Application Notes
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如何实现比基准更低的输出电压

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Abstracts

目前 DC/DC 变换器的内部参考电压基本都是 0.6V，从反馈原理上讲，只能输出大于等于 0.6V 的输出，如果遇到某些要求低于 0.6V 输出的应用就没有办法了，本应用报告给出了如何产生低于内部基准输出电压的办法。

Contents

Figures

1.应用背景

随着半导体工艺的不断升级，有越来越多的低电压供电芯片出现，0.8V 以下的核电压随处可见，最低电压甚至到了 0.6V 以下，而目前的 DC/DC 的内部基准大部分都是 0.6V 或更高，所以相应的输出电压最低是 0.6V，如何输出 0.6V 以下的电压，一方面可以选择更低基准的变换器，但选择会很少，另一方面我们可以在现有芯片的基础上做些修改去实现。本文分别介绍固定输出和可调输出两种应用。

2.TPS53355 输出固定的 0.52V/10A

Figure1 为典型的电压型反馈补偿网络，该直流输出传递函数是 $Vout=V_{REF}*(1+R_{FBT}/R_{FBB})$。这个式子括号内的值是大于等于 1 的，所以输出是大于等于 VREF 的，TPS53355 的 V_{REF} 是 0.6V，那么该变换器的最低输出电压就是 0.6V.

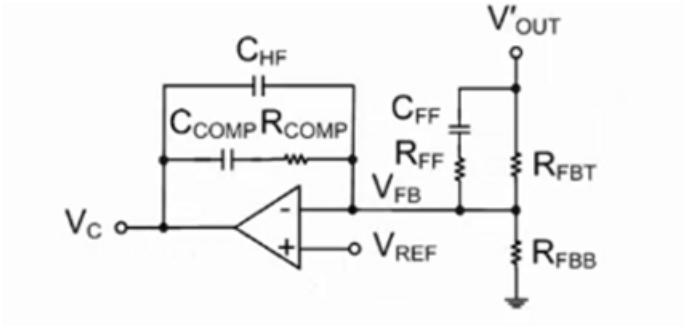

Figure 1 反馈网络示意图

那么如何让 TPS53355 输出 0.52V,Figure2 为 TPS53355 的 EVM 图纸，在不做任何修改时，输出电压有 R10 和 R12 决定，$Vout=V_{REF}*(1+R_{10}/R_{12})=0.6\times(1+0.78/10)=0.647V$，通过加入 Rx 并连接到 VREG 上，见下图圈内部分，通过改变 Rx 的值可以改变输出电压，当 Rx 为 27K 时，输出电压便为 0.52V。针对这种应用需要变换器本身有一个稳定 LDO 输出去产生额外的偏置电流，这对大部分 DC/DC convert 来说是可以实现的，但需要注意三点：1 是需要注意 LDO 输出电流的能力，一般仅需要 1mA 以下的偏置电流；2 是需要注意 LDO 电压的精度，LDO 电压的精度会直接影响输出电压的精度；3 是因加入偏置电流，该电流是从 FB 往输出方向流的，该电流无法流入变换器，需要一个相应电流（小于 1mA）的假负载形成回流路径。我们分别进行了空满载测试和动态负载测试，测试波形见 Fig3-Fig5.

