DAC Primer

This training course covers DAC operation and definitions to include the relationship between the DAC's reference and digital input code.

The intent is to present a simple, easy to understand familiarization with DACs on a fairly intuitive level. The math presented is limited to simple algebra.

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1. Course Navigation

1.1 Course Navigation

1.1 Course Navigation

This course is organized like a book with multiple chapters. Each chapter may have one or more pages.

- The previous and next arrows move you forward and back through the course page by page.
- The left navigation bar takes you to any chapter. It also contains the bookmarking buttons, 'save' and 'go to.' To save your place in a course, press the 'save' button. The next time you open the course, clicking on 'go to' will take you to the page you saved or bookmarked.
- The 'Go to Final Test' button on the left navigation bar takes you back to the Analog University course listing, where you started. Take the course final test by clicking on 'Test Yourself.'
- The top services bar contains additional information such as glossary of terms, who to go to for help with this subject and an FAQ. Clicking home on this bar will take you back to the course beginning.
- Don't miss the hints, references, exercises and quizzes which appear at the bottom of some pages.

2. The DAC

This chapter describes the DAC, what it does and the mathematical relationship between the DAC input code and its output.

At the end of every page there is a quiz to confirm your understanding of the material. This quiz is not your exam for the material and there are no reporting of the results. To be sure that you see all of the material, be sure to continue down the page until you see the quiz.

2.1 What is a DAC?

A **DAC** (Digital-to-Analog Converter, also written Digital to Analog Converter, D/A Converter and, simply, D/A) is an electronic device or circuit used to convert a digital word into an analog voltage or current.

Like the ADC, the DAC it is often misunderstood.

- Because the Digital-to- Analog Converter (D/A Converter or **DAC**) has both analog and digital functions, it is a **mixed-signal** device. Like the ADC, the DAC is often considered to be a mysterious device. It should, however, be considered to be the instrument that it is: a device that provides an analog output **current** or **voltage** that represents the DAC input code.
- Notice that the DAC output can be a **voltage** or a **current**, depending upon the particular DAC. Also, some DACs have a reference voltage and others has a reference current. Whether a DAC has a voltage or current output has no necessary relationship to whether it has a voltage or current reference input.
- A DAC has an **analog reference** voltage or current which is multiplied by the digital input word. So, basically, the DAC is a **multiplier**.

2.1.1 What is a DAC?

Q

1 A DAC is an electronic device or circuit that converts

1. A digital word into an analog voltage.
2. A digital word into an analog current.
3. A DAC might do either of these.

4. None of these is correct.

1 Answer: 3 - A DAC might do either of these.

Q **2** The DAC output

1. Is always a voltage.
2. Is always a current.
3. Can be either a voltage or current, depending upon the setting of a pin.
4. None of these is correct.

2 Answer: 4 - None of these is correct.

Q **3** Whether a DAC output is a voltage or current depends upon.

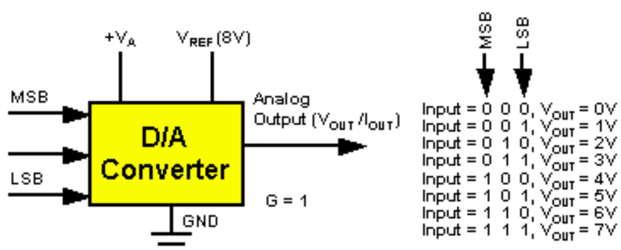
1. The setting of a pin on the DAC.
2. The design of the DAC
3. Whether the reference is a voltage or a current.
4. None of these is correct.

3 Answer: 2 - The design of the DAC

2.2 What, exactly, does a DAC do?

The DAC provides an analog output **voltage** or **current** that is proportional to the product of its digital input word and its analog reference.

