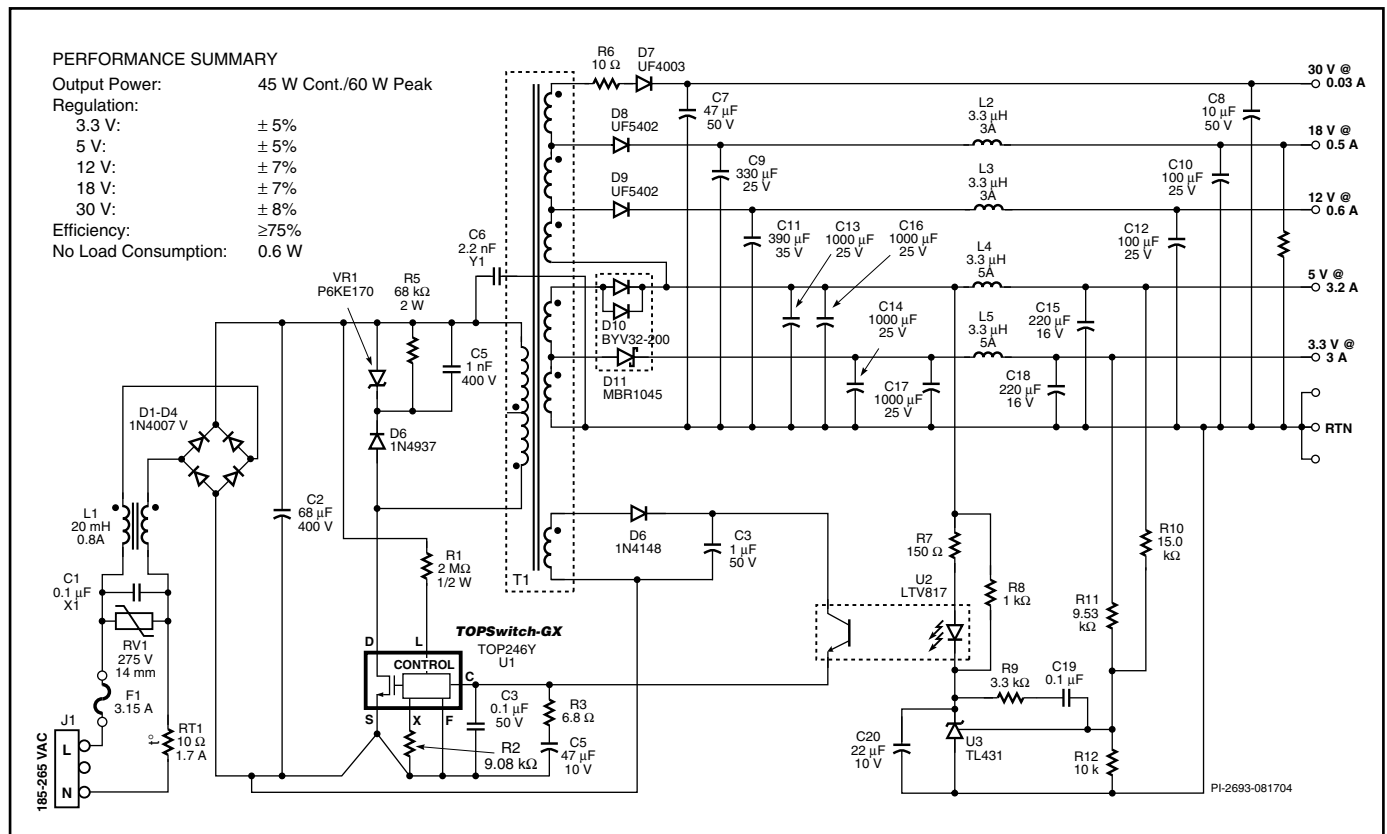


图 44. 使用TOP246的60 W多输出电源

处理器控制电源开关

在打印机等应用中，可以用受微处理器控制的廉价瞬时接触开关来实现TOPSwitch-GX的电源通断。利用TOPSwitch-GX的低功耗远程关断特性，用很少几个外围元件就可以轻易地实现此功能，如图45所示。按钮式瞬时接触开关P1被用户关闭时，光耦U3被激活并通知微处理器。电源处于初始关断状态时（M脚悬空），闭合P1将通过一个二极管使TOPSwitch-GX的M引脚和源极引脚短接，接通电源（远程开）。当次级输出电压 V_{CC} 确立后，微处理器被激活并通过由光耦U3输出驱动的开关状态输入得知P1已闭合，此时它通过光耦U4发出使电源保持接通状态的控制信号。如果用户再次按下开关P1发出关断命令，微处理器通过光耦U3检测到此信号后，启动产品特定的关断程序。例如在喷墨打印机中，关断程序可能包括将打印头安全地停在存储位置。在带有磁盘驱动的产品中，关断

程序可能包括保存数据或设置存储到磁盘上。当关断程序结束、电源可安全关断后，微处理器通过将光耦U4关断来释放M脚。如果手动开关和光耦U3、U4距M引脚的距离较远，则需要用一个电容 C_M 来防止在M引脚开路时将噪声耦合到引脚中。

电源也可通过用逻辑信号驱动光耦合器U4的输入LED，用本地局域网或串口 / 并口来远程接通。有时通过电缆传送一系列逻辑脉冲（例如由电缆的交流耦合）作为唤醒信号比直流逻辑电平更容易实现。在这种情况下，可以用简单的RC滤波器来产生驱动U4的直流电平信号（图45中未显示）。此远程接通特性方便计算机根据需要唤醒打印机、扫描仪、外部调制解调器、磁盘驱动器等外设。为了节电，外设通常设计为一段时间没有使用后自动关断。

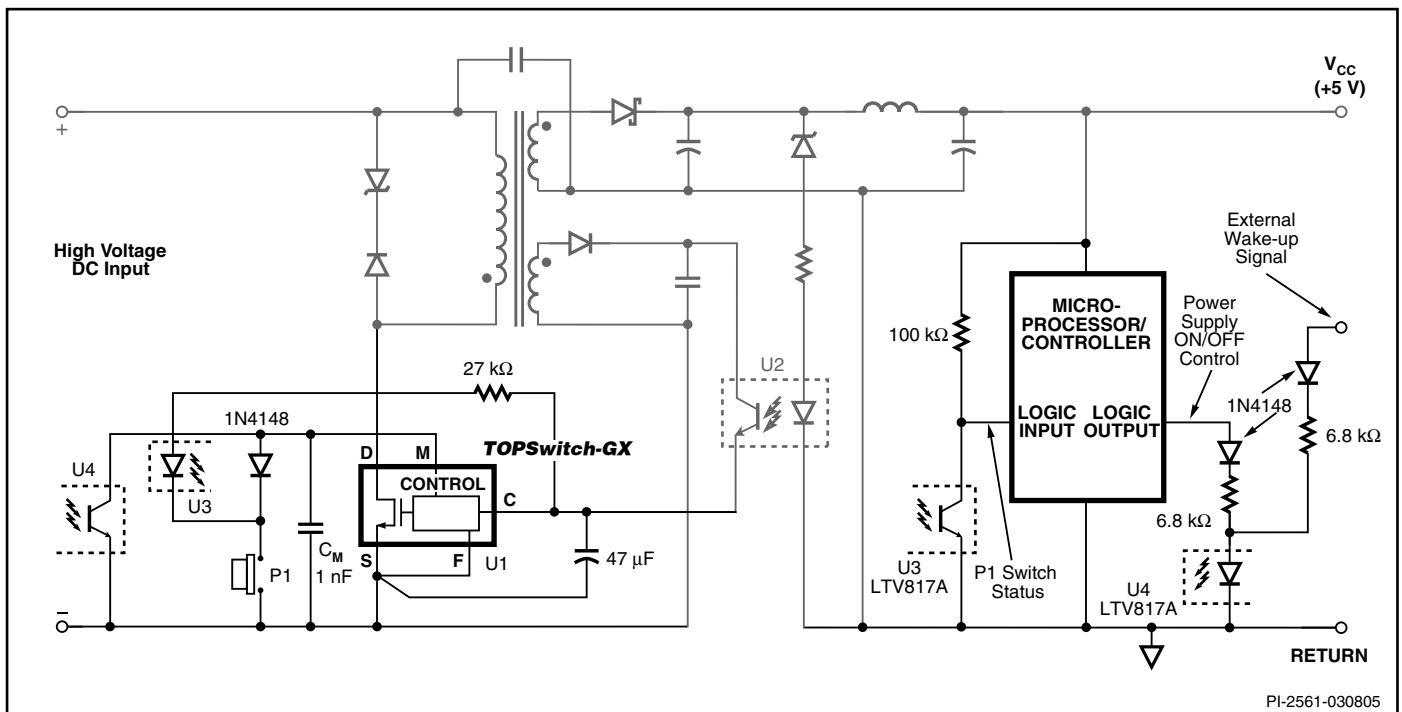


图 45. 使用微控制器的远程开 / 关

除了使用最少的元器件外，TOPSwitch-GX在此类应用中还具有许多技术性的优势：

1. 关断模式时几乎不消耗能量：110 VAC时通常为80 mW，230 VAC时为160 mW。TOPSwitch-GX的关断模式功耗特别低而外部电路也不消耗高压直流输入上的电流（M、L或X脚开路）。
2. 可以使用廉价的、低电压 / 电流的瞬时接触开关。
3. 瞬时接触开关无需去抖动电路。在接通期间，电源的启动时间（通常为10到20 ms）与微处理器的初始化时间起到去抖动滤波器的作用，保证只有当开关被按下至少达到上述时间才允许接通。在关断期间，微处理器在检测到开关的第一次闭合时开始关断程序，其后的开关反弹则不起作用。如果有必要，微处理器可以用软件实现关断时的开关去抖动，或用滤波电容作为开关状态输入。
4. 由于M引脚电流提供内部流限，光耦U4输出工作无需外部流限电路。
5. 无需用连接到输入直流电压线的高压电阻为初级的外部电路供电。甚至U3的LED电流也可由控制引脚提供。这不仅节省了元件，简化了电路布局，还消除了开关状态时由高压电阻引起的功率损耗。
6. 坚固耐用的设计：不含有会被瞬态意外触发的开关锁存，而是由次级端的微处理器使电源保持接通状态。

关键应用考量

TOPSwitch-II 与 TOPSwitch-GX

表4列举了TOPSwitch-GX与TOPSwitch-II的特点和性能差异。TOPSwitch-GX的多项新特性减少了对昂贵的分立元件的需求，可以节约变压器和其它功率元件的成本。

功能	TOPSwitch-II	TOPSwitch-GX	插图	TOPSwitch-GX 产品优点
软启动	N/A*	10 ms		<ul style="list-style-type: none"> 限制启动期间的峰值电流和电压对元件的压力 节约大多数应用中用于软启动的外围元件 降低或消除输出过冲
外部流限	N/A*	从100%到30%缺省流限值可编程	11,20,21, 24,25,27, 28,34,35, 38,39	<ul style="list-style-type: none"> 变压器更小 效率更高 允许功率限制（过载功率恒定，与电压无关） 允许使用较大的器件来降低损耗、提高效率、减小散热面积
DC _{MAX}	67%	78%	7	<ul style="list-style-type: none"> 输入电容更小（动态范围更宽） 功率更高（当使用V_{OR}更大的RCD箝位电路时） 可用肖特基次级整流二极管提供达15 V高效输出
降低DC _{MAX} 的电压前馈	N/A*	78% 到 38%	7,11,17, 26,27,28, 31,40	<ul style="list-style-type: none"> 防止电压纹波
过压关断	N/A*	单电阻可编程	11,17,19, 26,27,28 31,33,40	<ul style="list-style-type: none"> 增加瞬态和浪涌电压的承受力
欠压检测	N/A*	单电阻可编程	11,17,18, 26,27,28, 31,32,40	<ul style="list-style-type: none"> 在电源关断时防止自动重新启动脉冲
开关频率	100 kHz ± 10%	132 kHz ± 6%	13,15	<ul style="list-style-type: none"> 变压器更小 工作频率低于传导EMI扫描的起始频率点

表 4. TOPSwitch-II与TOPSwitch-GX比较（接下页）*不具有

功能	TOPSwitch-II	TOPSwitch-GX	插图	TOPSwitch-GX 产品优点
开关频率选择 (仅限Y、R和F封装)	N/A*	66 kHz \pm 7%	14,15	<ul style="list-style-type: none"> 在视频应用中用RC和RCD缓冲器来降低噪声时的损耗 使待机模式的效率更高 EMI更低(二次谐波低于150 kHz)
频率调制	N/A*	\pm 4 kHz @ 132 kHz \pm 2 kHz @ 66 kHz	9,46	<ul style="list-style-type: none"> 降低传导EMI
频率降低	N/A*	占空比低于10%	7	<ul style="list-style-type: none"> 零负载时维持输出稳定而无需假负载 空载时低功耗
远程开 / 关	N/A*	单晶体管、光耦接口 或手动开关	11,22,23, 24,25,26, 27,29,36, 37,38,39, 40	<ul style="list-style-type: none"> 快速开 / 关(逐周期) 激活或失效控制 远程关断状态时功耗低 防故障的激活控制 线路中无需使用昂贵的通断开关 可以用处理器控制开 / 关 可以通过本地局域网或并口关断 / 唤醒外设
同步	N/A*	单晶体管或光耦接口		<ul style="list-style-type: none"> 可与外部频率较低的信号同步 可根据需要开始新开关周期
热关断	达到125 °C时锁存	迟滞式130°C关断 (75 °C迟滞)		<ul style="list-style-type: none"> 能从热故障中自动恢复 迟滞值较大, 防止电路板过热
流限容差	\pm 10% (@ 25 °C) -8% (0 °C 到 100 °C)	\pm 7% (@ 25 °C) -4% Typical (0 °C 到 100 °C)**		<ul style="list-style-type: none"> 由于容差更小,功率可提高10%
封装的漏极 漏电	DIP	0.037" / 0.94 mm	0.137" / 3.48 mm	<ul style="list-style-type: none"> 对灰尘、污物等污染物引起的重弧具有更高抵抗力
	SMD	0.037" / 0.94 mm	0.137" / 3.48 mm	
	TO-220	0.046" / 1.17 mm	0.068" / 1.73 mm	
Y、R及F封装的 PCB漏极漏电	0.045" / 1.14 mm (R及F封装不具备*)	0.113" / 2.87 mm (预成型引脚)		<ul style="list-style-type: none"> 预成型引脚, 为PCB布局提供更大漏电距离 更易符合安全法规(UL/VDE)

表4 (继上) .TOPSwitch-II与TOPSwitch-GX比较。*不具有。**设置内部流限

功能	TOPSwitch-FX	TOPSwitch-GX	TOPSwitch-GX 产品优点
轻载	周期跳过	降低频率和占空比	<ul style="list-style-type: none"> 改善轻载效率 降低空载消耗
线电压检测 / 外部设置流限 (Y、R及F封装)	线电压检测和外部设置流限相互排斥 (M引脚)	可同时进行线电压检测和外部设置流限 (功能分配到L和X引脚)	<ul style="list-style-type: none"> 允许各项特性同时使用, 增加了设计的灵活性
流限编程范围	100% 到 40%	100% 到 30%	<ul style="list-style-type: none"> 使高连续性设计的变压器磁芯尺寸最小
P/G封装流限	与Y封装相等	TOP243-246的P和G封装内部流限更低	<ul style="list-style-type: none"> 使器件流限与封装耗散能力相符 允许连续性更高的设计降低器件损耗 (降低RMS电流)
Y/R/F封装流限	100% (R及F封装不具备*)	90% (等同于 $R_{DS(ON)}$)	<ul style="list-style-type: none"> 使变压器磁芯的尺寸最小 使大多数应用的效率最高
热关断	最低125 °C 70 °C迟滞	最低130 °C 75 °C迟滞	<ul style="list-style-type: none"> 高温环境应用中的输出功率更高
降低最大占空比的阈值	90 μ A	60 μ A	<ul style="list-style-type: none"> 降低低压时的输出电压频率纹波 最适于正向设计、使用TOP248、TOP249及TOP250的DC_{MAX}降低
线电压欠压负 (关断) 阈值	N/A*	正 (接通) 阈值的40%	<ul style="list-style-type: none"> 明确定义了线电压下降时的关断阈值
软启动	10 ms (占空比)	10 ms (占空比+流限)	<ul style="list-style-type: none"> 除占空比外, 在软启动期间还逐步增加流限, 进一步降低峰值电流和电压 进一步减轻启动期间的元件压力

表 5. TOPSwitch-FX与TOPSwitch-GX比较。*不具有

TOPSwitch-FX 与 TOPSwitch-GX

表5就TOPSwitch-GX和TOPSwitch-FX的性能及特性进行了比较。许多的新特性都无需额外分立元件, 一些特性增强了设计的强度, 可以节约变压器及其他功率元件的成本。

TOPSwitch-GX 设计考量

功率表

数据手册中的功率表 (表1) 代表了以下条件下的最大实际连续输出功率: TOP242到TOP246: 12 V输出、肖特基二极管、150 V反射电压(V_{OR})条件下由应用手册AN29中的曲线有效估算。TOP247到TOP249: 最大输出电流为6 A,

输出电压更高。

假定各器件在85-265 VAC输入时的最小直流电压为100 VDC, 230 VAC时为250 VDC, 散热能力足以使器件温度保持在100 °C以下。功率表内显示的R封装的各功率级假定在一个密闭适配器中, 有6.45 cm²(610g/m²)的铜箔散热区域, 或在开放式设计中有19.4 cm²的铜箔散热区域。

选择恰当的 TOPSwitch-GX 器件

在应用中, 我们应该根据所需的最大输出功率、效率、散热条件及成本目标来选择最适当的TOPSwitch-GX产品型号。由于可以选择外部降低流限, 在需要更高效率或散热条件很差的低功率应用中, 可以选用较大的TOPSwitch-GX器件。

输入电容

输入电容应能提供TOPSwitch-GX转换器所需的最小直流电压，以保持最低额定输入电压和最大输出功率条件下电压受控。由于TOPSwitch-GX的 DC_{MAX} 比TOPSwitch-II的高，它可以使用更小的输入电容。对TOPSwitch-GX而言，只要变压器设计得当，通用输入的电容通常只需每瓦2 μF 。

初级箝位和输出反射电压 V_{OR}

初级箝位电路限制TOPSwitch-GX的峰值漏源极电压。齐纳箝位所需元件数少，占用电路板面积也较小。为提高效率，箝位齐纳管的电压至少应是输出反射电压的1.5倍，以缩短漏电尖峰传导时间。在通用输入应用中，使用齐纳箝位 V_{OR} 的值最好小于135 V，以实现齐纳二极管的绝对容差和温差。这样可以保证箝位电路的高效工作，并将最大漏极电压控制在TOPSwitch-GX MOSFET的额定击穿电压之下。

要完全发挥TOPSwitch-GX DC_{MAX} 范围更宽的优势， V_{OR} 必须更高。RCD箝位比齐纳箝位的箝位电压容差更严格， V_{OR} 可达150 V。通过将外部流限简化为一项输入电压功能，可将RCD箝位的损耗降至最低（见图21和35）。RCD箝位比齐纳箝位的效率更高，但需要更加仔细的设计（见快速设计校验清单）。

输出二极管

输出二极管的选择通常由峰值反向电压、输出电流和应用的热条件（包括热吸收、空气流通等）来确定。TOPSwitch-GX的 DC_{MAX} 较高，只要变压器匝数比恰当，在高达15 V的输出电压上可使用60 V肖特二极管，以获得更高效率（见图41：使用60 V肖特输出二极管的12 V、30 W设计）。

偏置绕组电容

由于空载时工作频率很低，建议使用1 μF 的偏置绕组电容。

软启动

通常在启动时，电源在反馈回路稳定前承受的压力最大。接通时，片内软启动在10 ms内使占空比从零线性增大到

缺省的 DC_{MAX} 同时初级流限从85%上升至100%。这使得输出电压依次上升，为反馈回路控制占空比提供时间。这不仅降低了TOPSwitch-GX的MOSFET、箝位电路和输出二极管的压力，也有助于防止在启动期间变压器过饱和。软启动同时还能限制输出电压过冲的幅值，在大多数应用中都无需软结束电容。

EMI

频率调制特性是将开关频率调制在狭窄的波段内，从而降低与基本开关频率的各次谐波相关的EMI峰值。此特性对均值探测模式特别有利。从图46我们可以看出，频率偏离越大，开关谐波阶次越高，抖动的益处就越明显。

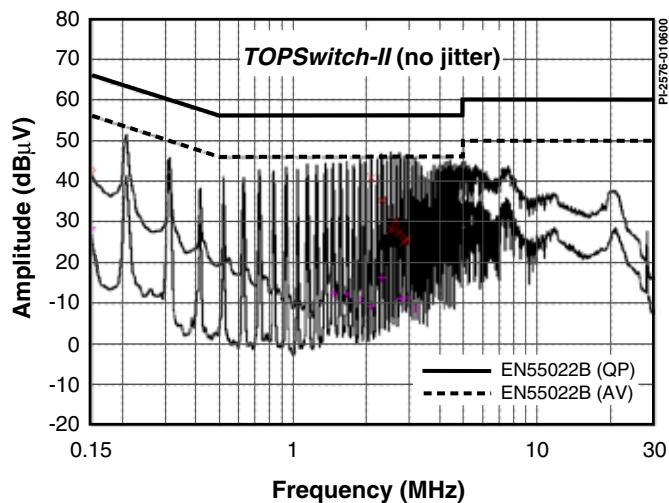


图 46a. TOPSwitch-II的全程EMI扫描（100 kHz、无抖动）

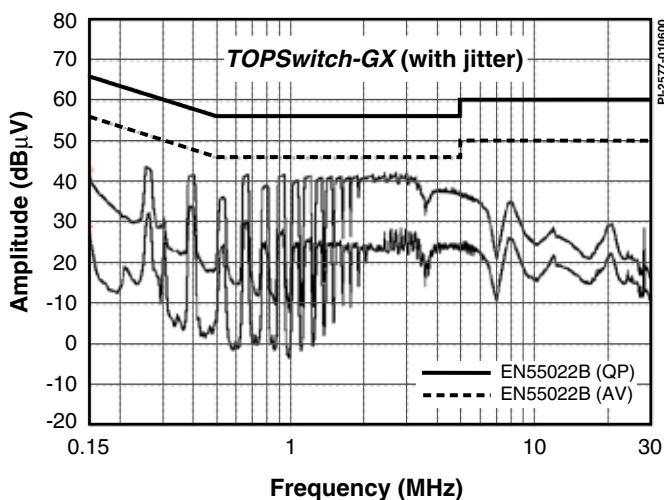


图 46b. 同一电路和条件下，TOPSwitch-GX的全程EMI扫描（132 kHz、有抖动）

*TOPSwitch-GX*的开关频率可以通过频率(F)引脚选为132 kHz或66 kHz。某些应用为了降低高频辐射噪声，漏极节点需要较大的缓冲器（例如VCR、DVD、显示屏、电视机等等），这时选择66 kHz工作频率可以降低缓冲器损耗，提高效率。同样，在变压器尺寸无关紧要的应用中，选择66 kHz也能降低EMI，提高效率。可以看到66 kHz的二次谐波仍低于150 kHz，而频率在150 kHz以上时EMI指标要求会严格得多。

对10 W以下应用，用简单的电感就可以满足全世界各种关于EMI的限制条件，而无需更昂贵的交流输入共模电感。

变压器设计

变压器的工作磁通密度最好不超过3000高斯，最大流限时的峰值磁通密度不超过4200高斯。匝数比的选择应能满足以下条件：反射电压(V_{OR})在使用齐纳箝位时不超过135 V，使用前馈电压降低流限（过载保护）的RCD箝位时不超过150 V（最大）。

如果设计的工作电流远远低于缺省的流限值，最好用接近峰值工作电流的外部流限，降低峰值磁通密度和峰值功率(见图20和34)。在大多数应用中，*TOPSwitch-GX*比*TOPSwitch-II*具有更严格的流限容差、更高的开关频率和特有的软启动特性，这些都助于减小变压器尺寸。

待机功耗

频率降低特性能显著降低轻载或空载功耗，特别是使用齐纳箝位时。如果次级功耗很低，也可以使用TL431调节器来控制反馈。另外，开关频率从正常时的132 kHz降至轻载条件下的66 kHz，也能显著降低开关损耗。

TOPSwitch-GX 的布局考虑

与*TOPSwitch*系列相比，*TOPSwitch-GX*拥有更多引脚并且功率更高，应严格参考如下指南。

初级端连接

*TOPSwitch-GX*源极引脚的输入滤波电容的负极端采用单点连接到偏置绕组的回路，使电涌电流从偏置绕组直接返回输入滤波电容，增强了浪涌的承受力。

控制引脚旁路电容应尽可能接近源极和控制引脚，其源极连线上不应有电源MOSFET的开关电流流过。所有以源极为参考，连接到多功能引脚、线路检测引脚或外部流限引脚的元件同样也应尽可能靠近源极和相应引脚，而且源极连线上仍不应有电源MOSFET的开关电流流过。重要的是，由于源极引脚也是控制器的参考地引脚，其开关电流必须经独立的通路返回到输入电容的负端，而不能和连接到控制脚、多功能引脚、线路检测引脚或外部流限引脚的其它元件共用同一通路。

多功能(M)、线路检测(L)或外部流限(X)引脚的连线应尽可能短，并且远离漏极连线以防止噪声耦合。线路检测电阻（图47和48中的R1）应接近M或L引脚，使其到M或L引脚的连线长度最短。

用一个高频旁路电容与47 μ F控制脚电容并联使用，能更好地预防噪声。反馈光耦合器的输出也应接近*TOPSwitch-GX*的控制和源极引脚。

Y-电容

Y-电容的位置应接近变压器的次级输出回路引脚和初级直流正极输入引脚。

散热

Y封装(TO-220)或F封装(TO-262)的散热部分电气上与源极引脚内部相连接。为避免循环电流，在引脚上附加的散热装置不应与电路板上任何初级地 / 源节点电气连接。

使用P(DIP-8)、G(SMD-8)或R(TO-263)型封装时，器件下靠近源极引脚的铜片区域可起有效的散热作用。在双面电路板中（如图49），连接顶层和底层之间的过孔可用来提高散热。

此外，输出二极管的正负极引脚下的铜片面积应足够大，以利于器件散热。

在图47、48及49中，可看到在输出整流管和输出滤波电容之间的一个狭窄的连线。此连线可在整流管和输出滤波电容之间起到阻止散热的作用，以防止电容过热。

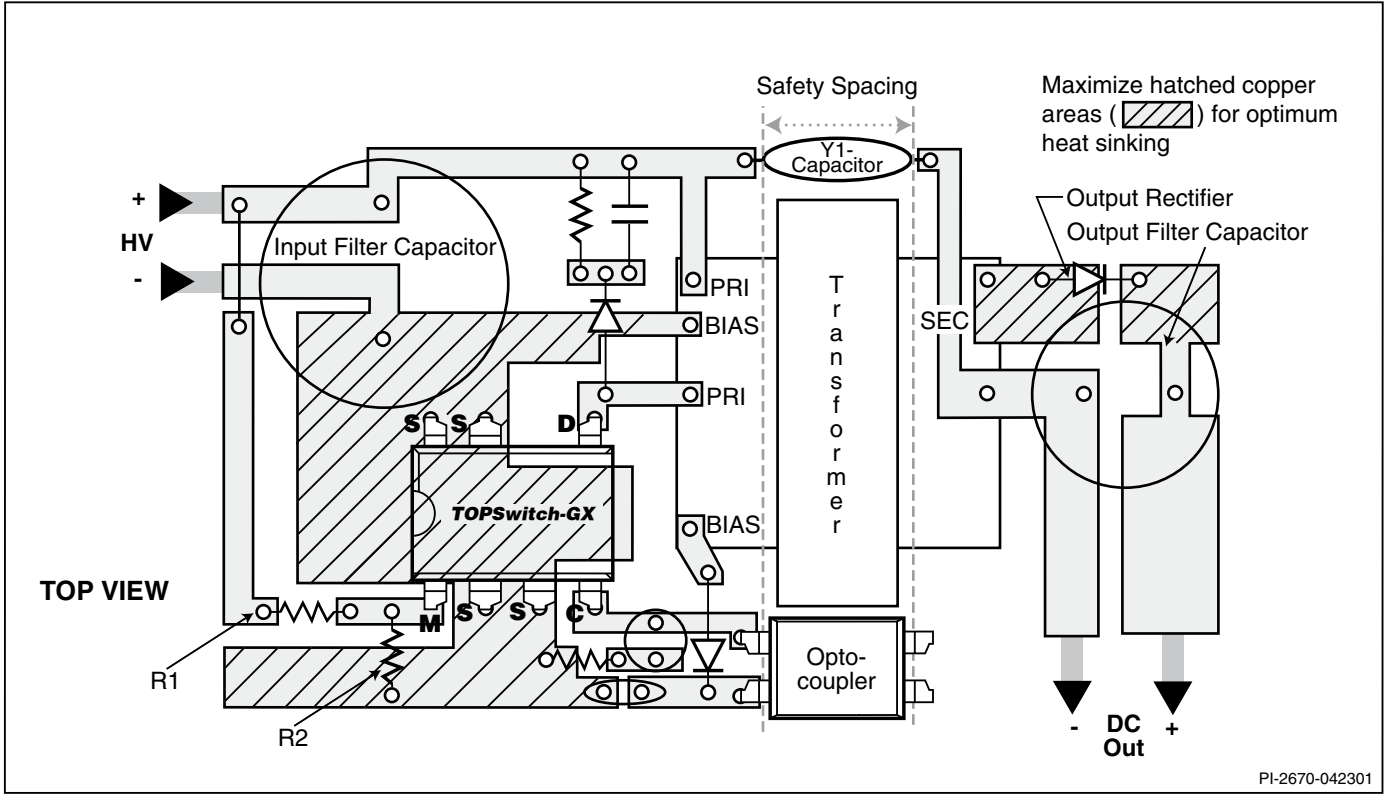


图 47. 使用P或G封装的TOPSwitch-GX布局考量

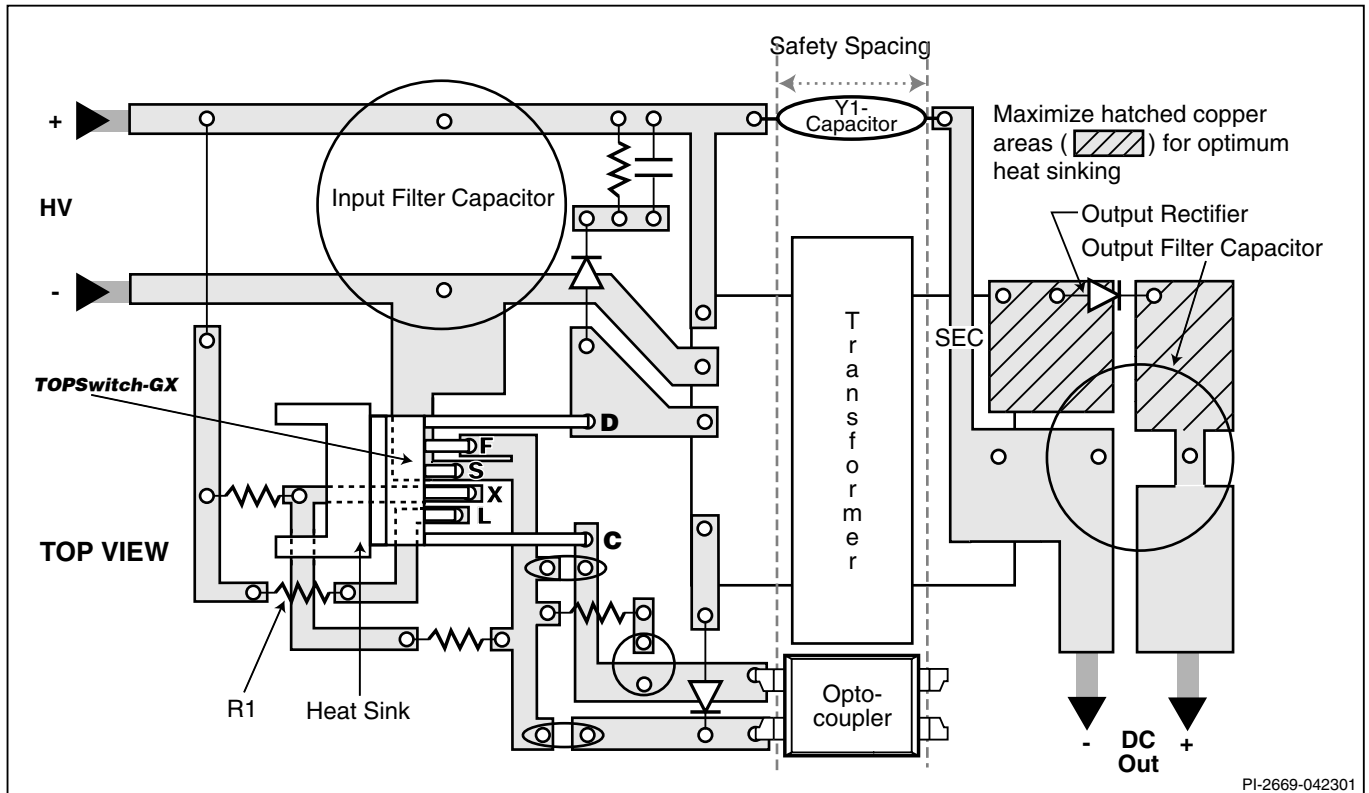


图 48. 使用Y或F封装的TOPSwitch-GX布局考量

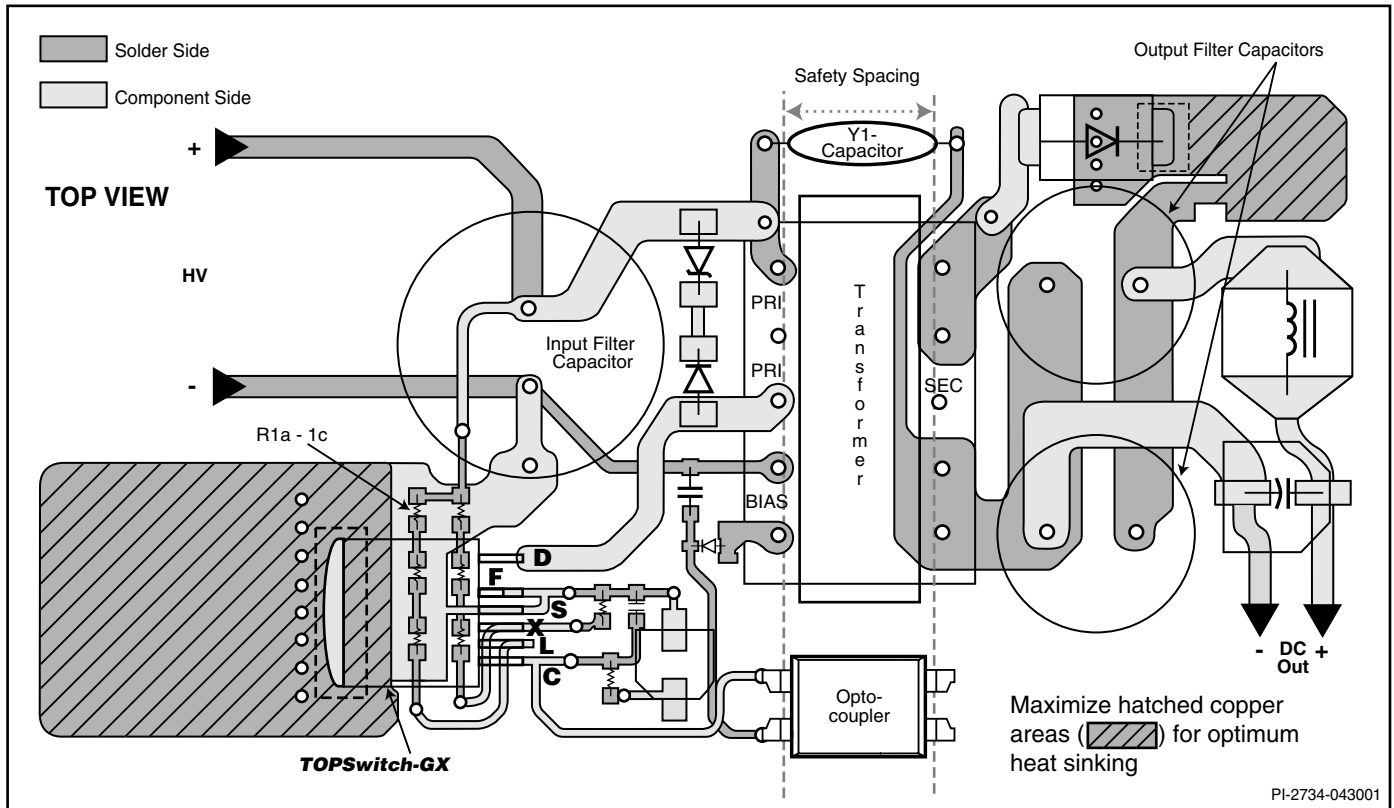


图 49. 使用P封装的TOPSwitch-GX布局考量

快速设计校验

在进行电源设计时，所有TOPSwitch-GX的设计均应进行校验，以确保在最坏条件下不超过元件指标。建议至少进行如下测试：

1. 最大漏极电压 — 检验峰值最高输入电压和最大过载输出功率时， V_{DS} 是否超过675 V。当输出过载到电源即将进入自动重新启动状态（稳压丢失）时的功率即为最大过载功率。
2. 最大漏极电流 — 在最高环境温度、最高输入电压和最大输出负载情况下，观察启动时的漏极电流波形，检验是否出现变压器饱和的征兆和过多的前沿电流尖峰。TOPSwitch-GX的前沿消隐时间为220 ns，可以防止接通周期过早地终止。在220 ns消隐时间结束前，观察漏极电流波形，检验前沿电流是否在允许的流限范围内。

3. 热检查 — 在最大输出功率、最小输入电压和最高环境温度条件下，检验TOPSwitch-GX、变压器、输出二极管和输电容是否超过温度指标。由于数据手册所说明的TOPSwitch-GX器件与器件之间的 $R_{DS(ON)}$ 存在差异，应留出足够的温度裕量。此温度裕量既可以通过容差计算得出，也可以采用如下方法测量计算得到。将一个外部电阻与漏极引脚串联，并将相同的散热片附着在上面，其电阻取值为此器件测得的导通电阻与数据手册中规定的最大导通电阻值之差。

设计工具

关于TOP248、TOP249及TOP250在正激式转换器中的应用，请参考TOPSwitch-GX正激式设计方法应用指南。

Power Integration公司的网站www.powerint.com上提供设计工具的最新信息。

绝对最大额定值^(1,4)