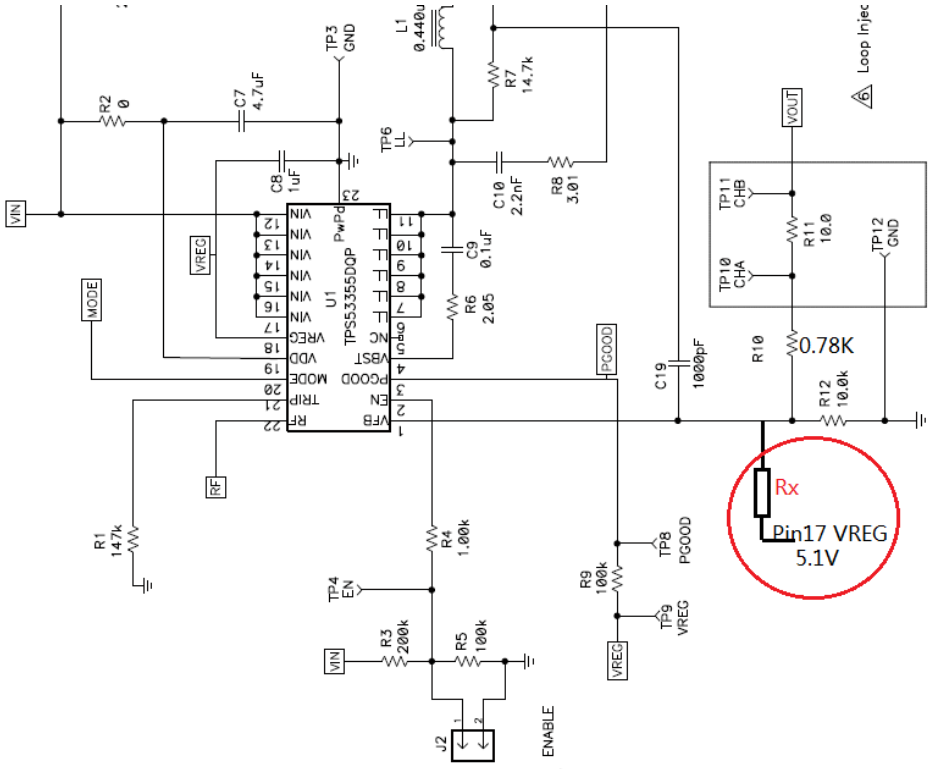

Figure 2 TPS53355 EVM 原理图

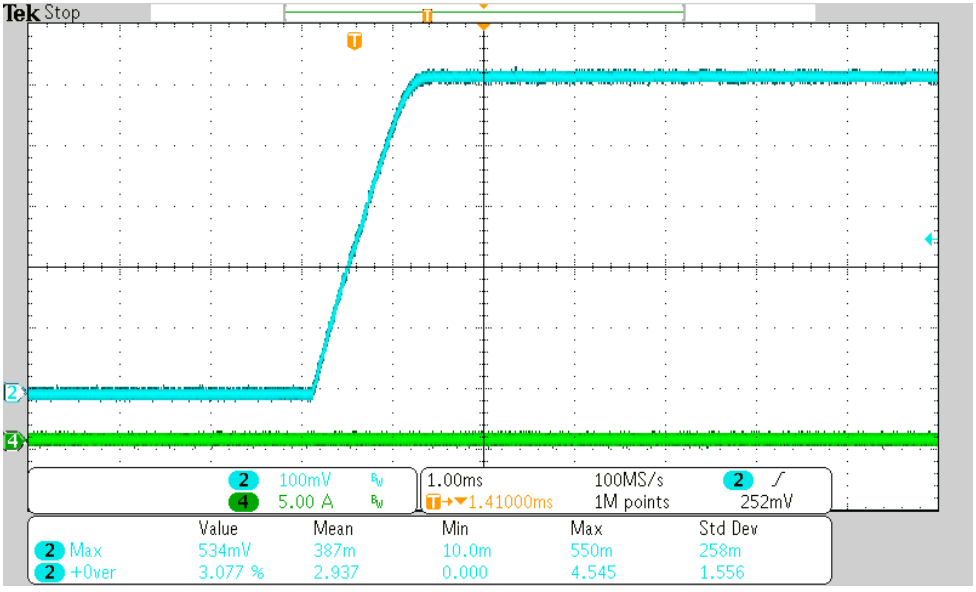

Figure 3 TPS53355 空载启动

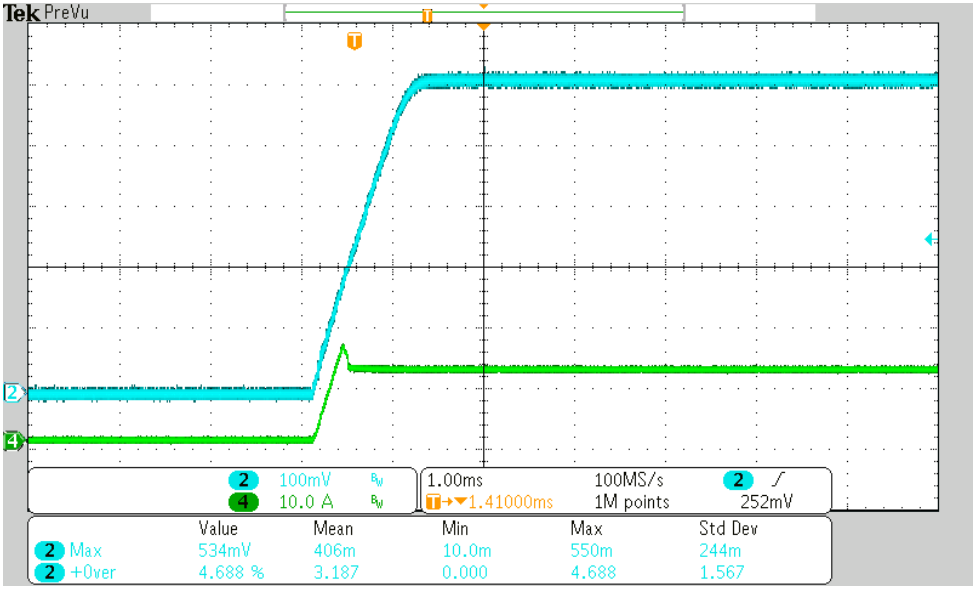

Figure 4 TPS53355 满载启动

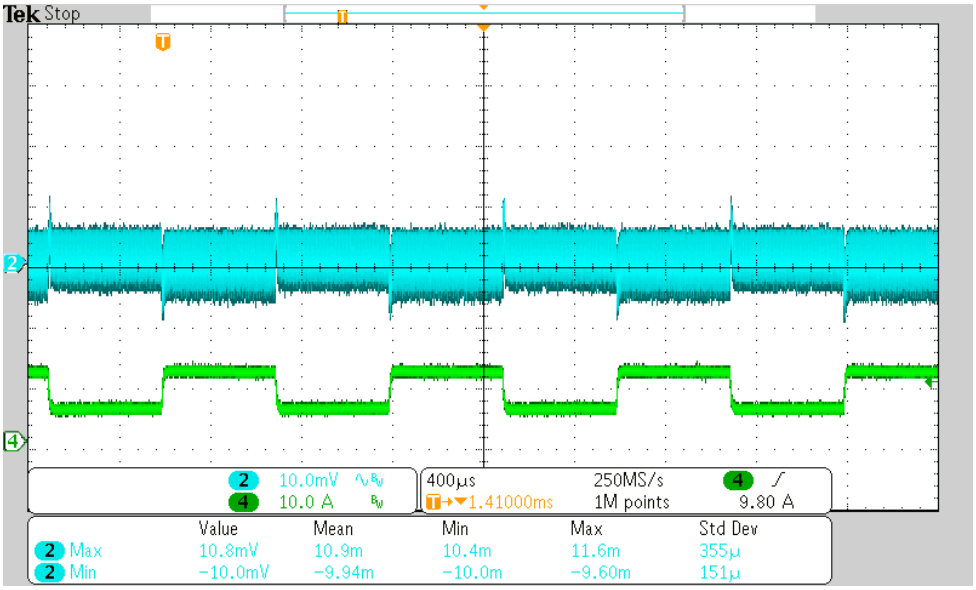

Figure 5 TPS53355 6A-12A Transient

3.TPS546C23 输出 0.57V-0.75V/15A

除了利用芯片自身的 LDO 提供偏置，还可以利用 DAC 的输出提供偏置，这样既没有前面提到的自身 LDO 电流能力和精度问题，而且还可以实现调压。实际客户需要 TPS546C23 提供

0.57V-0.75V 输出，TPS546C23 的基准是 0.6V，所以没有额外的偏置是无法输出 0.57V 的，因为要利用 DAC 进行调压，因此利用 DAC 提供偏置，实现低于 0.6V 的输出，客户要求 DAC 的 0V-2.5V 对应 0.75V-0.57V 的调压。