- Here is an example of a 3-bit D/A converter. Because it has 3 bits, there are $2^3 = 8$ possible input codes, each producing a different output voltage or current. The difference between each output voltage is, in the ideal case, the size of the LSB, which is $G \times V_{REF} / 2^n$, where "G" is the DAC gain factor and V_{REF} is the DAC reference voltage, assuming the reference is a voltage



- Assuming that the output response has no errors, every time you increase the input code by one count, the output voltage or current will increase by one LSB. This means, in this example, that the least significant bit (LSB) represents 1 Volt, which is the smallest increment that this converter can resolve.
- If the reference voltage were reduced to **0.8V**, the LSB size would then be **100mV**, allowing the output to take on a smaller range of voltages (0 to 0.8V) with greater accuracy.
- The Resolution of a D/A converter is the number of input bits it has (3 bits, in this example). Resolution may also be defined as the size of the smallest output voltage or current step, or **one LSB** (Least Significant Bit), which is 1 Volt, in this example.
- When we speak of the resolution of a DAC we usually are referring to the number of input bits it has.

2.2.1

Q **1** A 12-bit DAC has how many output levels?

1. 256
2. 1024

3. 4095

4. None of these is correct.

1 Answer: 4 - None of these is correct.

Q 2 A 12-bit DAC with a 2.0V reference has the input code decreased by 1 LSB. Its output will

1. Increase by about 485 microvolts
2. Increase by 488 microvolts
3. Increase by 490 millivolts
4. None of these is correct.

2 Answer: 4 - None of these is correct.

Q 3 The resolution of a DAC is

1. The number of input data bits it has
2. The size of one LSB
3. Both of these are correct
4. Neither of these is correct.

3 Answer: 3 - Both of these are correct

Q 4 When we speak of the resolution of a DAC we usually are referring to the number of input bits it has.

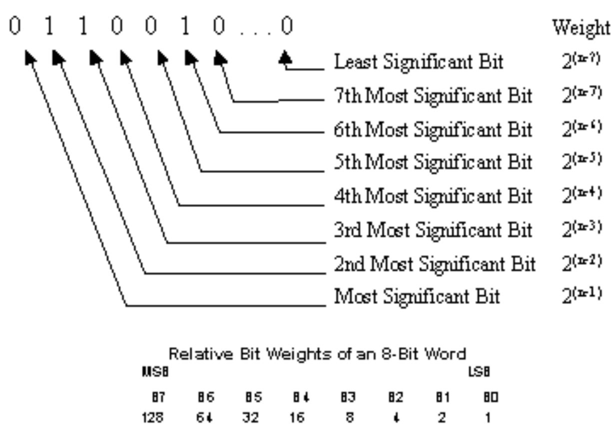
1. True.
2. False.

4 Answer: 1 - True.

2.3 MSB & LSB

The **MSB** has a value of half the output maximum and each lower bit has a value that is half of its next highest bit.

- The Least and Most Significant Bits (**LSB** and **MSB**) are just what their names imply: those bits that have the least weight (**LSB**) and most weight (**MSB**) in a digital word.



- For an **n**-bit word, the MSB has a weight of $\mathbf{2^{(n-1)} = 2^n / 2}$ where "n" is the total number of bits in the digital input word.
- The value of the MSB is 1/2 of full-scale.
- The LSB has a weight of **1**.

- The value of the LSB is **$G \times V_{REF} / 2^n$**.
- Higher resolution neans a smaller LSB size, while a higher reference voltage means a larger LSB size.

2.3.1

1 The MSB has a value (or G = 1) of

1. 2^n
2. $2^n - 1$
3. $2^{(n-1)}$
4. None of these is correct.

1 Answer: 3 - $2^{(n-1)}$

2 The LSB has a value (for G = 1) of

1. 2^n
2. $V_{REF} / 2^{(n-1)}$
3. $V_{REF} / 2^n$
4. None of these is correct.

2 Answer: 3 - V_{REF} /
2^n

3 The value of the LSB of the DAC depends upon

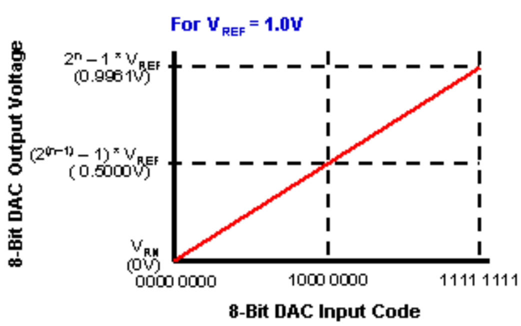
1. The DAC resolution .
2. The DAC reference value.
3. Both of these are true.
4. Neither of these is true.