漏极电压.....	-0.3 V到700 V	流限引脚电压	-0.3 V到4.5 V
漏极峰值电流:		多功能引脚电压	-0.3 V到9 V
TOP242.....	0.72 A	频率引脚电压	-0.3 V到9 V
TOP243.....	1.44 A	贮存温度	-65 °C到150 °C
TOP244.....	2.16 A	工作结温度 ⁽²⁾	-40 °C到150 °C
TOP245.....	2.88 A	引脚温度 ⁽³⁾	260 °C
TOP246.....	4.32 A	注释:	
TOP247.....	5.76 A	1. 所有电压都是以 $T_A = 25\text{ °C}$ 时的源极为参考点。	
TOP248.....	7.20 A	2. 通常由内部电路控制。	
TOP249.....	8.64 A	3. 在距壳体1/16英寸处测量, 持续时间5秒。	
TOP250	10.08 A	4. 在非重复性短时间内施加器件允许的最大额定值不会引起产 品永久性的损坏。但长时间对器件施加允许的最大额定值 时, 会对产品的可靠性造成影响。	
控制脚电压	-0.3 V到9		
控制脚电流	100 mA		
线电压检测引脚电压	-0.3 V到9 V		

热阻抗

热阻抗: Y 或 F 封装:	注释:
$(\theta_{JA})^{(1)}$	1. 无须常设散热片。
$(\theta_{JC})^{(2)}$	2. 在塑封本体散热片的背面处测量得到。
P 或 G 封装:	3. 焊在0.36平方英寸(232 mm ²)、2盎司(610 克/m ²)铜铂区域。
(θ_{JA})	4. 焊在1平方英寸(645 mm ²)、2盎司(610 克/m ²)铜铂区域。
$(\theta_{JC})^{(5)}$	5. 在靠近塑料封体表面的源极引脚测得。
R 封装:	6. 焊在3平方英寸(1935 mm ²)、2盎司(610 克/m ²)铜铂区域。
(θ_{JA})	7. 引脚焊在2盎司(610 克/mm ²)的铜铂区域。
$(\theta_{JC})^{(5)}$	

参数	符号	条件		最小值	典型值	最大值	单位
		源极 = 0 V; $T_J = -40$ 到 125 °C 见图 53 (有另行说明除外)					
控制功能							
开关频率 (平均)	f_{OSC}	$I_C = 3\text{ mA};$ $T_J = 25\text{ °C}$	FREQUENCY Pin Connected 到 SOURCE	124	132	140	kHz
			FREQUENCY Pin Connected 到 CONTROL	61.5	66	70.5	
频率降低开始的占空比	$DC_{(ONSET)}$				10		%
开关频率接近0%时的占空比	$f_{OSC(DMIN)}$		132 kHz Operation		30		kHz
			66 kHz Operation		15		
频率抖动偏离	Δf		132 kHz Operation		± 4		kHz
			66 kHz Operation		± 2		
频率抖动调制率	f_M				250		Hz

参数	符号	条件		最小值	典型值	最大值	单位
		源极 = 0 V; $T_J = -40$ 到 $125\text{ }^\circ\text{C}$ 见图 53 (有另行说明除外)					
控制功能 (继上)							
最大占空比	DC_{MAX}	$I_C = I_{CD1}$	$I_L \leq I_{L(DC)}$ 或 $I_M \leq I_{M(DC)}$	75	78	83	%
			I_L 或 $I_M = 190\text{ }\mu\text{A}$ TOP242-247	28	38	50	
			I_L 或 $I_M = 100\text{ }\mu\text{A}$ TOP242-247		66.5		
			$I_L = 190\text{ }\mu\text{A}$ TOP248-250	33	41.3	49.5	
			$I_L = 100\text{ }\mu\text{A}$ TOP248-250	60	66.8	73.5	
软启动时间	t_{SOFT}	$T_J = 25\text{ }^\circ\text{C}; DC_{MIN}$ 到 DC_{MAX}			10	15	ms
PWM增益	DC_{reg}	$I_C = 4\text{ mA}; T_J = 25\text{ }^\circ\text{C}$		-28	-23	-18	%/mA
PWM增益温度 漂移		见注释 A			-0.01		%/mA/°C
外部偏置电流	I_B	见图 7	TOP242-245	1.2	2.0	3.0	mA
			TOP246-249	1.6	2.6	4.0	
			TOP250	1.7	2.7	4.2	
占空比为0%时的 控制引脚电流	$I_{C(OFF)}$	$T_J = 25\text{ }^\circ\text{C}$	TOP242-245		6.0	7.0	mA
			TOP246-249		6.6	8.0	
			TOP250		7.3	8.5	
动态阻抗	Z_C	$I_C = 4\text{ mA}; T_J = 25\text{ }^\circ\text{C}$ 见图 51		10	15	22	Ω
动态阻抗温漂					0.18		%/°C
控制引脚内部滤波 器极点					7		kHz
关断 / 自动重新启动							
控制引脚充电电流	$I_{C(CH)}$	$T_J = 25\text{ }^\circ\text{C}$	$V_C = 0\text{ V}$	-5.0	-3.5	-2.0	mA
			$V_C = 5\text{ V}$	-3.0	-1.8	-0.6	
充电电流温漂		见注释 A			0.5		%/°C
自动重新启动上限阈 值电压	$V_{C(AR)U}$				5.8		V
自动重新启动下限阈 值电压	$V_{C(AR)L}$			4.5	4.8	5.1	V

参数	符号	条件		最小值	典型值	最大值	单位
		源极 = 0 V; $T_J = -40$ 到 $125\text{ }^\circ\text{C}$ 见图 53 (有另行说明除外)					
关断 / 自动重新启动 (继上)							
自动重新启动迟滞电压	$V_{C(AR)hyst}$			0.8	1.0		V
自动重新启动占空比	$DC_{(AR)}$				4	8	%
自动重新启动频率	$f_{(AR)}$				1.0		Hz
多功能引脚 (M)、线电压检测引脚 (L) 及外部流限引脚 (X) 输入							
欠压阈值电流和迟滞 (M或L引脚)	I_{UV}	$T_J = 25\text{ }^\circ\text{C}$	Threshold	44	50	54	μA
			Hysteresis		30		μA
欠压或远程开 / 关阈值 电流及迟滞 (M或L引脚)	I_{OV}	$T_J = 25\text{ }^\circ\text{C}$	Threshold	210	225	240	μA
			Hysteresis		8		μA
L引脚电压阈值	$V_{L(TH)}$			0.5	1.0	1.6	V
远程开 / 关负阈值电 流及迟滞 (M或X引 脚)	$I_{REM(N)}$	$T_J = 25\text{ }^\circ\text{C}$	Threshold	-35	-27	-20	μA
			Hysteresis		5		μA
L或M引脚短路电流	$I_{L(SC)}$ 或 $I_{M(SC)}$	$V_L, V_M = V_C$		300	400	520	μA
X或M引脚短路电流	$I_{X(SC)}$ 或 $I_{M(SC)}$	$V_X, V_M = 0\text{ V}$	Normal Mode	-300	-240	-180	μA
			Auto-Restart Mode	-110	-90	-70	
L或M引脚电压 (正电流)	V_L, V_M		I_L 或 $I_M = 50\text{ }\mu\text{A}$	1.90	2.50	3.00	V
			I_L 或 $I_M = 225\text{ }\mu\text{A}$	2.30	2.90	3.30	
X引脚电压 (负电流)	V_X		$I_X = -50\text{ }\mu\text{A}$	1.26	1.33	1.40	V
			$I_X = -150\text{ }\mu\text{A}$	1.18	1.24	1.30	
M引脚电压 (负电流)	V_M		$I_M = -50\text{ }\mu\text{A}$	1.24	1.31	1.39	V
			$I_M = -150\text{ }\mu\text{A}$	1.13	1.19	1.25	

参数	符号	条件		最小值	典型值	最大值	单位
		源极 = 0 V; $T_J = -40$ 到 $125\text{ }^\circ\text{C}$ 见图 53 (有另行说明除外)					
多功能引脚 (M)、线电压检测引脚 (L) 及外部流限引脚 (X) 输入 (继上)							
最大占空比开始降低时的阈值电流	$I_{L(DC)}$ 或 $I_{M(DC)}$	$T_J = 25\text{ }^\circ\text{C}$		40	60	75	μA
远程关断漏极供电电流	$I_{D(RMT)}$	见图 71 $V_{DRAIN} = 150\text{ V}$	X, L 或 M Pin Floating		0.6	1.0	mA
			L 或 M Pin Shorted 到 CONTROL		1.0	1.6	
远程接通延迟	$t_{R(ON)}$	From Remote ON 到 Drain Turn-On 见注释 B			2.5		μs
远程关断建立时间	$t_{R(OFF)}$	Minimum Time Before Drain Turn-On 到 Disable Cycle, 见注释 B			2.5		μs
频率输入							
频率引脚阈值电压	V_F	见注释 B			2.9		V
频率引脚输入电流	I_F	$V_F = V_C$		10	40	100	μA
电路保护							
自保护流限 (见注释 C)	I_{LIMIT}	TOP242 P/G TOP242 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 90\text{ mA}/\mu\text{s}$	0.418	0.45	0.481	A
		TOP243 P/G $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 150\text{ mA}/\mu\text{s}$	0.697	0.75	0.802	
		TOP243 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 180\text{ mA}/\mu\text{s}$	0.837	0.90	0.963	
		TOP244 P/G $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 200\text{ mA}/\mu\text{s}$	0.930	1.00	1.070	
		TOP244 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 270\text{ mA}/\mu\text{s}$	1.256	1.35	1.445	
		TOP245 P/G $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 220\text{ mA}/\mu\text{s}$	1.02	1.10	1.18	
		TOP245 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 360\text{ mA}/\mu\text{s}$	1.674	1.80	1.926	
		TOP246 P/G $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 270\text{ mA}/\mu\text{s}$	1.256	1.35	1.445	
		TOP246 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 540\text{ mA}/\mu\text{s}$	2.511	2.70	2.889	
		TOP247 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 720\text{ mA}/\mu\text{s}$	3.348	3.60	3.852	

参数	符号	条件		最小值	典型值	最大值	单位
		源极 = 0 V; $T_J = -40$ 到 $125\text{ }^\circ\text{C}$ 见图 53 (有另行说明除外)					
电路保护 (继上)							
自保护流限 (见注释 C)	I_{LIMIT}	TOP248 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 900\text{ mA}/\mu\text{s}$	4.185	4.50	4.815	A
		TOP249 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 1080\text{ mA}/\mu\text{s}$	5.022	5.40	5.778	
		TOP250 Y/R/F $T_J = 25\text{ }^\circ\text{C}$	Internal $di/dt = 1260\text{ mA}/\mu\text{s}$	5.859	6.30	6.741	
初始流限	I_{INIT}	见注释 B	$\leq 85\text{ VAC}$ (Rectified Line Input)	$0.75 \times$ $I_{LIMIT(MIN)}$			A
			265 VAC (Rectified Line Input)	$0.6 \times$ $I_{LIMIT(MIN)}$			
前沿消隐时间	t_{LEB}	见图 52 $T_J = 25\text{ }^\circ\text{C}$, $I_C = 4\text{ mA}$			220		ns
流限延迟	$t_{L(D)}$	$I_C = 4\text{ mA}$			100		ns
热关断温度				130	140	150	$^\circ\text{C}$
热关断迟滞		Ω			75		$^\circ\text{C}$
上电复位阈值电压	$V_{C(RESET)}$	图 53, S1 Open		1.75	3.0	4.25	V
输出							
导通电阻	$R_{DS(ON)}$	TOP242 $I_D = 50\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		15.6	18.0	Ω
			$T_J = 100\text{ }^\circ\text{C}$		25.7	30.0	
		TOP243 $I_D = 100\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		7.80	9.00	
			$T_J = 100\text{ }^\circ\text{C}$		12.9	15.0	
		TOP244 $I_D = 150\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		5.20	6.00	
			$T_J = 100\text{ }^\circ\text{C}$		8.60	10.0	
		TOP245 $I_D = 200\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		3.90	4.50	
			$T_J = 100\text{ }^\circ\text{C}$		6.45	7.50	
		TOP246 $I_D = 300\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		2.60	3.00	
			$T_J = 100\text{ }^\circ\text{C}$		4.30	5.00	
		TOP247 $I_D = 400\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		1.95	2.25	
			$T_J = 100\text{ }^\circ\text{C}$		3.22	3.75	
		TOP248 $I_D = 500\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		1.56	1.80	
			$T_J = 100\text{ }^\circ\text{C}$		2.58	3.00	

参数	符号	条件		最小值	典型值	最大值	单位
		源极 = 0 V; $T_J = -40$ 到 $125\text{ }^\circ\text{C}$ 见图 53 (有另行说明除外)					
输出 (继上)							
导通电阻	$R_{DS(ON)}$	TOP249 $I_D = 600\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		1.30	1.50	Ω
			$T_J = 100\text{ }^\circ\text{C}$		2.15	2.50	
		TOP250 $I_D = 700\text{ mA}$	$T_J = 25\text{ }^\circ\text{C}$		1.10	1.28	
			$T_J = 100\text{ }^\circ\text{C}$		1.85	2.15	
关断状态漏极漏电流	I_{DSS}	$V_L, V_M = \text{Floating}; I_C = 4\text{ mA}$ $V_{DS} = 560\text{ V}; T_J = 125\text{ }^\circ\text{C}$				470	μA
击穿电压	BV_{DSS}	$V_L, V_M = \text{Floating}; I_C = 4\text{ mA}$ 见注释 D, $T_J = 25\text{ }^\circ\text{C}$		700			V
上升时间	t_R	Measured in a Typical Flyback Converter Application			100		ns
下降时间	t_F				50		ns
电源电压特性							
漏极供电电压		见注释 E		36			V
分路稳压器电压	$V_{C(SHUNT)}$	$I_C = 4\text{ mA}$		5.60	5.85	6.10	V
分路稳压器温漂					± 50		ppm/ $^\circ\text{C}$
控制脚供电 / 放电电流	I_{CD1}	Output MOSFET Enabled $V_X, V_L, V_M = 0\text{ V}$	TOP242-245	1.0	1.6	2.5	mA
			TOP246-249	1.2	2.2	3.2	
			TOP250	1.3	2.4	3.65	
	I_{CD2}	Output MOSFET Disabled $V_X, V_L, V_M = 0\text{ V}$		0.3	0.6	1.3	

注释:

- A. 对带有负号的技术指标, 负温度系数随温度增加其数值增加, 正温度系数随温度增加其数值减少。
- B. 由特性保证。生产时未经测试。
- C. 外部调节流限时, 请参考典型性能特性一节中的图54b、55b及56b (流限与外部流限电阻)。所列明的容差仅在工作在最大限流点处有效。
- D. 可通过抬高漏极引脚电压, 但不超过最小 BV_{DSS} 的方式来检查击穿电压。
- E. *TOPSwitch-GX*在漏极电压比36 V低很多的情况下也可以启动和工作。但是, 控制脚的充电电流会减少, 这会影响启动时间、自动重新启动频率和自动重新启动占空比。请参阅图68的低压工作特性曲线中控制脚充电电流(I_C)与漏极电压之间的关系曲线。

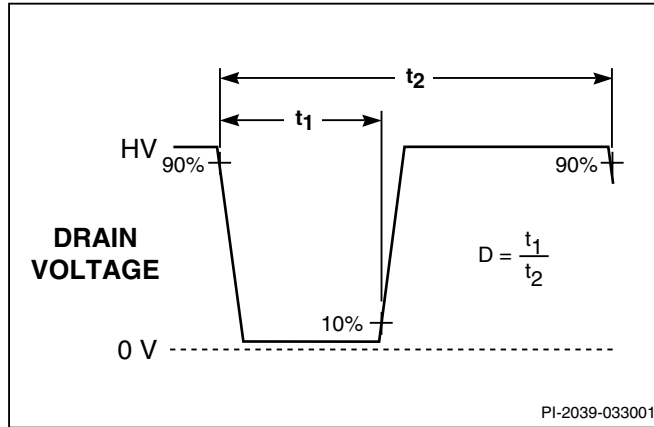


图 50. 占空比测量

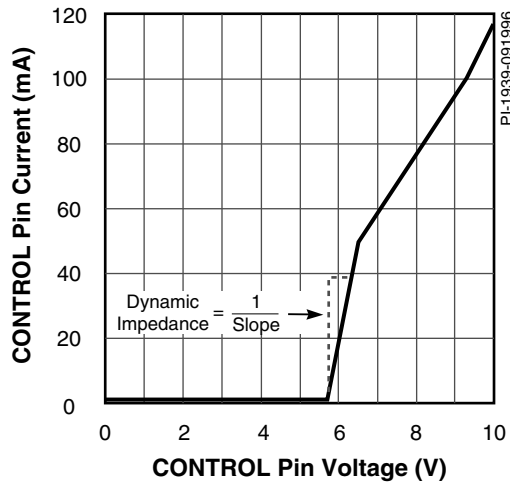


图 51. 控制引脚 I-V 特性

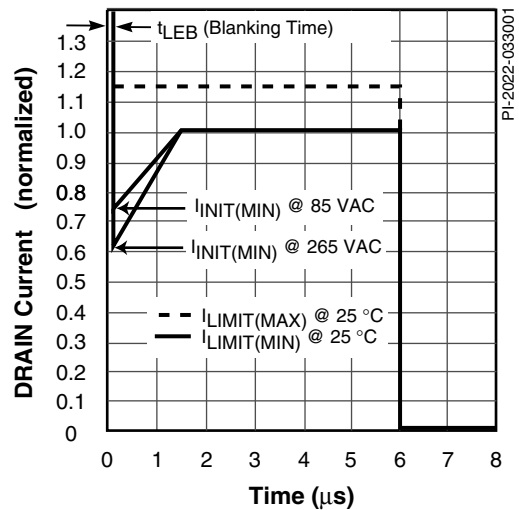


图 52. 漏极电流工作包络

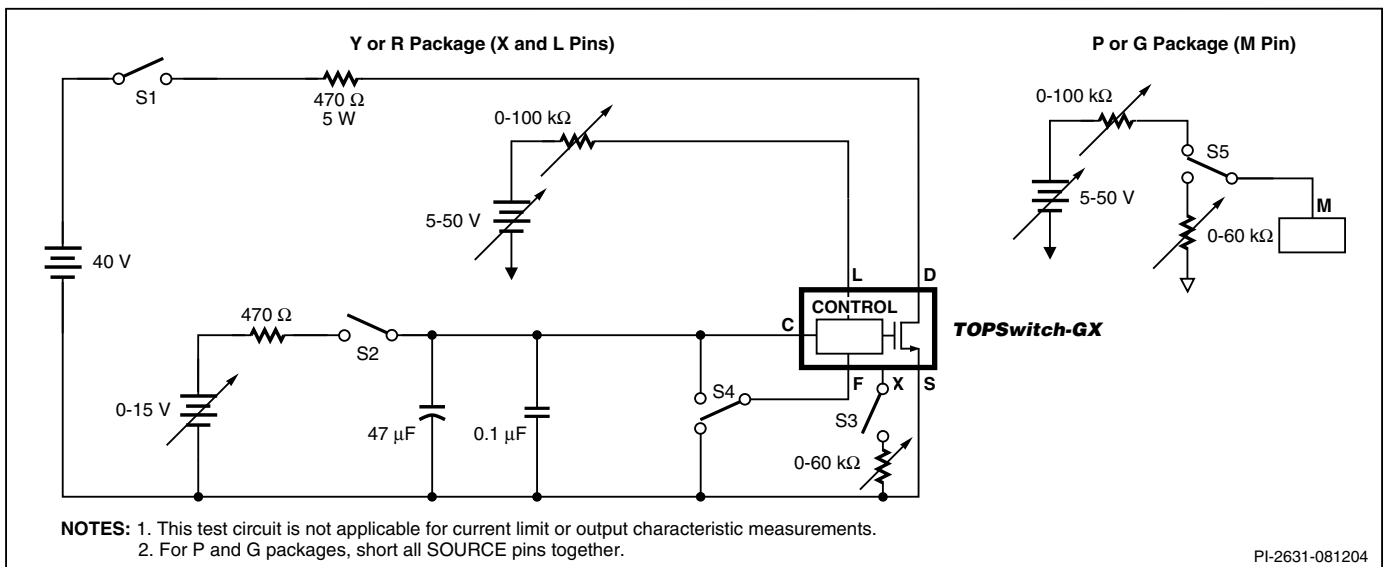


图 53. TOPSwitch-GX 通用测试电路

在测试器件的电气特性时需要注意的问题

在电源外对TOPSwitch-GX单独进行测试时，应该注意下面的问题。图53是对TOPSwitch-GX进行实验室测试时建议使用的电路图。

当漏极电源加上时，器件将进入自动重新启动模式。控制引脚电压将在4.8 V到5.8 V这一较低的频率范围内振荡，而漏极则在控制引脚每进入第八个振荡周期时导通。如果在此自动重新启动模式中接通控制引脚电源，控制引脚振荡能够

处于正确状态（漏极工作状态），从而观察到连续的漏极波形的可能性只要12.5%。因此如果想要观察到连续的漏极波形，就应先将 V_C 的电源电压加上，然后再把漏极的电源接通。上述的12.5%的可能性是由除8计数器造成的。可临时将控制脚和源极引脚短路来复位TOPSwitch-GX，使之出现正确的状态。

典型性能特性

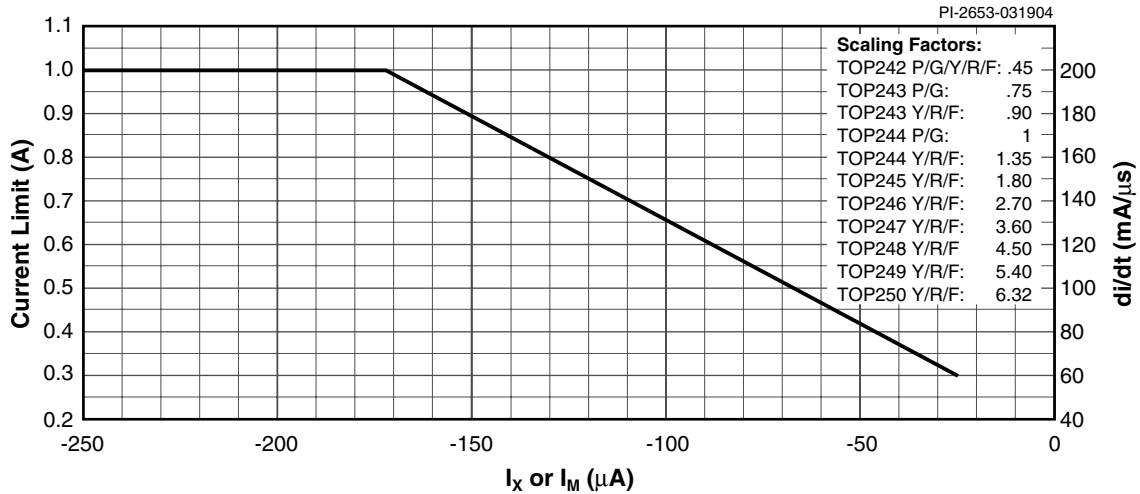


图 54a. 流限随X或M引脚电流的变化（见图55a和56a关于TOP245P/G和TOP246P/G）

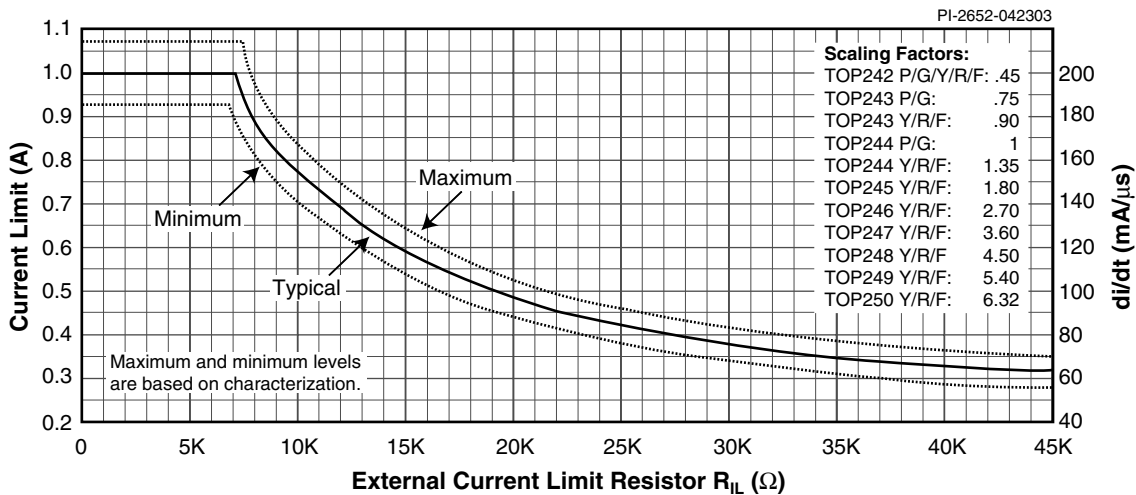


图 54b. 流限随外部流限阻抗的变化（见图55a和56a关于TOP245P/G和TOP246P/G）

典型性能特性 (继上)

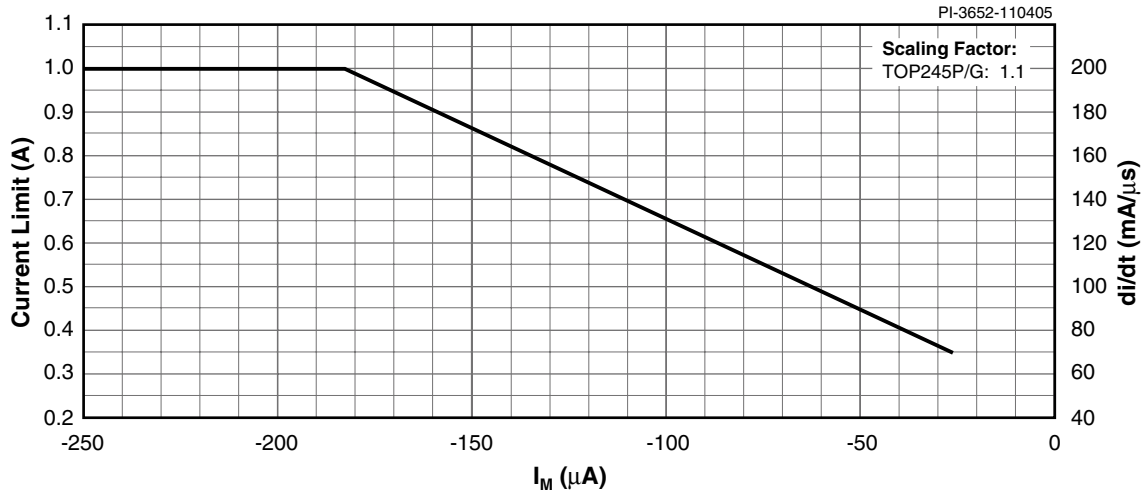


图 55a. 流限随多功能引脚电流的变化 (仅限TOP245P/G)

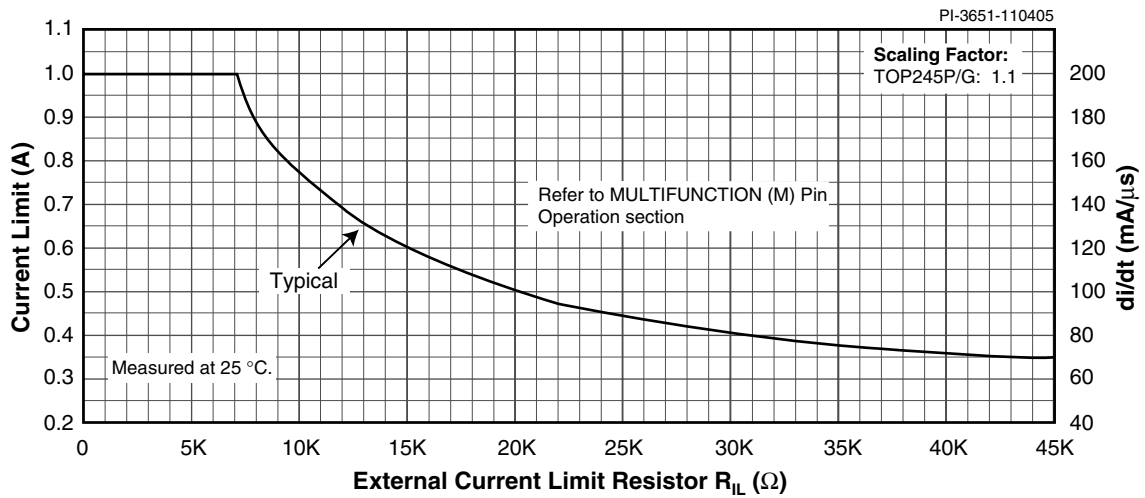


图 55b. 流限随外部流限阻抗的变化 (仅限TOP245P/G)

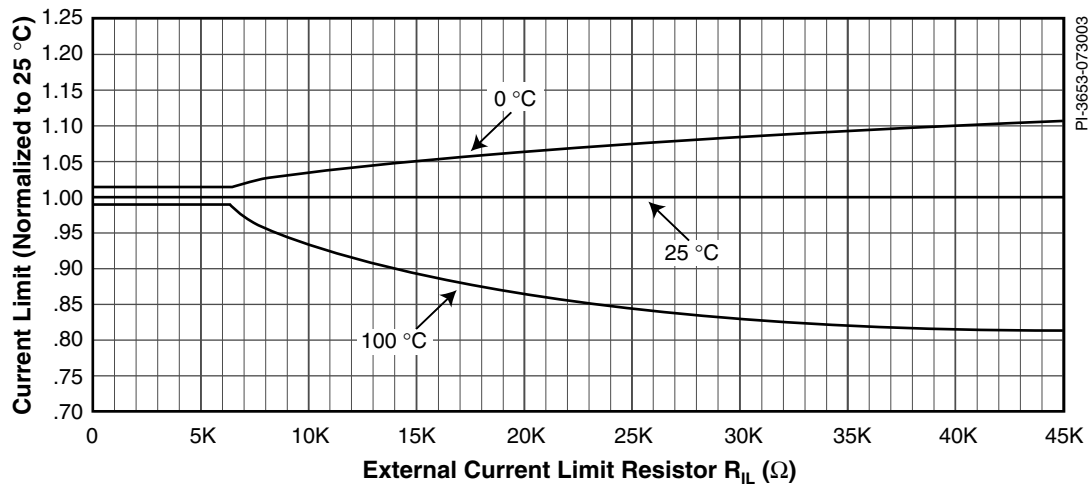


图 55c. 在 0 °C、25 °C 及 100 °C 结温时外部流限随外部流限阻抗的变化 (仅限TOP245P/G)

典型性能特性 (继上)

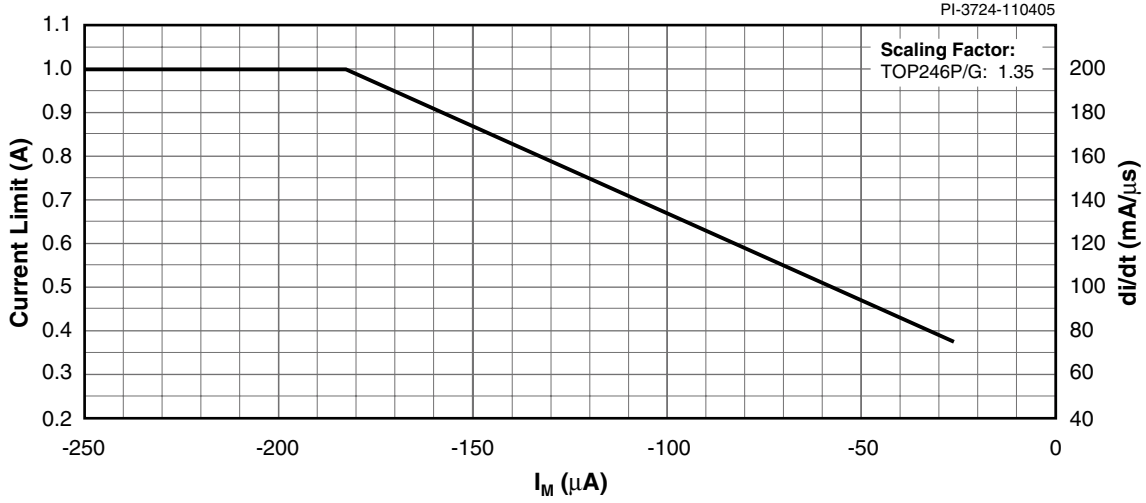


图 56a. 流限随多功能引脚电流的变化 (仅限TOP246P/G)

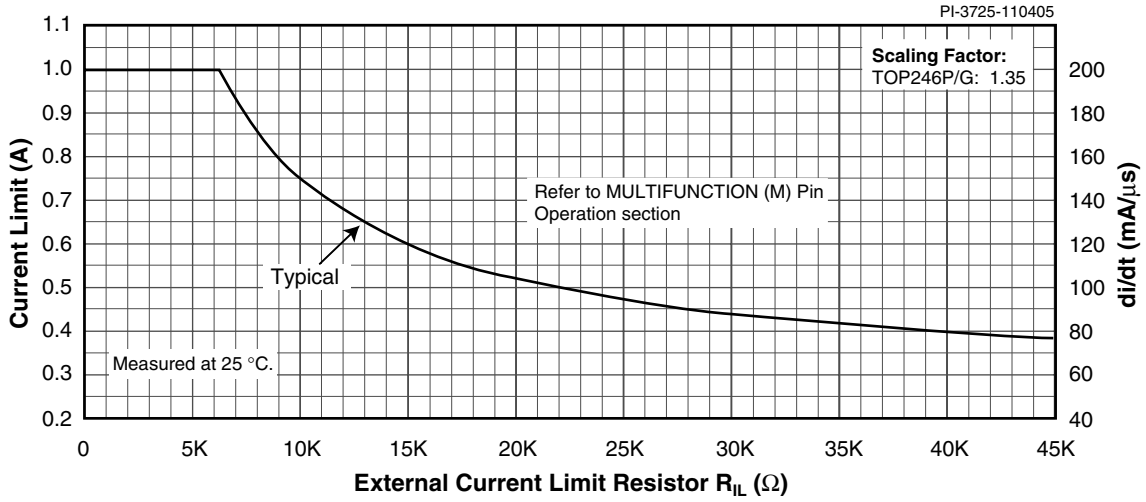


图 56b. 流限随外部流限阻抗的变化 (仅限TOP246P/G)

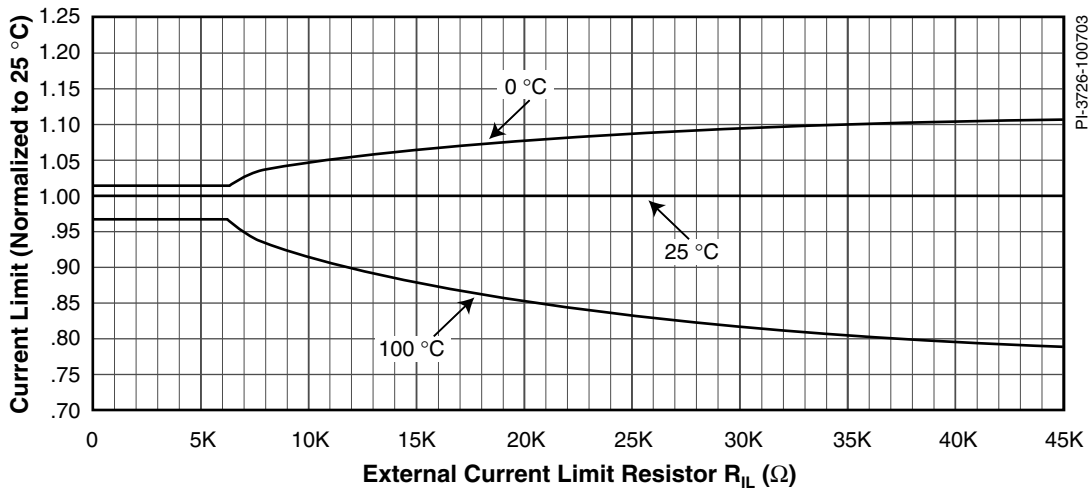


图 56c. 在 0 °C、25 °C 及 100 °C 结温时外部流限随外部流限阻抗的变化 (仅限TOP246P/G)

典型性能特性 (继上)

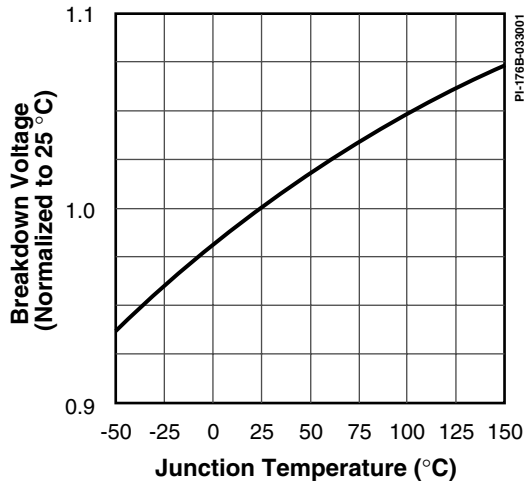


图 57. 击穿电压随温度的变化

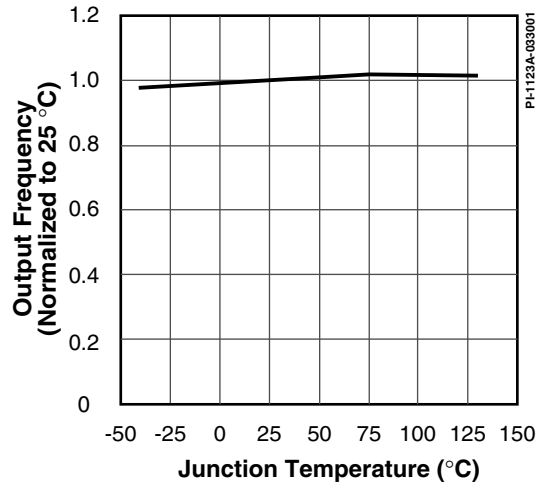


图 58. 频率随温度的变化

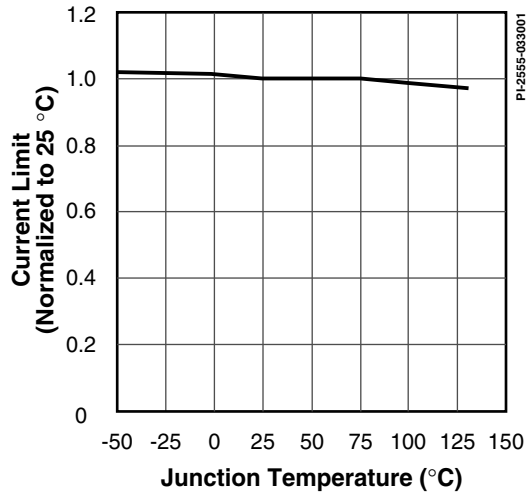


图 59. 内部流限随温度的变化

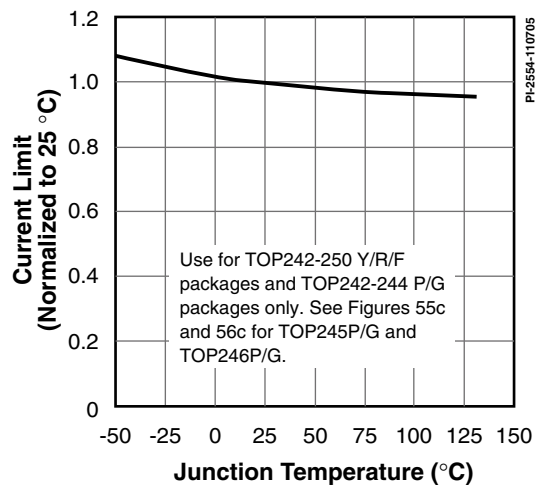
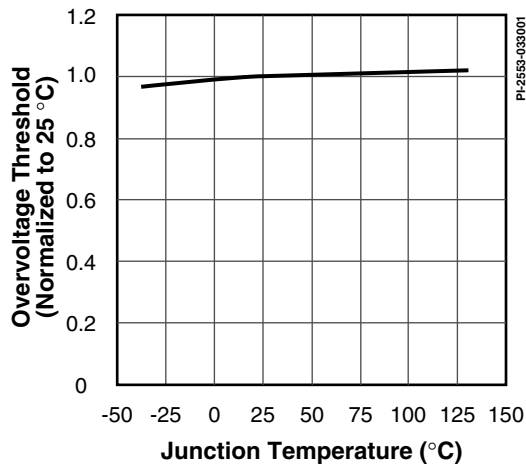
图 60. 外部流限随温度变化($R_{IL} = 12 \text{ k}\Omega$)