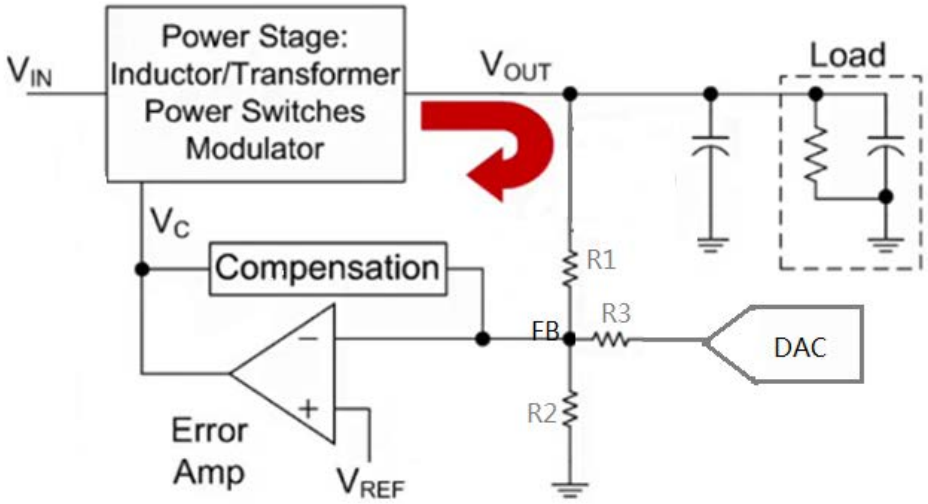

Figure 6 TPS546C23 反馈

利用叠加定理得到下式：

$$V_{FB} = \frac{R_2 \| R_3}{R_1 + R_2 \| R_3} V_{OUT} + \frac{R_1 \| R_2}{R_3 + R_1 \| R_2} V_{DAC}$$

$$V_{FB} = K_1 V_{OUT} + K_2 V_{DAC}$$

$$V_{OUT} = \frac{1}{K_1} V_{FB} - \frac{K_2}{K_1} V_{DAC}$$

预设 R1=1K

VFB=0.6V，

VDAC=0V 时，Vout=0.75V;

VDAC=2.5V 时。Vout=0.57V

求得：

R2=12.2K

R3=13.9K

Vout 和 VDAC 的关系见下图：

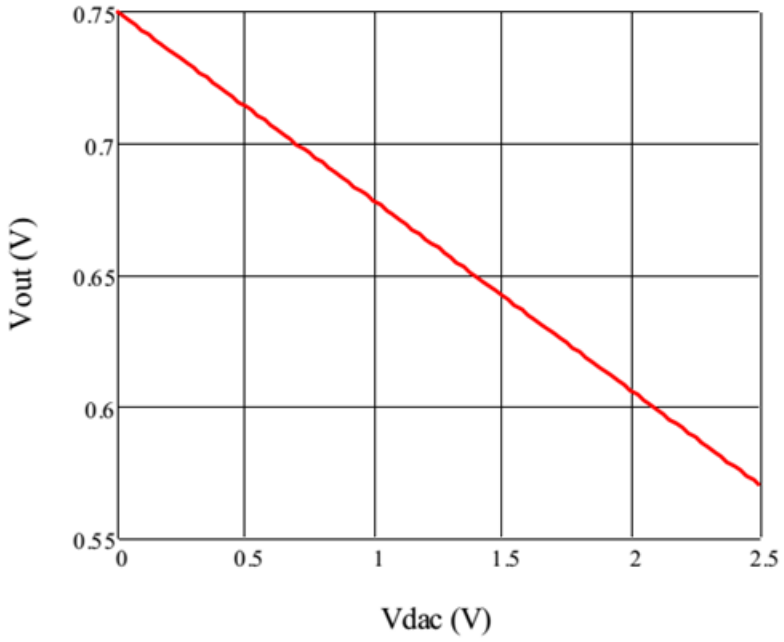

Figure 7 Vout vs VDAC

4.结论

本应用报告提供了如何实现低于内部基准输出的方法，提出了两种解决思路，为此类应用场景提供了解决方案。

5.参考文献

1. TPS546C23 datasheet，Texas Instruments Inc.
2. TPS546C23EVM2-746，Texas Instruments Inc.
3. TPS53355 datasheet，Texas Instruments Inc.
4. TPS53355EVM-743，Texas Instruments Inc.

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