3 Answer: 3 - Both of these are true.

2.4 DAC Transfer Characteristic

The basic DAC transfer function is a straight line with output values between a lower (negative) and upper (positive) reference.

- All DACs have a Top (or Positive) Reference and a Bottom (or Negative) Reference. We do not often hear or think about a bottom or negative reference because it is usually ground potential (0.0V) in a DAC with a voltage reference and we generally ground (sometimes through a resistance) the negative reference of a DAC with a current reference.



  - The Bottom or Negative Reference, when a voltage, is not necessarily a negative voltage, but is negative in relation to the Top or Positive reference voltage.

- The Bottom Reference of a DAC, like that of an ADC, is not necessarily ground.

- The analog output range for a DAC with a voltage reference and voltage output is

$$G \times V_{RN} \leq \text{Output} \leq G \times V_{RP}$$

  - Where V_{RP} is the positive or top reference voltage, V_{RN} is the negative or bottom reference voltage and "G" is the DAC gain factor. Also, the total, or net, reference is $V_{REF} = V_{RP} - V_{RN}$.

    Assuming a gain (G) of one, the output range formula reduces to

$$V_{RN} \leq \text{Output} \leq V_{RP}$$

- Further assuming that V_{RN} is 0V, as in the example of the figure above, these two relationships reduce to

$$0V \leq \text{Output} \leq G \times V_{RP}$$

and

$$0V \leq \text{Output} \leq V_{REF}$$

- So, with a gain of G = 1, a V_{RN} of 0V and an input code of 0000 0000, the output of an ideal 8-bit DAC is 0V. With an input code of 1111 1111, the output voltage is $V_{OUT} = G \times (2^8 - 1) \times V_{REF} / 2^8 = G \times 255 \times V_{REF} / 256$, which is the full-scale output value. With an input code of 1000 0000, the output voltage = $G \times 2^7 \times V_{REF} / 2^8 = G \times 128 \times V_{REF} / 256 = G \times V_{REF} / 2$, which is the half-scale output value.

- So, with a gain of G = 1, a V_{RN} of 0V and an input code of 0000 0000, the output of an ideal 8-bit DAC is 0V. With an input code of 1111 1111, the output voltage = $G \times (2^8 - 1) \times V_{REF} / 2^8 = G \times 255 \times V_{REF} / 256$, which is the full-scale output value. With an input code of 1000 0000, the output voltage = $G \times 2^7 \times V_{REF} / 2^8 = G \times 128 \times V_{REF} / 256 = G \times V_{REF} / 2$, which is the half-scale output value.

- While the basic DAC input/output transfer characteristic is a straight line, some DACs have been produced with other characteristics. A Logarithmic characteristic is an example.

2.4.1

Q **1** The basic DAC transfer function is a straight line with output values between

1. Zero and V_{REF}
2. A lower and an upper reference.
3. Zero and the analog supply.
4. None of these is correct.

1 Answer: 2 - A lower and an upper reference.

Q **2** We do not often hear or think about a bottom or negative reference of a DAC with a voltage reference because

1. It is usually 0V.
2. It is taken care of on the die.
3. It does not really exist.
4. None of these is correct.

2 Answer: 1 - It is usually 0V.

Q **3** The full-scale output of a Voltage Output DAC with a gain factor = 1 is

1. 1.0 V
2. One LSB less than V_{REF}.
3. V_{REF}.

4. None of these is correct.

3 Answer: 2 - One LSB less than V_{REF}.

2.5 LSB Values by Resolution and Reference Voltage

LSB Value depends upon the reference value and the number of input bits the DAC has.

- Since one LSB is equal to V_{REF} / 2^n, better accuracy (lower error) can be realized if we did either (or both) of two things: (1) use a higher resolution converter (more bits) and/or (2) use a smaller reference voltage.