图 61. 过压阈值随温度的变化

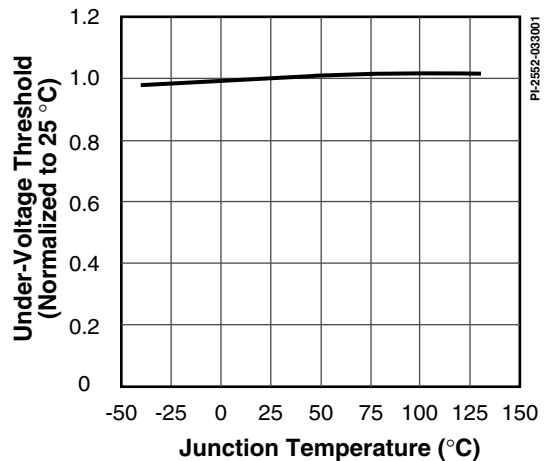


图 62. 欠压阈值随温度的变化

典型性能特性 (继上)

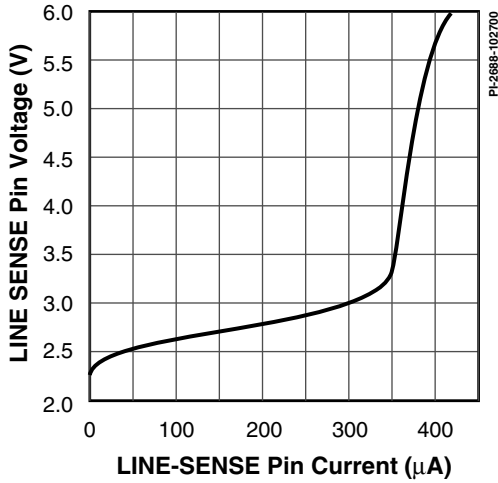


图 63a. 线电压检测引脚电压随电流的变化

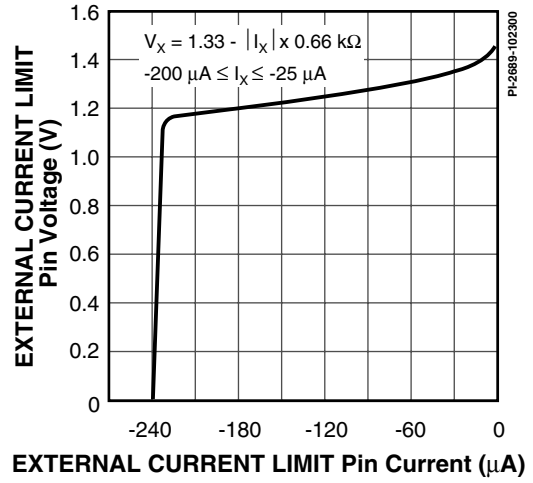


图 63b. 外部流限引脚电压随电流的变化

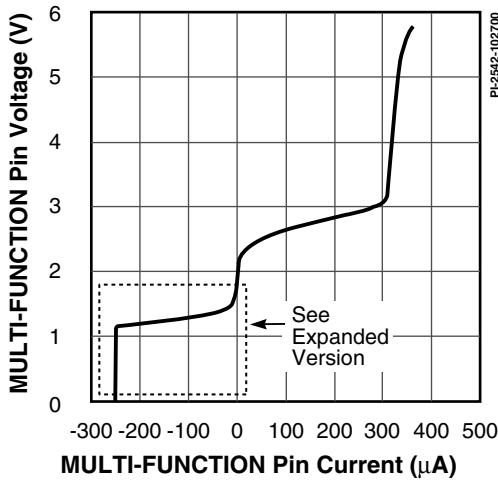


图 64a. 多功能引脚电压随电流的变化

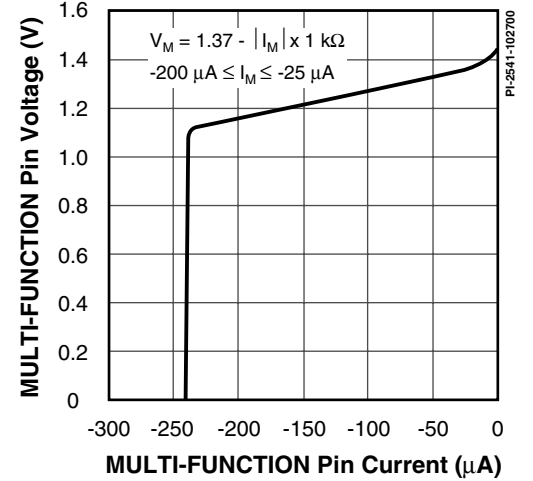


图 64b. 多功能引脚电压随电流的变化 (已扩展)

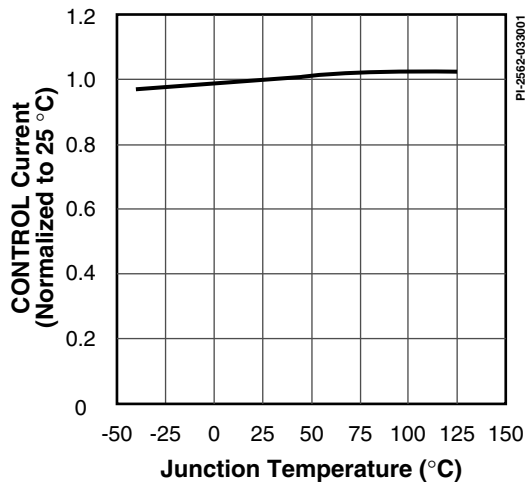


图 65. 占空比为0时控制电流输出随温度的变化

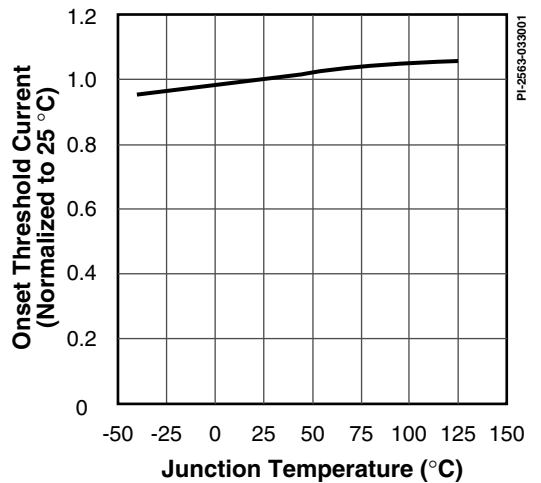


图 66. 最大占空比降低的初始阈值电流随温度的变化

典型性能特性 (继上)

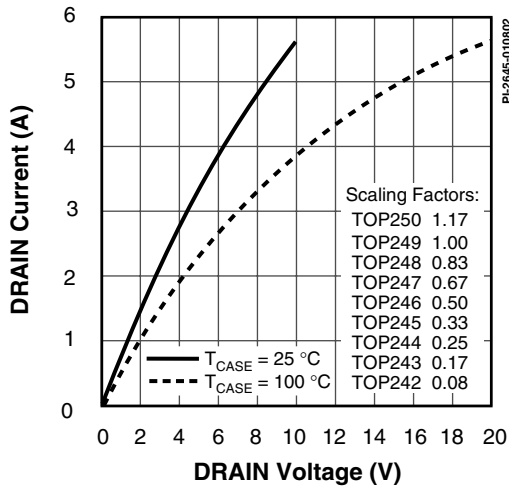


图 67. 输出特性

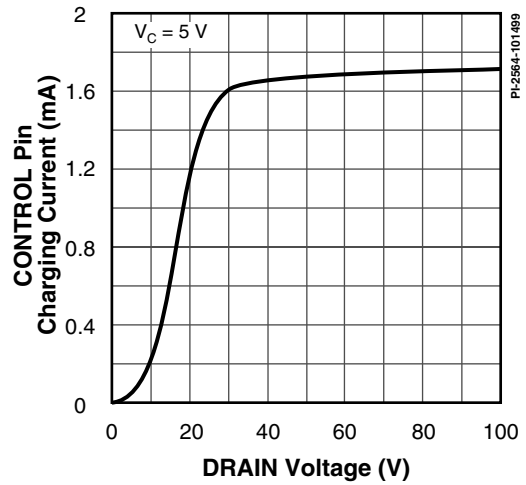


图 68. I_c 随漏极电压的变化

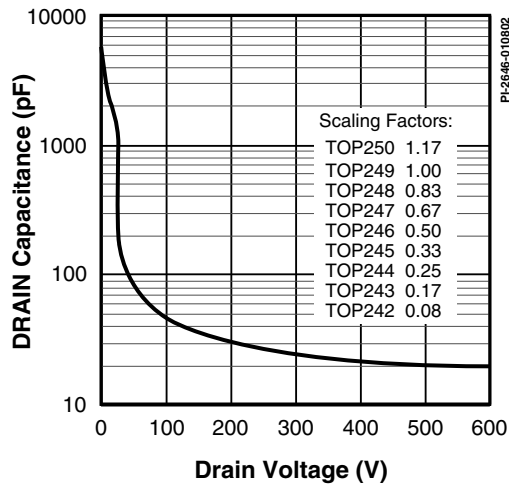


图 69. C_{oss} 随漏极电压的变化

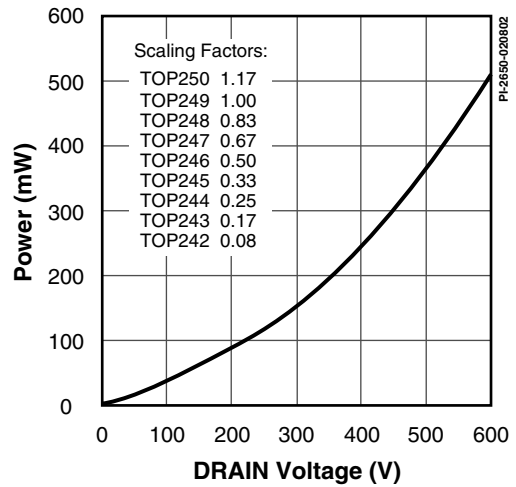


图 70. 漏极电容功耗

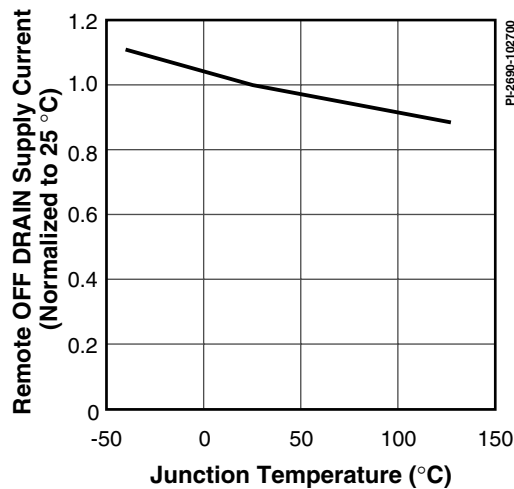
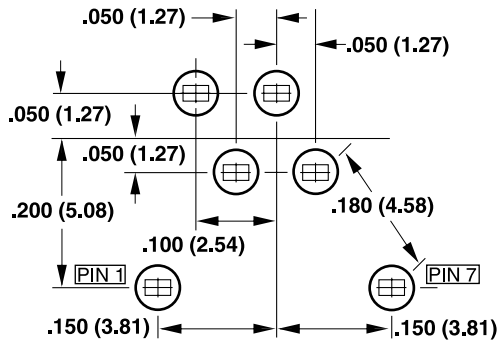
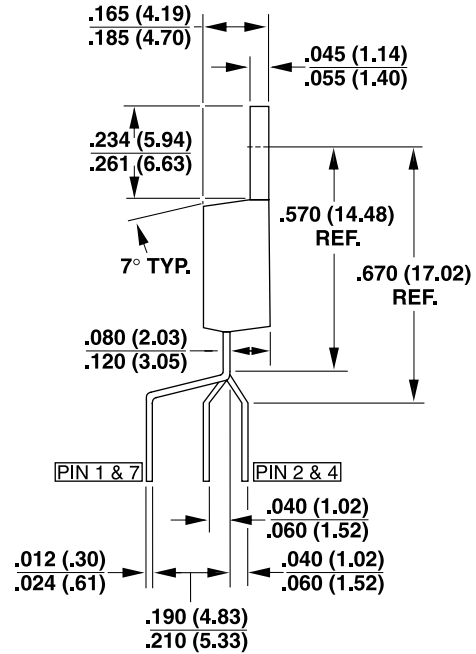
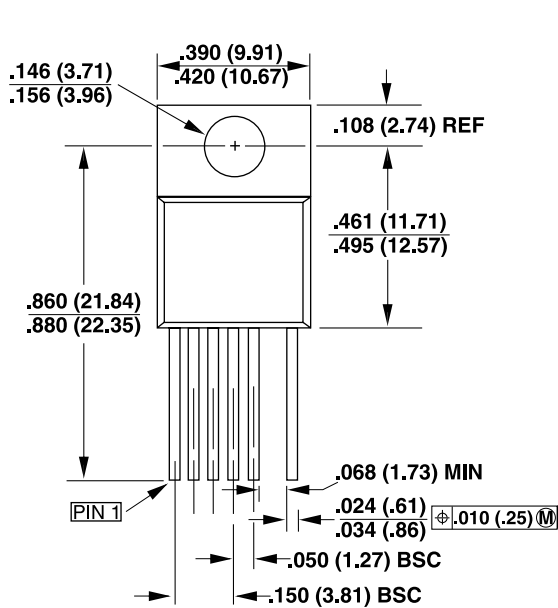


图 71. 远程关断漏极供电电流随温度的变化

器件订购信息			
<p>TOP 242 G N - TL</p>	TOPSwitch 产品系列		
	GX 序列号		
	封装信息		
	G	塑封表面贴 SMD-8B	(仅限TOP242-246)
	P	塑封直插式DIP-8B	(仅限TOP242-246)
	Y	塑封 TO-220-7C	
	R	塑封 TO-263-7C (TL选项具备)	
	F	塑封 TO-262-7C	
	无铅封装		
	空白	标准 (Sn Pb)	
	N	纯镀锡封装 (P、G、Y & F封装)	
	带装 & 卷轴装及其他包装形式		
	空白	标准配置	
	TL	带装 & 卷轴装, (G封装, 至少1000个; R封装, 至少750个)	

TO-220-7C



Y07C

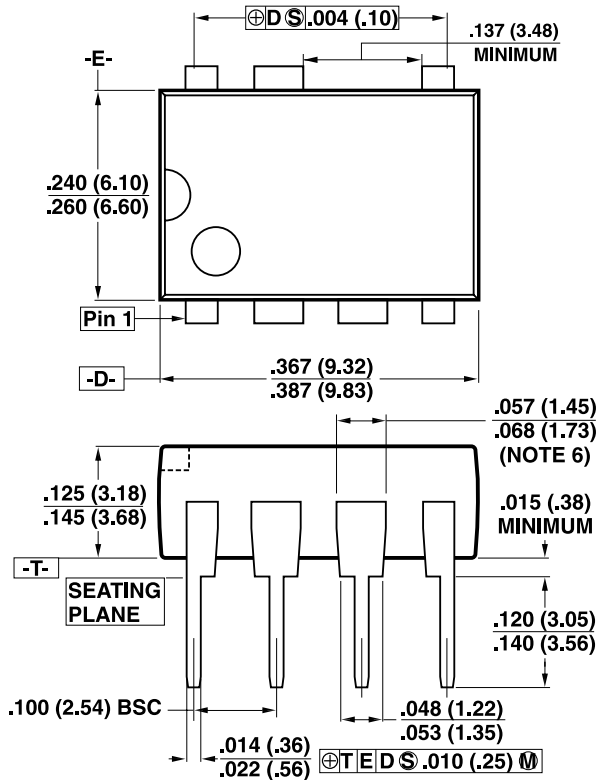
MOUNTING HOLE PATTERN

Notes:

1. Controlling dimensions are inches. Millimeter dimensions are shown in parentheses.
2. Pin numbers start with Pin 1, and continue from left to right when viewed from the front.
3. Dimensions do not include mold flash or other protrusions. Mold flash or protrusions shall not exceed $.006$ (.15mm) on any side.
4. Minimum metal to metal spacing at the package body for omitted pin locations is $.068$ in. (1.73 mm).
5. Position of terminals to be measured at a location $.25$ (6.35) below the package body.
6. All terminals are solder plated.

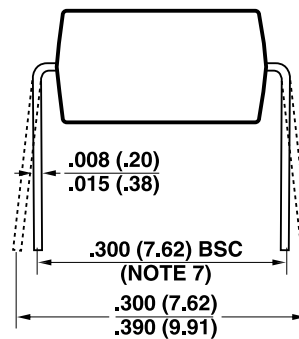
PI-2644-122004

DIP-8B



Notes:

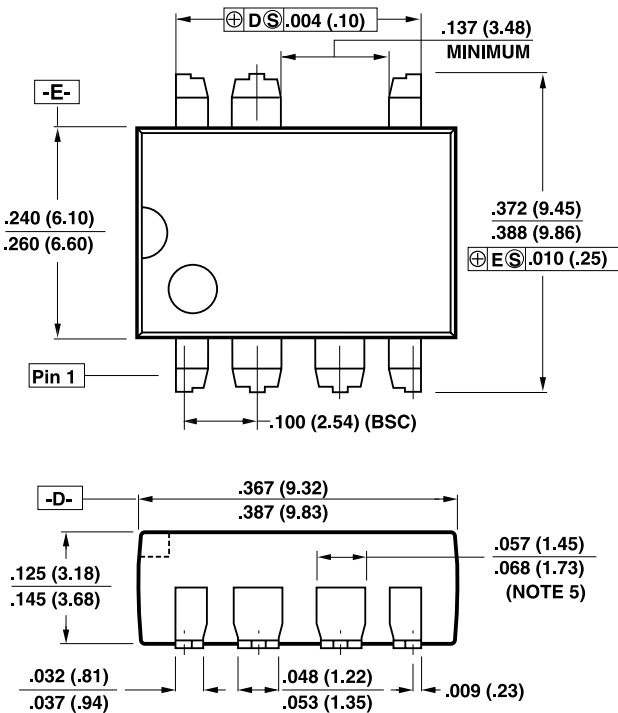
1. Package dimensions conform to JEDEC specification MS-001-AB (Issue B 7/85) for standard dual-in-line (DIP) package with .300 inch row spacing.
2. Controlling dimensions are inches. Millimeter sizes are shown in parentheses.
3. Dimensions shown do not include mold flash or other protrusions. Mold flash or protrusions shall not exceed .006 (.15) on any side.
4. Pin locations start with Pin 1, and continue counter-clockwise to Pin 8 when viewed from the top. The notch and/or dimple are aids in locating Pin 1. Pin 6 is omitted.
5. Minimum metal to metal spacing at the package body for the omitted lead location is .137 inch (3.48 mm).
6. Lead width measured at package body.
7. Lead spacing measured with the leads constrained to be perpendicular to plane T.



P08B

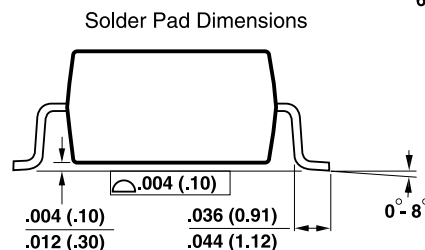
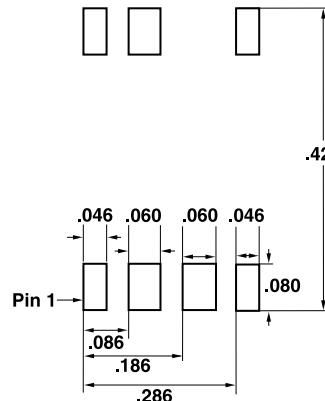
PI-2551-121504

SMD-8B



Notes:

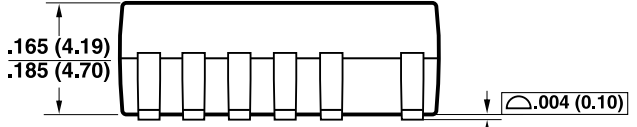
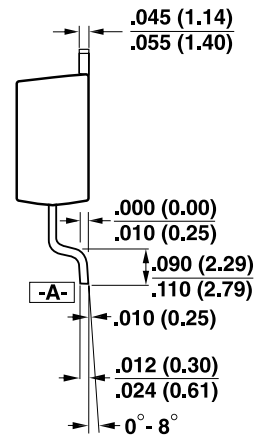
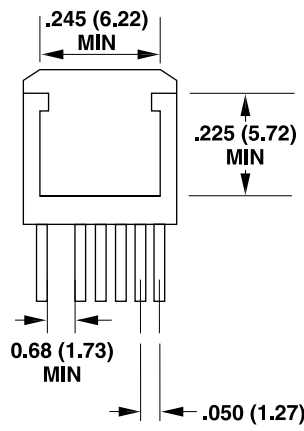
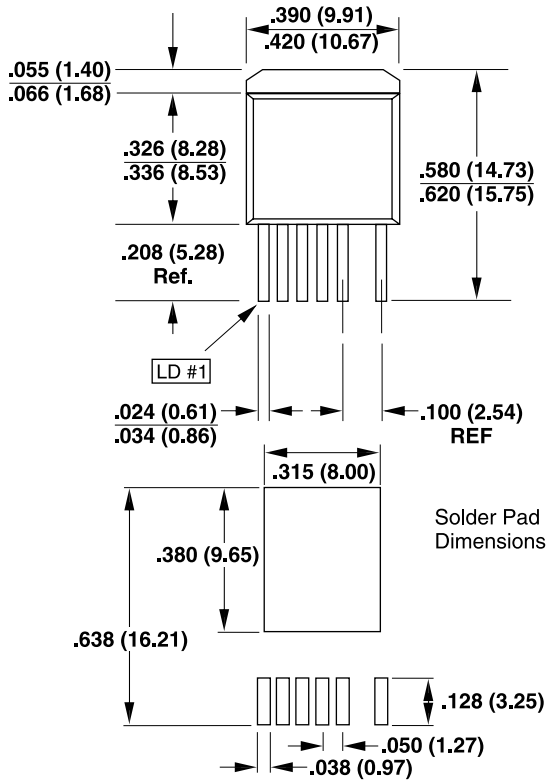
1. Controlling dimensions are inches. Millimeter sizes are shown in parentheses.
2. Dimensions shown do not include mold flash or other protrusions. Mold flash or protrusions shall not exceed .006 (.15) on any side.
3. Pin locations start with Pin 1, and continue counter-clockwise to Pin 8 when viewed from the top. Pin 6 is omitted.
4. Minimum metal to metal spacing at the package body for the omitted lead location is .137 inch (3.48 mm).
5. Lead width measured at package body.
6. D and E are referenced datums on the package body.



G08B

PI-2546-121504

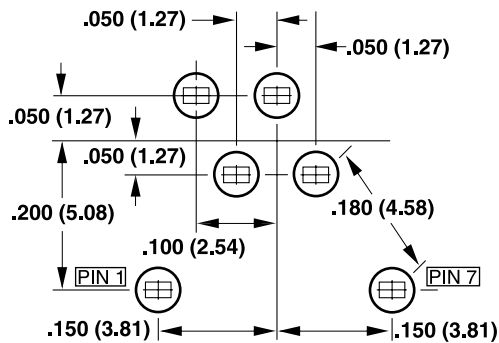
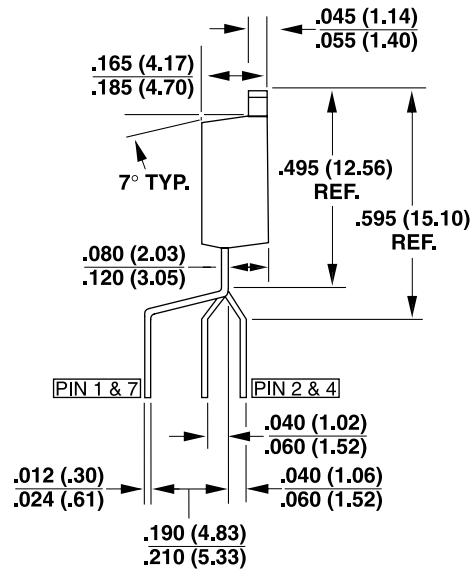
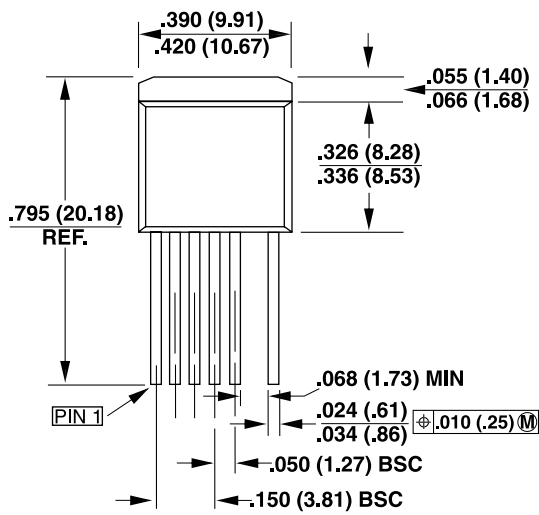
TO-263-7C



- Notes:
1. Package Outline Exclusive of Mold Flash & Metal Burr.
 2. Package Outline Inclusive of Plating Thickness.
 3. Foot Length Measured at Intercept Point Between Datum A Lead Surface.
 4. Controlling Dimensions are in Inches. Millimeter Dimensions are shown in Parentheses.
 5. Minimum metal to metal spacing at the package body for the omitted pin locations is .068 in. (1.73 mm).

R07C
 PI-2664-122004

TO-262-7C



F07C

MOUNTING HOLE PATTERN

Notes:

1. Controlling dimensions are inches. Millimeter dimensions are shown in parentheses.
2. Pin numbers start with Pin 1, and continue from left to right when viewed from the front.
3. Dimensions do not include mold flash or other protrusions. Mold flash or protrusions shall not exceed $.006$ (.15mm) on any side.
4. Minimum metal to metal spacing at the package body for omitted pin locations is $.068$ inch (1.73 mm).
5. Position of terminals to be measured at a location $.25$ (6.35) below the package body.
6. All terminals are solder plated.

PI-2757-122004

版本	注释	日期
D	-	11/00
E	1) 增加了R封装(D2PAK)。 2) 更正了缩写(s = seconds)。 3) 更正了图11中x轴单位(μA)。 4) 在图25中增加了外部流限电阻(R_{IL})。 5) 更正某些拼写。 6) 在表4中增加了说明。 7) 更正了击穿电压参数条件($T_j = 25\text{ }^\circ\text{C}$)。 8) 更正了插图中字体大小。 9) 更新了图40。 10) 更新了图44原理图中的元件值。	7/01
F	1) 更正了功率表内的数值。	9/01
G	1) 增加了TOP250器件和F封装 (TO-262)。 2) 在表1中增加了R封装的热阻抗参数及调整了表1中输出功率值。 3) 调整了关断状态电流值。	1/02
H	1) 增加了击穿电压测量的参数表。 2) 更正一些文字。	9/02
I	1) 更新了P、Y、R和F封装信息。 2) 更正了所有封装类型的热阻抗(θ_{JA})。 3) 增大了最大占空比并删除了最大占空比降低斜坡参数。 4) 更正了DIP-8B和SMD-8B封装图。	4/03
J	1) 增加了 TOP245P。 2) 更正了一些文字。	8/03
K	1) 更正了图4、6、20、28和34内的文字以及多功能引脚工作部分。	9/03
L	1) 增加了TOP246P。	3/04
M	1) 增加了无铅订购信息。	12/04
N	1) 更新了最大占空比条件。 2) 更正了一些文字。 3) 在最大额定功率规格内增加了注释4。	4/05
O	1) 增加了TOP245G和TOP246G。	11/05

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TOP242-249

TOPSwitch[®]-GX Family

Extended Power, Design Flexible, EcoSmart[®], Integrated Off-line Switcher



Product Highlights

Lower System Cost, High Design Flexibility

- Extended power range to 250 W
- Features eliminate or reduce cost of external components
- Fully integrated soft-start for minimum stress/overshoot
- Externally programmable accurate current limit
- Wider duty cycle for more power, smaller input capacitor
- Separate line sense and current limit pins on Y/R packages
- Line under-voltage (UV) detection: no turn off glitches
- Line overvoltage (OV) shutdown extends line surge limit
- Line feed forward with maximum duty cycle (DC_{MAX}) reduction rejects line ripple and limits DC_{MAX} at high line
- Frequency jittering reduces EMI and EMI filtering costs
- Regulates to zero load without dummy loading
- 132 kHz frequency reduces transformer/power supply size
- Half frequency option in Y/R packages for video applications
- Hysteretic thermal shutdown for automatic fault recovery
- Large thermal hysteresis prevents PC board overheating

EcoSmart - Energy Efficient

- Extremely low consumption in remote off mode (80 mW @ 110 VAC, 160 mW @ 230 VAC)
- Frequency lowered with load for high standby efficiency
- Allows shutdown/wake-up via LAN/input port

Description

TOPSwitch-GX uses the same proven topology as TOPSwitch, cost effectively integrating the high voltage power MOSFET, PWM control, fault protection and other control circuitry onto a single CMOS chip. Many new functions are integrated to reduce system cost and improve design flexibility, performance and energy efficiency.

Depending on package type, the TOPSwitch-GX family has either 1 or 3 additional pins over the standard DRAIN, SOURCE and CONTROL terminals, allowing the following functions: line sensing (OV/UV, line feedforward/DC max reduction), accurate externally set current limit, remote on/off, and synchronization to an external lower frequency and frequency selection (132 kHz/66 kHz).

All package types provide the following transparent features: Soft-start, 132 kHz switching frequency (automatically reduced at light load), frequency jittering for lower EMI, wider DC_{MAX}, hysteretic thermal shutdown and larger creepage packages. In addition, all critical parameters (i.e. current limit, frequency, PWM gain) have tighter temperature and absolute tolerance, to simplify design and optimize system cost.

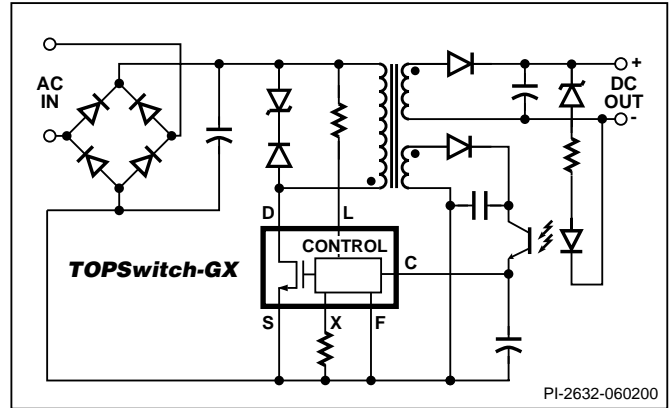


Figure 1. Typical Flyback Application.

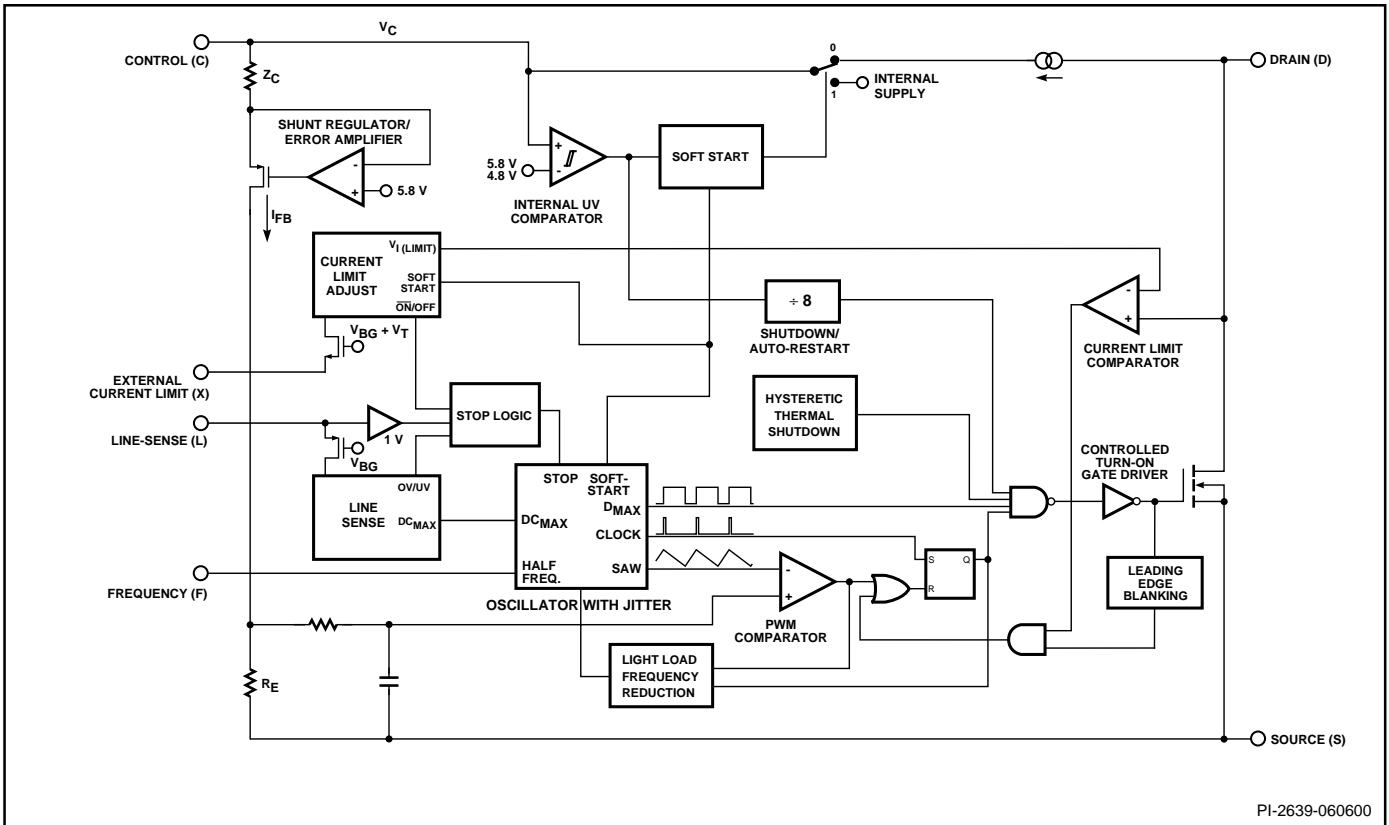
OUTPUT POWER TABLE				
PRODUCT ³	230 VAC ±15% ⁴		85-265 VAC	
	Adapter ¹	Open Frame ²	Adapter ¹	Open Frame ²
TOP242 P or G	9 W	15 W	6.5 W	10 W
TOP242 R	10 W	22 W	7 W	14 W
TOP242 Y	10 W	22 W	7 W	14 W
TOP243 P or G	13 W	25 W	9 W	15 W
TOP243 R	20 W	43 W	15 W	23 W
TOP243 Y	13 W	45 W	15 W	30 W
TOP244 P or G	16 W	30 W	11 W	20 W
TOP244 R	28 W	52 W	18 W	28 W
TOP244 Y	30 W	65 W	20 W	45 W
TOP245 R	33 W	58 W	20 W	32 W
TOP245 Y	40 W	85 W	26 W	60 W
TOP246 R	37 W	65 W	24 W	36 W
TOP246 Y	60 W	125 W	40 W	90 W
TOP247 R	41 W	73 W	26 W	43 W
TOP247 Y	85 W	165 W	55 W	125 W
TOP248 R	43 W	78 W	28 W	48 W
TOP248 Y	105 W	205 W	70 W	155 W
TOP249 R	45 W	82 W	30 W	52 W
TOP249 Y	120 W	250 W	80 W	180 W

Table 1. Notes: 1. Typical continuous power in a non-ventilated enclosed adapter measured at 50 °C ambient. Assumes 1 sq. in. of 2 oz. copper heat sink area for R package. 2. Maximum practical continuous power in an open frame design at 50 °C ambient. See Key Applications for detailed conditions. Assumes 3 sq. in. of 2 oz. copper heat sink area for R package. 3. See Part Ordering Information. 4. 230 VAC or 100/115 VAC with doubler.

Section List

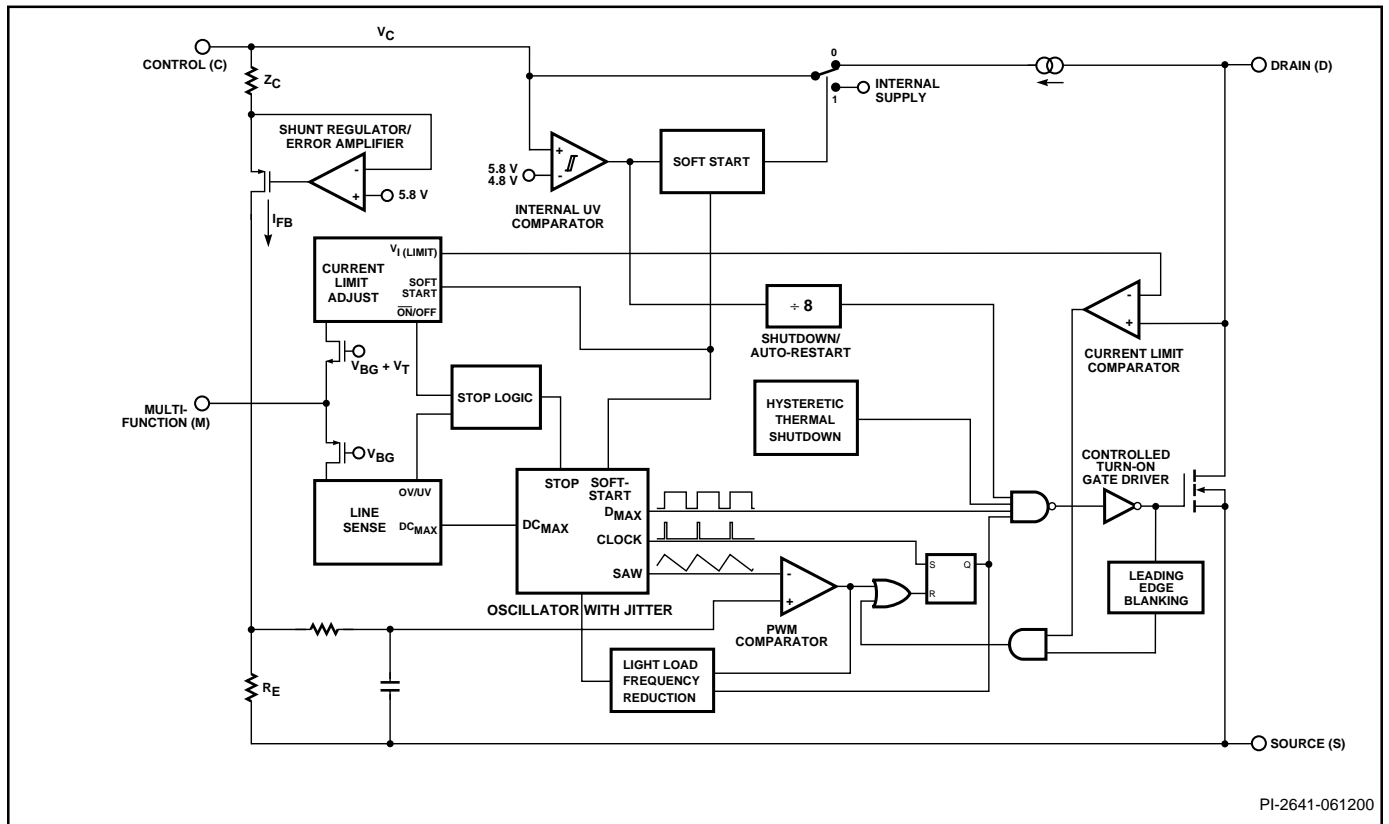
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PI-2639-060600

Figure 2a. Functional Block Diagram (Y or R Package).



