Micro Networks
A DIVISION OF UNITRODE CORPORATION

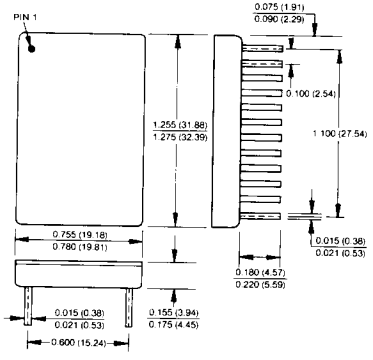
# DAC812

ULTRA-HIGH-SPEED
CURRENT-OUTPUT
12-Bit DAC

## FEATURES

- **65nsec Maximum Settling Time (DAC812C)**
- **±1/2 LSB Linearity Guaranteed Over Temperature (DAC812C)**
- **12-Bit Monotonicity Guaranteed Over Temperature**
- **TTL Compatible**
- **Internal Reference**
- **10mA Output Current**
- **Standard 24-Pin Hermetically Sealed Metal DIP**
- **MIL-STD-883 Screening Optional. MIL-STD-1772 Certified Facility**

**24 PIN DIP**




**Dimensions in Inches (millimeters)**

## DESCRIPTION

DAC812 is an extremely fast (65nsec max settling time for a full-scale output step settling to ±1/2 LSB), current-output (10mA), 12-bit D/A converter. Unlike other current-out DAC's in its speed class, DAC812 is TTL compatible, not ECL compatible, and it boasts a comparatively wide output compliance voltage (±4V) that enables it to directly drive resistive loads optimizing its speed performance.

DAC812 comes in two performance grades. DAC812C guarantees ±1/2 LSB integral linearity over temperature and specifies a maximum settling time of 65nsec. DAC812B guarantees ±1 LSB integral linearity over temperature and specifies a maximum settling time of 80nsec. Both grades have a −25°C to +85°C specified temperature range and guarantee 12-bit monotonicity over the full range.

DAC812 is packaged in a standard, 24-pin, hermetic, metal DIP and contains its own internal low-drift reference. Its output current range is 0 to −10mA, and the internal bipolar-offset resistor can be used to generate a bipolar ±5mA output. The internal application resistor is designed to be used as the feedback resistor of a user-selected external op amp to generate 0 to +10V and ±5V output voltages.

The Micro Networks DAC812 is a pin-compatible, functionally-equivalent, second source for the industry-standard DAC812. For military/aerospace and harsh-environment commercial/industrial applications, DAC812 offers optional screening to Method 5008 of MIL-STD-883 performed in Micro Networks MIL-STD-1772 certified facility.



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**ABSOLUTE MAXIMUM RATINGS**

| | |
|---|---|
| Operating Temperature Range | −55°C to +125°C |
| Specified Temperature Range: | |
| DAC812B, B/B | −25°C to +85°C |
| DAC812C, C/B | −25°C to +85°C |
| Storage Temperature Range | −55°C to +150°C |
| +15 Volt Supply (+Vcc, Pin 24) | −0.5 to +18 Volts |
| −15 Volt Supply (−Vcc, Pin 23) | +0.5 to −18 Volts |
| +5 Volt Supply (+Vdd, Pin 19) | −0.5 to +7 Volts |
| Digital Inputs (Pins 1-12) | 0 to +5.25 Volts |

**ORDERING INFORMATION**

PART NUMBER — **DAC812X/B**
Select either DAC812B or DAC812C for desired speed, linearity and drift performance as specified.
Add "/B" suffix to either part number for high-reliability screening. Contact factory for details.

