Understanding Current Output Digital to Analog Converters

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Introduction

This Application Note provides information concerning the current output Digital to Analog Converters (DAC) offered by Intersil. This includes theory and design considerations for their general use.

DAC Current Output Theory

Current output DACs utilize a binary weighted current ladder to develop the output current. These DACs are just like voltage output DACs in terms of the corresponding output being a function of the applied digital input code. The main difference is current output devices “steer” the full scale current while voltage output devices simply provide an output proportional to applied voltage reference. Current output DACs uses a current steering technique which divides the full scale output current between two ports. These ports are typically named IOUT and $\overline{\text{IOUT}}$. The division or steering of the full scale current is proportional to the digital code applied to the inputs. Full scale current is set by applying a reference voltage and resistor to derive reference current. The reference current is internally scaled by a fixed multiplication factor. To convert the output current to a desired voltage, the user supplies a carefully selected load resistor to the IOUT port while directly grounding $\overline{\text{IOUT}}$ (single-ended output).

Intersil has many different current output DACs which have been optimized for specific applications such as video and wireless. Key parameters to consider are maximum conversion speed, load resistance, full scale current and compliance voltage (full scale output voltage). To ensure reliable performance, do not exceed the guaranteed maximum output current in the datasheet. The device will typically drive higher current than specified but long term reliability (electromigration) will degrade significantly. In addition, the specified output compliance voltage should be maintained to obtain guaranteed linearity performance. The load resistance selection will affect settling time due to dependence on the output RC time constant.

The following is an example to walk through the design process and highlight concerns.

System Design

The key principle to understanding is full scale output current is simply the reference current multiplied by a constant factor.

$I_{FS} = I_{REF} * M_F$

The choice of the reference voltage, reference resistor and load resistor are in support of this key principle.

$I_{REF} = V_{REF} / R_{REF}$
$R_{REF} = V_{REF} / I_{REF}$
$V_{FS} = R_L * I_{FS}$

Example 1

Video application (HI3050, triple 10-bit 50MSPS D/A) to supply a 2V full scale voltage to the standard video load of 75Ω. (See Figure 1).

Given: $V_{FS} = 2V$, $R_L = 75\Omega$
$I_{FS} = V_{FS} / R_L = 2 / 75 = 26.7mA$
$V_{FS} = V_{REF}$
$I_{REF} = I_{FS} /16 = 1.67mA$ (multiplication factor = 16)
$R_{REF} = V_{REF} / I_{REF} = 1200\Omega$

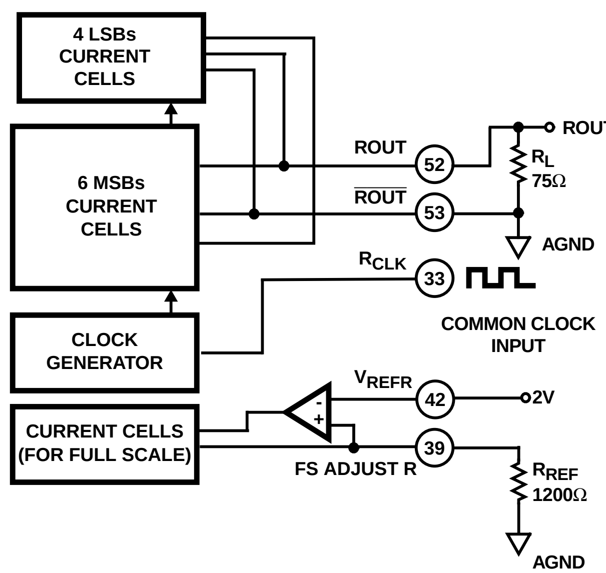

FIGURE 1. RED CHANNEL SECTION OF HI3050

Example 2

HI2315, 10-bit 80 MSPS D/A) to supply a 2V full scale voltage to a 200Ω load using internal reference (1.2V). (See Figure 2).

Given: V_{FS} = 2V, R_L = 200Ω and V_{REF} = 1.2V (25^{o}C typical)
$I_{FS} = V_{FS} / R_L = 2 / 200 = 10mA$
$I_{REF} = I_{FS} /16 = 10mA / 16 = 0.625mA$
$R_{REF} = V_{REF} / I_{REF} = 1.2 / 0.625mA = 1920Ω$

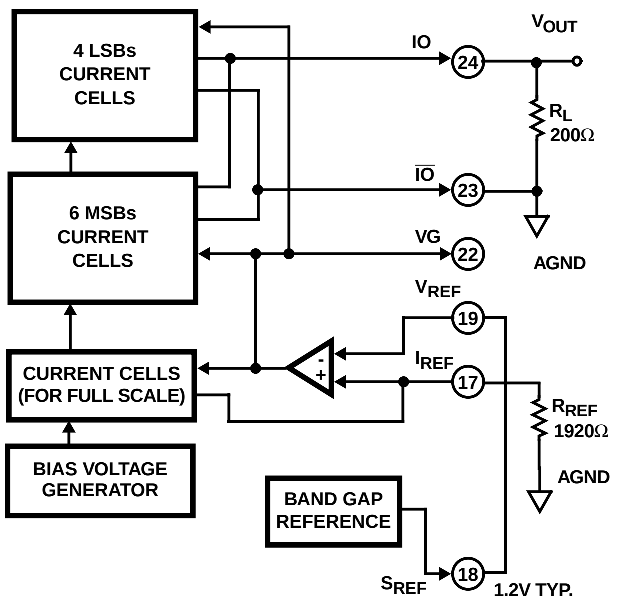

FIGURE 2. HI2315 USING INTERNAL VOLTAGE REFERENCE

Conclusion

This paper details the theory and use of the Intersil current output DACs. A comparison between voltage and current output devices were discussed. In addition, examples were provided to detail the exact system design. For complete details on each device please refer to the appropriate data sheet.

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