PI-2641-061200

Figure 2b. Functional Block Diagram (P or G Package).



Pin Functional Description

DRAIN (D) Pin:

High voltage power MOSFET drain output. The internal start-up bias current is drawn from this pin through a switched high-voltage current source. Internal current limit sense point for drain current.

CONTROL (C) Pin:

Error amplifier and feedback current input pin for duty cycle control. Internal shunt regulator connection to provide internal bias current during normal operation. It is also used as the connection point for the supply bypass and auto-restart/compensation capacitor.

LINE-SENSE (L) Pin: (Y or R package only)

Input pin for OV, UV, line feed forward with DC_{MAX} reduction, remote ON/OFF and synchronization. A connection to SOURCE pin disables all functions on this pin.

EXTERNAL CURRENT LIMIT (X) Pin: (Y or R package only)

Input pin for external current limit adjustment, remote ON/OFF, and synchronization. A connection to SOURCE pin disables all functions on this pin.

MULTI-FUNCTION (M) Pin: (P or G package only)

This pin combines the functions of the LINE-SENSE (L) and EXTERNAL CURRENT LIMIT (X) pins of the Y package into one pin. Input pin for OV, UV, line feed forward with DC_{MAX} reduction, external current limit adjustment, remote ON/OFF and synchronization. A connection to SOURCE pin disables all functions on this pin and makes *TOPSwitch-GX* operate in simple three terminal mode (like *TOPSwitch-II*).

FREQUENCY (F) Pin: (Y or R package only)

Input pin for selecting switching frequency: 132 kHz if

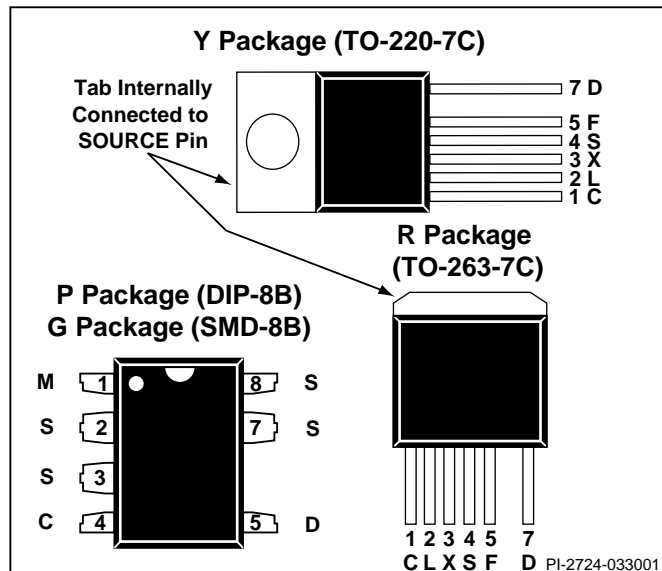


Figure 3. Pin Configuration (top view).

connected to SOURCE pin and 66 kHz if connected to CONTROL pin. The switching frequency is internally set for fixed 132 kHz operation in P and G packages.

SOURCE (S) Pin:

Output MOSFET source connection for high voltage power return. Primary side control circuit common and reference point.

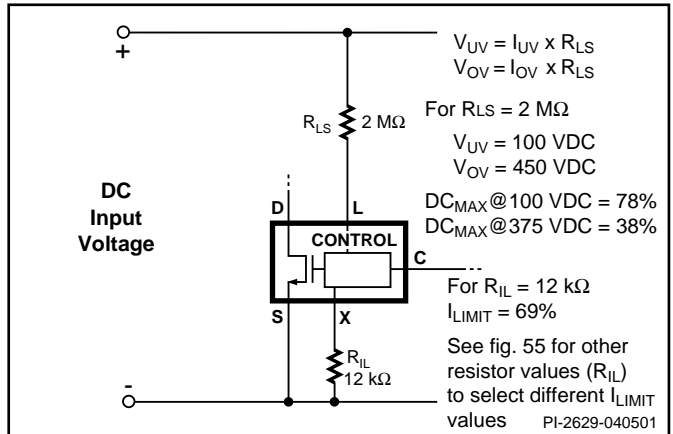


Figure 4. Y/R Package Line Sense and Externally Set Current Limit.

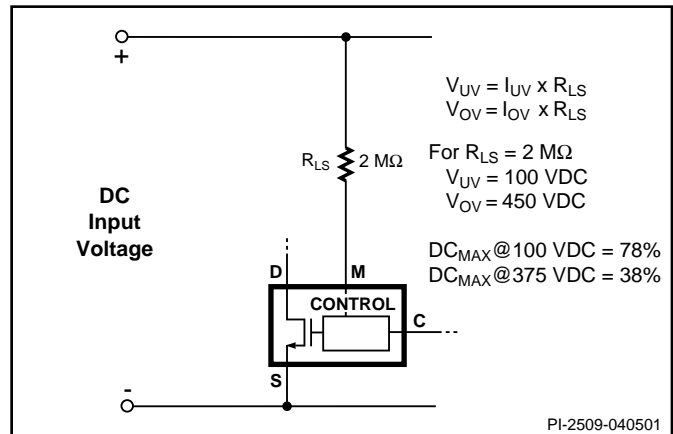


Figure 5. P/G Package Line Sense.

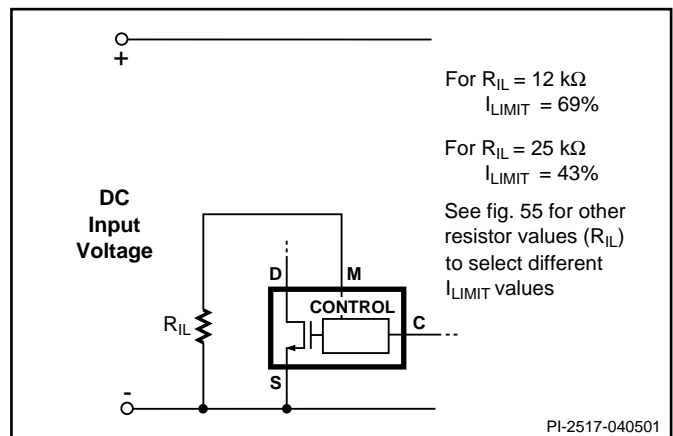


Figure 6. P/G Package Externally Set Current Limit.



TOPSwitch-GX Family Functional Description

Like *TOPSwitch*, *TOPSwitch-GX* is an integrated switched mode power supply chip that converts a current at the control input to a duty cycle at the open drain output of a high voltage power MOSFET. During normal operation the duty cycle of the power MOSFET decreases linearly with increasing CONTROL pin current as shown in Figure 7.

In addition to the three terminal *TOPSwitch* features, such as the high voltage start-up, the cycle-by-cycle current limiting, loop compensation circuitry, auto-restart, thermal shutdown, the *TOPSwitch-GX* incorporates many additional functions that reduce system cost, increase power supply performance and design flexibility. A patented high voltage CMOS technology allows both the high voltage power MOSFET and all the low voltage control circuitry to be cost effectively integrated onto a single monolithic chip.

Three terminals, FREQUENCY, LINE-SENSE, and EXTERNAL CURRENT LIMIT (available in Y or R package) or one terminal MULTI-FUNCTION (available in P or G Package) have been added to implement some of the new functions. These terminals can be connected to the SOURCE pin to operate the *TOPSwitch-GX* in a *TOPSwitch*-like three terminal mode. However, even in this three terminal mode, the *TOPSwitch-GX* offers many new transparent features that do not require any external components:

1. A fully integrated 10 ms soft-start limits peak currents and voltages during start-up and dramatically reduces or eliminates output overshoot in most applications.
2. DC_{MAX} of 78% allows smaller input storage capacitor, lower input voltage requirement and/or higher power capability.
3. Frequency reduction at light loads lowers the switching losses and maintains good cross regulation in multiple output supplies.
4. Higher switching frequency of 132 kHz reduces the transformer size with no noticeable impact on EMI.
5. Frequency jittering reduces EMI.
6. Hysteretic over-temperature shutdown ensures automatic recovery from thermal fault. Large hysteresis prevents circuit board overheating.
7. Packages with omitted pins and lead forming provide large drain creepage distance.
8. Tighter absolute tolerances and smaller temperature variations on switching frequency, current limit and PWM gain.

The LINE-SENSE (L) pin is usually used for line sensing by connecting a resistor from this pin to the rectified DC high voltage bus to implement line overvoltage (OV), under-voltage (UV) and line feed forward with DC_{MAX} reduction. In this mode, the value of the resistor determines the OV/UV thresholds and the DC_{MAX} is reduced linearly starting from a line voltage above the under-voltage threshold. See Table 2 and Figure 11.

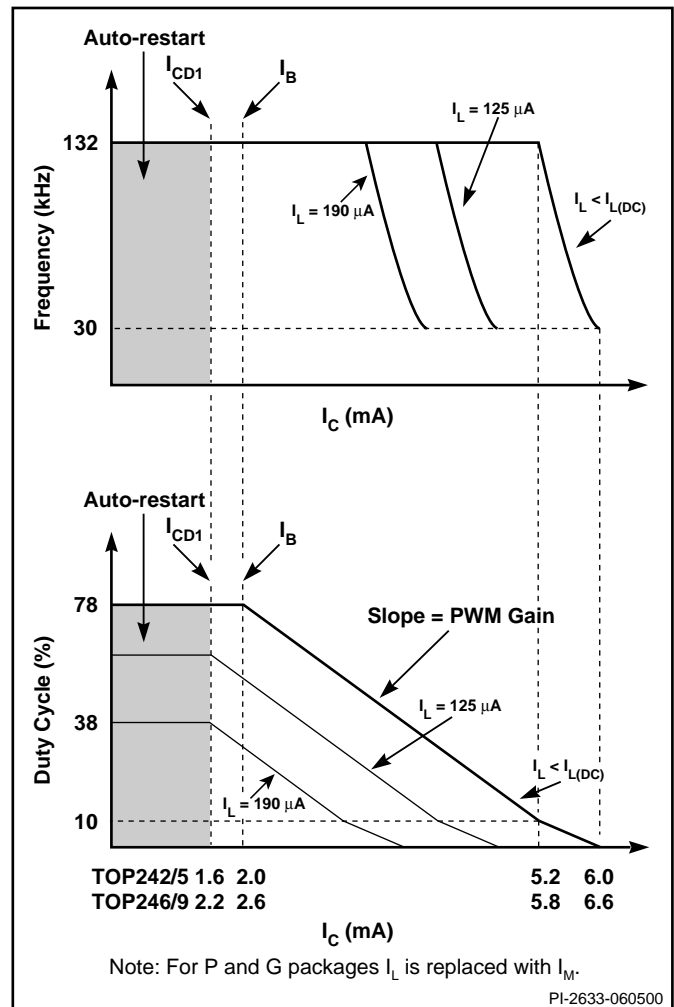


Figure 7. Relationship of Duty Cycle and Frequency to CONTROL Pin Current.

The pin can also be used as a remote ON/OFF and a synchronization input.

The EXTERNAL CURRENT LIMIT (X) pin is usually used to reduce the current limit externally to a value close to the operating peak current, by connecting the pin to SOURCE through a resistor. This pin can also be used as a remote ON/OFF and a synchronization input in both modes. See Table 2 and Figure 11.

For the P or G packages the LINE-SENSE and EXTERNAL CURRENT LIMIT pin functions are combined on one MULTI-FUNCTION (M) pin. However, some of the functions become mutually exclusive as shown in Table 3.

The FREQUENCY (F) pin in the Y or R package sets the switching frequency to the default value of 132 kHz when connected to SOURCE pin. A half frequency option of 66 kHz can be chosen by connecting this pin to CONTROL pin instead. Leaving this pin open is not recommended.



CONTROL (C) Pin Operation

The CONTROL pin is a low impedance node that is capable of receiving a combined supply and feedback current. During normal operation, a shunt regulator is used to separate the feedback signal from the supply current. CONTROL pin voltage V_C is the supply voltage for the control circuitry including the MOSFET gate driver. An external bypass capacitor closely connected between the CONTROL and SOURCE pins is required to supply the instantaneous gate drive current. The total amount of capacitance connected to this pin also sets the auto-restart timing as well as control loop compensation.

When rectified DC high voltage is applied to the DRAIN pin during start-up, the MOSFET is initially off, and the CONTROL pin capacitor is charged through a switched high voltage current source connected internally between the DRAIN and CONTROL pins. When the CONTROL pin voltage V_C reaches approximately 5.8 V, the control circuitry is activated and the soft-start begins. The soft-start circuit gradually increases the duty cycle of the MOSFET from zero to the maximum value over approximately 10 ms. If no external feedback/supply current is fed into the CONTROL pin by the end of the soft-start, the high voltage current source is turned off and the CONTROL pin will start discharging in response to the supply current drawn by the control circuitry. If the power supply is designed properly, and no fault condition such as open loop or shorted output exists, the feedback loop will close, providing external CONTROL pin current, before the CONTROL pin voltage has had a chance to discharge to the lower threshold voltage of approximately 4.8 V (internal supply under-voltage lockout threshold). When the externally fed current charges the CONTROL pin to the shunt regulator voltage of 5.8 V, current

in excess of the consumption of the chip is shunted to SOURCE through resistor R_E as shown in Figure 2. This current flowing through R_E controls the duty cycle of the power MOSFET to provide closed loop regulation. The shunt regulator has a finite low output impedance Z_C that sets the gain of the error amplifier when used in a primary feedback configuration. The dynamic impedance Z_C of the CONTROL pin together with the external CONTROL pin capacitance sets the dominant pole for the control loop.

When a fault condition such as an open loop or shorted output prevents the flow of an external current into the CONTROL pin, the capacitor on the CONTROL pin discharges towards 4.8 V. At 4.8 V, auto-restart is activated which turns the output MOSFET off and puts the control circuitry in a low current standby mode. The high-voltage current source turns on and charges the external capacitance again. A hysteretic internal supply under-voltage comparator keeps V_C within a window of typically 4.8 to 5.8 V by turning the high-voltage current source on and off as shown in Figure 8. The auto-restart circuit has a divide-by-8 counter which prevents the output MOSFET from turning on again until eight discharge/charge cycles have elapsed. This is accomplished by enabling the output MOSFET only when the divide-by-8 counter reaches full count (S7). The counter effectively limits TOPSwitch-GX power dissipation by reducing the auto-restart duty cycle to typically 4%. Auto-restart mode continues until output voltage regulation is again achieved through closure of the feedback loop.

Oscillator and Switching Frequency

The internal oscillator linearly charges and discharges an internal capacitance between two voltage levels to create a sawtooth

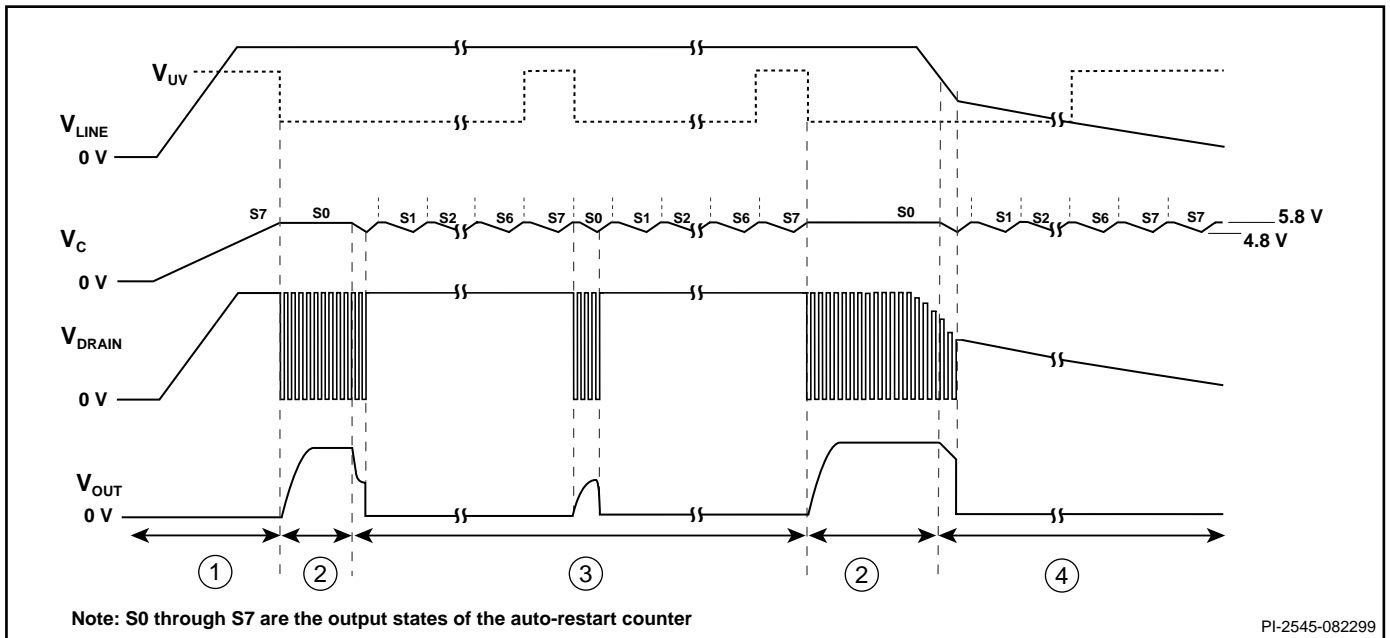


Figure 8. Typical Waveforms for (1) Power Up (2) Normal Operation (3) Auto-restart (4) Power Down.



waveform for the pulse width modulator. This oscillator sets the pulse width modulator/current limit latch at the beginning of each cycle.

The nominal switching frequency of 132 kHz was chosen to minimize transformer size while keeping the fundamental EMI frequency below 150 kHz. The FREQUENCY pin (available only in Y or R package), when shorted to the CONTROL pin, lowers the switching frequency to 66 kHz (half frequency) which may be preferable in some cases such as noise sensitive video applications or a high efficiency standby mode. Otherwise, the FREQUENCY pin should be connected to the SOURCE pin for the default 132 kHz.

To further reduce the EMI level, the switching frequency is jittered (frequency modulated) by approximately ± 4 kHz at 250 Hz (typical) rate as shown in Figure 9. Figure 46 shows the typical improvement of EMI measurements with frequency jitter.

Pulse Width Modulator and Maximum Duty Cycle

The pulse width modulator implements voltage mode control by driving the output MOSFET with a duty cycle inversely proportional to the current into the CONTROL pin that is in excess of the internal supply current of the chip (see Figure 7). The excess current is the feedback error signal that appears across R_E (see Figure 2). This signal is filtered by an RC network with a typical corner frequency of 7 kHz to reduce the effect of switching noise in the chip supply current generated by the MOSFET gate driver. The filtered error signal is compared with the internal oscillator sawtooth waveform to generate the duty cycle waveform. As the control current increases, the duty cycle decreases. A clock signal from the oscillator sets a latch which turns on the output MOSFET. The pulse width modulator resets the latch, turning off the output MOSFET. Note that a minimum current must be driven into the CONTROL pin before the duty cycle begins to change.

The maximum duty cycle, DC_{MAX} , is set at a default maximum value of 78% (typical). However, by connecting the LINE-SENSE or MULTI-FUNCTION pin (depending on the package) to the rectified DC high voltage bus through a resistor with appropriate value, the maximum duty cycle can be made to decrease from 78% to 38% (typical) as shown in Figure 11 when input line voltage increases (see line feed forward with DC_{MAX} reduction).

Light Load Frequency Reduction

The pulse width modulator duty cycle reduces as the load at the power supply output decreases. This reduction in duty cycle is proportional to the current flowing into the CONTROL pin. As the CONTROL pin current increases, the duty cycle decreases linearly towards a duty cycle of 10%. Below 10% duty cycle, to maintain high efficiency at light loads, the frequency is also reduced linearly until a minimum frequency is reached at a duty

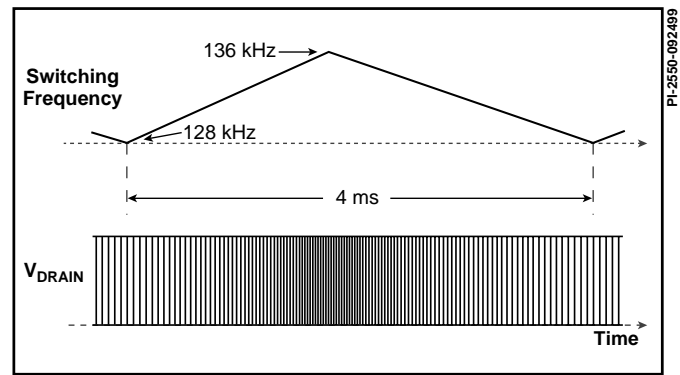


Figure 9. Switching Frequency Jitter. (Idealized V_{DRAIN} waveform)

cycle of 0% (refer to Figure 7). The minimum frequency is typically 30 kHz and 15 kHz for 132 kHz and 66 kHz operation, respectively.

This feature allows a power supply to operate at lower frequency at light loads thus lowering the switching losses while maintaining good cross regulation performance and low output ripple.

Error Amplifier

The shunt regulator can also perform the function of an error amplifier in primary side feedback applications. The shunt regulator voltage is accurately derived from a temperature-compensated bandgap reference. The gain of the error amplifier is set by the CONTROL pin dynamic impedance. The CONTROL pin clamps external circuit signals to the V_C voltage level. The CONTROL pin current in excess of the supply current is separated by the shunt regulator and flows through R_E as a voltage error signal.

On-chip Current Limit with External Programmability

The cycle-by-cycle peak drain current limit circuit uses the output MOSFET ON-resistance as a sense resistor. A current limit comparator compares the output MOSFET on-state drain to source voltage, $V_{DS(ON)}$ with a threshold voltage. High drain current causes $V_{DS(ON)}$ to exceed the threshold voltage and turns the output MOSFET off until the start of the next clock cycle. The current limit comparator threshold voltage is temperature compensated to minimize the variation of the current limit due to temperature related changes in $R_{DS(ON)}$ of the output MOSFET. The default current limit of *TOPSwitch-GX* is preset internally. However, with a resistor connected between EXTERNAL CURRENT LIMIT (X) pin (Y or R package) or MULTI-FUNCTION (M) pin (P or G package) and SOURCE pin, current limit can be programmed externally to a lower level between 30% and 100% of the default current limit. Please refer to the graphs in the typical performance characteristics section for the selection of the resistor value. By setting current limit low, a larger *TOPSwitch-GX* than necessary for the power required can be used to take advantage of the lower $R_{DS(ON)}$ for higher efficiency/smaller heat sinking requirements. With a

second resistor connected between the EXTERNAL CURRENT LIMIT (X) pin (Y or R package) or MULTI-FUNCTION (M) pin (P or G package) and the rectified DC high voltage bus, the current limit is reduced with increasing line voltage, allowing a true power limiting operation against line variation to be implemented. When using an RCD clamp, this power limiting technique reduces maximum clamp voltage at high line. This allows for higher reflected voltage designs as well as reducing clamp dissipation.

The leading edge blanking circuit inhibits the current limit comparator for a short time after the output MOSFET is turned on. The leading edge blanking time has been set so that, if a power supply is designed properly, current spikes caused by primary-side capacitances and secondary-side rectifier reverse recovery time should not cause premature termination of the switching pulse.

The current limit is lower for a short period after the leading edge blanking time as shown in Figure 52. This is due to dynamic characteristics of the MOSFET. To avoid triggering the current limit in normal operation, the drain current waveform should stay within the envelope shown.

Line Under-Voltage Detection (UV)

At power up, UV keeps *TOPSwitch-GX* off until the input line voltage reaches the under voltage threshold. At power down, UV prevents auto-restart attempts after the output goes out of regulation. This eliminates power down glitches caused by the slow discharge of large input storage capacitor present in applications such as standby supplies. A single resistor connected from the LINE-SENSE pin (Y or R package) or MULTI-FUNCTION pin (P or G package) to the rectified DC high voltage bus sets UV threshold during power up. Once the power supply is successfully turned on, the UV threshold is lowered to

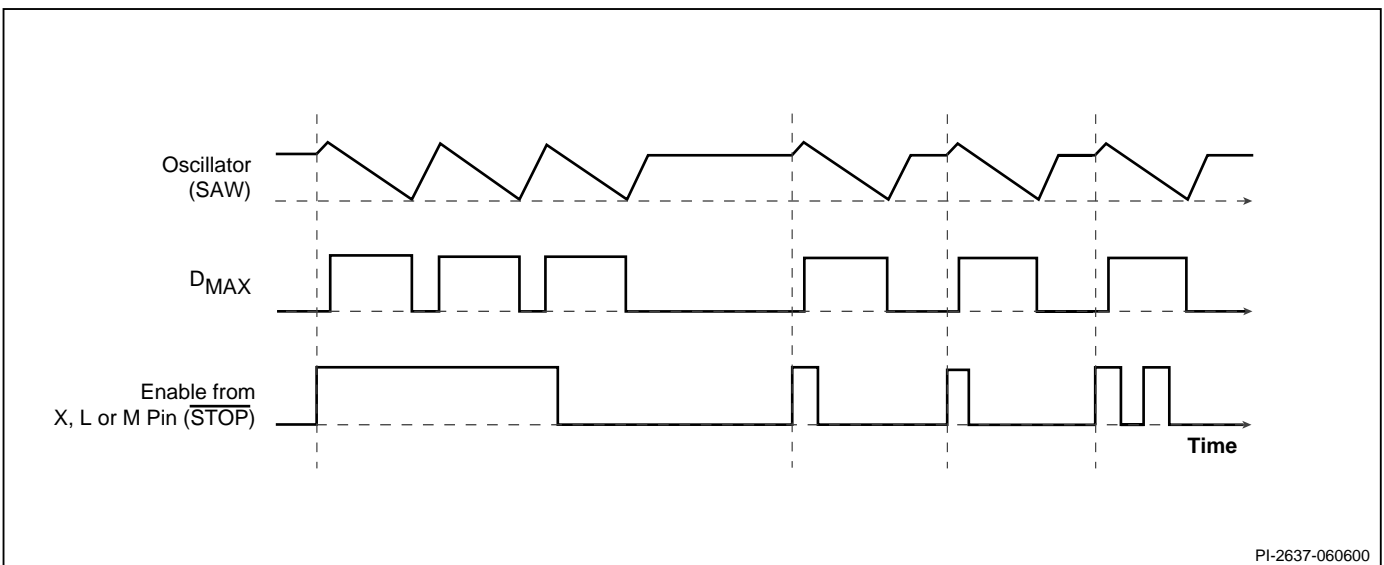
40% of the initial UV threshold to allow extended input voltage operating range (UV low threshold). If the UV low threshold is reached during operation without the power supply losing regulation the device will turn off and stay off until UV (high threshold) has been reached again. If the power supply loses regulation before reaching the UV low threshold, the device will enter auto-restart. At the end of each auto-restart cycle (S7), the UV comparator is enabled. If the UV high threshold is not exceeded the MOSFET will be disabled during the next cycle (see figure 8). The UV feature can be disabled independent of OV feature as shown in Figure 19 and 23.

Line Overvoltage Shutdown (OV)

The same resistor used for UV also sets an overvoltage threshold which, once exceeded, will force *TOPSwitch-GX* output into off-state. The ratio of OV and UV thresholds is preset at 4.5 as can be seen in Figure 11. When the MOSFET is off, the rectified DC high voltage surge capability is increased to the voltage rating of the MOSFET (700 V), due to the absence of the reflected voltage and leakage spikes on the drain. A small amount of hysteresis is provided on the OV threshold to prevent noise triggering. The OV feature can be disabled independent of the UV feature as shown in Figure 18 and 32.

Line Feed Forward with DC_{MAX} Reduction

The same resistor used for UV and OV also implements line voltage feed forward which minimizes output line ripple and reduces power supply output sensitivity to line transients. This feed forward operation is illustrated in Figure 7 by the different values of I_L (Y or R package) or I_M (P or G Package). Note that for the same CONTROL pin current, higher line voltage results in smaller operating duty cycle. As an added feature, the maximum duty cycle DC_{MAX} is also reduced from 78% (typical) at a voltage slightly higher than the UV threshold to 38% (typical) at the OV threshold (see Figures 7, 11). Limiting



PI-2637-060600

Figure 10. Synchronization Timing Diagram.



DC_{MAX} at higher line voltages helps prevent transformer saturation due to large load transients in forward converter applications. DC_{MAX} of 38% at the OV threshold was chosen to ensure that the power capability of the *TOPSwitch-GX* is not restricted by this feature under normal operation.

Remote ON/OFF and Synchronization

TOPSwitch-GX can be turned on or off by controlling the current into the LINE-SENSE pin or out from the EXTERNAL CURRENT LIMIT pin (Y or R package) and into or out from the MULTI-FUNCTION pin (P or G package) (see Figure 11). In addition, the LINE-SENSE pin has a 1 V threshold comparator connected at its input. This voltage threshold can also be used to perform remote ON/OFF control. This allows easy implementation of remote ON/OFF control of *TOPSwitch-GX* in several different ways. A transistor or an optocoupler output connected between the EXTERNAL CURRENT LIMIT or LINE-SENSE pins (Y or R package) or the MULTI-FUNCTION pin (P or G package) and the SOURCE pin implements this function with “active-on” (Figure 22, 29 and 36) while a transistor or an optocoupler output connected between the LINE-SENSE pin (Y or R package) or the MULTI-FUNCTION (P or G package) pin and the CONTROL pin implements the function with “active-off” (Figure 23 and 37).

When a signal is received at the LINE-SENSE pin or the EXTERNAL CURRENT LIMIT pin (Y or R package) or the MULTI-FUNCTION pin (P or G package) to disable the output through any of the pin functions such as OV, UV and remote ON/OFF, *TOPSwitch-GX* always completes its current switching cycle, as illustrated in Figure 10, before the output is forced off. The internal oscillator is stopped slightly before the end of the current cycle and stays there as long as the disable signal exists. When the signal at the above pins changes state from disable to enable, the internal oscillator starts the next switching cycle. This approach allows the use of this pin to synchronize *TOPSwitch-GX* to any external signal with a frequency lower than its internal switching frequency.

As seen above, the remote ON/OFF feature allows the *TOPSwitch-GX* to be turned on and off instantly, on a cycle-by-cycle basis, with very little delay. However, remote ON/OFF can also be used as a standby or power switch to turn off the *TOPSwitch-GX* and keep it in a very low power consumption state for indefinitely long periods. If the *TOPSwitch-GX* is held in remote off state for long enough time to allow the CONTROL pin to discharge to the internal supply under-voltage threshold of 4.8 V (approximately 32 ms for a 47 μ F CONTROL pin capacitance), the CONTROL pin goes into the hysteretic mode of regulation. In this mode, the CONTROL pin goes through alternate charge and discharge cycles between 4.8 V and 5.8 V (see CONTROL pin operation section above) and runs entirely off the high voltage DC input, but with very low power consumption (160 mW typical at 230 VAC with M or X pins

open). When the *TOPSwitch-GX* is remotely turned on after entering this mode, it will initiate a normal start-up sequence with soft-start the next time the CONTROL pin reaches 5.8 V. In the worst case, the delay from remote on to start-up can be equal to the full discharge/charge cycle time of the CONTROL pin, which is approximately 125 ms for a 47 μ F CONTROL pin capacitor. This reduced consumption remote off mode can eliminate expensive and unreliable in-line mechanical switches. It also allows for microprocessor controlled turn-on and turn-off sequences that may be required in certain applications such as inkjet and laser printers.

Soft-Start

Two on-chip soft-start functions are activated at start-up with a duration of 10 ms (typical). Maximum duty cycle starts from 0% and linearly increases to the default maximum of 78% at the end of the 10 ms duration and the current limit starts from about 85% and linearly increases to 100% at the end of the 10ms duration. In addition to start-up, soft-start is also activated at each restart attempt during auto-restart and when restarting after being in hysteretic regulation of CONTROL pin voltage (V_c), due to remote off or thermal shutdown conditions. This effectively minimizes current and voltage stresses on the output MOSFET, the clamp circuit and the output rectifier during start-up. This feature also helps minimize output overshoot and prevents saturation of the transformer during start-up.

Shutdown/Auto-Restart

To minimize *TOPSwitch-GX* power dissipation under fault conditions, the shutdown/auto-restart circuit turns the power supply on and off at an auto-restart duty cycle of typically 4% if an out of regulation condition persists. Loss of regulation interrupts the external current into the CONTROL pin. V_c regulation changes from shunt mode to the hysteretic auto-restart mode as described in CONTROL pin operation section. When the fault condition is removed, the power supply output becomes regulated, V_c regulation returns to shunt mode, and normal operation of the power supply resumes.

Hysteretic Over-Temperature Protection

Temperature protection is provided by a precision analog circuit that turns the output MOSFET off when the junction temperature exceeds the thermal shutdown temperature (140 °C typical). When the junction temperature cools to below the hysteretic temperature, normal operation resumes providing automatic recovery. A large hysteresis of 70 °C (typical) is provided to prevent overheating of the PC board due to a continuous fault condition. V_c is regulated in hysteretic mode and a 4.8 V to 5.8 V (typical) sawtooth waveform is present on the CONTROL pin while in thermal shutdown.

Bandgap Reference

All critical *TOPSwitch-GX* internal voltages are derived from a temperature-compensated bandgap reference. This reference is



also used to generate a temperature-compensated current reference which is trimmed to accurately set the switching frequency, MOSFET gate drive current, current limit, and the line OV/UV thresholds. *TOPSwitch-GX* has improved circuitry to maintain all of the above critical parameters within very tight absolute and temperature tolerances.

High-Voltage Bias Current Source

This current source biases *TOPSwitch-GX* from the DRAIN pin and charges the CONTROL pin external capacitance during start-up or hysteretic operation. Hysteretic operation occurs during auto-restart, remote off and over-temperature shutdown. In this mode of operation, the current source is switched on and off with an effective duty cycle of approximately 35%. This duty cycle is determined by the ratio of CONTROL pin charge (I_C) and discharge currents (I_{CD1} and I_{CD2}). This current source is turned off during normal operation when the output MOSFET is switching. The effect of the current source switching will be seen on the DRAIN voltage waveform as small disturbances and is normal.



Using Feature Pins

FREQUENCY (F) Pin Operation

The FREQUENCY pin is a digital input pin available in the Y or R package only. Shorting the FREQUENCY pin to SOURCE pin selects the nominal switching frequency of 132 kHz (Figure 13) which is suited for most applications. For other cases that may benefit from lower switching frequency such as noise sensitive video applications, a 66 kHz switching frequency (half frequency) can be selected by shorting the FREQUENCY pin to the CONTROL pin (Figure 14). In addition, an example circuit shown in Figure 15 may be used to lower the switching frequency from 132 kHz in normal operation to 66 kHz in standby mode for very low standby power consumption.

LINE-SENSE (L) Pin Operation (Y and R Packages)

When current is fed into the LINE-SENSE pin, it works as a voltage source of approximately 2.6 V up to a maximum current of +400 μ A (typical). At +400 μ A, this pin turns into a constant current sink. Refer to Figure 12a. In addition, a comparator with a threshold of 1 V is connected at the pin and is used to detect when the pin is shorted to the SOURCE pin.

There are a total of four functions available through the use of the LINE-SENSE pin: OV, UV, line feed forward with DC_{MAX} reduction, and remote ON/OFF. Connecting the LINE-SENSE pin to the SOURCE pin disables all four functions. The LINE-SENSE pin is typically used for line sensing by connecting a resistor from this pin to the rectified DC high voltage bus to implement OV, UV and DC_{MAX} reduction with line voltage. In this mode, the value of the resistor determines the line OV/UV thresholds, and the DC_{MAX} is reduced linearly with rectified DC high voltage starting from just above the UV threshold. The pin can also be used as a remote on/off and a synchronization input.

Refer to Table 2 for possible combinations of the functions with example circuits shown in Figure 16 through Figure 40. A description of specific functions in terms of the LINE-SENSE pin I/V characteristic is shown in Figure 11 (right hand side). The horizontal axis represents LINE-SENSE pin current with positive polarity indicating currents flowing into the pin. The meaning of the vertical axes varies with functions. For those that control the on/off states of the output such as UV, OV and remote ON/OFF, the vertical axis represents the enable/disable states of the output. UV triggers at I_{UV} (+50 μ A typical with 30 μ A hysteresis) and OV triggers at I_{OV} (+225 μ A typical with 8 μ A hysteresis). Between the UV and OV thresholds, the output is enabled. For line feed forward with DC_{MAX} reduction, the vertical axis represents the magnitude of the DC_{MAX} . Line feed forward with DC_{MAX} reduction lowers maximum duty cycle from 78% at $I_{L(DC)}$ (+60 μ A typical) to 38% at I_{OV} (+225 μ A).

EXTERNAL CURRENT LIMIT (X) Pin Operation (Y and R Packages)

When current is drawn out of the EXTERNAL CURRENT LIMIT pin, it works as a voltage source of approximately 1.3 V up to a maximum current of -240 μ A (typical). At -240 μ A, it turns into a constant current source (refer to Figure 12a).

There are two functions available through the use of the EXTERNAL CURRENT LIMIT pin: external current limit and remote ON/OFF. Connecting the EXTERNAL CURRENT LIMIT pin and SOURCE pin disables the two functions. In high efficiency applications this pin can be used to reduce the current limit externally to a value close to the operating peak current, by connecting the pin to the SOURCE pin through a resistor. The pin can also be used as a remote on/off. Table 2 shows several possible combinations using this pin. See Figure

LINE-SENSE AND EXTERNAL CURRENT LIMIT PIN TABLE*

Figure Number ►	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Three Terminal Operation	✓													
Under-Voltage		✓	✓								✓	✓	✓	
Overvoltage		✓		✓							✓	✓	✓	
Line Feed Forward (DC_{MAX})		✓									✓	✓	✓	
Overload Power Limiting						✓								
External Current Limit					✓	✓			✓	✓		✓	✓	
Remote ON/OFF							✓	✓	✓	✓	✓	✓		✓

*This table is only a partial list of many LINE-SENSE and EXTERNAL CURRENT LIMIT pin configurations that are possible.