The value of an LSB depends upon the ADC Reference Voltage and Resolution

V_{REF}	Resolution	1 LSB
1.00V	8	3.9062 mV
1.00V	12	244.14 µV
2.00V	8	7.8125 mV
2.00V	10	1.9531 mV
2.00V	12	488.28 µV
2.048V	10	2.0000 mV
2.048V	12	500.00 µV
4.00V	8	15.625 mV
4.00V	10	3.9062 mV
4.00V	12	976.56 µV

- The problem with higher resolution (more bits) is the cost. The problem with reducing the reference voltage is that whatever noise is present at the output is a larger part of the LSB if the reference is very small. However, noise is always a problem when it is desired to be very accurate. Careful design and layout will help to minimize noise.

2.5.1

Q 1 Better accuracy (lower error) can be realized by using

1. A higher resolution converter (more bits)
2. A smaller reference voltage.
3. Either or both of these can be done.
4. Neither of these is correct.

1 Answer: 3 - Either or both of these can be done.

Q 2 A very, very small reference value could result in poor noise performance.

1. True.
2. False.

2 Answer: 1 - True.

2.6 DAC Output Characteristic

What are the **Output Characteristics** of the DAC?

- The ADC tells us what is the ratio between the input and a reference, we say it is a divider. However, the DAC output is the product of the input word and its reference, so it is a multiplier. Both the ADC and the DAC have a gain factor that is most often unity.

- Just as the ADC analog input can be a voltage or a current, the DAC analog output can be a voltage or a current.

It's True

The output impedance of the DAC can be high or it can be low, depending upon the design of the DAC.

2.6.1

Q

1 The DAC has a gain factor that is usually a value of 2.

1. True
2. False

1 Answer: 2 - False

Q

2 The DAC can have either a voltage output or a current output.

1. True
2. False

2 Answer: 1 - True

2.7 Types of DACs

There are a few ways we typically classify DACs. These classifications are based upon the characteristics and function of the DAC.

- A DAC may have either a **voltage** output or a **current** output, depending upon its design. The voltage output DAC is preferred for most applications, but a current output DAC on the same fabrication process will have a faster settling time.
- All DACs are multipliers in that their output is the product of the input word and a reference voltage or current. Most DACs are designed to function well over a narrow range of d.c. reference voltages or currents. But a DAC that is called a multiplying DAC is special in that it is designed to function well with an a.c. signal at the reference input, allowing the DAC to be used as a digital attenuator.
- One type of multiplying DAC is a single quadrant one where the reference and output each can only be positive for proper functioning.
- Another type of multiplying DAC is a two quadrant one where the reference must be positive but the output can take on positive or negative values, or where the reference can be positive or negative but the output can only be positive. Most commonly, a two quadrant DAC is limited to a positive only reference.
- The four quadrant multiplying DAC may have both reference and output values that can be either positive or negative.
  - The multiplying DAC is also called an MDAC.
- The Trim DAC is used to trim the offset or gain of other circuits and is actually more of an application than a particular DAC design, except that these devices generally use a fairly low reference value as its output range does not need to be very great.

It's True

TRUE: A negative reference and/or output can be single-ended, in which case a negative supply is needed, or they can be differential, where a negative value is defined as the minus reference input or analog output having a higher current or voltage than does the positive reference input or analog output.

2.7.1

Q

1 DACs are generally classified by

1. Voltage or current output
2. Multiplying or not.
3. Both of these are correct.
4. Neither of these is correct.

1 Answer: 3 - Both of these are correct.

Q

2 A multiplying DAC can be a

1. Two quadrant one
2. Four quadrant one.
3. Both of these are correct.
4. Neither of these is correct.

2 Answer: 3 - Both of these are correct.

3. DAC Input/Output Relationship

Here we look at the DAC Input/Output transfer function.

3.1 DAC Output vs. Input

There are many binary coding schemes in existence. The single coding method **nearly** always used for DACs is Straight Binary, although other input codes are sometimes used.

