



## Programmable DC Output with the DDS9m or 409B

### AN004

#### **Introduction:**

The Models DDS9m and 409B provides four synchronized sinewave outputs which can be independently controlled in frequency, phase, and amplitude. The frequency of each channel is programmable with 32-bits of resolution and phase can be controlled with 14-bits of resolution ( $0.022^\circ$ ), along with 10-bits of amplitude resolution. These features can be used to generate a variable DC output voltage.

#### **Setting the Output Voltage:**

Each of the four sinewave output channels on the DDS9m and 409B is direct coupled to the DDS (direct digital synthesizer). Since a frequency of zero Hertz (DC) can be programmed, there are two ways to set a programmable level on the outputs.

The output set by the DDS generator is:

$$V_o = V_a \cdot \sin(2\pi F t + P)$$

where  $V_a$  is the maximum amplitude in volts,  $F$  is the output frequency,  $P$  is the output phase, with time,  $t$ , as the variable. If  $F$  is set to zero:

$$V_o = V_a \cdot \sin(P)$$

$V_a$  is programmable over a 10-bit range by the "Vn N" command and  $P$  is controlled over a 14-bit range by the "Pn N" command. Either can be chosen as your control variable. Since the absolute phase is needed, the "M a" command must be sent before using these techniques.

#### **Example using $V_a$ , via the "Vn N" command:**

To use the control of  $V_a$  to set a DC output, the frequency needs to be set to zero and the value of the  $\sin(P)$  term must be maximized. This requires setting the mode to auto and the phase to  $90^\circ$ . The phase must be set to 4096 to get  $+90^\circ$  for positive outputs. The command sequence to set up a channel to output a DC voltage in this example is (shown for channel 0):

```
M a  
F0 0  
P0 4096
```

That will set the output to approximately +1 Volt. The "Vn N" command is then issued to scale the output:

```
V0 512
```

will result in a half scale output, or approximately 0.5V into an open circuit. For negative outputs, the command sequence would be (setting  $-90^\circ$ ):

M a  
F0 0  
P0 12288

V0 512

to get approximately -0.5 Volt.

Note that it isn't necessary to resend the mode, frequency or phase commands after the channel is configured for a DC output. This method provides 10-bits of control over the full positive scale and full negative scale range, or approximately 1mV of resolution. The output is linear with this setting method.

### **Example using P, via the “Pn N” command:**

Finer resolution control of the DC voltage can be obtained by using the phase command, which provides a 14-bit range. The trade-off is now the output voltage follows the sine of the input phase. As before, the mode must be set to auto and the frequency to zero Hertz:

M a  
F0 0

Now, however, the “Pn N” command provides the control. Recall that the output is:

$$V_o = V_a * \sin(P)$$

with  $V_a=1$  V into an open circuit by default. So this reduces to:

$$V_o = \sin(P)$$

which shows that the amplitude follows the sine of the input phase. If the same half scale outputs were desired ( $\sin(30^\circ)=0.5$ ):

P0 1365

for +0.5 Volts, and:

P0 15019

for -0.5 Volts ( $\sin(330^\circ)=-0.5$ ). This is based upon a full  $360^\circ$  being equal to 16,384 (14-bits). The user must calculate the appropriate angle and scale it to fit into the 14-bit range of the phase command.

The DDS9m and 409B are designed as frequency synthesizers, so the DC accuracy of the output is not “calibrator” accurate or stable, but these DC outputs can be used when a DC voltage is needed.