**SPECIFICATIONS ($T_A$ = +25°C, ±Vcc = ±15V, +Vdd = +5V unless otherwise indicated) (Note 1)**

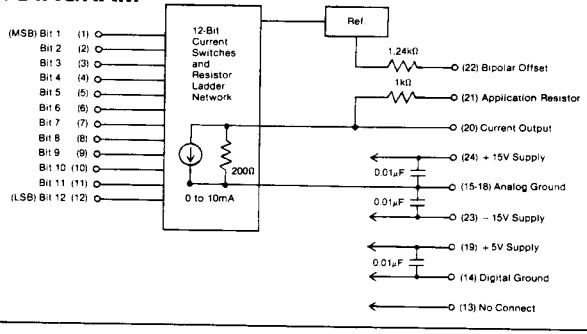
| DIGITAL INPUTS | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|
| Logic Levels: Logic "1" | +2.0 | | | Volts |
| Logic "0" | | | +0.8 | Volts |
| Logic Currents: Logic "1" ($V_{IH}$ = +2.7V) | | | +20 | μA |
| Logic "0" ($V_{IL}$ = +0.4V) | | | −800 | μA |
| Logic Coding (Note 2): Unipolar Range | | CSB | | |
| Bipolar Range | | COB | | |
| **ANALOG OUTPUT** | | | | |
| Output Current: Unipolar Range | | 0 to −10 | | mA |
| Bipolar Range | | ±5 | | mA |
| Output Voltage (Note 3): Unipolar Range | | 0 to +10 | | Volts |
| Bipolar Range | | ±5 | | Volts |
| Output Impedance (Notes 4,12): Unipolar Range | | 170 | | Ohms |
| Bipolar Range | | 150 | | Ohms |
| Output Compliance (Note 5) | ±4 | | | Volts |
| **TRANSFER CHARACTERISTICS** | | | | |
| Linearity Error (Note 6): DAC812B: Initial (+25°C) | | ±0.009 | ±0.018 | %FSR |
| Over Temperature (Note 7) | | | ±0.024 | %FSR |
| DAC812C: Initial (+25°C) | | ±0.006 | ±0.012 | %FSR |
| Over Temperature (Note 7) | | | ±0.012 | %FSR |
| Differential Linearity Error: DAC812B: Initial (+25°C) | | ±0.012 | ±0.018 | %FSR |
| Over Temperature (Note 7) | | | ±0.04 | %FSR |
| DAC812C: Initial (+25°C) | | ±0.006 | ±0.012 | %FSR |
| Over Temperature (Note 7) | | | ±0.024 | %FSR |
| 12-Bit Monotonicity | Guaranteed Over Temperature | | | |
| Offset Error (Notes 8,9): Unipolar | | ±0.02 | ±0.04 | %FSR |
| Bipolar | | ±0.03 | ±0.1 | %FSR |
| Offset Drift: DAC812B: Unipolar | | ±0.5 | ±1 | ppm of FSR/°C |
| Bipolar | | ±5 | ±15 | ppm of FSR/°C |
| DAC812C: Unipolar | | ±0.25 | ±0.5 | ppm of FSR/°C |
| Bipolar | | ±5 | ±10 | ppm of FSR/°C |
| Gain Error (Notes 8,10) | | ±0.03 | ±0.1 | % |
| Gain Drift: DAC812B | | ±20 | ±40 | ppm/°C |
| DAC812C | | ±10 | ±20 | ppm/°C |
| **DYNAMIC CHARACTERISTICS** | | | | |
| Settling Time to ±1/2 LSB (Note 11): | | | | |
| DAC812B: Full Scale Change | | 60 | 80 | nsec |
| 1 LSB Change (Note 4) | | 35 | | nsec |
| DAC812C: Full Scale Change | | 55 | 65 | nsec |
| 1 LSB Change (Note 4) | | 25 | | nsec |

| POWER SUPPLIES | MIN. | TYP. | MAX. | UNITS |
|---|---|---|---|---|
| Power Supply Range: +15V Supply<br>−15V Supply<br>+5V Supply | +14<br>−14<br>+4.5 | +15<br>−15<br>+5 | +16<br>−16<br>+5.5 | Volts<br>Volts<br>Volts |
| Power Supply Rejection: +15V Supply<br>−15V Supply<br>+5V Supply | | ±0.002<br>±0.0005<br>±0.0001 | ±0.004<br>±0.001<br>±0.0002 | %FSR/%Supply<br>%FSR/%Supply<br>%FSR/%Supply |
| Current Drain: +15V Supply<br>−15V Supply<br>+5V Supply | | +30<br>−40<br>+25 | +40<br>−50<br>+40 | mA<br>mA<br>mA |
| Power Consumption | | 1.2 | 1.6 | Watts |