- We have said that the DAC is a multiplier because the output is proportional to the product of the input word and the DAC reference. Other terms that affect the DAC output are the DAC gain, *G*, and resolution, *n*.
- The Input/Output transfer function is given by the formula indicated here. You may sometimes see this formula without the "G" (Gain) term. This is because the gain of most DACs is "1". This formula is a direct result of the fact that the DAC multiplies the digital input word and its analog reference to produces an output level.

$$\text{DAC Output} = G \times D \times V_{REF} / 2^n$$

- Where G = DAC Gain Factor

  D = Digital Input Word Decimal Value

  n = DAC Resolution (# of Output Bits)

  V_{REF} (or I_{REF}) = DAC Reference Voltage (or Current)

It's True

The normal ½ LSB offset that is built into ADCs is not incorporated into DACs.

3.1.1

Q

Like the ADC, the DAC is a divider

1. True.
2. False.

1 Answer: 2. False

3.2 Example 1

This example will help illustrate the functioning of the DAC.

- **Given:** 8-Bit Voltage Output DAC with G = 1, V_{REF} = 3.3V, Input Code = 1100 1000b
- **Question:** What is the output voltage?
- **Solution:** 1100 1000b = 200d

  DAC Output = G x D x V_{REF} / 2^n = 1 x 200 x 3.3 / 2^8

  DAC Output = 2.578125V

3.2.1

The DAC output is

1. Proportional to its reference and input word.
2. Inversely proportional to its reference
3. Both of these are correct.
4. Neither of these is correct.

1 Answer: 1 - Proportional to its reference and input word.

3.3 Example 2

This exercise will further help with understanding of the DAC.

- **Given**: 8-Bit Voltage Output DAC with G = 1, V_{REF} = 3.3V, Desired Output = **1.500V**.
- **Question**: What binary input code will give an output voltage closest to that desired?

  What is the percentage error from the desired output voltage?
- **Solution:**

  D = 2n x V_{OUT} / V_{REF}

  D = 256 x 1.500V / 3.3V

  D = 116.3636d; round to 116d = **0111 0100b**.

  DAC Output = G x D x V_{REF} / 2^n

  = 1 x 116 x 3.3 / 2^8 = **1.4953125V**

  Error = (1.5V - 1.4953125V) / 1.5V

  = 0.003125 = **0.3125% Error**

3.3.1

Q If the desired digital code is calculated to be 204.85 and a rounded off code of 205 is entered into the DAC, the output deviation from the ideal output is

1. About 88 microvolts.
2. 0.15 LSB.
3. 0.85 LSB.
4. None of these is correct.

1 Answer: 2 - 0.15 LSB

3.4 Example 3

Let's be sure we understand this.

- **Question**: In the previous question, what part of an LSB is the output error?
- To answer this question we need to know both the error and the value of the LSB, then divide the the error by the LSB value.
- **Solution**:

  Error = 1.5V - 1 .4953125V

  = 0.0046875V

  1 LSB = VREF / 2^n = 3.3 / 2^8

  = 0.01289063V/LSB

  LSB Error = Error / 1 LSB

  = 0.0046875V / 0.01289063V/LSB

  LSB Error = **0.3636 LSB**

It's True

The input code we actually desired was 116.3636, which we had to round to 116. The LSB error is the same as the round off error, which is always the case.

3.4.1

Q The LSB size at the DAC output is equal to

1. D x V_{REF} / 2^n.
2. G x V_{REF} / 2^n.
3. D x V_{REF} x 2^n.
4. None of these is correct.

1 Answer: 2 - G x V_{REF} / 2^n.

3.5 Example 4

Work through this simple example to help you better understand this formula and what the DAC does.

- **Given:**

  DAC = DAC121S101

  DAC Gain Factor = 1

  DAC Supply Voltage = 3.0V

  Desired Output Voltage = 1.8750V

- **Question:**

  What is the required DAC Input Code in binary?

- Since the ratio of the reference to the desired output is the sum of binarily weighted integers, the exact output desired can be obtained, with an ideal DAC, with no error.

It's True

You can not have a fractional input code.

Tip

You will need to look up the DAC data sheet to determine the reference voltage.