Table 2. Typical LINE-SENSE and EXTERNAL CURRENT LIMIT Pin Configurations.



MULTI-FUNCTION PIN TABLE*

Figure Number ►	30	31	32	33	34	35	36	37	38	39	40
Three Terminal Operation	✓										
Under-Voltage		✓	✓								✓
Overvoltage		✓		✓							✓
Line Feed Forward (DC_{MAX})		✓									✓
Overload Power Limiting						✓					
External Current Limit					✓	✓			✓	✓	
Remote ON/OFF							✓	✓	✓	✓	✓

*This table is only a partial list of many MULTI-FUNCTION pin configurations that are possible.

Table 3. Typical MULTI-FUNCTION Pin Configurations.

11 for a description of the functions where the horizontal axis (left hand side) represents the EXTERNAL CURRENT LIMIT pin current. The meaning of the vertical axes varies with function. For those that control the on/off states of the output such as remote ON/OFF, the vertical axis represents the enable/disable states of the output. For external current limit, the vertical axis represents the magnitude of the I_{LIMIT} . Please see graphs in the typical performance characteristics section for the current limit programming range and the selection of appropriate resistor value.

MULTI-FUNCTION (M) Pin Operation (P and G Packages)

The LINE-SENSE and EXTERNAL CURRENT LIMIT pin functions are combined to a single MULTI-FUNCTION pin for P and G packages. The comparator with a 1 V threshold at the LINE-SENSE pin is removed in this case as shown in Figure 2b. All of the other functions are kept intact. However, since some of the functions require opposite polarity of input current (MULTI-FUNCTION pin), they are mutually exclusive. For example, line sensing features cannot be used simultaneously with external current limit setting. When current is fed into the MULTI-FUNCTION pin, it works as a voltage source of approximately 2.6 V up to a maximum current of +400 μ A (typical). At +400 μ A, this pin turns into a constant current sink. When current is drawn out of the MULTI-FUNCTION pin, it works as a voltage source of approximately 1.3 V up to a maximum current of -240 μ A (typical). At -240 μ A, it turns into a constant current source. Refer to Figure 12b.

There are a total of five functions available through the use of the MULTI-FUNCTION pin: OV, UV, line feed forward with DC_{MAX} reduction, external current limit and remote ON/OFF. A short circuit between the MULTI-FUNCTION pin and SOURCE pin disables all five functions and forces

TOPSwitch-GX to operate in a simple three terminal mode like TOPSwitch-II. The MULTI-FUNCTION pin is typically used for line sensing by connecting a resistor from this pin to the rectified DC high voltage bus to implement OV, UV and DC_{MAX} reduction with line voltage. In this mode, the value of the resistor determines the line OV/UV thresholds, and the DC_{MAX} is reduced linearly with rectified DC high voltage starting from just above the UV threshold. In high efficiency applications this pin can be used in the external current limit mode instead, to reduce the current limit externally to a value close to the operating peak current, by connecting the pin to the SOURCE pin through a resistor. The same pin can also be used as a remote on/off and a synchronization input in both modes. Please refer to Table 3 for possible combinations of the functions with example circuits shown in Figure 30 through Figure 40. A description of specific functions in terms of the MULTI-FUNCTION pin I/V characteristic is shown in Figure 11. The horizontal axis represents MULTI-FUNCTION pin current with positive polarity indicating currents flowing into the pin. The meaning of the vertical axes varies with functions. For those that control the on/off states of the output such as UV, OV and remote ON/OFF, the vertical axis represents the enable/disable states of the output. UV triggers at I_{UV} (+50 μ A typical) and OV triggers at I_{OV} (+225 μ A typical with 30 μ A hysteresis). Between the UV and OV thresholds, the output is enabled. For external current limit and line feed forward with DC_{MAX} reduction, the vertical axis represents the magnitude of the I_{LIMIT} and DC_{MAX} . Line feed forward with DC_{MAX} reduction lowers maximum duty cycle from 78% at $I_{M(DC)}$ (+60 μ A typical) to 38% at I_{OV} (+225 μ A). External current limit is available only with negative MULTI-FUNCTION pin current. Please see graphs in the typical performance characteristics section for the current limit programming range and the selection of appropriate resistor value.



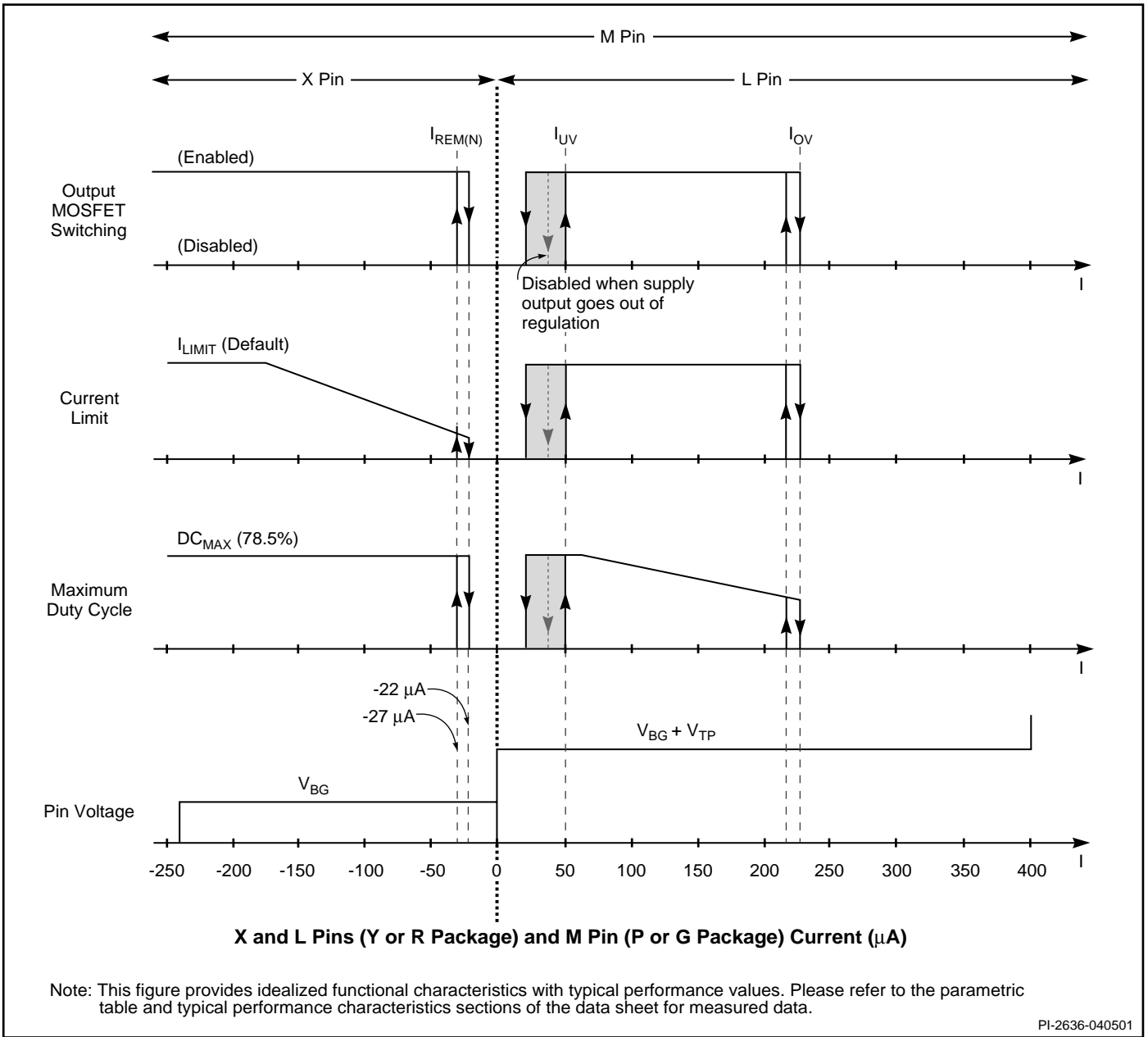


Figure 11. MULTI-FUNCTION (P or G package), LINE-SENSE, and EXTERNAL CURRENT LIMIT (Y or R package) Pin Characteristics.



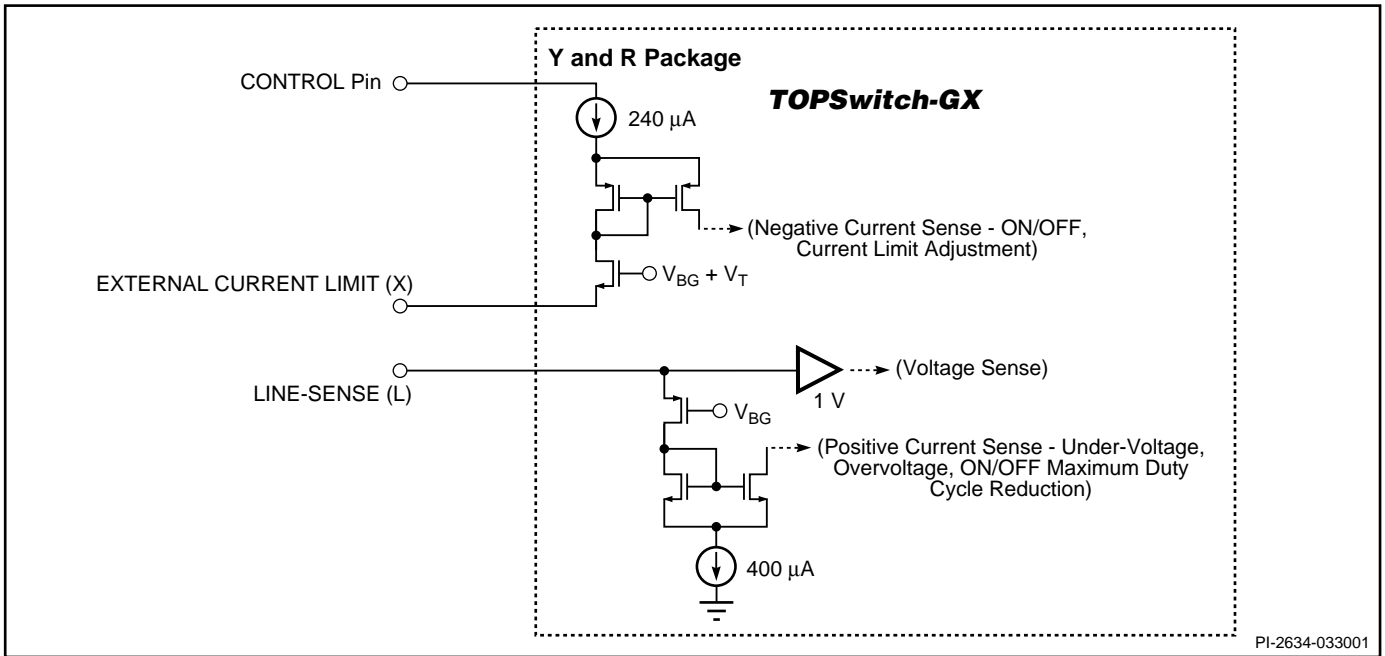


Figure 12a. LINE-SENSE (L), and EXTERNAL CURRENT LIMIT (X) Pin Input Simplified Schematic.

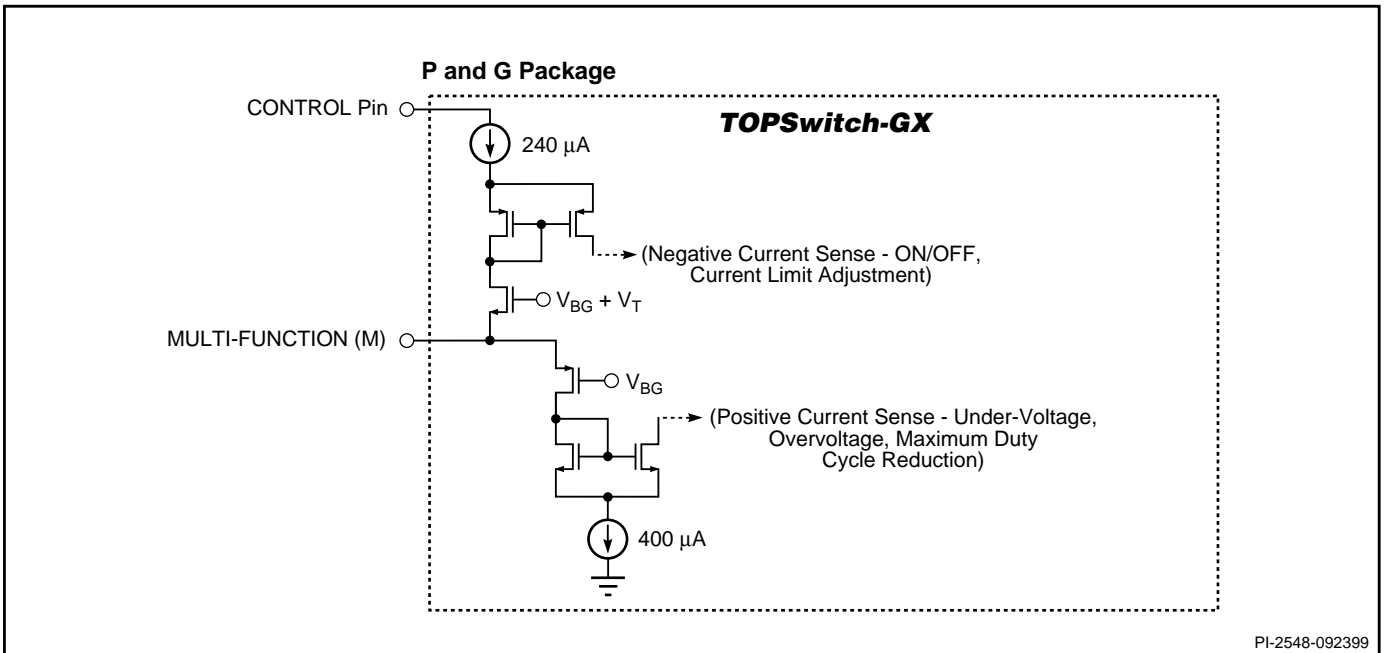


Figure 12b. MULTI-FUNCTION (M) Pin Input Simplified Schematic.



Typical Uses of FREQUENCY (F) Pin

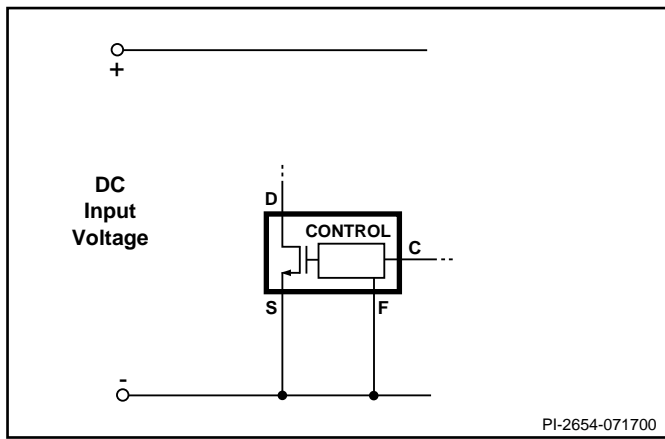


Figure 13. Full Frequency Operation (132 kHz).

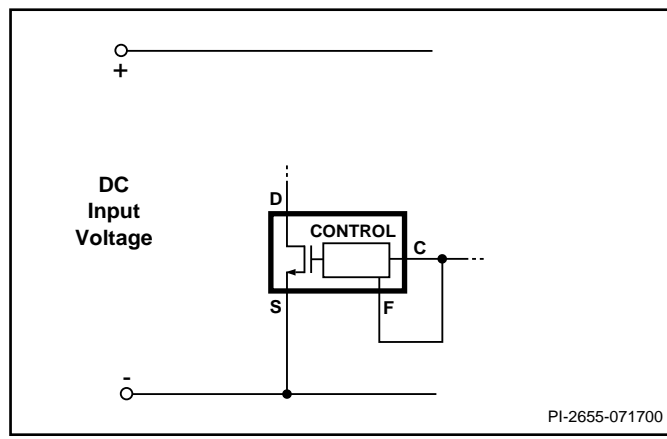


Figure 14. Half Frequency Operation (66 kHz).

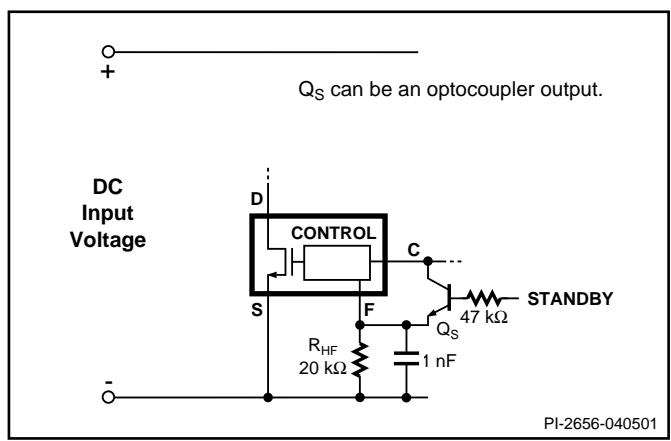


Figure 15. Half Frequency Standby Mode (For High Standby Efficiency).



Typical Uses of LINE-SENSE (L) and EXTERNAL CURRENT LIMIT (X) Pins

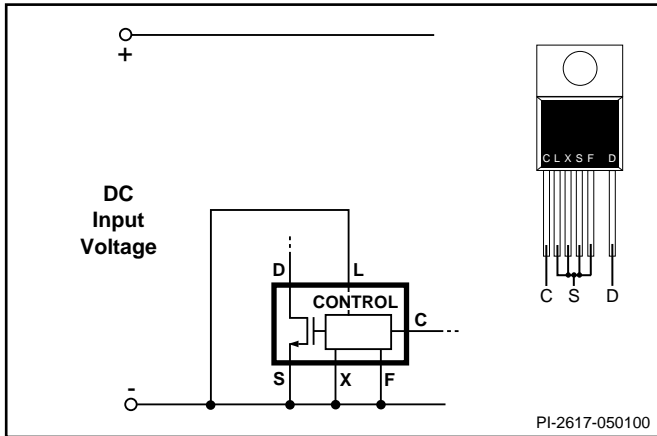


Figure 16. Three Terminal Operation (LINE-SENSE and EXTERNAL CURRENT LIMIT Features Disabled. FREQUENCY Pin can be tied to SOURCE or CONTROL Pin).

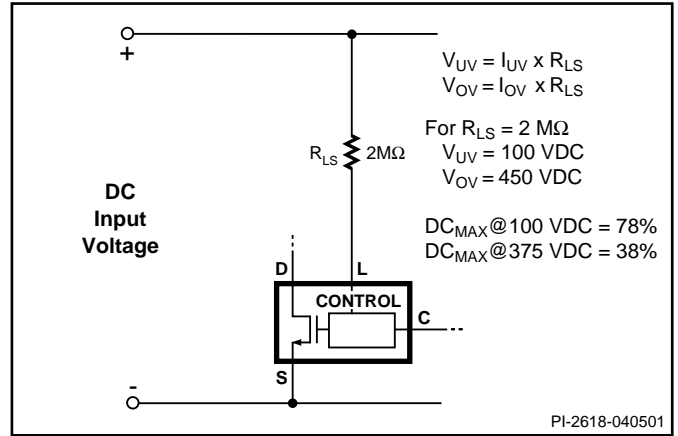


Figure 17. Line-Sensing for Under-Voltage, Overvoltage and Line Feed Forward.

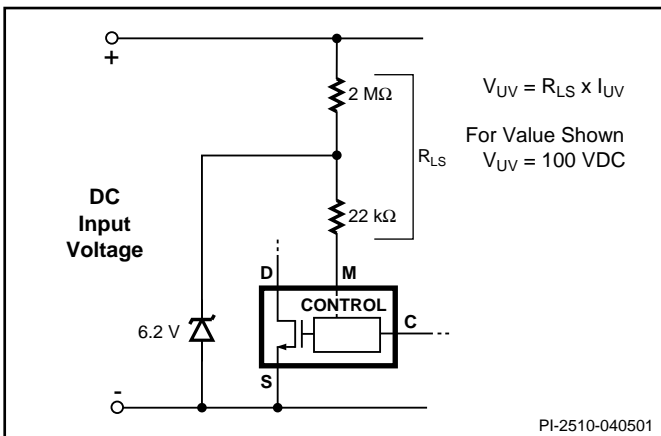


Figure 18. Line-Sensing for Under-Voltage Only (Overvoltage Disabled).

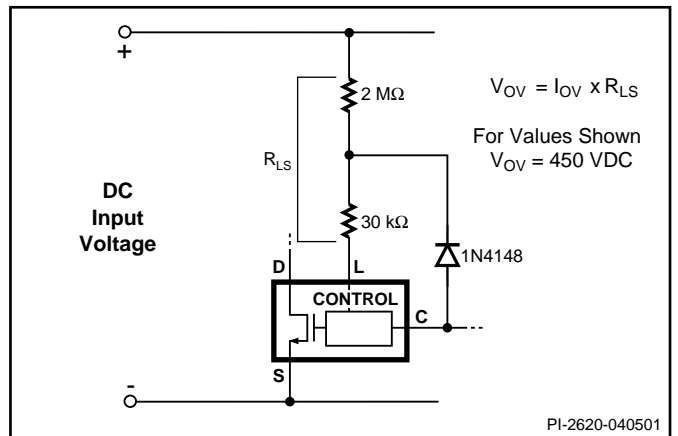


Figure 19. Line-Sensing for Overvoltage Only (Under-Voltage Disabled). Maximum Duty Cycle will be reduced at Low Line.

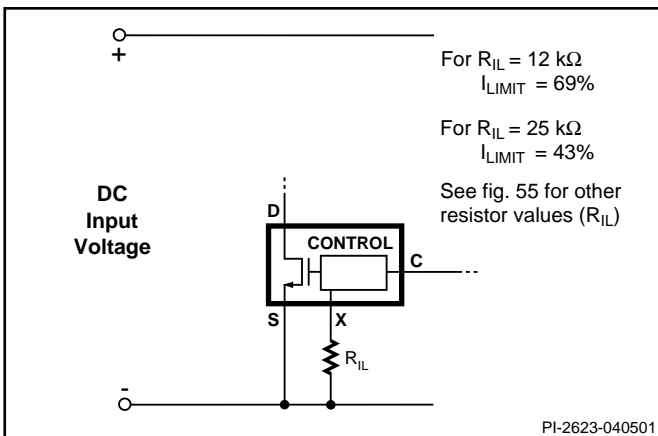


Figure 20. Externally Set Current Limit.

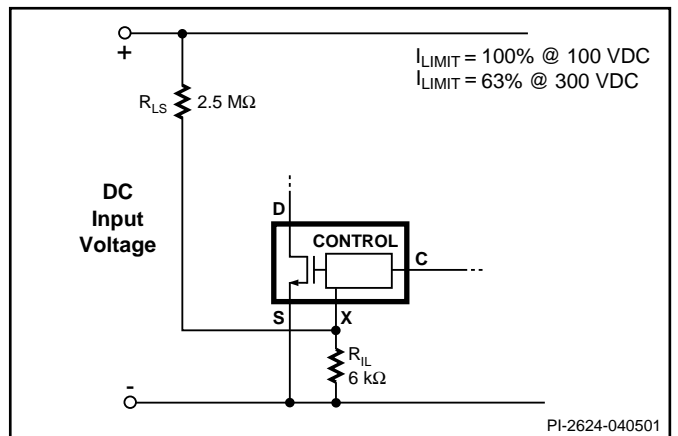


Figure 21. Current Limit Reduction with Line Voltage.



Typical Uses of LINE-SENSE (L) and EXTERNAL CURRENT LIMIT (X) Pins (cont.)

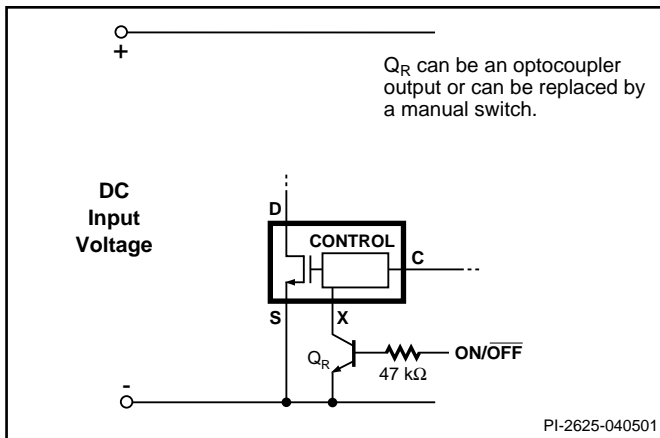


Figure 22. Active-on (Fail Safe) Remote ON/OFF.

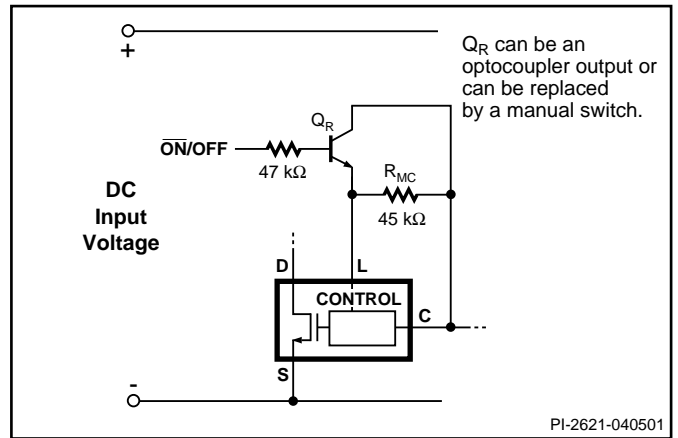


Figure 23. Active-off Remote ON/OFF. Maximum Duty Cycle will be reduced.

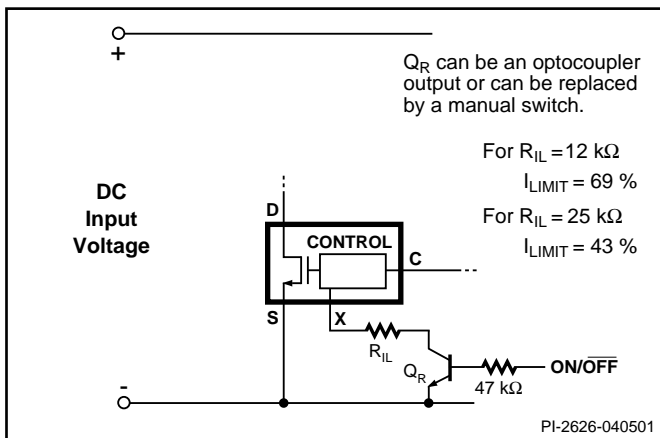


Figure 24. Active-on Remote ON/OFF with Externally Set Current Limit.

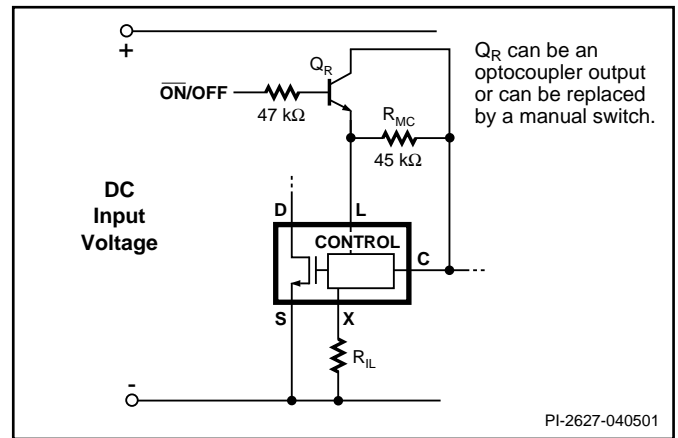


Figure 25. Active-off Remote ON/OFF with Externally Set Current Limit.

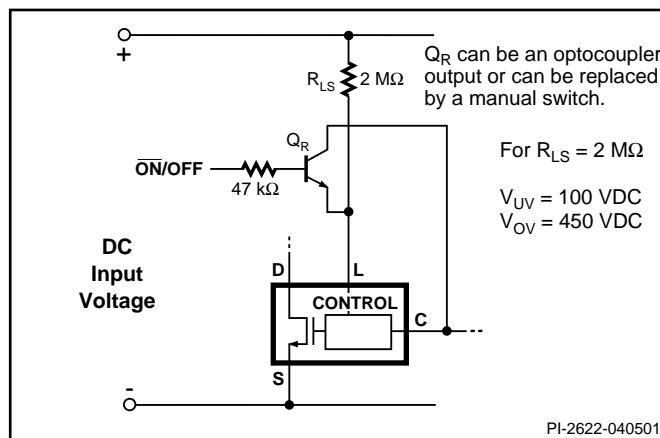


Figure 26. Active-off Remote ON/OFF with LINE-SENSE.

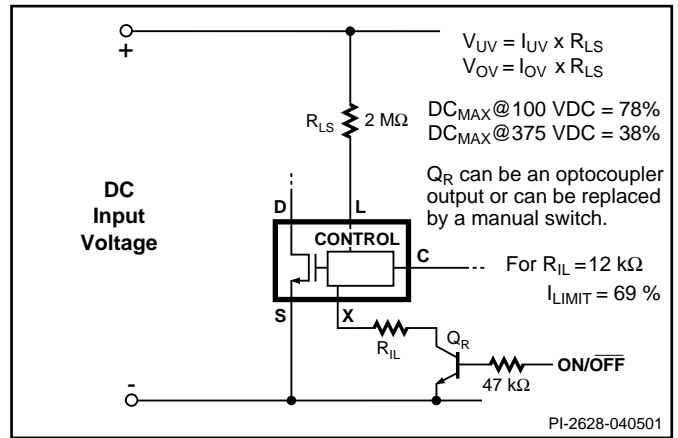


Figure 27. Active-on Remote ON/OFF with LINE-SENSE and EXTERNAL CURRENT LIMIT.



Typical Uses of LINE-SENSE (L) and EXTERNAL CURRENT LIMIT (X) Pins (cont.)

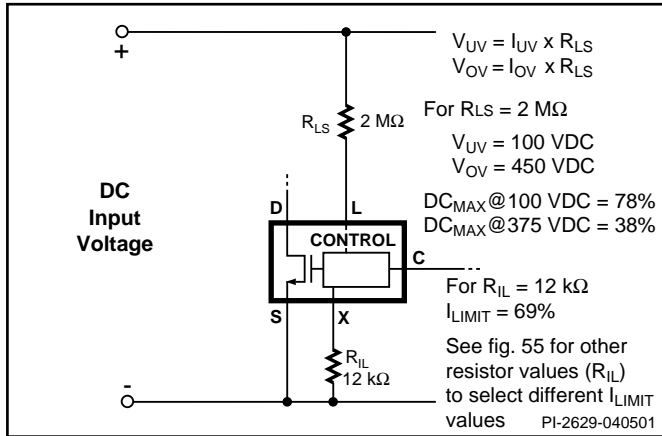


Figure 28. Line-Sensing and Externally Set Current Limit.

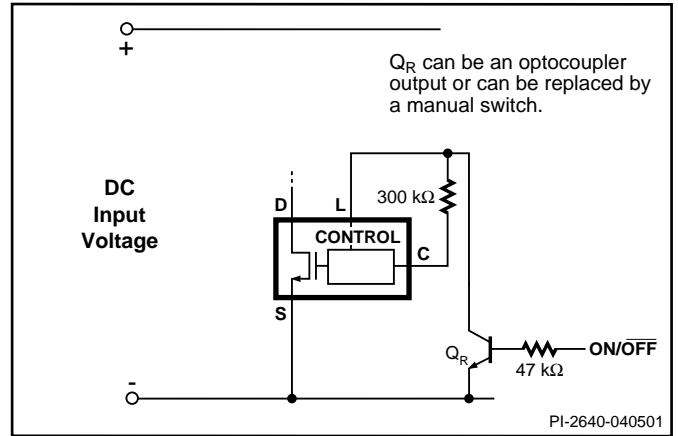


Figure 29. Active-on Remote ON/OFF.



Typical Uses of MULTI-FUNCTION (M) Pin

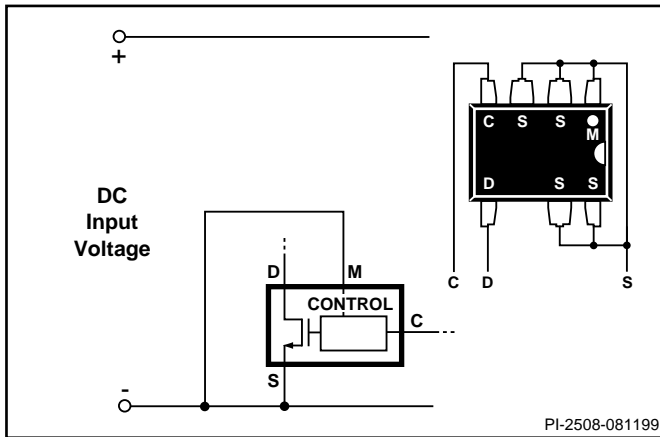


Figure 30. Three Terminal Operation (MULTI-FUNCTION Features Disabled).

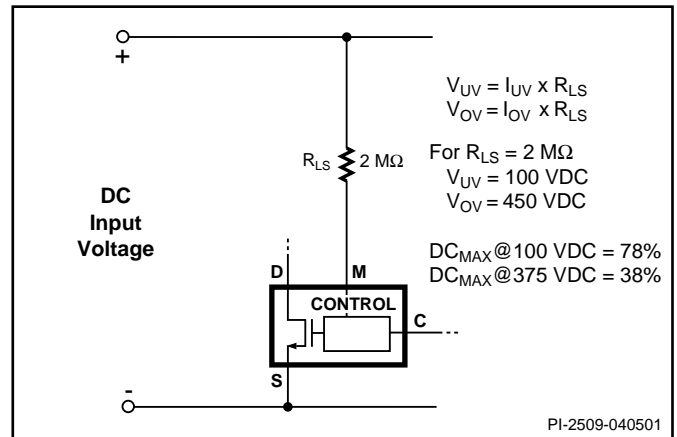


Figure 31. Line Sensing for Undervoltage, Over-Voltage and Line Feed Forward.

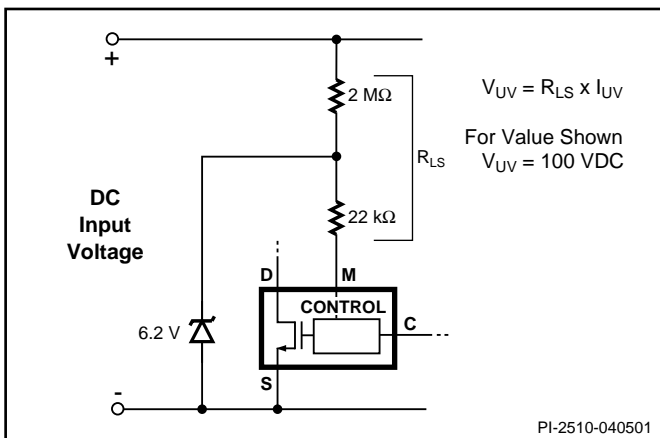


Figure 32. Line Sensing for Under-Voltage Only (Overvoltage Disabled).

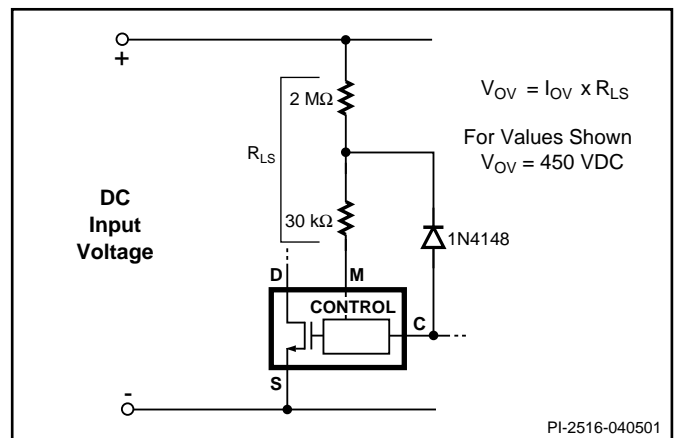


Figure 33. Line Sensing for Overvoltage Only (Under-Voltage Disabled). Maximum Duty Cycle will be reduced at Low Line.

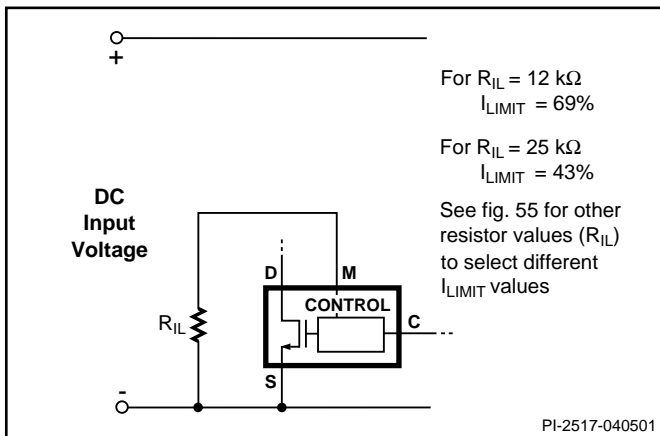


Figure 34. Externally Set Current Limit.

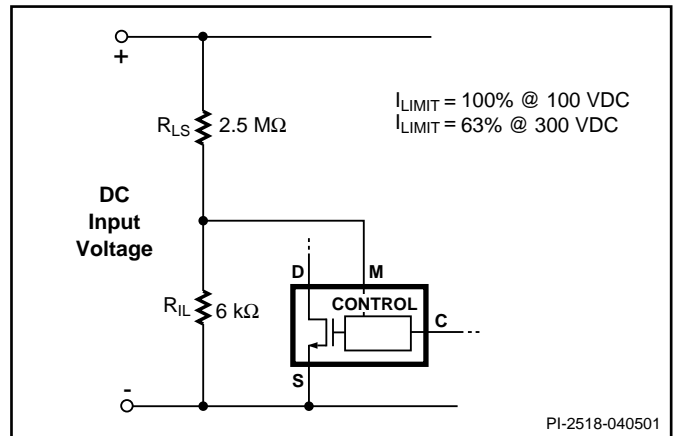


Figure 35. Current Limit Reduction with Line Voltage.



Typical Uses of MULTI-FUNCTION (M) Pin (cont.)