**SPECIFICATION NOTES:**

1. Listed specifications apply for both DAC812B and DAC812C unless otherwise indicated.
2. CSB = Complementary straight binary. COB = Complementary offset binary. Listed codings assume the use of an external op amp to produce a voltage output. See Digital Coding for details.
3. An external op amp must be used to produce voltage outputs.
4. These parameters are listed for reference only and are not tested.
5. Compliance voltage is the maximum voltage swing allowed at the output node in order to maintain guaranteed linearity and accuracy. The specification is listed as a minimum because we guarantee compliance with a ±4V output swing. Typically, higher output voltages are possible though not recommended.
6. For a 12-bit converter, 0.024%FSR corresponds to 1 LSB; 0.012%FSR corresponds to 1/2 LSB. FSR stands for full scale range, and it is equal to the nominal peak-to-peak output range of either 10mA or 10V.
7. DAC812B and DAC812C are both fully specified for −25°C to +85°C operation. Please contact factory to discuss operation over other extended temperature ranges.
8. Initial offset and gain errors are adjustable to zero with user-optional external potentiometers.
9. Offset error is defined as the difference between the actual and ideal output currents with a digital input of all "1's". For the unipolar range, the ideal output is 0mA. For the bipolar range, the ideal output is −5mA. ±0.1%FSR = ±10μA. See Digital Coding.
10. Gain error is defined as the error in the slope of the converter transfer function. It is expressed as a percentage and is equivalent to the deviation (divided by the ideal value) between the actual and the ideal value for the full output current span from the output current with an all "1's" digital input to the output current with an all "0's" digital input.
11. Settling time is specified for the generated voltage when driving current into a 150Ω load. For the 1 LSB settling time, the digital input is changed from 1000 0000 0000 to 0111 1111 1111.
12. DAC812's equivalent output circuit is a 10mA current source with a 200Ω shunt resistor. Since it is recommended that the 1kΩ application resistor be connected to ground in current-out applications, the effective output impedance becomes 170Ω for unipolar configurations and 150Ω for bipolar configurations (pin 22 connected to pin 20). Output capacitance is typically 10pF.

## BLOCK DIAGRAM




## PIN DESIGNATIONS

| | | | |
|---|---|---|---|
| 1 | Bit 1 (MSB) | 24 | +15V Supply (+Vcc) |
| 2 | Bit 2 | 23 | −15V Supply (−Vcc) |
| 3 | Bit 3 | 22 | Bipolar Offset |
| 4 | Bit 4 | 21 | Application Resistor |
| 5 | Bit 5 | 20 | Current Output |
| 6 | Bit 6 | 19 | +5V Supply (+Vdd) |
| 7 | Bit 7 | 18 | Analog Ground |
| 8 | Bit 8 | 17 | Analog Ground |
| 9 | Bit 9 | 16 | Analog Ground |
| 10 | Bit 10 | 15 | Analog Ground |
| 11 | Bit 11 | 14 | Digital Ground |
| 12 | Bit 12 (LSB) | 13 | No Connect |

## APPLICATIONS INFORMATION

**LAYOUT CONSIDERATIONS AND GROUNDING**—Proper attention to layout and decoupling is necessary to obtain specified accuracy from the DAC812. It is critically important that the device's power supplies be filtered, well-regulated and free from high-frequency noise. Use of noisy supplies may cause unstable and noisy output signals to be generated. Switching power supplies are not recommended for circuits attempting to achieve 12-bit accuracy unless great care is used in filtering any switching spikes present in the output.