Net Links

DAC121S101 Data Sheet

3.5.1 Required DAC Input Code

Q

For the question on this page, the answer is

1. a. 1001 0001 0111
2. b. 1001 0001 1000
3. c. 1010 0000 0000
4. None of these is correct

1 Answer: C - 1010 0000 0000

4. Important DAC Specifications

Any product has a few specifications that tend to be more important than others in the sense that everyone expect to see them and uses these to compare the product against others. In this chapter we will look briefly at those DAC specifications that tend to be most important.

4.1 Update (Sample) Rate

4.2 DC Errors

4.3 Settling Time

4.4 Output Glitch

4.5 Digital Feedthrough

4.6 Output Compliance

4.1 Update (Sample) Rate

- Unlike the ADC, the DAC does not take samples.
- What we generally call "Sample Rate" is more properly called Update Rate because it is the rate at which the DAC information and

output is changed or updated.

- The limit on update rate is how fast data can be loaded into the DAC.

4.1.1

Q

1 The DAC takes samples at its "Sample Rate".

1. True
2. False

1 Answer: 2 - False

Q

2 The maximum DAC "Update Rate"

1. Is its minimum "Sample Rate".
2. Will Depend upon the speed capability of the DAC.
3. Both of these are correct.
4. Neither of these is correct.

2 Answer: 2 - Will Depend upon the speed capability of the DAC.

4.2 DC Errors

- The DC errors (DNL, INL, Offset Error and Full-Scale Error) are very similar to the way they are defined for the ADC.
  - DNL (Dynamic Nonlinearity) is a measure of the worst case deviation from the ideal 1LSB step. Ideally, any two adjacent digital codes correspond to output analog voltages that are exactly one LSB apart. A differential non-linearity greater than 1 LSB will lead to a non-monotonic transfer function in a DAC.
  - INL (Integral Nonlinearity) is the worst-case deviation from the line between the endpoints (zero and full scale). Can be expressed as a percentage of full scale or in fraction of an LSB.
  - Offset Error (or Zero Error) is the output voltage that exists when the input digital code is set to give an ideal output of zero volts. All the digital codes in the transfer curve are offset by the same value. Offset error is usually expressed in LSB.
  - Full-Scale Error (or Gain Error) is the difference between the output voltage (or current) with full scale input code and the ideal voltage (or current) that should exist with a full scale input code.
- A negative DNL lower than -1 causes non-monotonic behavior.
- While the **DNL** of an **ADC** can not be more negative than -1, the DNL of a DAC can be more negative than -1.

4.2.1

Q

A DNL error in a DAC that is more negative than -1 will cause

1. Missing Codes
2. Non-monotonic behavior
3. Both of these are correct
4. Neither of these is correct

1 Answer: 2 - Non-monotonic behavior

4.3 Settling Time

- Settling Time for DACs is pretty much the same as defined for operational amplifiers.
- Settling time is defined as the time it takes the output to enter and remain within the specified error band, measured from whatever digital edge calls for an output update.
- Care should be taken when comparing settling time specifications because it can appear to improve when a larger error band is specified and/or when a smaller output swing (code change) is specified.

4.3.1

Q The Settling Time specification can be improved by

1. Specifying a larger error band
2. Specifying a smaller output swing for the test.
3. Both of these are correct.
4. Neither of these is correct.

1 Answer: 3 - Both of these are correct.

4.4 Output Glitch

- Output Glitch Energy, generally specified in Volt-Seconds (or nV-S), is the maximum energy in the glitch that occurs at the DAC output when the input code is changed.
- Maximum glitch energy generally occurs at the major carry, that is, when the input code changes between a zero followed by all ones and a one followed by all zeroes.
- The output glitch adds noise to the output of a reconstructed dynamic wave form.

4.4.1

Q **1** The maximum Output Glitch Energy usually occurs at the major carry.

1. True.
2. False.

1 Answer: 1 - True.

Q **2** An output glitch adds noise to the output of a reconstructed signal.

