Specifying Selected Op Amps and Comparators

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It is not infrequent that commercially available standard IC components do not fit a particular application as they are specified. Often, however, a standard device selected to tighter limits will work. Thereupon, the IC manufacturer may be requested to supply a specially tested device.

The usual chain of events for a selected part is as follows: A specification is sent to the manufacturer with a request for quote. It is evaluated at the manufacturer for feasibility, yield, and testing requirements. Then price and delivery are quoted to the customer. (Sometimes this route is shortened by calling the manufacturer — but this does not always work.)

Some insight into the IC design and IC testing can help both the manufacturer and IC user with special selection. Proper specification helps the manufacturer test as well as reduce IC costs. Ambiguous or impossible specs will usually result in the return of the specification to the customer for clarification and delay the delivery of the required parts.

The manufacturer is usually familiar with the product and production spread of devices. Further, test equipment is available for measuring parameters specified by the data sheet. In general, tightening selected data sheet parameters causes no problems. Further, no additional test equipment is needed for these tests — only the limits need be changed.

Perhaps one of the largest problems is over-specification. Each tightened specification reduces the number of parts available to the specification. For example, tightening several specifications at once could result in a 1% or 0.1% yield; to supply 100 parts at this yield, between 10,000 and 100,000 parts might have to be tested, and that gets expensive.

Of course, spec limits cannot be tightened to any desired value. This is due to limitations on the IC design. For example, bias current, which depends on transistor H_{fe}; can not be tightened by a factor of 10. This would require beta's 10 times higher than normal. Also, some specifications are not independent, such as op amp bandwidth and slew-rate.

Op Amp and Comparators

These are the two most popular linear IC components requiring selection. Since many of the same specifications apply to both types of devices, they will be covered together. *Table 1* shows the most common parameters tested on these devices and the relative difficulty of testing on high speed equipment.

Selected offset voltage and drift are very commonly specified parameters. Offset voltage and drift depends on component matching. In general, drift is not usually tested on general purpose devices; although, it may be guaranteed. Offset voltage can be correlated to drift, and the offset limits are set to guarantee the standard drift specification. Of course, very low drift devices must be 100% tested for drift, making them relatively expensive. Drift testing requires measuring the offset voltage at three or more temperatures; then subtracting and dividing by the temperature change to obtain the drift — a long and tedious measurement.

In some cases tightened offset voltage specifications over the operating temperature range offer the same performance as a drift tested device, but are less expensive. This is because offset voltage measurement can be a go/no-go measurement. For example, 15 µV/˚C can be guaranteed over a 100˚C range by limiting the maximum offset voltage to ±0.75 mV or a 1.5 mV band. If the application has an error budget of ± "X" volts, it may be better to tighten the offset voltage rather than have the manufacturer to drift test. Drift testing a comparator is virtually impossible since they are not designed to operate closed loop.

Other parameters dependent upon matching are: offset current, common mode rejection, and supply rejections. These can be greatly tightened at the expense of yield.

Bias current, supply current, gain, slew rate, and response time are dependent upon both device design and processing. The limits for tighter parameters on these specifications are more restrictive. *Table 2* gives reasonable special selection limits. This is only a guideline and, of course, depends on the device.

Noise testing is in a class by itself. Op amp noise will vary between manufacturers of the same device. Further, noise will vary between different types of devices from the same manufacturer. Since noise on a particular device is mostly process dependent, it will be relatively consistant from a single IC producer.

Noise can be broken into two categories: white noise, and popcorn noise. Both of these noise sources can be either voltage or current noise. It is possible with advanced processing to make IC transistors as good as the best discrete low noise transistors. With good processing only a very small percentage of op amps will have any popcorn noise.

Noise measurements are time consuming and costly. Popcorn noise testing may take as much as 30 seconds per unit which limits production to about 100 devices per hour. This low production rate will increase costs. If not absolutely necessary — do not specify noise.

As a final note, some mention should be made of other special testing. Anything reasonable can be done; however, it should be kept in mind that accurate specification in terms of the IC parameters is necessary. It is unlikely a positive result will come from a specification showing a system schematic, system output, and stating "select devices to produce desired outputs." Although this is an exaggeration, it points out the type of specification to be avoided. Performance specification should apply to the IC not to a circuit using the IC. Many manufacturers have circuits available showing the various electrical tests and the way they are done.

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Op Amp and Comparators (Continued)

TABLE 1. Relative Ease of Parameter Testing

Parameter	Op Amp	Comparator	Cost
Offset Voltage	Easy	Easy	Low
Offset Current	Easy	Easy	Low
Bias Current	Easy	Easy	Low
Supply Current	Easy	Easy	Low
Common Mode/Supply Rejection	Easy	Easy	Low
Gain	Moderate	Moderate	Low
Input Resistance	Guaranteed by Bias Current Measurement	Guaranteed by Bias Current Measurement	Not Tested
Slew Rate	Moderate	Moderate	Relatively Low
Bandwidth/Response Time	Difficult	Difficult	Moderate
Offset Voltage Drift	Very Difficult	Very Difficult	High
Offset Current Drift	Very Difficult	Very Difficult	High

TABLE 2. Guideline to Tightened Specifications

Parameters	Limit	Comments
Offset Voltage	0.1 mV	Matching
Offset Current	–50% of Nominal	Matching
Bias Current	–50% of Nominal	Depends on H_{fe}
Supply Current	–25% of Nominal	Depends on Various Process Parameters
Gain	+100% of Nominal	Set by Design
Common Mode/Supply Rejection	+200% of Nominal	Matching
Slew Rate	+30% of Nominal	Set by Design
Bandwidth	+30% of Nominal	Set by Design
Response Time	–30% of Nominal	Set by Design and Processing
Offset Voltage Drift	0.2 µV/˚C to 5 µV/˚C	Lower Limit May Not Apply to Many Op Amps
Offset Current Drift	Guarantee by Offset Current Limit	

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National Semiconductor Corporation
Americas
Email: support@nsc.com

www.national.com

National Semiconductor Europe
Fax: +49 (0) 180-530 85 86
Email: europe.support@nsc.com
Deutsch Tel: +49 (0) 69 9508 6208
English Tel: +44 (0) 870 24 0 2171
Français Tel: +33 (0) 1 41 91 8790

National Semiconductor Asia Pacific Customer Response Group
Tel: 65-2544466
Fax: 65-2504466
Email: ap.support@nsc.com

National Semiconductor Japan Ltd.
Tel: 81-3-5639-7560
Fax: 81-3-5639-7507

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