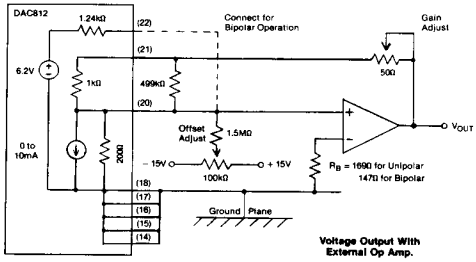
DAC812's two ground systems (Analog Ground, pins 15-18; Digital Ground, pin 14) are not connected to each other internal to the package. It is important that all 5 ground pins be connected together and all tied to system analog ground as close to the unit as possible, preferably through a large analog ground plane beneath the package. If a potential is allowed to develop between any of these 5 pins, it could degrade both speed and linearity performance.

DAC812 provides internal 0.01μF ceramic bypass capacitors on each of its supply lines. The +5V supply is bypassed to pin 14. The ±15V supplies are bypassed to pins 15-18. Additional external deccupling capacitors should be used on all power-supply pins. For optimum performance and noise rejection, 1μF tantalum capacitors in parallel with 0.01μF ceramic capacitors are the most effective combination. Single 1μF ceramic capacitors can be used if necessary to save board space.

Coupling between digital and analog output signals should be minimized to avoid noise pickup. Analog runs should be well separated from digital clock lines and other noise sources. The use of wire-wrap circuit construction is not recommended. Careful printed-circuit construction is preferred.

**DRIVING AN EXTERNAL OP AMP**—DAC812 may be used with an external, high-speed, operational amplifier in the

standard current-to-voltage conversion mode to produce an output voltage. DAC812 provides an internal 1kΩ resistor (pin 21) to be used as the op amp's feedback resistor and an internal 1.24kΩ resistor (pin 22) to be used in conjunction with the device's internal reference to generate the offset current for bipolar operation. Both these resistors are part of the same thin-film resistor network that holds DAC812's resistor ladder network. This ensures excellent thermal tracking which enables DAC812 to meet all its published relative-accuracy (linearity) specs even with an external op amp.



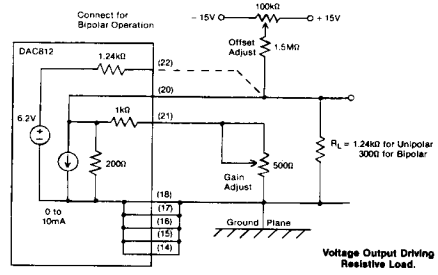

**Voltage Output With External Op Amp.**

In the circuit shown above, gain adjusting is performed by altering the value of the effective feedback resistance. The 499kΩ resistor in parallel with DAC812's 1kΩ feedback resistor drops the net value of the pair to slightly less than 1kΩ. The 50Ω pot in the feedback loop is then used to perform gain adjusting. If gain-adjust capability is not required, both the 499kΩ resistor and the 50Ω pot can be removed and the 1kΩ feedback resistor used directly.

Offset adjusting is performed by using the circuit illustrated to inject current into the op amp summing junction. If offset-adjust capability is not required, the pot and series resistor may also be removed. $R_B$ is a bias-current compensation resistor, and its value should be selected in the traditional manner.

If DAC812 is used to drive a resistive load, the load should be connected directly to pin 20 as illustrated. DAC812's internal current source is then driving a load resistance equivalent to its 200Ω source resistance, in parallel with its 1kΩ feedback resistance, in parallel with the external load resistor. For bipolar operation, pin 22 must also be connected to pin 20. If required, offset adjusting can be performed by injecting current at pin 20, and gain adjusting can be performed by effectively varying the load resistance.