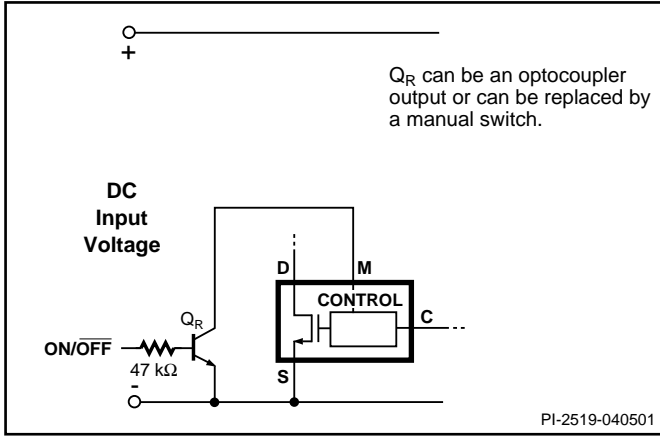


Figure 36. Active-on (Fail Safe) Remote ON/OFF.

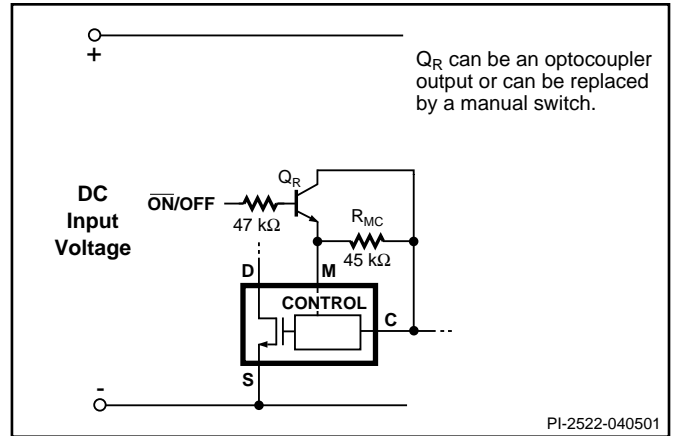


Figure 37. Active-off Remote ON/OFF. Maximum Duty Cycle will be Reduced.

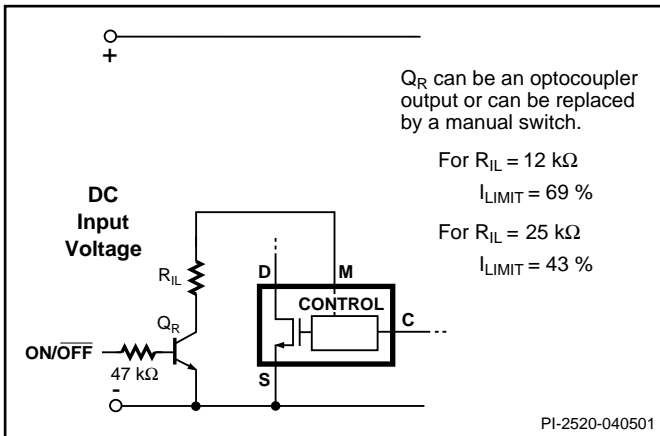


Figure 38. Active-on Remote ON/OFF with Externally Set Current Limit.

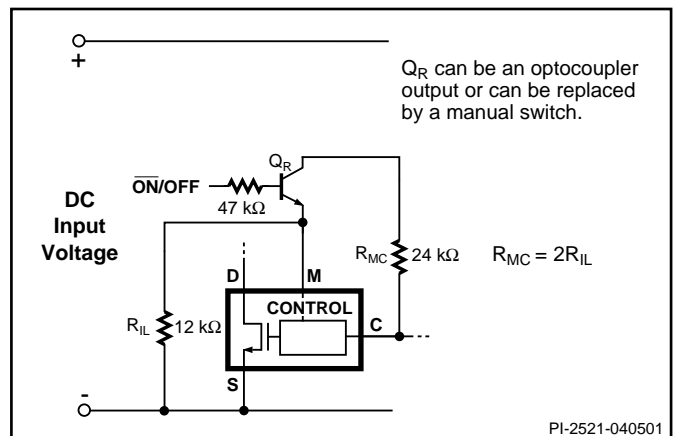


Figure 39. Active-off Remote ON/OFF with Externally Set Current Limit.

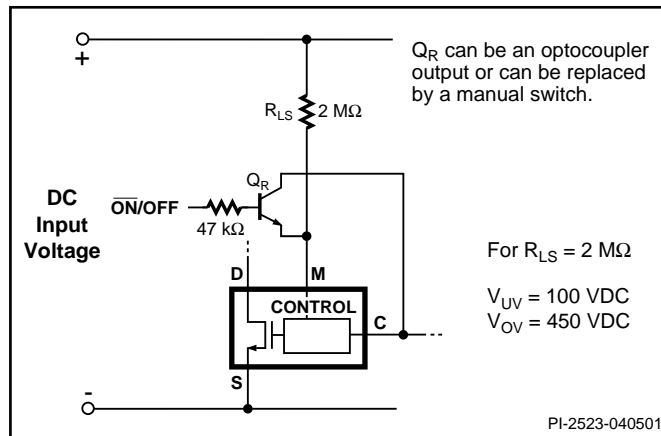


Figure 40. Active-off Remote ON/OFF with LINE-SENSE.



Application Examples

A High Efficiency, 30 W, Universal Input Power Supply

The circuit shown in Figure 41 takes advantage of several of the *TOPSwitch-GX* features to reduce system cost and power supply size and to improve efficiency. This design delivers 30 W at 12 V, from an 85 to 265 VAC input, at an ambient of 50 °C, in an open frame configuration. A nominal efficiency of 80% at full load is achieved using TOP244Y.

The current limit is externally set by resistors R1 and R2 to a value just above the low line operating peak DRAIN current of approximately 70% of the default current limit. This allows use of a smaller transformer core size and/or higher transformer primary inductance for a given output power, reducing *TOPSwitch-GX* power dissipation, while at the same time avoiding transformer core saturation during startup and output transient conditions. The resistors R1 & R2 provide a signal that reduces the current limit with increasing line voltage, which in turn limits the maximum overload power at high input line voltage. This function in combination with the built-in soft-start feature of *TOPSwitch-GX*, allows the use of a low cost RCD clamp (R3, C3 and D1) with a higher reflected voltage, by safely limiting the *TOPSwitch-GX* drain voltage, with adequate

margin under worst case conditions. Resistor R4 provides line sensing, setting UV at 100 VDC and OV at 450 VDC. The extended maximum duty cycle feature of *TOPSwitch-GX* (guaranteed minimum value of 75% vs. 64% for *TOPSwitch-II*) allows the use of a smaller input capacitor (C1). The extended maximum duty cycle and the higher reflected voltage possible with the RCD clamp also permit the use of a higher primary to secondary turns ratio for T1 which reduces the peak reverse voltage experienced by the secondary rectifier D8. As a result a 60 V Schottky rectifier can be used for up to 15 V outputs, which greatly improves power supply efficiency. The frequency reduction feature of the *TOPSwitch-GX* eliminates the need for any dummy loading for regulation at no load and reduces the no load/standby consumption of the power supply. Frequency jitter provides improved margin for conducted EMI meeting the CISPR 22 (FCC B) specification.

Output regulation is achieved by using a simple Zener sense circuit for low cost. The output voltage is determined by the Zener diode (VR2) voltage and the voltage drops across the optocoupler (U2) LED and resistor R6. Resistor R8 provides bias current to Zener VR2 for typical regulation of $\pm 5\%$ at the 12 V output level, over line and load and component variations.

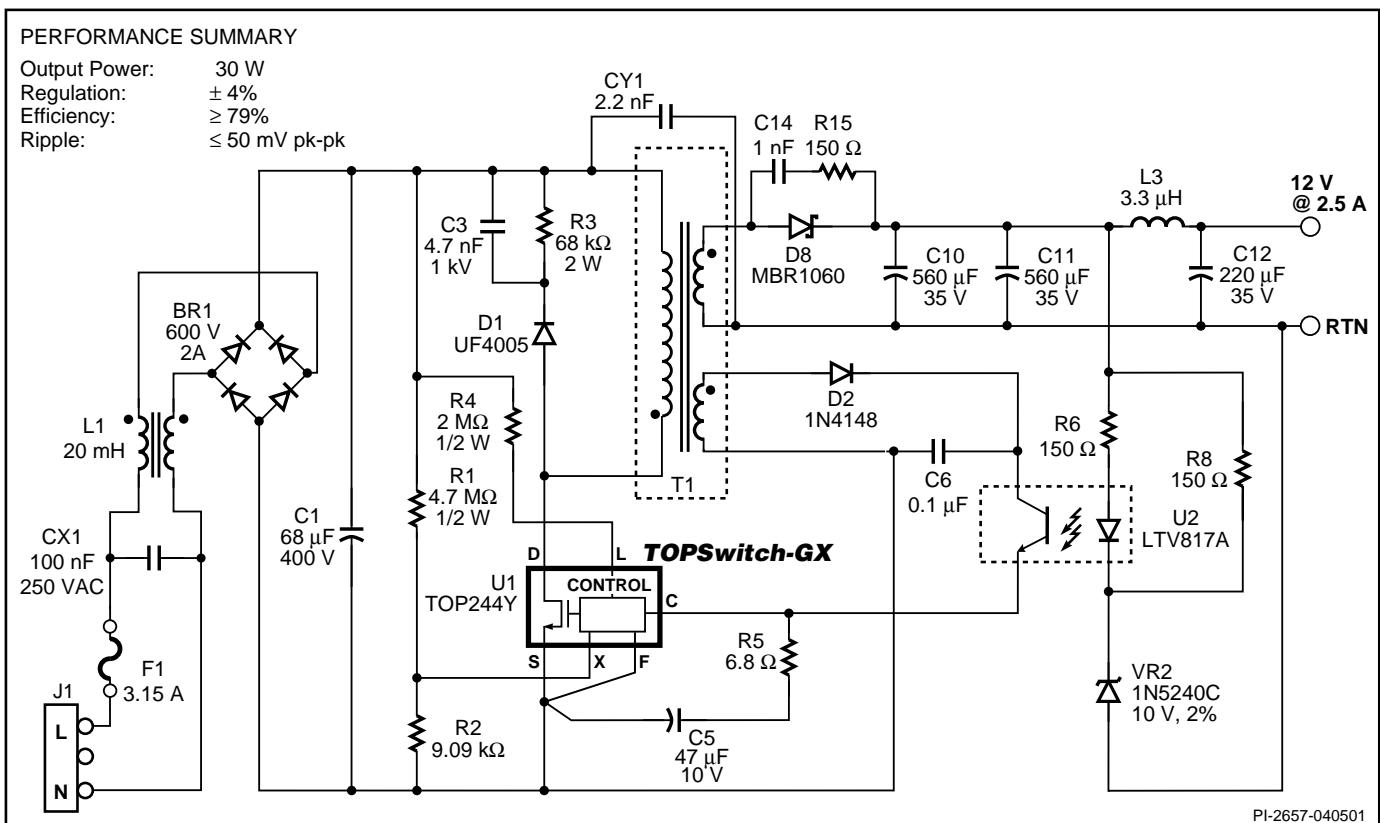


Figure 41. 30 W Power Supply using External Current Limit Programming and Line Sensing for UV and OV.



A High Efficiency, Enclosed, 70 W, Universal Adapter Supply

The circuit shown in figure 42 takes advantage of several of the *TOPSwitch-GX* features to reduce cost, power supply size and increase efficiency. This design delivers 70 W at 19 V, from an 85 to 265 VAC input, at an ambient of 40 °C, in a small sealed adapter case (4" x 2.15" x 1"). Full load efficiency is 85% at 85 VAC rising to 90% at 230 VAC input.

Due to the thermal environment of a sealed adapter a TOP249Y is used to minimize device dissipation. Resistors R9 and R10 externally program the current limit level to just above the operating peak DRAIN current at full load and low line. This allows the use of a smaller transformer core size without saturation during startup or output load transients. Resistors R9 and R10 also reduce the current limit with increasing line voltage, limiting the maximum overload power at high input line voltage, removing the need for any protection circuitry on the secondary. Resistor R11 implements an under voltage and over voltage sense as well as providing line feed forward for reduced output line frequency ripple. With resistor R11 set at 2 MΩ the power supply does not start operating until the DC rail voltage reaches 100 VDC. On removal of the AC input the UV sense prevents the output glitching as C1 discharges, turning off the *TOPSwitch-GX* when the output regulation is lost or when the input voltage falls to below 40 V, whichever occurs first. This same value of R11 sets the OV threshold to 450 V. If exceeded, for example during a line surge, *TOPSwitch-GX* stops switching for the duration of the surge extending the high voltage withstand to 700 V without device damage.

Capacitor C11 has been added in parallel with VR1 to reduce Zener clamp dissipation. With a switching frequency of 132 kHz a PQ26/20 core can be used to provide 70 W. To maximize efficiency, by reducing winding losses, two output windings are used each with their own dual 100 V Schottky rectifier (D2 and D3). The frequency reduction feature of the *TOPSwitch-GX* eliminates any dummy loading to maintain regulation at no-load and reduces the no-load consumption of the power supply to only 520 mW at 230 VAC input. Frequency jittering provides conducted EMI meeting the CISPR 22 (FCC B) / EN55022B specification, using simple filter components (C7, L2, L3 and C6) even with the output earth grounded.

To regulate the output an optocoupler (U2) is used with a secondary reference sensing the output voltage via a resistor divider (U3, R4, R5, R6). Diode D4 and C15 filter and smooth the output of the bias winding. Capacitor C15 (1uF) prevents the bias voltage from falling during zero to full load transients. Resistor R8 provides filtering of leakage inductance spikes keeping the bias voltage constant even at high output loads. Resistor R7, C9 and C10 together with C5 and R3 provide loop compensation.

Due to the large primary currents, all the small signal control components are connected to a separate source node that is Kelvin connected to the source pin of the *TOPSwitch-GX*. For improved common mode surge immunity the bias winding common returns directly to the DC bulk capacitor (C1).

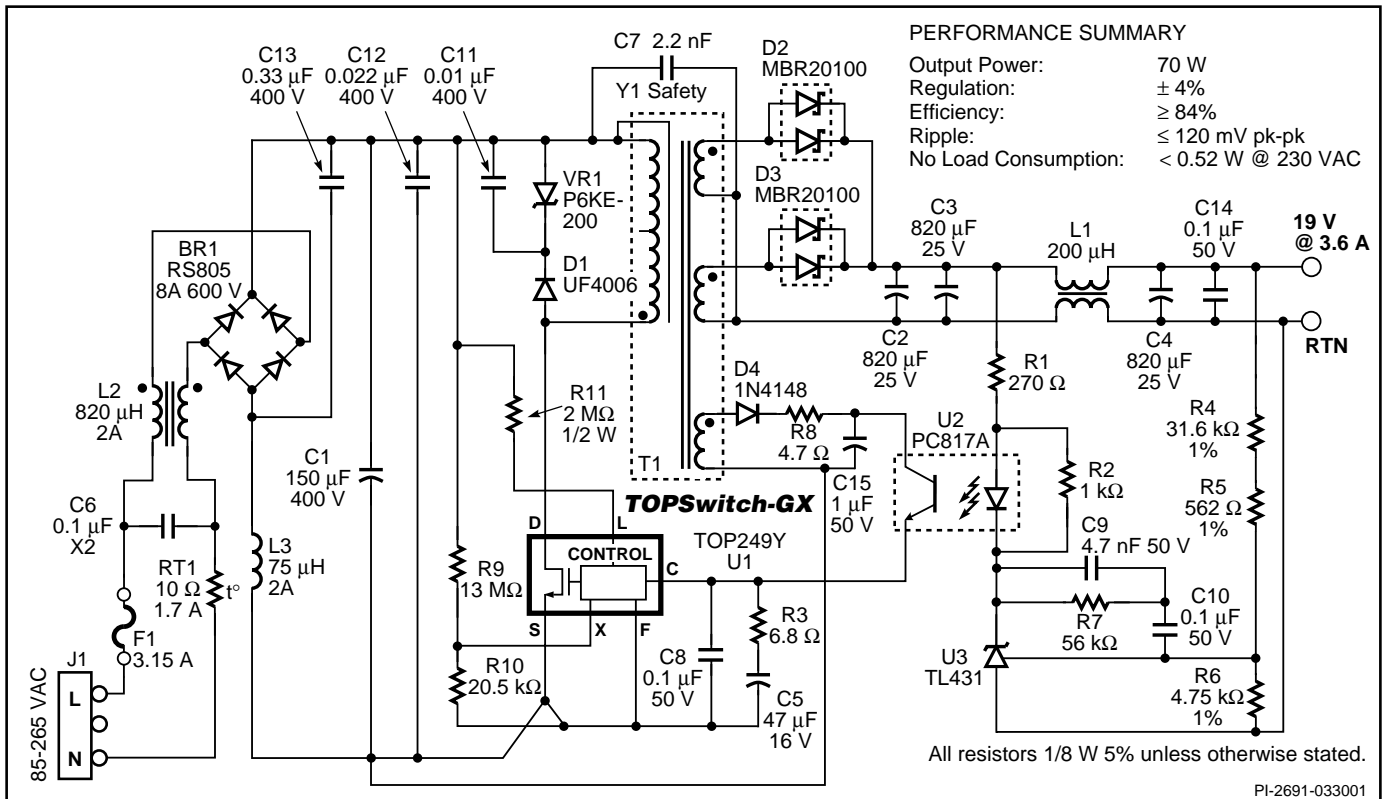


Figure 42. 70 W Power Supply using Current Limit Reduction with Line and Line Sensing for UV and OV.



A High Efficiency, 250 W, 250–380 VDC Input Power Supply

The circuit shown in figure 43 delivers 250 W (48 V @ 5.2 A) at 84% efficiency using a TOP249 from a 250 to 380 VDC input. DC input is shown, as typically at this power level a p.f.c. boost stage would precede this supply, providing the DC input (C1 is included to provide local decoupling). Flyback topology is still useable at this power level due to the high output voltage, keeping the secondary peak currents low enough so that the output diode and capacitors are reasonably sized.

In this example the TOP249 is at the upper limit of its power capability and the current limit is set to the internal maximum by connecting the X pin to SOURCE. However, line sensing is implemented by connecting a 2 MΩ resistor from the L pin to the DC rail. If the DC input rail rises above 450 VDC, then TOPSwitch-GX will stop switching until the voltage returns to normal, preventing device damage.

Due to the high primary current, a low leakage inductance transformer is essential. Therefore, a sandwich winding with a copper foil secondary was used. Even with this technique the leakage inductance energy is beyond the power capability of a simple Zener clamp. Therefore, R2, R3 and C6 are added in parallel to VR1. These have been sized such that during normal operation very little power is dissipated by VR1, the leakage energy instead being dissipated by R2 and R3. However, VR1

is essential to limit the peak drain voltage during start-up and/or overload conditions to below the 700 V rating of the TOPSwitch-GX MOSFET.

The secondary is rectified and smoothed by D2 and C9, C10 and C11. Three capacitors are used to meet the secondary ripple current requirement. Inductor L2 and C12 provide switching noise filtering.

A simple Zener sensing chain regulates the output voltage. The sum of the voltage drop of VR2, VR3 and VR4 plus the LED drop of U2 gives the desired output voltage. Resistor R6 limits LED current and sets overall control loop DC gain. Diode D4 and C14 provide secondary soft-finish, feeding current into the CONTROL pin prior to output regulation and thus ensuring that the output voltage reaches regulation at start-up under low line, full load conditions. Resistor R9 provides a discharge path for C14. Capacitor C13 and R8 provide control loop compensation and are required due to the gain associated with such a high output voltage.

Sufficient heat sinking is required to keep the TOPSwitch-GX device below 110 °C when operating under full load, low line and maximum ambient temperature. Airflow may also be required if a large heat sink area is not acceptable.

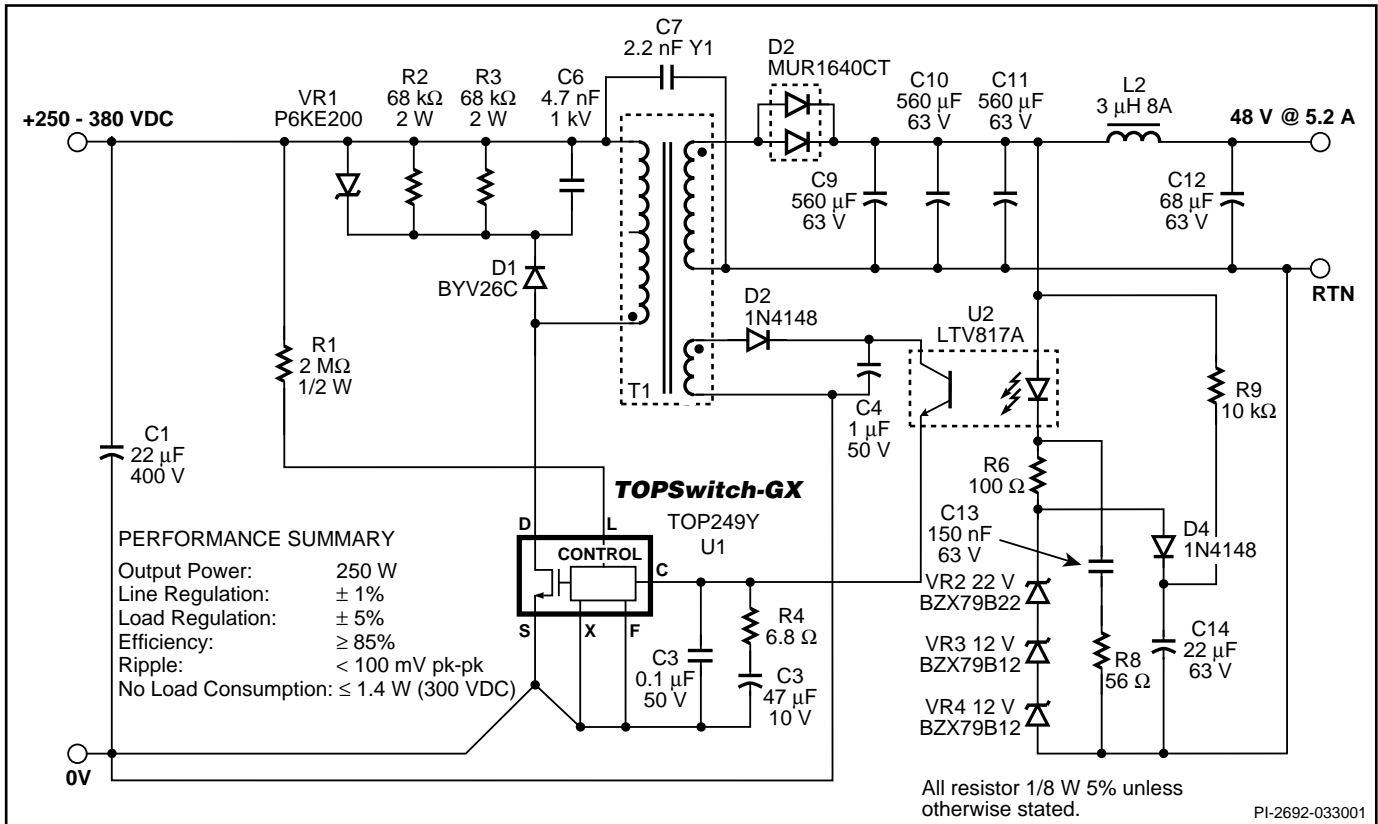


Figure 43. 250 W, 48 V Power Supply using TOP249.



Multiple Output, 60 W, 185-265 VAC Input Power Supply

Figure 44 shows a multiple output supply typical for high end set-top boxes or cable decoders containing high capacity hard disks for recording. The supply delivers an output power of 45 W cont./60 W peak (thermally limited) from an input voltage of 185 to 265 VAC. Efficiency at 45 W, 185 VAC is $\geq 75\%$.

The 3.3 V and 5 V outputs are regulated to $\pm 5\%$ without the need for secondary linear regulators. DC stacking (the secondary winding reference for the other output voltages is connected to the cathode of D10 rather than the anode) is used to minimize the voltage error for the higher voltage outputs.

Due to the high ambient operating temperature requirement typical of a set-top box (60 °C) the TOP246Y is used to reduce conduction losses and minimize heat sink size. Resistor R2 sets the device current limit to 80% of typical to limit overload power. The line sense resistor (R1) protects the TOPSwitch-GX from line surges and transients by sensing when the DC rail voltage rises to above 450 V. In this condition the TOPSwitch-GX stops switching, extending the input voltage withstand to 496 VAC which is ideal for countries with poor power quality. A thermistor (RT1) is used to prevent premature failure of the fuse by limiting the inrush current (due to the relatively large size of C2). An optional MOV (RV1) extends the differential surge protection to 6 kV from 4 kV.

Leakage inductance clamping is provided by VR1, R5 and C5, keeping the DRAIN voltage below 700 V under all conditions. Resistor R5 and capacitor C5 are selected such that VR1 dissipates very little power except during overload conditions. The frequency jittering feature of TOPSwitch-GX allows the circuit shown to meet CISPR22B with simple EMI filtering (C1, L1 and C6) and the output grounded.

The secondaries are rectified and smoothed by D7 to D11, C7, C9, C11, C13, C14, C16 and C17. Diode D11 for the 3.3 V output is a Schottky diode to maximize efficiency. Diode D10 for the 5 V output is a PN type to center the 5 V output at 5 V. The 3.3 V and 5 V output require two capacitors in parallel to meet the ripple current requirement. Switching noise filtering is provided by L2 to L5 and C8, C10, C12, C15 and C18. Resistor R6 prevents peak charging of the lightly loaded 30 V output. The outputs are regulated using a secondary reference (U3). Both the 3.3 V and 5 V outputs are sensed via R11 and R10. Resistor R8 provides bias for U3 and R7 sets the overall DC gain. Resistor R9, C19, R3 and C4 provide loop compensation. A soft-finish capacitor (C20) eliminates output overshoot.

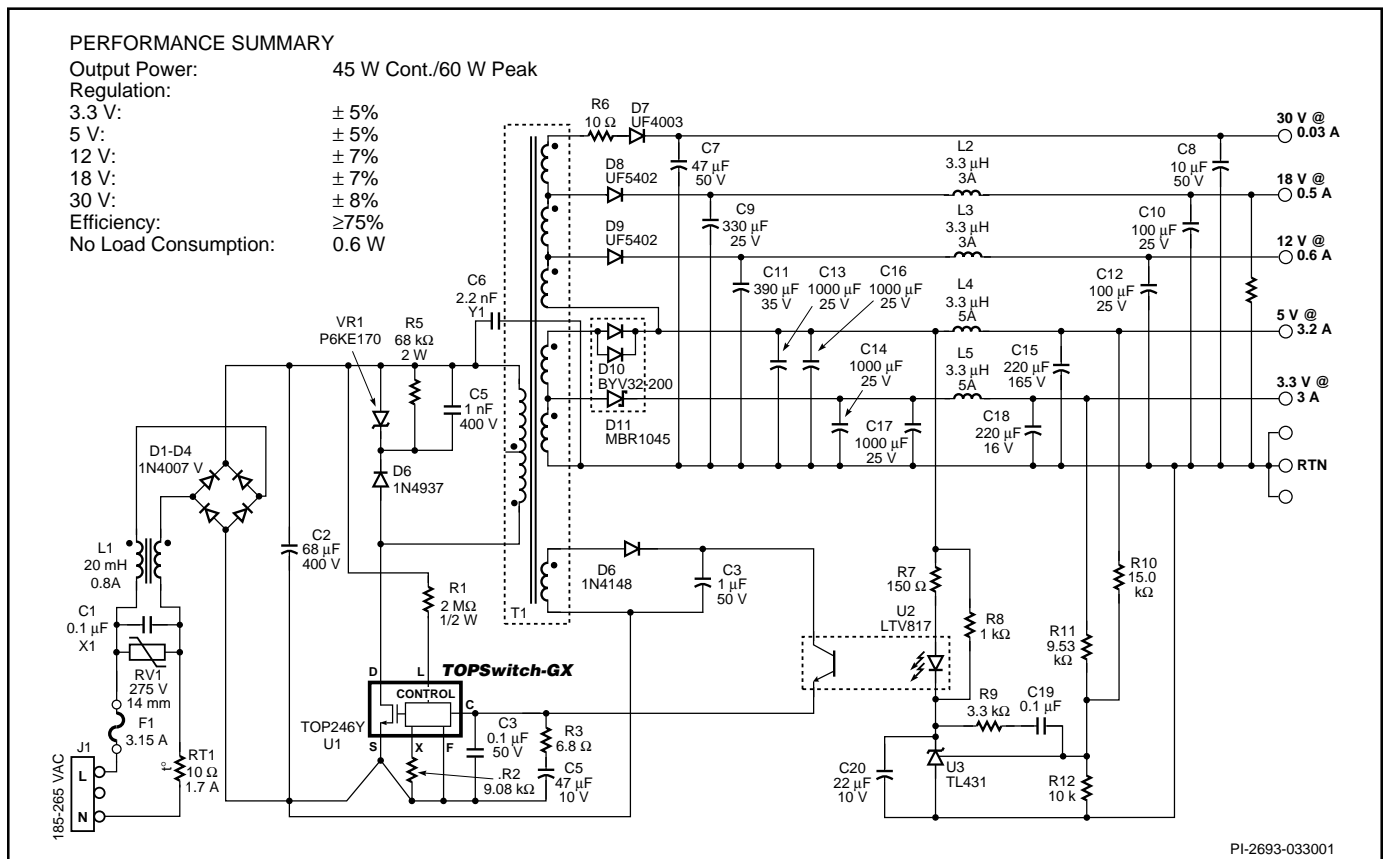


Figure 44. 60 W Multiple Output Power Supply using TOP246.



Processor Controlled Supply Turn On/Off

A low cost momentary contact switch can be used to turn the *TOPSwitch-GX* power on and off under microprocessor control that may be required in some applications such as printers. The low power remote off feature allows an elegant implementation of this function with very few external components as shown in Figure 45. Whenever the push button momentary contact switch P1 is closed by the user, the optocoupler U3 is activated to inform the microprocessor of this action. Initially, when the power supply is off (M pin is floating), closing of P1 turns the power supply on by shorting the M pin of the *TOPSwitch-GX* to SOURCE through a diode (remote on). When the secondary output voltage VCC is established, the microprocessor comes alive and recognizes that the switch P1 is closed through the switch status input that is driven by the optocoupler U3 output. The microprocessor then sends a power supply control signal to hold the power supply in the on-state through the optocoupler U4. If the user presses the switch P1 again to command a turn off, the microprocessor detects this through the optocoupler U3 and initiates a shutdown procedure that is product specific. For example, in the case of the inkjet printer, the shutdown procedure may include safely parking the print heads in the storage

position. In the case of products with a disk drive, the shutdown procedure may include saving data or settings to the disk. After the shutdown procedure is complete, when it is safe to turn off the power supply, the microprocessor releases the M pin by turning the optocoupler U4 off. If the manual switch and the optocouplers U3 and U4 are not located close to the M pin, a capacitor C_M may be needed to prevent noise coupling to the pin when it is open.

The power supply could also be turned on remotely through a local area network or a parallel or serial port by driving the optocoupler U4 input LED with a logic signal. Sometimes it is easier to send a train of logic pulses through a cable (due to AC coupling of cable, for example) instead of a DC logic level as a wake up signal. In this case, a simple RC filter can be used to generate a DC level to drive U4 (not shown in Figure 45). This remote on feature can be used to wake up peripherals such as printers, scanners, external modems, disk drives, etc., as needed from a computer. Peripherals are usually designed to turn off automatically if they are not being used for a period of time, to save power.

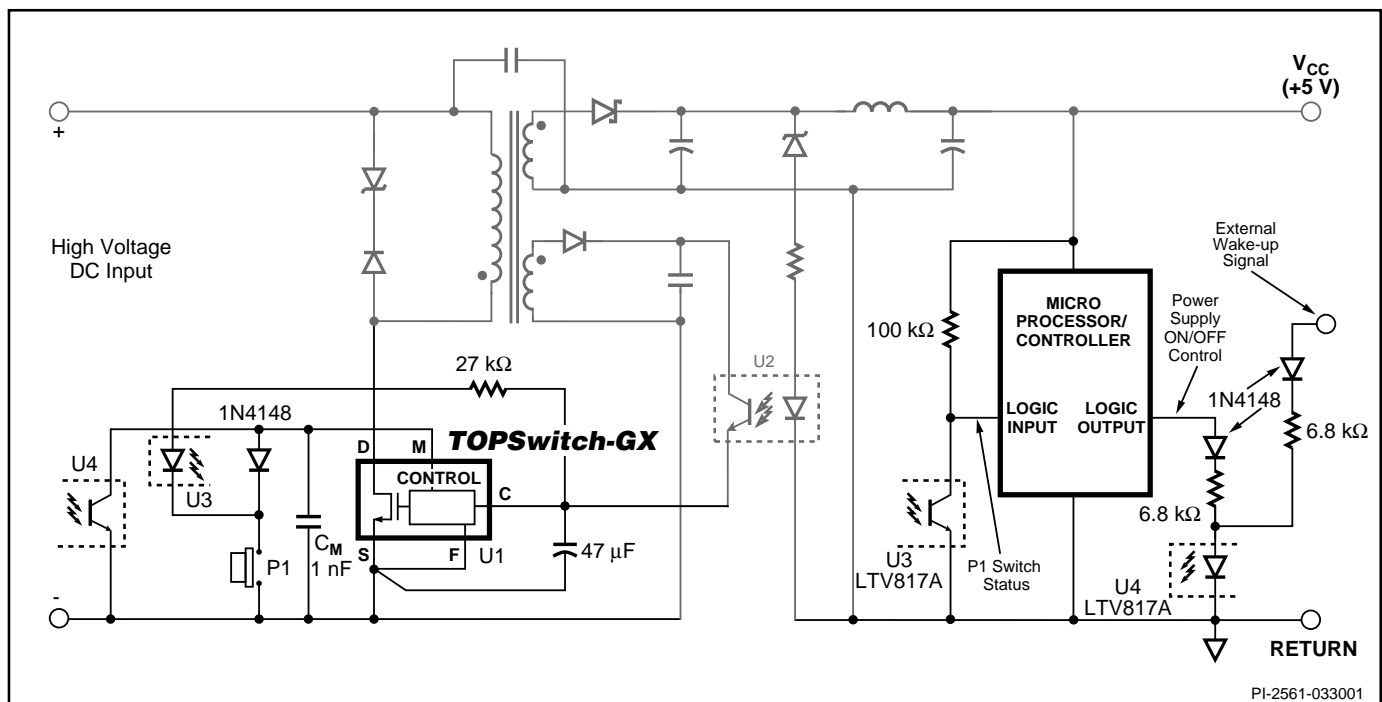


Figure 45. Remote ON/OFF using Microcontroller.



In addition to using a minimum number of components, *TOPSwitch-GX* provides many technical advantages in this type of application:

1. Extremely low power consumption in the off mode: 80 mW typical at 110 VAC and 160 mW typical at 230 VAC. This is because in the remote/off mode the *TOPSwitch-GX* consumes very little power, and the external circuitry does not consume any current (either M, L or X pin is open) from the high voltage DC input.
2. A very low cost, low voltage/current, momentary contact switch can be used.
3. No debouncing circuitry for the momentary switch is required. During turn-on, the start-up time of the power supply (typically 10 to 20 ms) plus the microprocessor initiation time act as a debouncing filter, allowing a turn-on only if the switch is depressed firmly for at least the above delay time. During turn-off, the microprocessor initiates the shutdown sequence when it detects the first closure of the switch, and subsequent bouncing of the switch has no effect. If necessary, the microprocessor could implement the switch debouncing in software during turn-off, or a filter capacitor can be used at the switch status input.
4. No external current limiting circuitry is needed for the operation of the U4 optocoupler output due to internal limiting of M pin current.
5. No high voltage resistors to the input DC voltage rail are required to power the external circuitry in the primary. Even the LED current for U3 can be derived from the CONTROL pin. This not only saves components and simplifies layout, but also eliminates the power loss associated with the high voltage resistors in both on and off states.
6. Robust design: There is no on/off latch that can be accidentally triggered by transients. Instead, the power supply is held in the on-state through the secondary side microprocessor.



Key Application Considerations

TOPSwitch-II vs. TOPSwitch-GX

Table 4 compares the features and performance differences between TOPSwitch-GX and TOPSwitch-II. Many of the new features eliminate the need for additional discrete components.

Other features increase the robustness of design allowing cost savings in the transformer and other power components.

Function	TOPSwitch-II	TOPSwitch-GX	Figures	TOPSwitch-GX Advantages
Soft-Start	N/A*	10 ms		<ul style="list-style-type: none"> Limits peak current and voltage component stresses during start-up Eliminates external components used for soft-start in most applications Reduces or eliminates output overshoot
External Current Limit	N/A*	Programmable 100% to 30% of default current limit	11,20,21, 24,25,27, 28,34,35, 38,39	<ul style="list-style-type: none"> Smaller transformer Higher efficiency Allows power limiting (constant overload power independent of line voltage) Allows use of larger device for lower losses, higher efficiency and smaller heatsink
DC _{MAX}	67%	78%	7	<ul style="list-style-type: none"> Smaller input cap (wider dynamic range) Higher power capability (when used with RCD clamp for large V_{OR}) Allows use of Schottky secondary rectifier diode for up to 15 V output for high efficiency
Line Feed Forward with DC _{MAX} Reduction	N/A*	78% to 38%	7,11,17, 26,27,28, 31,40	<ul style="list-style-type: none"> Rejects line ripple
Line OV Shutdown	N/A*	Single resistor programmable	11,17,19, 26,27,28, 31,33,40	<ul style="list-style-type: none"> Increases voltage withstand capability against line surge
Line UV Detection	N/A*	Single resistor programmable	11,17,18, 26,27,28, 31,32,40	<ul style="list-style-type: none"> Prevents auto-restart glitches during power down
Switching Frequency	100 kHz ±10%	132 kHz ±6%	13,15	<ul style="list-style-type: none"> Smaller transformer Below start of conducted EMI limits
Switching Frequency Option (Y and R Packages)	N/A*	66 kHz ±7%	14,15	<ul style="list-style-type: none"> Lower losses when using RC and RCD snubber for noise reduction in video applications Allows for higher efficiency in standby mode Lower EMI (second harmonic below 150 kHz)
Frequency Jitter	N/A*	±4 kHz@132 kHz ±2 kHz@66 kHz	9,46	<ul style="list-style-type: none"> Reduces conducted EMI
Frequency Reduction	N/A*	At a Duty Cycle below 10%	7	<ul style="list-style-type: none"> Zero load regulation without dummy load Low power consumption at no load

Table 4. Comparison Between TOPSwitch-II and TOPSwitch-GX. (continued on next page) *Not available



Function	TOPSwitch-II	TOPSwitch-GX	Figures	TOPSwitch-GX Advantages
Remote ON/OFF	N/A*	Single transistor or optocoupler interface or manual switch	11, 22, 23, 24, 25, 26, 27, 29, 36, 37, 38, 39, 40	<ul style="list-style-type: none"> • Fast on/off (cycle by cycle) • Active-on or active-off control • Low consumption in remote off state • Active-on control for fail-safe • Eliminates expensive in-line on/off switch • Allows processor controlled turn on/off • Permits shutdown/wake-up of peripherals via LAN or parallel port
Synchronization	N/A*	Single transistor or optocoupler interface		<ul style="list-style-type: none"> • Synchronization to external lower frequency signal • Starts new switching cycle on demand
Thermal Shutdown	125 °C min. Latched	Hysteretic 130 °C min. Shutdown (with 75 °C hysteresis)		<ul style="list-style-type: none"> • Automatic recovery from thermal fault • Large hysteresis prevents circuit board overheating
Current Limit Tolerance	±10% (@25 °C) -8% (0 °C to 100 °C)	±7% (@25 °C) -4% (0 °C to 100 °C)		<ul style="list-style-type: none"> • 10% higher power capability due to tighter tolerance
DRAIN Creepage at Package	DIP	0.037" / 0.94 mm	0.137" / 3.48 mm	<ul style="list-style-type: none"> • Greater immunity to arcing as a result of build-up of dust, debris and other contaminants
	SMD	0.037" / 0.94 mm	0.137" / 3.48 mm	
	TO-220	0.046" / 1.17 mm	0.068" / 1.73 mm	
DRAIN Creepage at PCB for Y and R Packages	0.045" / 1.14 mm (R Package N/A*)	0.113" / 2.87 mm (preformed leads)		<ul style="list-style-type: none"> • Preformed leads accommodate large creepage for PCB layout • Easier to meet Safety (UL/VDE)

Table 4 (cont). Comparison Between TOPSwitch-II and TOPSwitch-GX. *Not available

TOPSwitch-FX vs. TOPSwitch-GX

Table 5 compares the features and performance differences between TOPSwitch-GX and TOPSwitch-FX. Many of the new features eliminate the need for additional discrete components.

