# Slew Rate and the DA3



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## Introduction

This technical note defines slew rate and describes its effect on low- and high-frequency signal reproduction. It also presents the measurements of slew rate for one DA3.

## Background

The DA3 switches very quickly between discrete levels of the D/A output. This rate of transition is known as the slew rate. A high slew rate is a desirable characteristic for a D/A converter because it allows for undistorted reproduction of high-frequency signals. However, at lower frequencies, a high slew rate produces a staircase effect that can produce significant high-frequency components in the output. One solution is to use an external anti-imaging filter with a cutoff frequency at half the sampling frequency. Another solution is to use the DA3's built-in slew distortion correction circuit.

## DA3 Slew Correction

The DA3 slew distortion correction circuit employs an array of capacitors to smooth the staircase transition. You can select a capacitance between 100 and 1780 pF in 15 discrete steps (see the description of the DA3setslew() function in the XBDRV Software Reference for details).

Larger values of capacitance slow the rate of change of the output signal (reduce the slew rate). This smoothes the output and "connects the dots" better than the staircase output of the D/A. Too much capacitance, however, can attenuate the signal you want to present.

The following values of slew rate were measured by playing a 250 kHz, 10 Vp square wave through a DA3:

| DA3 slew mode | Capacitance (pF) | Slew Rate (V/us) |
|---|---|---|
| off (default) | none | 5. |
| 1 | 100 | 3. |
| 2 | 220 | 1.6 |
| 4 / Auto | 560 | 0.7 |
| 8 | 1000 | 0.4 |
| 15 | 1780 | 0.2 |

## Selecting the Right Setting

The maximum slope (slew) of a sinusoidal signal is amplitude * 2 * pi * frequency. A full-scale (10Vp) 1 kHz signal will have a maximum slew of 0.063 V/usec. The same signal at 100 kHz will have a slew rate of 6.3 V/usec. As seen in the above table, this latter value exceeds the maximum slew rate of the DA3.

When the maximum slew rate of the DA3 is exceeded, the output signal will not reach its peak voltages, resulting in a triangular output signal rather than a sinusoid. To prevent such signal distortion, use the equation above to calculate the maximum amplitude you can play your signal for a given slew rate. E.g.: The maximum slew rate of the DA3 (with no slew correction enabled) is about 5 V/us. This means the amplitude of a 100 kHz tone can be as high as 8 Vp without distorting the signal.

For human hearing experiments (signals <20 kHz), use a DA3setslew() value of 2 or 3. Auto mode (value of 0) sets the code to a value of 4 (560 pF), which is good for full-range signals not exceeding about 10 kHz, or 5 Vp signals not exceeding 20 kHz.

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The following is a listing of the code used to generate the 250 kHz square wave used in gathering the data for this technical note:

```
dpush(50000);          // create 50 ksample buffer
value(10.0);           // make buffer of max values
scale(32767.0);
qdup();                // duplicate it and invert the copy
scale(-1.0);
shuf();                // shuffle together to get a max
                       //   amplitude square wave
allot16(1, 50000);     // create DAMA buffer
qpop16(1);

DA3clear(1);           // DA3 to factory defaults
DA3mode(1, 0);         // use Chan 1 in fast mode
DA3srate(1, 2.0);      // sample rate = 500 kHz (max)
DA3setslew(1, 0);      // use AutoSlew(0) or values
                       //   1-15 for 100 to 1780 pF;
                       // omit for no slew correction

DA3npts(1, -1);        // play “countinously”
DA3arm(1);
DA3go(1);
```

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One useful characteristic to note is that slew rate and the capacitance setting are inversely proportional:

$$
\begin{aligned}
C * \text{slew} &= \text{pF} * \text{V/us} \\
&= [\text{C/V}] * 10^{-12} * [\text{V/s}] * 10^{-6} \\
&= \text{uA}
\end{aligned}
$$

In this system, C * slew ≅ 30 to 40 uA.