

利用 AD5662 DAC 实现 4 mA 至 20 mA 过程控制环路

电路功能与优势

在许多过程控制应用中,经常使用两线式电流发射器在高噪声环境中传输模拟信号。这些电流发射器的零电平信号电流为 4 mA,满量程信号电流为 20 mA,因此得名“4 mA 至 20 mA 转换器”。本文所述电路提供一种具有 16 位分辨率和单调性的低功耗电流发射器,它直接采用 4 mA 至 20 mA 控制环路电源供电,功耗低于 4 mA。功耗高于 4 mA 的发射器无法直接采用环路电源供电,因而需要一个附加电源。

电路描述

本电路将AD5662 nanoDAC转换器用作控制器，提供4 mA至20 mA可编程输出电流。环路电流通过测量RS上的压降 V_{OUT} 进行检测。如果DAC输出为0 V，则电流

$$\frac{V_{REF}}{R2} = \frac{5 \text{ V}}{1 \text{ M}\Omega} = 5 \mu\text{A} \quad (1)$$

流经 R2 和 R3, 迫使 PCB 地电压比 RS 负载端测得的电压正值高出 349 mV。这相当于环路电流

$$\frac{V_{OUT}}{RS} = \frac{349 \text{ mV}}{100 \Omega} = 3.49 \text{ mA} \quad (2)$$

当 DAC 输出 5 V 满量程电压时, 流经 R2 的电流为

$$\frac{V_{REF}}{R2} = \frac{5\text{ V}}{1\text{ M}\Omega} = 5\text{ }\mu\text{A} \quad (3)$$

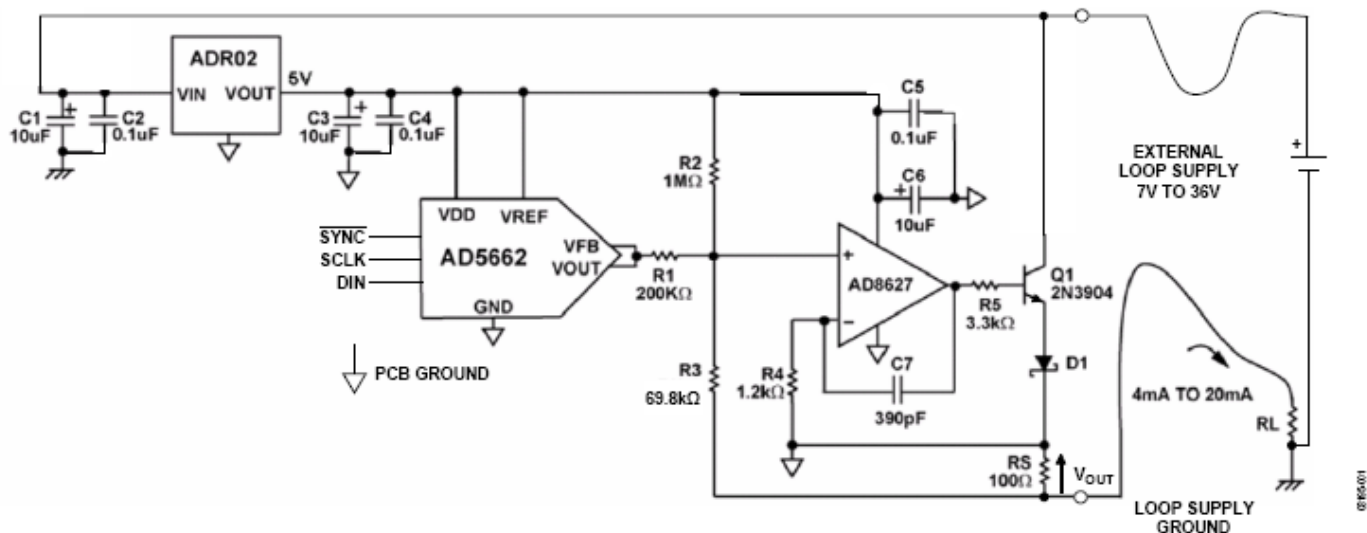


图1.可编程4 mA至20 mA过程控制器(原理示意图)

Rev.A

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One Technology Way, P.O. Box 9106, Norwood, MA 02062-9106, U.S.A.
Tel: 781.329.4700 www.analog.com
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流经 R1 的电流为

$$\frac{V_{REF}}{R1} = \frac{5 \text{ V}}{200 \text{ k}\Omega} = 25 \mu\text{A} \quad (4)$$

因此, 流经 R3 的电流为

$$\frac{V_{REF}}{R2} + \frac{V_{REF}}{R1} = 5 \mu\text{A} + 25 \mu\text{A} = 30 \mu\text{A} \quad (5)$$

这就迫使RS上的电压V_{OUT}等于

$$30 \mu\text{A} \times 69.8 \text{ k}\Omega = 2.09 \text{ V} \quad (6)$$

围绕AD8627的反馈环路迫使其同相输入端的电压等于PCB地电压。因此, 输出电流与数字码成正比。AD8627调节DAC输出电流, 以满足其同相节点上的电流求和条件。输出电流可通过以下公式计算:

$$I_{OUT} = \frac{1}{RS} \left[\left(V_{DAC} \times \frac{R3}{R1} \right) + \left(V_{REF} \times \frac{R3}{R2} \right) \right] \quad (7)$$

对于图 1所示的值:

$$I_{OUT} = (0.266 \mu\text{A} \times D) + 3.49 \text{ mA} \quad (8)$$

其中 $0 \leq D \leq 65,535$ 。当AD5662的数字码等于 0xFFFF时, 本电路提供 20.9 mA满量程输出电流。同样, 当AD5662 的数字码等于 0x0000 时, 输出电流将为 3.49 mA。扩展电流范围(3.49 mA至 20.9 mA) 允许用户利用软件和AD5662的 16 位分辨率校准 4 mA至 20 mA范围。本电路需要使用肖特基二极管, 以防止环路电源上电瞬态将AD8627的同相输入端拉至反相输入端 300 mV以下。该肖特基二极管必须能够处理至少 20 mA的全环路负载。

控制器的偏置电压由 5 V精密基准电压源ADR02提供, 而且本电路无需外部调整, 因为ADR02的初始输出电压容差很小, 并且AD8627和AD5662的电源电流很低。

容许的环路电源限值由ADR02的最小输入电压(7 V)和最大输入电压(36 V)设置。25°C时 2N3904 的最大容许功耗为 625 mW, 因此如果环路电源超过约 30 V, 必须使用更高功耗的晶体管。添加适当的降压电阻, 并与 2N3904 的集电极串联, 可以降低 2N3904 的功耗。

常见变化

这款基本电路比较灵活, 可以使用多种不同的基准电压源、电压输出 DAC 和运放。需要考虑的是基准电压源的精度, DAC 的分辨率和放大器的失调电压。主要要求是整个电路必须工作在环路电压下, 并且静态电流小于 4mA(DAC 码 0x0000)。

进一步阅读

[Voltage Reference Wizard Design Tool.](#)

数据手册和评估板

[AD5662 Data Sheet.](#)

[AD8627 Data Sheet.](#)

[ADR02 Data Sheet.](#)

修订历史

5/09—Rev. 0 to Rev. A

Updated Format Universal

10/08—Revision 0: Initial Version

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