Other features increase the robustness of design allowing cost savings in the transformer and other power components.

Function	TOPSwitch-FX	TOPSwitch-GX	TOPSwitch-GX Advantages
Light Load Operation	Cycle skipping	Frequency and Duty Cycle reduction	<ul style="list-style-type: none"> • Improves light load efficiency • Reduces no-load consumption
Line Sensing/Externally Set Current Limit (Y and R Packages)	Line sensing and externally set current limit mutually exclusive (M pin)	Line sensing and externally set current limit possible simultaneously (functions split onto L and X pins)	<ul style="list-style-type: none"> • Additional design flexibility allows all features to be used simultaneously
Current Limit Programming Range	100-40%	100-30%	<ul style="list-style-type: none"> • Minimizes transformer core size in highly continuous designs

Table 5. Comparison Between TOPSwitch-FX and TOPSwitch-GX. (continued on next page)



Function	TOPSwitch-FX	TOPSwitch-GX	TOPSwitch-GX Advantages
P/G Package Current Limits	Identical to Y packages	TOP243P or G and TOP244P or G internal current limits reduced	<ul style="list-style-type: none"> Matches device current limit to package dissipation capability Allows more continuous design to lower device dissipation (lower RMS currents)
Y/R Package Current Limits	100% (R package N/A*)	90% (for equivalent $R_{DS(ON)}$)	<ul style="list-style-type: none"> Minimizes transformer core size Optimizes efficiency for most applications
Thermal Shutdown	125 °C min. 70 °C hysteresis	130 °C min. 75 °C hysteresis	<ul style="list-style-type: none"> Allows higher output powers in high ambient temperature applications
Maximum Duty Cycle Reduction Threshold	90 μ A	60 μ A	<ul style="list-style-type: none"> Reduces output line frequency ripple at low line D_{MAX} reduction optimized for forward design
Line Under-Voltage Negative (turn-off) Threshold	N/A*	40% of positive (turn-on) threshold	<ul style="list-style-type: none"> Provides a well defined turn-off threshold as the line voltage falls
Soft-Start	10 ms (duty cycle)	10 ms (duty cycle + current limit)	<ul style="list-style-type: none"> Gradually increasing current limit in addition to duty cycle during soft-start further reduces peak current and voltage Further reduces component stresses during start up

Table 5 (cont). Comparison Between TOPSwitch-FX and TOPSwitch-GX. *Not available

TOPSwitch-GX Design Considerations

Power Table

Datasheet power table represents the maximum practical continuous output power based on the following conditions: TOP242 to TOP246: 12 V output, Schottky output diode, 150 V reflected voltage (VOR) and efficiency estimates from curves contained in application note AN-29. TOP247 to TOP249: Higher output voltages used with a maximum output current of 6 A.

For all devices a 100 VDC minimum for 85-265 VAC and 250 VDC minimum for 230 VDC are assumed and sufficient heat sinking to keep device temperature ≤ 100 °C. Power levels shown in the power table for the R package device assume 6.45 cm² of 610 g/m² copper heat sink area in an enclosed adapter, or 19.4 cm² in an open frame.

TOPSwitch-GX Selection

Selecting the optimum TOPSwitch-GX depends upon required maximum output power, efficiency, heat sinking constraints and cost goals. With the option to externally reduce current limit, a larger TOPSwitch-GX may be used for lower power

applications where higher efficiency is needed or minimal heat sinking is available.

Input Capacitor

The input capacitor must be chosen to provide the minimum DC voltage required for the TOPSwitch-GX converter to maintain regulation at the lowest specified input voltage and maximum output power. Since TOPSwitch-GX has a higher DC_{MAX} than TOPSwitch-II, it is possible to use a smaller input capacitor. For TOPSwitch-GX, a capacitance of 2 μ F per watt is possible for universal input with an appropriately designed transformer.

Primary Clamp and Output Reflected Voltage V_{OR}

A primary clamp is necessary to limit the peak TOPSwitch-GX drain to source voltage. A Zener clamp requires few parts and takes up little board space. For good efficiency, the clamp Zener should be selected to be at least 1.5 times the output reflected voltage V_{OR} as this keeps the leakage spike conduction time short. When using a Zener clamp in a universal input application, a V_{OR} of less than 135 V is recommended to allow for the absolute tolerances and temperature variations of the Zener. This will ensure efficient operation of the clamp circuit and will also keep the maximum drain voltage below the rated breakdown voltage of the TOPSwitch-GX MOSFET.



A high V_{OR} is required to take full advantage of the wider DC_{MAX} of *TOPSwitch-GX*. An RCD clamp provides tighter clamp voltage tolerance than a Zener clamp and allows a V_{OR} as high as 150 V. RCD clamp dissipation can be minimized by reducing the external current limit as a function of input line voltage (see Figure 21 and 35). The RCD clamp is more cost effective than the Zener clamp but requires more careful design (see quick design checklist).

Output Diode

The output diode is selected for peak inverse voltage, output current, and thermal conditions in the application (including heatsinking, air circulation, etc.). The higher DC_{MAX} of *TOPSwitch-GX* along with an appropriate transformer turns ratio can allow the use of a 60 V Schottky diode for higher efficiency on output voltages as high as 15 V (see Figure 41. A 12 V, 30 W design using a 60 V Schottky for the output diode).

Bias Winding Capacitor

Due to the low frequency operation at no-load a 1 μ F bias winding capacitor is recommended.

Soft-Start

Generally a power supply experiences maximum stress at start-up before the feedback loop achieves regulation. For a period of 10 ms the on-chip soft-start linearly increases the duty cycle from zero to the default DC_{MAX} at turn on. In addition, the primary current limit increases from 85% to 100% over the same period. This causes the output voltage to rise in an orderly manner allowing time for the feedback loop to take control of the duty cycle. This reduces the stress on the *TOPSwitch-GX* MOSFET, clamp circuit and output diode(s), and helps prevent transformer saturation during start-up. Also soft-start limits the amount of output voltage overshoot, and in many applications eliminates the need for a soft-finish capacitor.

EMI

The frequency jitter feature modulates the switching frequency over a narrow band as a means to reduce conducted EMI peaks associated with the harmonics of the fundamental switching frequency. This is particularly beneficial for average detection mode. As can be seen in Figure 46, the benefits of jitter increase with the order of the switching harmonic due to an increase in frequency deviation.

The FREQUENCY pin of *TOPSwitch-GX* offers a switching frequency option of 132 kHz or 66 kHz. In applications that require heavy snubbers on the drain node for reducing high frequency radiated noise (for example, video noise sensitive applications such as VCR, DVD, monitor, TV, etc.), operating at 66 kHz will reduce snubber loss resulting in better efficiency. Also, in applications where transformer size is not a concern, use of the 66 kHz option will provide lower EMI and higher efficiency. Note that the second harmonic of 66 kHz is still below 150 kHz, above which the conducted EMI specifications get much tighter.

For 10 W or below, it is possible to use a simple inductor in place of a more costly AC input common mode choke to meet worldwide conducted EMI limits.

Transformer Design

It is recommended that the transformer be designed for maximum operating flux density of 3000 Gauss and a peak flux density of 4200 Gauss at maximum current limit. The turns ratio should be chosen for a reflected voltage (V_{OR}) no greater than 135 V when using a Zener clamp, or 150 V (max) when using RCD clamp with current limit reduction with line voltage (overload protection).

For designs where operating current is significantly lower than the default current limit, it is recommended to use an externally set current limit close to the operating peak current to reduce peak flux density and peak power (see Figure 20 and 34). In most applications, the tighter current limit tolerance, higher

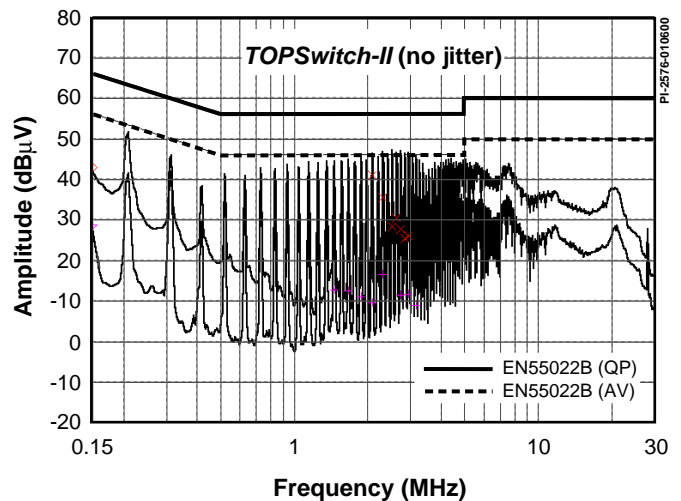


Figure 46a. *TOPSwitch-II* Full Range EMI Scan (100 kHz, no jitter)

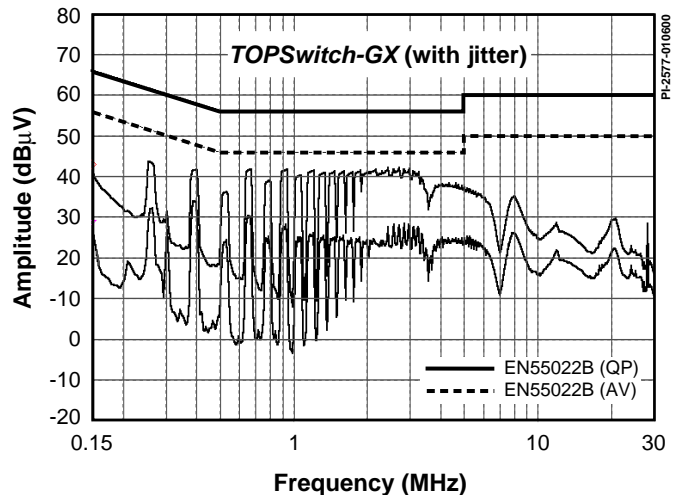


Figure 46b. *TOPSwitch-GX* Full Range EMI Scan (132 kHz, with jitter) with Identical Circuitry and Conditions.



switching frequency and soft-start features of *TOPSwitch-GX* contribute to a smaller transformer when compared to *TOPSwitch-II*.

Standby Consumption

Frequency reduction can significantly reduce power loss at light or no load, especially when a Zener clamp is used. For very low secondary power consumption use a TL431 regulator for feedback control. Alternately, switching losses can be significantly reduced by changing from 132 kHz in normal operation to 66 kHz under light load conditions.

TOPSwitch-GX Layout Considerations

As *TOPSwitch-GX* has additional pins and operates at much higher power levels compared to previous *TOPSwitch* families, the following guidelines should be carefully followed.

Primary Side Connections

Use a single point (Kelvin) connection at the negative terminal of the input filter capacitor for *TOPSwitch-GX* source pin and bias winding return. This improves surge capabilities by returning surge currents from the bias winding directly to the input filter capacitor.

The CONTROL pin bypass capacitor should be located as close as possible to the SOURCE and CONTROL pins and its SOURCE connection trace should not be shared by the main MOSFET switching currents. All SOURCE pin referenced components connected to the MULTI-FUNCTION, LINE-SENSE or EXTERNAL CURRENT LIMIT pins should also be located closely between their respective pin and SOURCE. Once again the SOURCE connection trace of these components should not be shared by the main MOSFET switching currents. It is very critical that SOURCE pin switching currents are returned to the input capacitor negative terminal through a separate trace that is not shared by the components connected to CONTROL, MULTI-FUNCTION, LINE-SENSE or EXTERNAL CURRENT LIMIT pins. This is because the SOURCE pin is also the controller ground reference pin.

Any traces to the M, L or X pins should be kept as short as possible and away from the DRAIN trace to prevent noise coupling. LINE-SENSE resistor (R1 in figures 47-49) should be located close to the M or L pin to minimize the trace length on the M or L pin side.

In addition to the 47 μ F CONTROL pin capacitor, a high frequency bypass capacitor in parallel may be used for better noise immunity. The feedback optocoupler output should also be located close to the CONTROL and SOURCE pins of *TOPSwitch-GX*.

Y-Capacitor

The Y-capacitor should be connected close to the secondary output return pin(s) and the positive primary DC input pin of the transformer.

Heat Sinking

The tab of the Y package (TO-220) is internally electrically tied to the SOURCE pin. To avoid circulating currents, a heat sink attached to the tab should not be electrically tied to any primary ground/source nodes on the PC board.

When using a P (DIP-8), G (SMD-8) or R (TO-263) package, a copper area underneath the package connected to the SOURCE pins will act as an effective heat sink. On double sided boards (Figure 49), top side and bottom side areas connected with vias can be used to increase the effective heat sinking area.

In addition, sufficient copper area should be provided at the anode and cathode leads of the output diode(s) for heat sinking.

In Figures 47, 48 and 49 a narrow trace is shown between the output rectifier and output filter capacitor. This trace acts as a thermal relief between the rectifier and filter capacitor to prevent excessive heating of the capacitor.

Quick Design Checklist

As with any power supply design, all *TOPSwitch-GX* designs should be verified on the bench to make sure that components specifications are not exceeded under worst case conditions. The following minimum set of tests is strongly recommended:

1. Maximum drain voltage – Verify that peak V_{DS} does not exceed 675 V at highest input voltage and maximum overload output power. Maximum overload output power occurs when the output is overloaded to a level just before the power supply goes into auto-restart (loss of regulation).
2. Maximum drain current – At maximum ambient temperature, maximum input voltage and maximum output load, verify drain current waveforms at start-up for any signs of transformer saturation and excessive leading edge current spikes. *TOPSwitch-GX* has a leading edge blanking time of 220 ns to prevent premature termination of the on-cycle. Verify that the leading edge current spike is below the allowed current limit envelope (see Figure 52) for the drain current waveform at the end of the 220 ns blanking period.
3. Thermal check – At maximum output power, minimum input voltage and maximum ambient temperature, verify that temperature specifications are not exceeded for *TOPSwitch-GX*, transformer, output diodes and output capacitors. Enough thermal margin should be allowed for



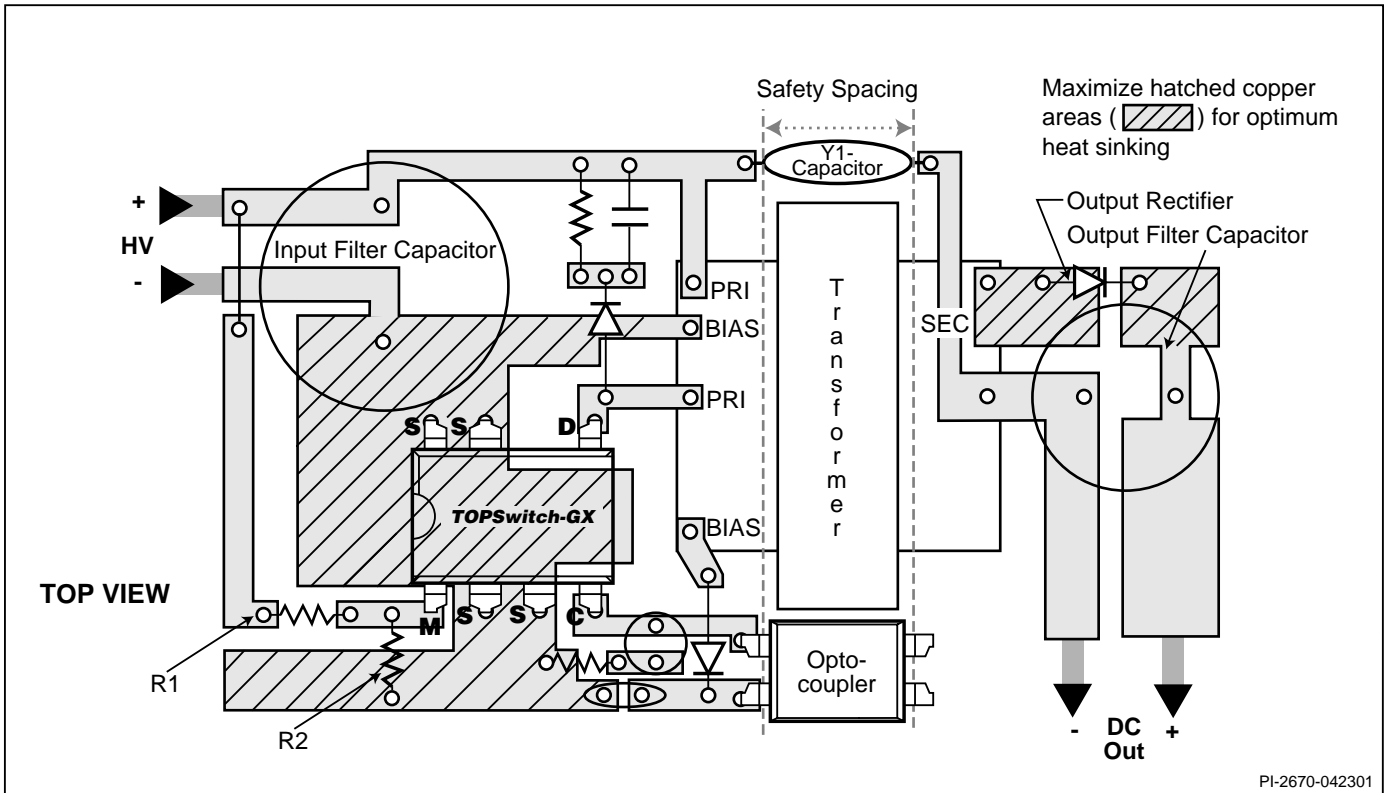


Figure 47. Layout Considerations for TOPSwitch-GX using P or G Packages.

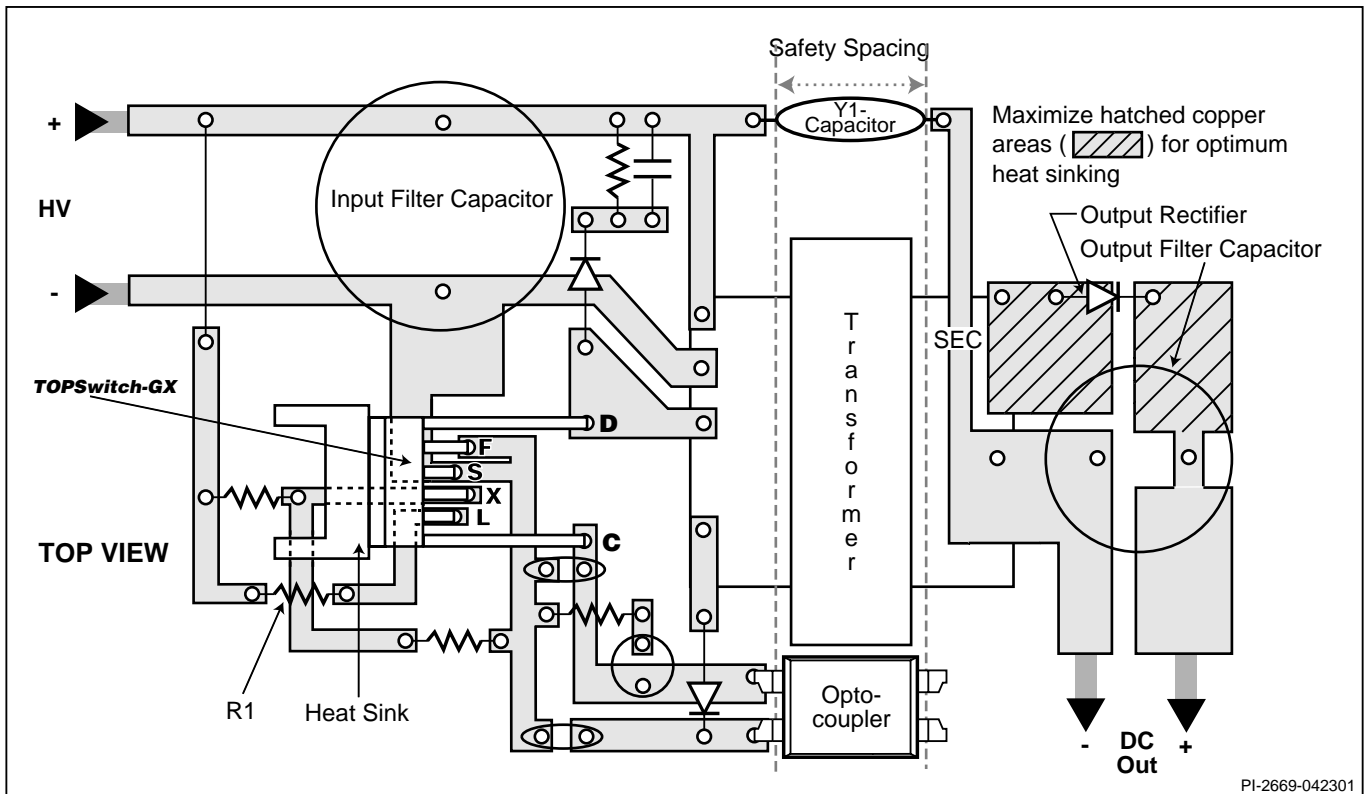


Figure 48. Layout Considerations for TOPSwitch-GX using Y Package.



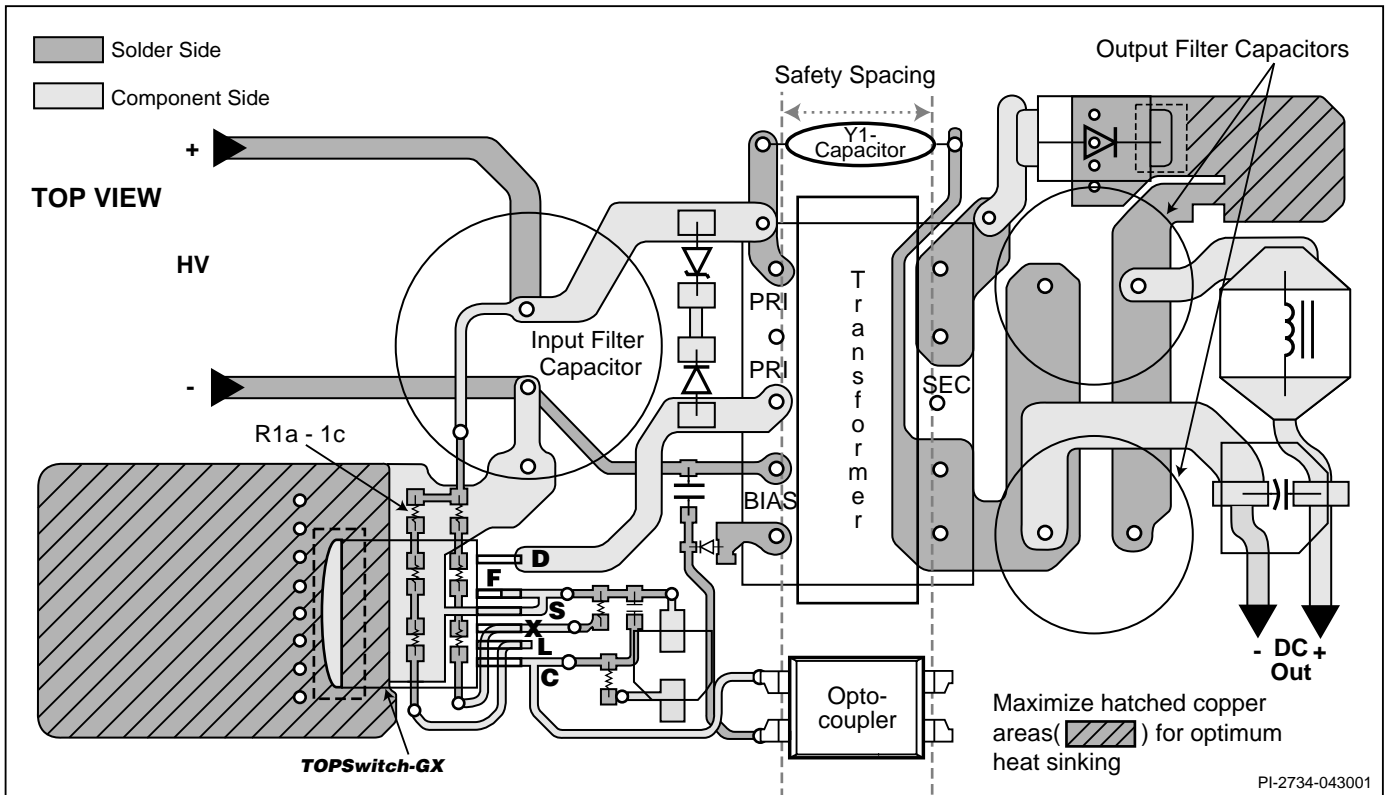


Figure 49. Layout Considerations for TOPSwitch-GX using R Package.

the part-to-part variation of the $R_{DS(ON)}$ of TOPSwitch-GX as specified in the data sheet. The margin required can either be calculated from the tolerances or it can be accounted for by connecting an external resistance in series with the DRAIN pin and attached to the same heatsink, having a resistance value that is equal to the difference between the measured $R_{DS(ON)}$ of the device under test and the worst case maximum specification.

Design Tools

Up to date information on design tools can be found at the Power Integrations Web site: www.powerint.com



ABSOLUTE MAXIMUM RATINGS⁽¹⁾

DRAIN Voltage	-0.3 to 700 V	LINE SENSE Pin Voltage	-0.3 to 9 V
DRAIN Peak Current: TOP242	0.72 A	CURRENT LIMIT Pin Voltage	-0.3 to 4.5 V
TOP243	1.44 A	MULTI-FUNCTION Pin Voltage	-0.3 to 9 V
TOP244	2.16 A	FREQUENCY Pin Voltage	-0.3 to 9 V
TOP245	2.88 A	Storage Temperature	-65 to 150 °C
TOP246	4.32 A	Operating Junction Temperature ⁽²⁾	-40 to 150 °C
TOP247	5.76 A	Lead Temperature ⁽³⁾	260 °C
TOP248	7.20 A		
TOP249	8.64 A	Notes:	
CONTROL Voltage	-0.3 to 9 V	1. All voltages referenced to SOURCE, T _A = 25 °C.	
CONTROL Current	100 mA	2. Normally limited by internal circuitry.	
		3. 1/16" from case for 5 seconds.	

THERMAL IMPEDANCE

Thermal Impedance: Y Package (θ _{JA}) ⁽¹⁾	70 °C/W	Notes:
(θ _{JC}) ⁽²⁾	2 °C/W	1. Free standing with no heatsink.
P or G Package:		2. Measured at the back surface of tab.
(θ _{JA})	45 °C/W ⁽³⁾ ; 35 °C/W ⁽⁴⁾	3. Soldered to 0.36 sq. inch (232 mm ²), 2oz. (610 gm/m ²) copper clad.
(θ _{JC}) ⁽⁵⁾	11 °C/W	4. Soldered to 1 sq. inch (645 mm ²), 2oz. (610 gm/m ²) copper clad.
		5. Measured on the SOURCE pin close to plastic interface.

Parameter	Symbol	Conditions (Unless Otherwise Specified) See Figure 53 SOURCE = 0 V; T _J = -40 to 125 °C	Min	Typ	Max	Units

CONTROL FUNCTIONS

Switching Frequency (average)	f _{OSC}	I _C = 3 mA; T _J = 25 °C	FREQUENCY Pin Connected to SOURCE	124	132	140	kHz
			FREQUENCY Pin Connected to CONTROL	61.5	66	70.5	
Duty Cycle at ONSET of Frequency Reduction	DC _(ONSET)			10			%
Switching Frequency near 0% Duty Cycle	f _{OSC (DMIN)}		132 kHz Operation		30		kHz
			66 kHz Operation		15		
Frequency Jitter Deviation	Δf		132 kHz Operation		± 4		kHz
			66 kHz Operation		± 2		
Frequency Jitter Modulation Rate	f _M			250			Hz
Maximum Duty Cycle	DC _{MAX}	I _C = I _{CD1}	I _L ≤ I _{L(DC)} or I _M ≤ I _{M(DC)}	75	78	83	%
			I _L or I _M = 190 μA	28	38	50	
Soft Start Time	t _{SOFT}	T _J = 25 °C; DC _{MIN} to DC _{MAX}		10	15		ms



Parameter	Symbol	Conditions (Unless Otherwise Specified) See Figure 53 SOURCE = 0 V; T _J = -40 to 125 °C		Min	Typ	Max	Units
CONTROL FUNCTIONS (cont.)							
PWM Gain	DC _{reg}	I _C = 4 mA; T _J = 25 °C		-28	-23	-18	%/mA
PWM Gain Temperature Drift		See Note A			-0.01		%/mA/°C
External Bias Current	I _B	See Figure 7	TOP242-245	1.2	2.0	3.0	mA
			TOP246-249	1.6	2.6	4.0	
CONTROL Current at 0% Duty Cycle	IC(OFF)	T _J = 25 °C	TOP242-245		6.0	7.0	mA
			TOP246-249		6.6	8.0	
Dynamic Impedance	Z _C	I _C = 4 mA; T _J = 25 °C See Figure 51		10	15	22	Ω
Dynamic Impedance Temperature Drift					0.18		%/°C
Control Pin Internal Filter Pole					7		kHz
SHUTDOWN/AUTO-RESTART							
Control Pin Charging Current	I _{C(CH)}	T _J = 25 °C	V _C = 0 V	-5.0	-3.5	-2.0	mA
			V _C = 5 V	-3.0	-1.8	-0.6	
Charging Current Temperature Drift		See Note A			0.5		%/°C
Auto-restart Upper Threshold Voltage	V _{C(AR)U}				5.8		V
Auto-restart Lower Threshold Voltage	V _{C(AR)L}			4.5	4.8	5.1	V
Auto-restart Hysteresis Voltage	V _{C(AR)hyst}			0.8	1.0		V
Auto-restart Duty Cycle	DC _(AR)				4	8	%
Auto-restart Frequency	f _(AR)				1.0		Hz



Parameter	Symbol	Conditions (Unless Otherwise Specified) See Figure 53 SOURCE = 0 V; $T_J = -40$ to 125 °C		Min	Typ	Max	Units
MULTI-FUNCTION (M), LINE-SENSE (L) AND EXTERNAL CURRENT LIMIT (X) INPUTS							
Line Under-Voltage Threshold Current and Hysteresis (M or L Pin)	I_{UV}	$T_J = 25$ °C	Threshold	44	50	54	μ A
			Hysteresis		30		μ A
Line Over-Voltage or Remote ON/OFF Threshold Current and Hysteresis (M or L Pin)	I_{OV}	$T_J = 25$ °C	Threshold	210	225	240	μ A
			Hysteresis		8		μ A
L Pin Voltage Threshold	$V_{L(TH)}$			0.5	1.0	1.6	V
Remote ON/OFF Negative Threshold Current and Hysteresis (M or X Pin)	$I_{REM(N)}$	$T_J = 25$ °C	Threshold	-35	-27	-20	μ A
			Hysteresis		5		μ A
L or M Pin Short Circuit Current	$I_{L(SC)}$ or $I_{M(SC)}$	$V_L, V_M = V_C$		300	400	520	μ A
X or M Pin Short Circuit Current	$I_{X(SC)}$ or $I_{M(SC)}$	$V_X, V_M = 0$ V	Normal Mode	-300	-240	-180	μ A
			Auto-restart Mode	-110	-90	-70	
L or M Pin Voltage (Positive Current)	V_L, V_M		I_L or $I_M = 50$ μ A	1.90	2.50	3.00	V
			I_L or $I_M = 225$ μ A	2.30	2.90	3.30	
X Pin Voltage (Negative Current)	V_X		$I_X = -50$ μ A	1.26	1.33	1.40	V
			$I_X = -150$ μ A	1.18	1.24	1.30	
M Pin Voltage (Negative Current)	V_M		$I_M = -50$ μ A	1.24	1.31	1.39	V
			$I_M = -150$ μ A	1.13	1.19	1.25	
Maximum Duty Cycle Reduction Onset Threshold Current	$I_{L(DC)}$ or $I_{M(DC)}$	$T_J = 25$ °C		40	60	75	μ A
Maximum Duty Cycle Reduction Slope		$I_L > I_{L(DC)}$ or $I_M > I_{M(DC)}$			0.25		%/ μ A
Remote OFF DRAIN Supply Current	$I_{D(RMT)}$	See Figure 70 $V_{DRAIN} = 150$ V $T_J = 25$ °C	X, L or M Pin Floating		0.6	1.0	mA
			L or M Pin Shorted to CONTROL		1.0	1.6	



Parameter	Symbol	Conditions (Unless Otherwise Specified) See Figure 53 SOURCE = 0 V; T _J = -40 to 125 °C		Min	Typ	Max	Units
MULTI-FUNCTION (M), LINE-SENSE (L) AND CURRENT LIMIT (I) INPUTS (cont)							
Remote ON Delay	t _{R(ON)}	From Remote On to Drain Turn-On See Note B			2.5		μs
Remote OFF Setup Time	t _{R(OFF)}	Minimum Time Before Drain Turn-On to Disable Cycle See Note B			2.5		μs
FREQUENCY INPUT							
FREQUENCY Pin Threshold Voltage	V _F	See Note B			2.9		V
FREQUENCY Pin Input Current	I _F	V _F = V _C		10	40	100	μA
CIRCUIT PROTECTION							
Self Protection Current Limit	I _{LIMIT}	TOP242 P/G TOP242 Y/R T _J = 25 °C	Internal; di/dt=90 mA/μs See Note C	0.418	0.45	0.481	A
		TOP243 P/G T _J = 25 °C	Internal; di/dt=150 mA/μs See Note C	0.697	0.75	0.802	
		TOP243 Y/R T _J = 25 °C	Internal; di/dt=180 mA/μs See Note C	0.837	0.90	0.963	
		TOP244 P/G T _J = 25 °C	Internal; di/dt=200 mA/μs See Note C	0.930	1.00	1.070	
		TOP244 Y/R T _J = 25 °C	Internal; di/dt=270 mA/μs See Note C	1.256	1.35	1.445	
		TOP245 Y/R T _J = 25 °C	Internal; di/dt=360 mA/μs See Note C	1.674	1.80	1.926	
		TOP246 Y/R T _J = 25 °C	Internal; di/dt=540 mA/μs See Note C	2.511	2.70	2.889	
		TOP247 Y/R T _J = 25 °C	Internal; di/dt=720 mA/μs See Note C	3.348	3.60	3.852	
		TOP248 Y/R T _J = 25 °C	Internal; di/dt=900 mA/μs See Note C	4.185	4.50	4.815	
		TOP249 Y/R T _J = 25 °C	Internal; di/dt=1080 mA/μs See Note C	5.022	5.40	5.778	
Initial Current Limit	I _{INIT}	See Note B	≤ 85 VAC (Rectified Line Input)	0.75 x I _{LIMIT(MIN)}			A
			265 VAC (Rectified Line Input)	0.6 x I _{LIMIT(MIN)}			
Leading Edge Blanking Time	t _{LEB}	See Fig. 52 T _J = 25 °C	I _C = 4 mA		220		ns



Parameter	Symbol	Conditions		Min	Typ	Max	Units
		(Unless Otherwise Specified) See Figure 53 SOURCE = 0 V; T _J = -40 to 125 °C					
CIRCUIT PROTECTION (cont)							
Current Limit Delay	t _{IL(D)}	I _C = 4 mA			100		ns
Thermal Shutdown Temperature				130	140	150	°C
Thermal Shutdown Hysteresis					75		°C
Power-up Reset Threshold Voltage	V _{C(RESET)}	Figure 53, S1 Open		1.75	3.0	4.25	V
OUTPUT							
ON-State Resistance	R _{DS(ON)}	TOP242 I _D = 50 mA	T _J = 25 °C		15.6	18.0	Ω
			T _J = 100 °C		25.7	30.0	
		TOP243 I _D = 100 mA	T _J = 25 °C		7.80	9.00	
			T _J = 100 °C		12.9	15.0	
		TOP244 I _D = 150 mA	T _J = 25 °C		5.20	6.00	
			T _J = 100 °C		8.60	10.0	
		TOP245 I _D = 200 mA	T _J = 25 °C		3.90	4.50	
			T _J = 100 °C		6.45	7.50	
		TOP246 I _D = 300 mA	T _J = 25 °C		2.60	3.00	
			T _J = 100 °C		4.30	5.00	
		TOP247 I _D = 400 mA	T _J = 25 °C		1.95	2.25	
			T _J = 100 °C		3.22	3.75	
		TOP248 I _D = 500 mA	T _J = 25 °C		1.56	1.80	
			T _J = 100 °C		2.58	3.00	
		TOP249 I _D = 600 mA	T _J = 25 °C		1.30	1.50	
			T _J = 100 °C		2.15	2.50	
Off-State Current	I _{DSS}	V _L , V _M = Floating; I _C = 4mA V _{DS} = 560 V; T _J = 125 °C				400	μA
Breakdown Voltage	BV _{DSS}	V _L , V _M = Floating; I _C = 4mA I _D = 100 μA; T _J = 25 °C		700			V
Rise Time	t _R	Measured in a Typical Flyback Converter Application			100		ns
Fall Time	t _F				50		ns



Parameter	Symbol	Conditions		Min	Typ	Max	Units
		(Unless Otherwise Specified) See Figure 53 SOURCE = 0 V; $T_J = -40$ to 125 °C					
SUPPLY VOLTAGE CHARACTERISTICS							
DRAIN Supply Voltage		See Note D		36			V
Shunt Regulator Voltage	$V_{C(SHUNT)}$	$I_C = 4$ mA		5.60	5.85	6.10	V
Shunt Regulator Temperature Drift					±50		ppm/°C
Control Supply/ Discharge Current	I_{CD1}	Output MOSFET Enabled $V_L, V_M = 0$ V	TOP 242-245	1.0	1.6	2.5	mA
			TOP 246-249	1.2	2.2	3.2	
	I_{CD2}	Output MOSFET Disabled $V_L, V_M = 0$ V		0.3	0.6	1.3	

NOTES:

- A. For specifications with negative values, a negative temperature coefficient corresponds to an increase in magnitude with increasing temperature, and a positive temperature coefficient corresponds to a decrease in magnitude with increasing temperature.
- B. Guaranteed by characterization. Not tested in production.
- C. For externally adjusted current limit values, please refer to Figure 55 (Current Limit vs. External Current Limit Resistance) in the Typical Performance Characteristics section.
- D. It is possible to start up and operate *TOPSwitch-GX* at DRAIN voltages well below 36 V. However, the CONTROL pin charging current is reduced, which affects start-up time, auto-restart frequency, and auto-restart duty cycle. Refer to Figure 67, the characteristic graph on CONTROL pin charge current (I_C) vs. DRAIN voltage for low voltage operation characteristics.