1. True.
2. False

2 Answer: 1 - True.

4.5 Digital Feedthrough

- Digital Feedthrough is the energy that gets to the output as a result of a change in the digital input code.
- For a DAC with parallel data input, it can be difficult to distinguish Output Glitch Energy from Digital Feedthrough unless the DAC output is updated some time after the digital code is changed, as when there is an input data latch.
- Digital Feedthrough is usually less than the major cary Glitch Energy.

4.5.1

Q Knowing what Digital Feedthrough is, it seems reasonable that it can be reduced by

1. Decreasing the amplitude of the digital input signals.
2. Slowing the edge rate of the digital input signals.
3. Both of these are correct.
4. Neither of these is correct.

1 Answer: 3 - Both of these are correct.

4.6 Output Compliance

- The **Output Compliance** specification of a DAC only applies to **current output** DACs. It does **not** apply to voltage output DACs.
- **Output Compliance** tells us the range of voltages that may be impressed upon the DAC output(s) to ensure rated accuracy.
- For example, the **DAC0800** has an output compliance range of -10V to +18V with +15V and -15V supplies. This means that the output voltage can be between -10V and +18V and still maintain accuracy. The similar **MC1408**, on the other hand, has an output compliance range of just -5V to +0.5V.

4.6.1 DAC Output Compliance

Q 1 The Output Compliance specification of a DAC is a measure of DAC accuracy.

1. True
2. False

1 Answer: 2 - False

Q 2 The Output Compliance of the **DAC0800**

1. Has a very **narrow range**
2. Has a **narrower** range than does the **MC1408**
3. Both of these are true
4. Neither of these is true

2 Answer: 4 - Neither of these is true

Q 3 The Output Compliance spec applies to

1. Current Output DACs
2. Voltage Output DACs
3. Both of these are true
4. Neither of these is true

3 Answer: 1 - Current Output DACs

5. Summary

We have discussed the very basics of the Digital-to-Analog Converter, digital encoding schemes and the mathematical relationship between the input and output of the DAC.

5.1 Summary

- What is a DAC?
- Bit Weights
- DAC Input Code
- LSB Value vs. Resolution and V_{REF}.
- Output vs. Input
- Important Specifications

DAC

Digital-to-Analog Converter. A circuit used to convert a digital input word to an analog ourput

Gain Factor

The multiplier that effectively multiplies the effective value of the reference.

LSB

The Least Significant Bit, this is the digital bit that has the smallest weight. In a DAC with a single-ended input, it has a weight of G x V_{REF} / 2^n, where V_{REF} is the DAC reference voltage and "G" is the DAC gain.

Mixed-Signal Device

A device that has both Analog and Digital functions on a single die.

Monotonic

MSB

The Most Significant Bit, this is the digital bit that has the greatest weight. In a single-ended DAC it has the weight of V_{REF} * G / 2_{n}, where V_{REF} is the DAC reference voltage, "n" is the DAC resolution and "G" is the DAC gain.

Reference

The voltage or current multiplier for the DAC analog output.

Resolution

There are two definitions of resolution: (1) the number of bits at the DAC intput and (2) the size of the LSB at the output.

The formula or characteristic that defines the input to output relationship.

A Multiplying DAC.

Multiplying DAC

A DAC designed to operate with very small reference values and is used to trim offsets and gains.

For a DAC, this is an improper, but commonly used, term for Update Rate.

The energy that gets to the output as a result of a change in the digital input code.

Output Glitch

The maximum energy in the glitch that occurs at the DAC output when the input code is changed.

Update Rate

The speed at which the DAC output is changed or updated

VREF

The ADC Reference Voltage, V_{REF} establishes the range of input voltages or currents that can be digitized without going over range or under range.

Frequently Asked Questions

Do you have a question? We may have already answered it. Check below to see if you can find the answer to your question.

Questions

Answers

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Contact/Help Information

For additional information on getting started go to http://www.national.com/analog/training/getting_started

To contact us, and send feedback go to

http://wwwd.national.com/feedback/newfeed.nsf/newfeedback?openform&category=pwdesignuniv

For Frequently Asked Questions go to

http://www.national.com/analog/training/faqs

Thank you,
PowerWise Design University Team