In the circuit illustrated, a load resistor of 1.24kΩ yields a unipolar output voltage range of 0 to −1.5V. A load resistor of 300Ω and pin 22 connected to pin 20 yields a bipolar voltage range of ±0.5V. See table for more details on digital coding.




**Voltage Output Driving Resistive Load.**

| Digital Input | | Analog Output | |
|---|---|---|---|
| MSB | LSB | Unipolar | Bipolar |
| 0000 0000 0000 | | −1.49963V | −0.49976V |
| 0000 0000 0001 | | −1.49927V | −0.49951V |
| 0111 1111 1110 | | −0.75037V | −0.00024V |
| 0111 1111 1111 | | −0.75000V | 0.00000V |
| 1000 0000 0000 | | −0.74963V | +0.00024V |
| 1111 1111 1110 | | −0.00037V | +0.49976V |
| 1111 1111 1111 | | 0.00000V | +0.50000V |
| Load Resistor | | 1.24kΩ | 300Ω |
| Pin 22 | | Open | Pin 20 |

## DIGITAL INPUT CODING

| Digital Input | | Analog Output | | | |
|---|---|---|---|---|---|
| MSB | LSB | 0 to −10mA | ±5mA | 0 to +10V | ±5V |
| 0000 0000 0000 | | −9.9976mA | −4.9976mA | +9.9976V | +4.9976V |
| 0000 0000 0001 | | −9.9951mA | −4.9951mA | +9.9951V | +4.9951V |
| 0100 0000 0000 | | −7.5000mA | −2.5000mA | +7.5000V | +2.5000V |
| 0111 1111 1110 | | −5.0024mA | −0.0024mA | +5.0024V | +0.0024V |
| 0111 1111 1111 | | −5.0000mA | 0.0000mA | +5.0000V | 0.0000V |
| 1000 0000 0000 | | −4.9976mA | +0.0024mA | +4.9976V | −0.0024V |
| 1000 0000 0001 | | −4.9951mA | +0.0049mA | +4.9951V | −0.0049V |
| 1100 0000 0000 | | −2.5000mA | +2.5000mA | +2.5000V | −2.5000V |
| 1111 1111 1110 | | −0.0024mA | +4.9976mA | +0.0024V | −4.9976V |
| 1111 1111 1111 | | 0.0000mA | +5.0000mA | 0.0000V | −5.0000V |

**GAIN AND OFFSET ADJUSTING**—Regardless of configuration, DAC812 offset adjusting should be performed with a digital input code of all "1's" (all switches off) and gain adjusting with a digital input of all "0's". To avoid interaction, offset should be adjusted before gain.

1. For 10mA FSR, 1 LSB = 2.44μA
2. For 10V FSR, 1 LSB = 2.44mV
3. For bipolar operation, connect Bipolar Offset (pin 22) to Output (pin 20).

## ORDERING INFORMATION

| Part Number | Max. Integral Linearity (LSB's) | | Monotonicity Over Temp (2) | Max. Gain Drift (ppm/°C) | Max. Unipolar Offset Drift (ppm of FSR/°C) | Max. Bipolar Offset Drift (ppm of FSR/°C) | Maximum Settling Time (to ± ½ LSB , nsec) |
|---|---|---|---|---|---|---|---|
| | +25°C | Temp. (2) | | | | | |
| DAC812B | ±3/4 | ±1 | 12 Bits | ±40 | ±1 | ±15 | 80 |
| DAC812B/B (1) | ±3/4 | ±1 | 12 Bits | ±40 | ±1 | ±15 | 80 |
| DAC812C | ±1/2 | ±1/2 | 12 Bits | ±20 | ±0.5 | ±10 | 65 |
| DAC812C/B (1) | ±1/2 | ±1/2 | 12 Bits | ±20 | ±0.5 | ±10 | 65 |

1. Includes high-reliability screening. Please contact factory.
2. Both DAC812B and DAC812C are fully specified for −25°C to +85°C operation. Please contact factory for information on extended temperature operation.