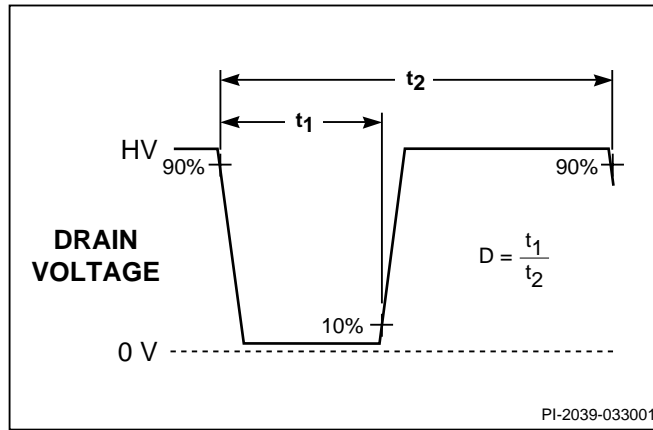


Figure 50. Duty Cycle Measurement.

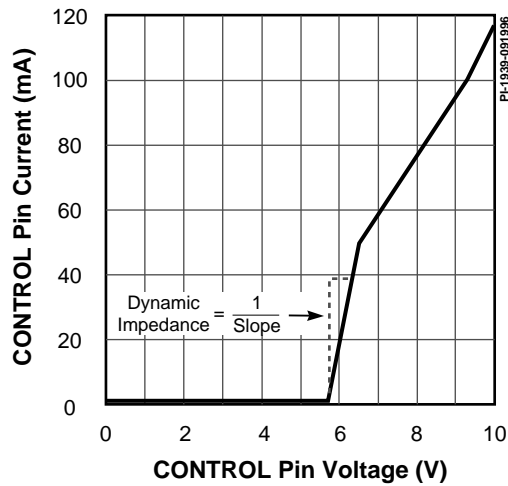


Figure 51. CONTROL Pin I-V Characteristic.

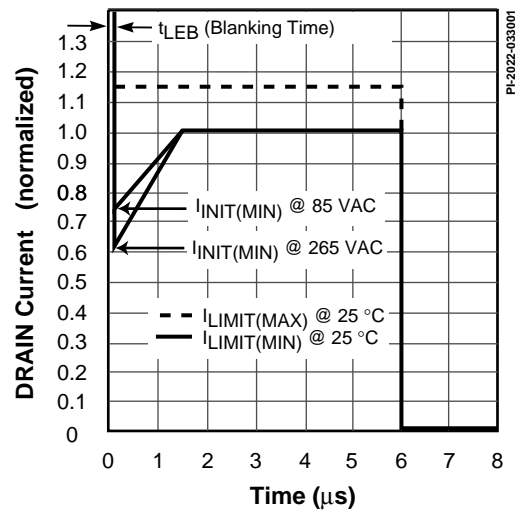


Figure 52. Drain Current Operating Envelope.

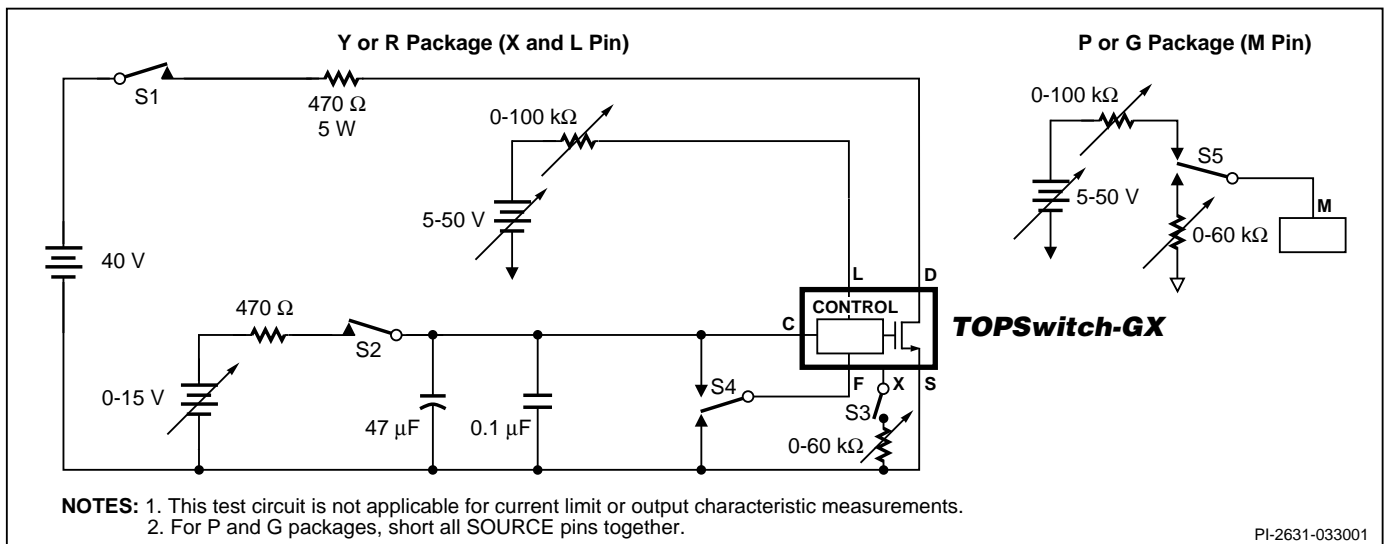


Figure 53. TOPSwitch-GX General Test Circuit.



BENCH TEST PRECAUTIONS FOR EVALUATION OF ELECTRICAL CHARACTERISTICS

The following precautions should be followed when testing *TOPSwitch-GX* by itself outside of a power supply. The schematic shown in Figure 53 is suggested for laboratory testing of *TOPSwitch-GX*.

When the DRAIN pin supply is turned on, the part will be in the auto-restart mode. The CONTROL pin voltage will be oscillating at a low frequency between 4.8 and 5.8 V and the drain is turned on every eighth cycle of the CONTROL pin oscillation. If the CONTROL pin power supply is turned on while in this auto-

restart mode, there is only a 12.5% chance that the CONTROL pin oscillation will be in the correct state (drain active state) so that the continuous drain voltage waveform may be observed. It is recommended that the V_C power supply be turned on first and the DRAIN pin power supply second if continuous drain voltage waveforms are to be observed. The 12.5% chance of being in the correct state is due to the divide-by-8 counter. Temporarily shorting the CONTROL pin to the SOURCE pin will reset *TOPSwitch-GX*, which then will come up in the correct state.

Typical Performance Characteristics

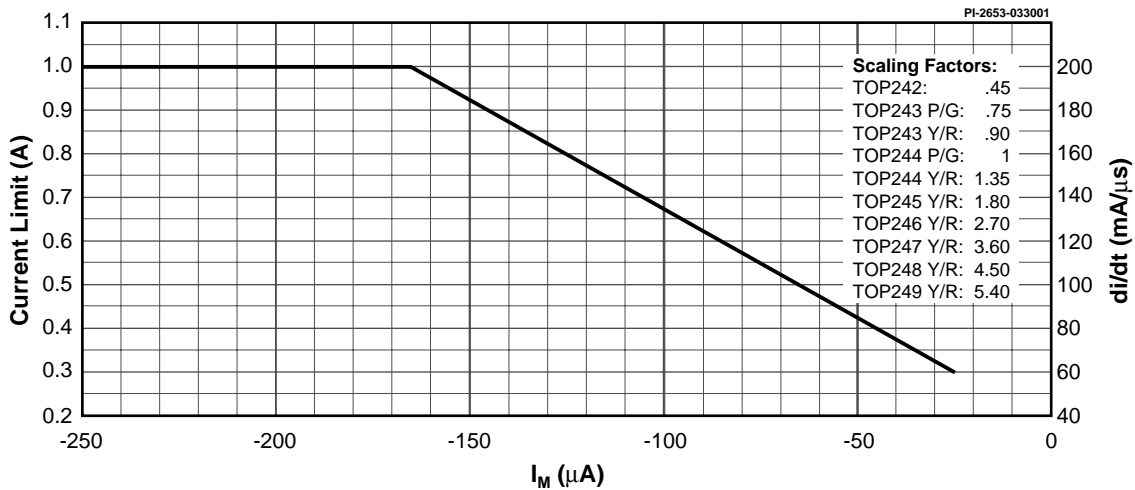


Figure 54. Current Limit vs. MULTI-FUNCTION Pin Current.

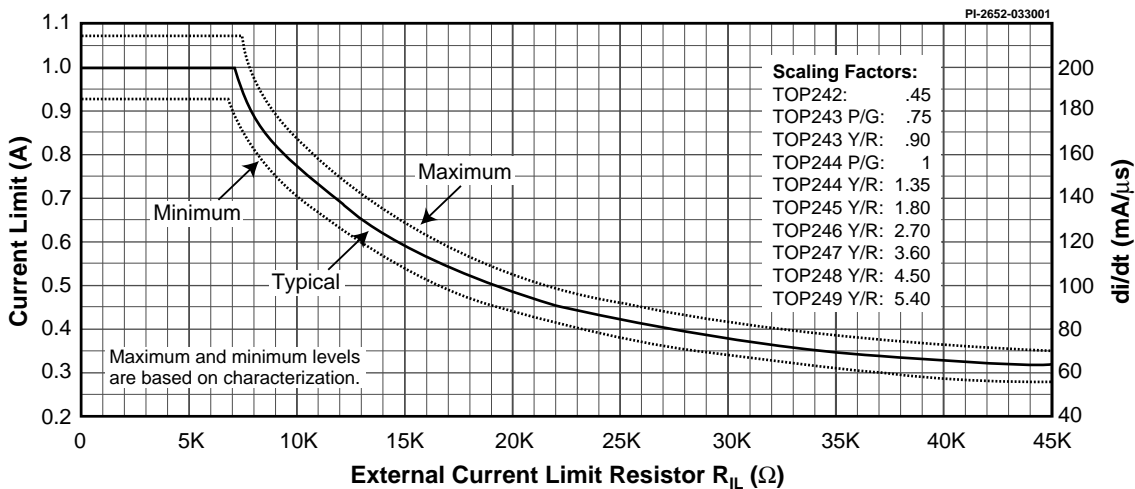


Figure 55. Current Limit vs. External Current Limit Resistance.



Typical Performance Characteristics (cont.)

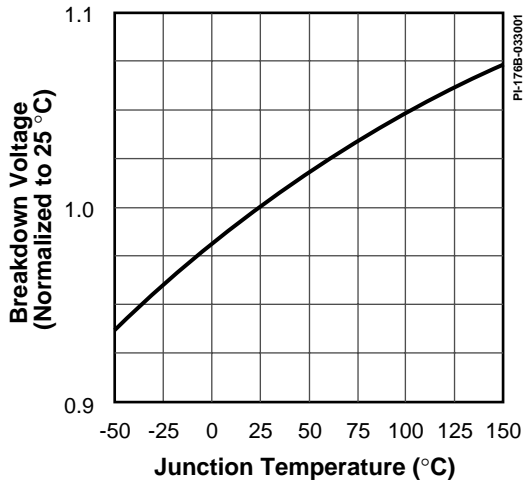


Figure 56. Breakdown Voltage vs. Temperature.

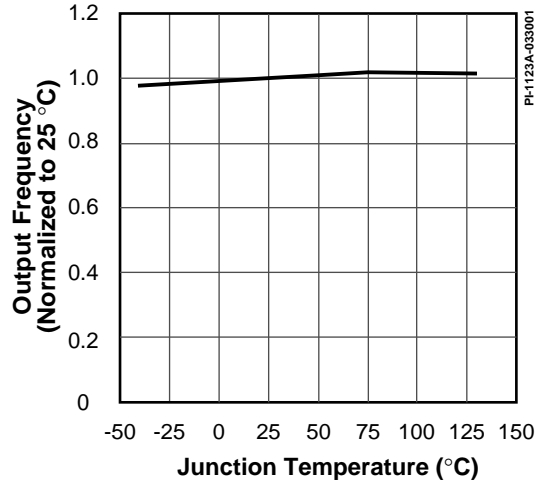


Figure 57. Frequency vs. Temperature.

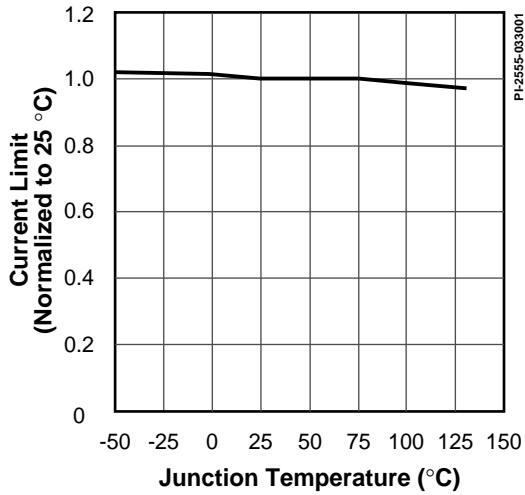


Figure 58. Internal Current Limit vs. Temperature.

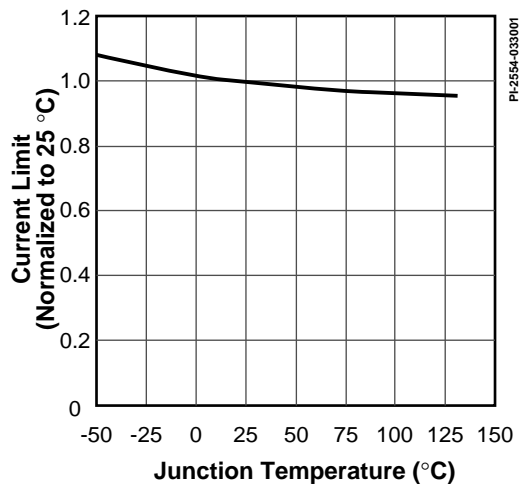


Figure 59. External Current Limit vs. Temperature with $R_{IL} = 12\text{ k}\Omega$.

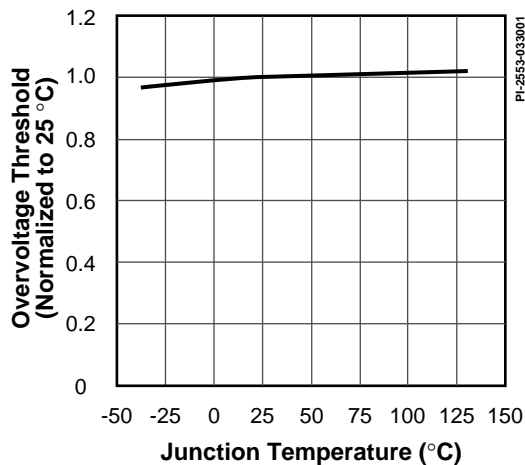


Figure 60. Overvoltage Threshold vs. Temperature.

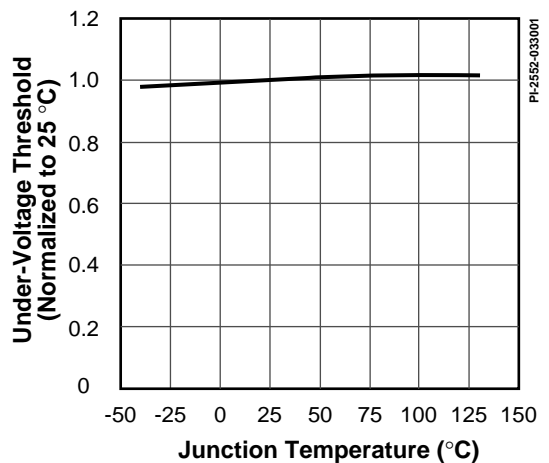


Figure 61. Under-Voltage Threshold vs. Temperature.



Typical Performance Characteristics (cont.)

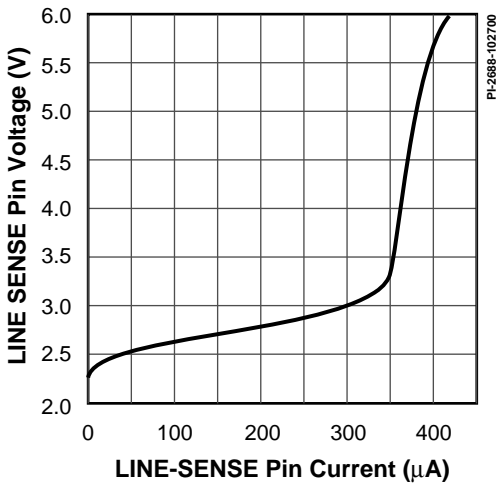


Figure 62a. LINE-SENSE Pin Voltage vs. Current.

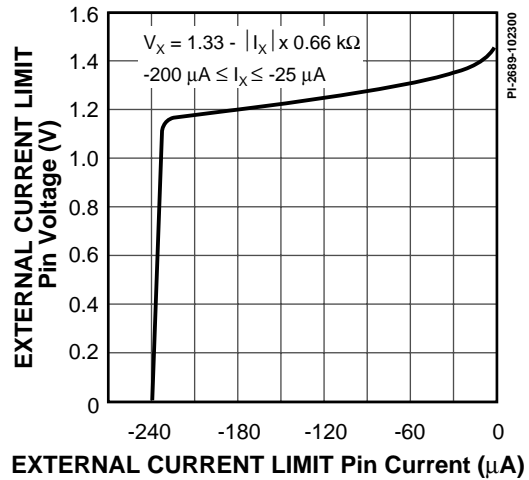


Figure 62b. EXTERNAL CURRENT LIMIT Pin Voltage vs. Current.

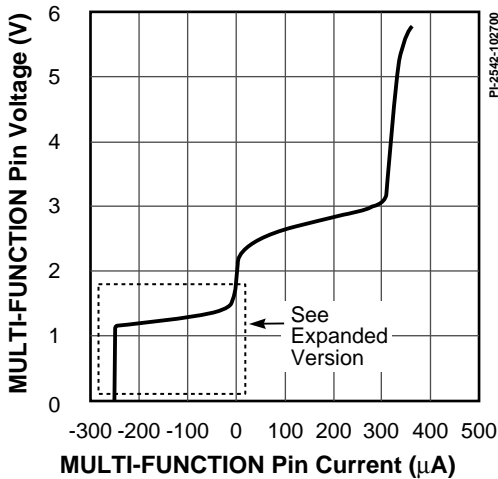


Figure 63a. MULTI-FUNCTION Pin Voltage vs. Current.

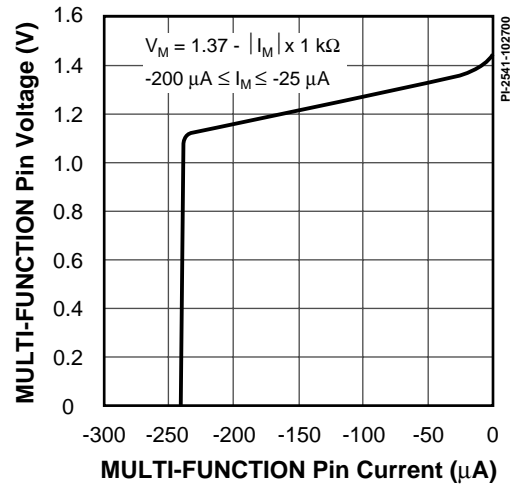


Figure 63b. MULTI-FUNCTION Pin Voltage vs. Current (Expanded).

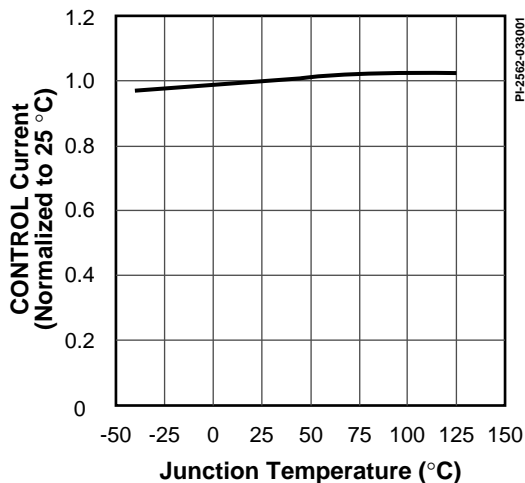


Figure 64. Control Current Out at 0% Duty Cycle vs. Temperature.

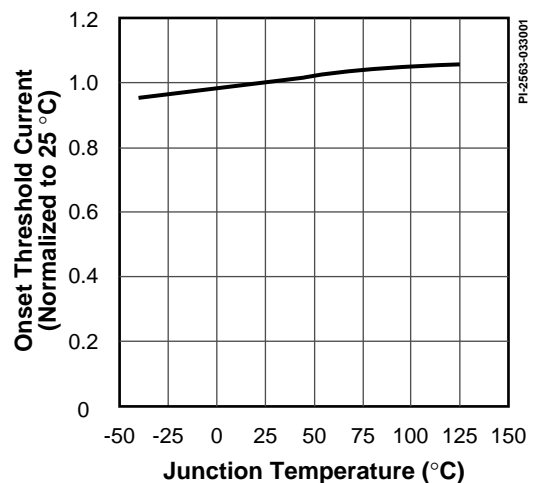


Figure 65. Max. Duty Cycle Reduction Onset Threshold Current vs. Temperature.



Typical Performance Characteristics (cont.)

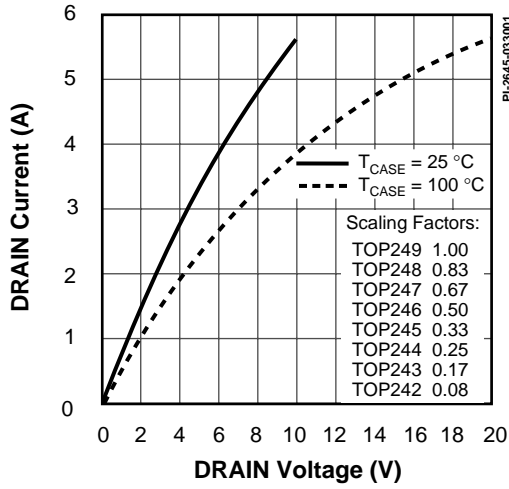


Figure 66. Output Characteristics.

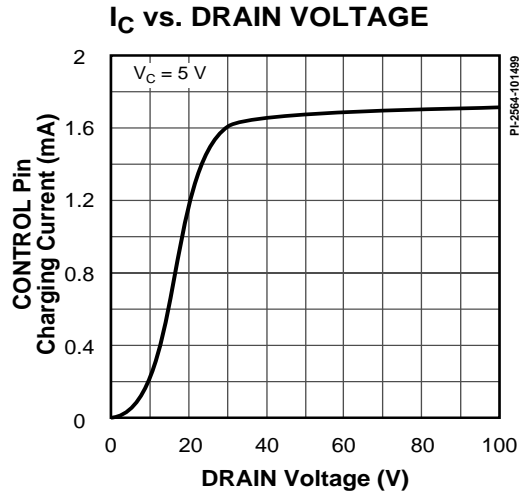


Figure 67. I_C vs. DRAIN Voltage.

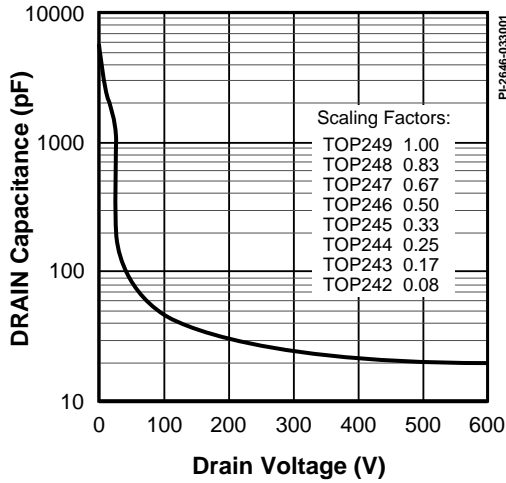


Figure 68. C_{OSS} vs. DRAIN Voltage.

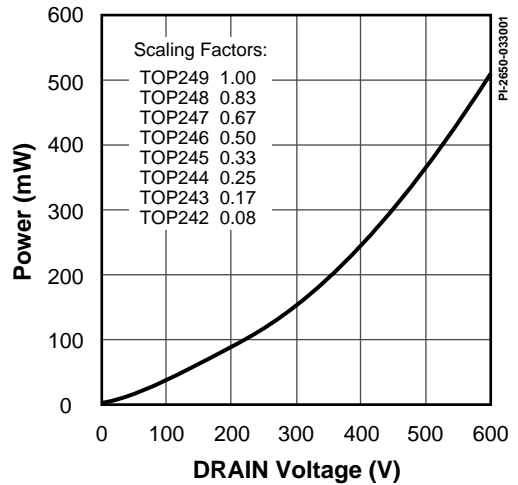


Figure 69. DRAIN Capacitance Power.

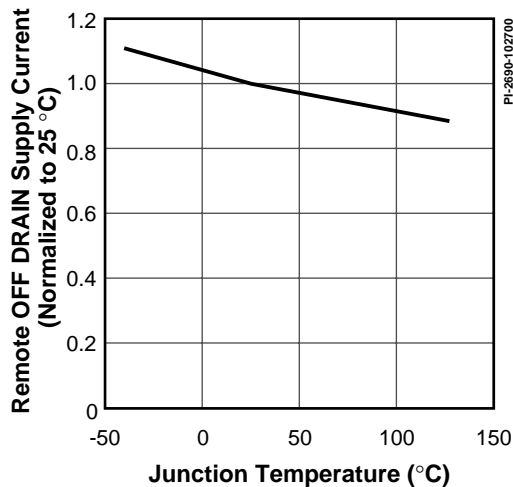
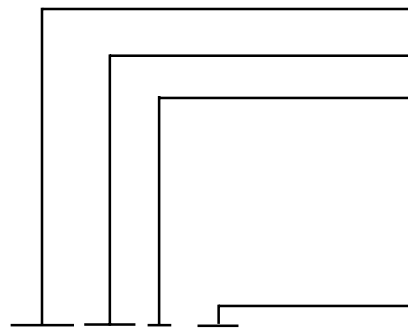


Figure 70. Remote OFF DRAIN Supply Current vs. Temperature.



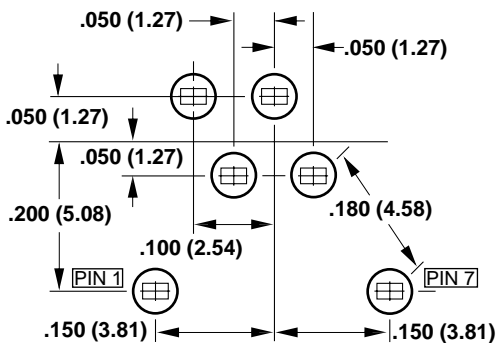
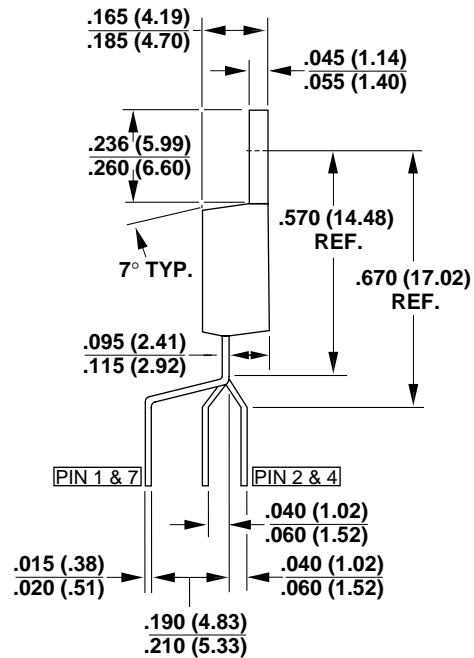
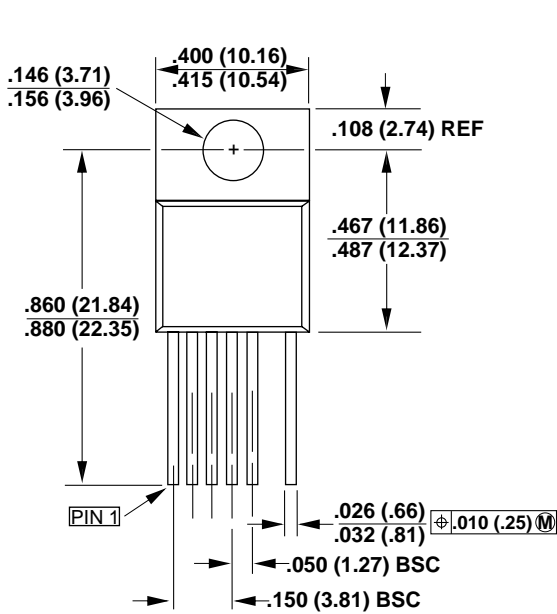
PART ORDERING INFORMATION



TOP 242 G - TL

TOPSwitch Product Family		
GX Series Number		
Package Identifier		
G	Plastic Surface Mount DIP	(242, 243 & 244 only)
P	Plastic DIP	
Y	Plastic TO-220-7C	
R	Plastic TO-263-7C (available only with TL option)	
Package/Lead Options		
Blank	Standard Configurations	
TL	Tape & Reel, (G Package: 1 k min., R Package: 750 min.)	

TO-220-7C



Y07C

MOUNTING HOLE PATTERN

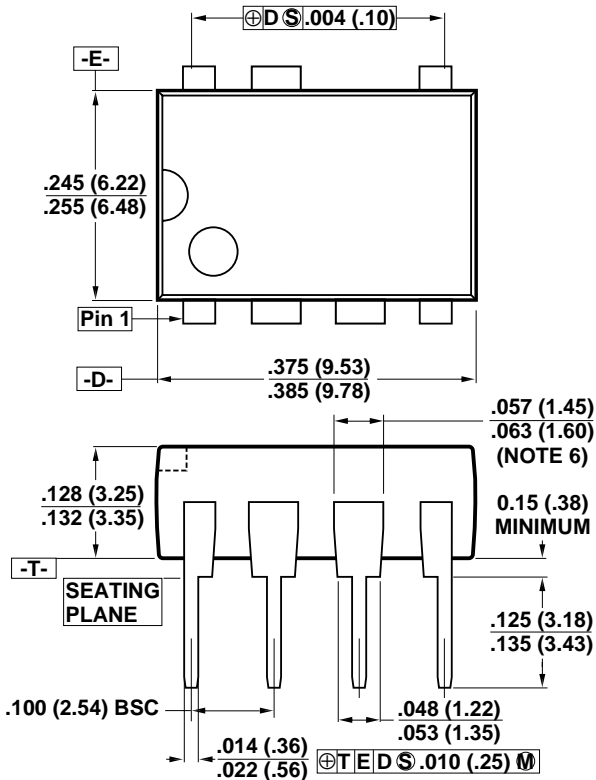
Notes:

1. Controlling dimensions are inches. Millimeter dimensions are shown in parentheses.
2. Pin numbers start with Pin 1, and continue from left to right when viewed from the front.
3. Dimensions do not include mold flash or other protrusions. Mold flash or protrusions shall not exceed .006 (.15mm) on any side.
4. Minimum metal to metal spacing at the package body for omitted pin locations is .068 inch (1.73 mm).
5. Position of terminals to be measured at a location .25 (6.35) below the package body.
6. All terminals are solder plated.

PI-2644-040501

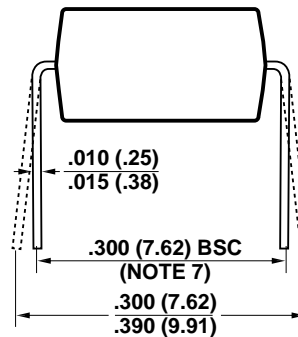


DIP-8B



Notes:

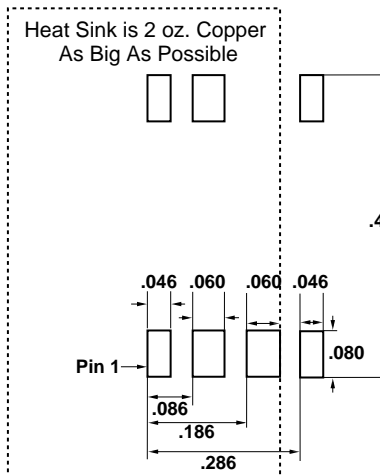
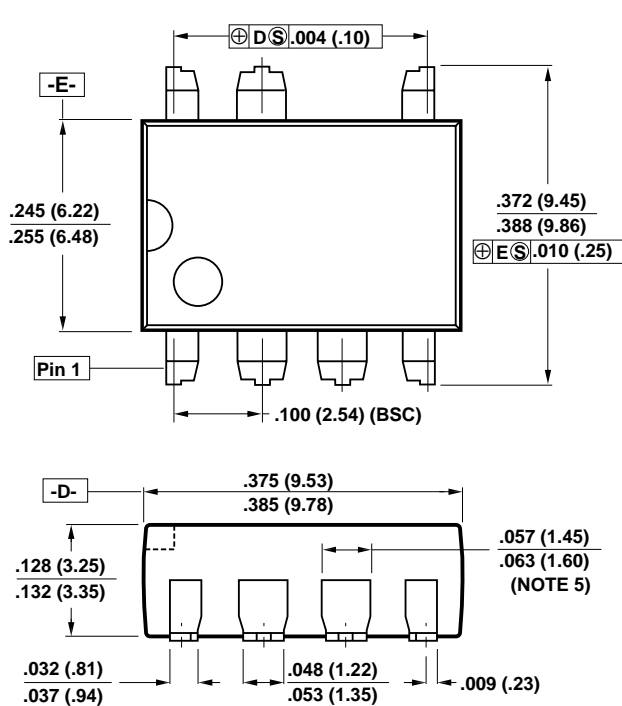
1. Package dimensions conform to JEDEC specification MS-001-AB (Issue B 7/85) for standard dual-in-line (DIP) package with .300 inch row spacing.
2. Controlling dimensions are inches. Millimeter sizes are shown in parentheses.
3. Dimensions shown do not include mold flash or other protrusions. Mold flash or protrusions shall not exceed .006 (.15) on any side.
4. Pin locations start with Pin 1, and continue counter-clockwise to Pin 8 when viewed from the top. The notch and/or dimple are aids in locating Pin 1. Pin 6 is omitted.
5. Minimum metal to metal spacing at the package body for the omitted lead location is .137 inch (3.48 mm).
6. Lead width measured at package body.
7. Lead spacing measured with the leads constrained to be perpendicular to plane T.



P08B

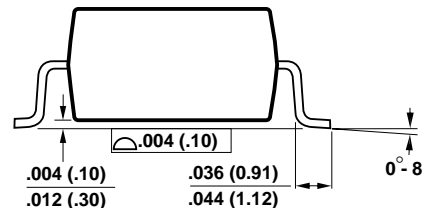
PI-2551-101599

SMD-8B



Notes:

1. Controlling dimensions are inches. Millimeter sizes are shown in parentheses.
2. Dimensions shown do not include mold flash or other protrusions. Mold flash or protrusions shall not exceed .006 (.15) on any side.
3. Pin locations start with Pin 1, and continue counter-clockwise to Pin 8 when viewed from the top. Pin 6 is omitted.
4. Minimum metal to metal spacing at the package body for the omitted lead location is .137 inch (3.48 mm).
5. Lead width measured at package body.
6. D and E are referenced datums on the package body.

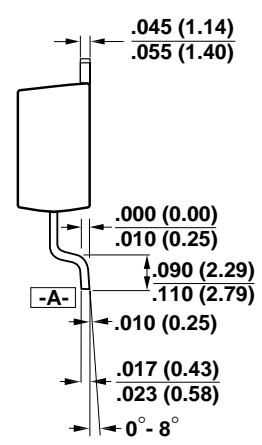
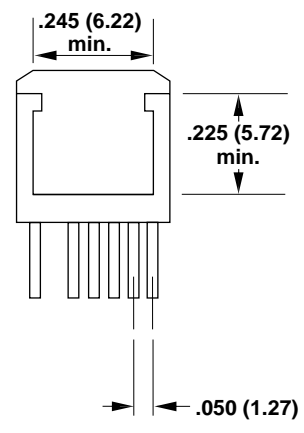
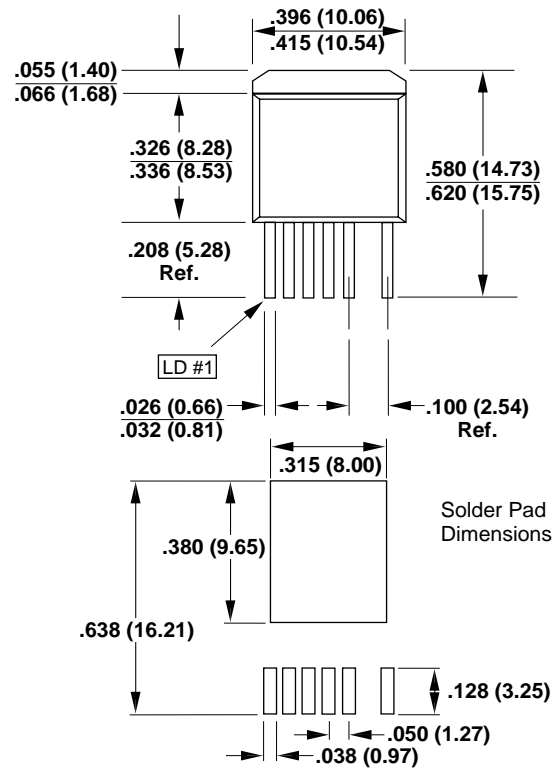


G08B

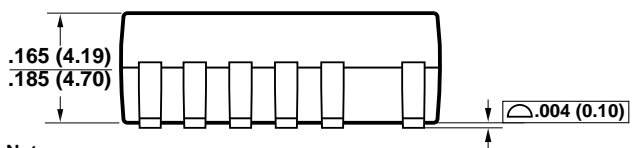
PI-2546-040501



TO-263-7C



Solder Pad Dimensions



Notes:

1. Package Outline Exclusive of Mold Flash & Metal Burr.
2. Package Outline Inclusive of Plating Thickness.
3. Foot Length Measured at Intercept Point Between Datum A Lead Surface.
4. Controlling Dimensions are in Inches. Millimeter Dimensions are shown in Parentheses.

R07C
 PI-2664-040501



Revision	Notes	Date
D	-	11/00
E	1) Added R package (D2PAK). 2) Corrected abbreviations (s = seconds). 3) Corrected x-axis units in Figure 11 (μA). 4) Added missing external current limit resistor in Figure 25 (R_{IL}). 5) Corrected spelling. 6) Added caption for Table 4. 7) Corrected Breakdown Voltage parameter condition ($T_J = 25\text{ }^\circ\text{C}$) 8) Corrected font sizes in figures. 9) Figure 40 replaced. 10) Corrected schematic component values in Figure 44.	7/01

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