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Application Engineering
TechNote

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Factors Affecting D/A Output

The output impedance of the D/A modules used on the H8/300 series is generally the same but there are a lot of factors that can change the linearity of the output. Typically the output drive capacity is a function of the capacitance and load resistance. The output is usually specified as a current level or a voltage output into a specified load. The D/A output is thus a function of the target design and must be accounted for in the circuit design.

For the H8/338 specifications are given for the operation with Vcc at both 5 volts and 3 volts but the AVcc is a 5 volt level in both cases. Also for both cases Vss = Avss = 0 V and the frequency is run from 0.5 mhz to maximum for the specific model of chip. While these are the "basic" numbers always looked at, the critical parameters the designer must consider are the conversion time and absolute accuracy. These parameters are usually specified at a specific output capacitance and resistance loading.

On the H8/338 the output is typically 2.0 ma but could be as much as 5.0 ma. Thus the designer must consider this variation in circuit load design. There is no specification that the analog output will be a nice straight series of steps with the digital input from $00 to $FF. The following is a brief list of parameters the designer might review for the specific application. Depending on the final application some of the parameters might be critical to the system's performance and play a major role on selecting the component.

Scale Error: This is the departure from design output voltage for a given input code. Usually this value is given at full scale deviation. The major factor that causes the error in this spec is the temperature coefficient. The spec for the H8/338 is -20 to +75 degrees C.

Offset Error: This is the zero error or the output of the D/A with an input code of $00. This can be minimized by connecting the Vss to AVss. The circuit layout should be as short as possible to minimize and ground loop current effects. This error is usually expressed in a percent of full scale or in a fraction of the LSB.

Linearity Error: This is more a non-linearity error or the deviation from the linear transfer curve. The specific value is not given for the H8/338 but is within the +/- 1 LSB for a 4 meg ohm load over the output voltage range. Since this may vary from part to part it should be considered if the application requires a very repeatable output when dealing with the LSB range of output voltages. This value does not include the effects of scale, gain or offset affects.

Monotonicity: This means that the slope of the output will have no change. That is for increasing values the slope will be positive with no negative segments as the count output is increased. The same relation applies for a count down sequence with a negative slope.

Settling Time: This spec is a key time factor as it includes the slew rate of the output analog amp. The settling time is shown in the absolute accuracy numbers and is a factor of output load impedance. Depending on the charge that must be sourced/sunk in a specific time the accuracy is affected. Note that with the H8/338 the lower output impedance the less accuracy you have on the output in a given time. Thus the output amp in the H8/338 cannot slew the voltage as fast with the lower output loading. For the best performance the output should be driving a high impedance load.

Long-Term Drift: This spec is a result of the aging of the silicon. The main factor effected is the scale error. If the processor is used in instrumentation that requires long term stability it is advised that some automatic calibration be performed through software and a "standard " load to compensate for the drift that may be encountered.

All of the above are sources of error on the output of a D/A but the most critical is the output loading. The higher the output impedance the better for the D/A. It allows faster settling times and less loading effects on the output stage. Generally the other non-linearity factors are taken into account in the design of the silicon but may not meet the design requirements for a specific design. Thus using a 8 bit port and driving an external D/A may be required as the internal D/A does not quite meet the design requirements.

The output impedance for most Hitachi micro's with D/As are about the same as the same building block of silicon is used across the product line. It is the application that determines if the D/A is the proper solution for the application and above were listed some of the more common parameters to look at when choosing the micro-D/A combination.

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