

THE STATE OF THE ART AND NEAR-FUTURE IN BIPOLAR ANALOG CIRCUIT DESIGN

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Many important developments have taken place in the field of electronics during the last decade, but there is no doubt that the most profound has been the evolution of silicon processes capable of producing chips having upwards of 100,000 transistors or more with excellent yield. The impact of this technology has been felt even in the analog design community, where it has forced a radical reappraisal of the way in which solutions to classical problems - notably in the area of filtering - are found.

This has led to the rather unexpected situation where many functions once considered unassailably analog can now be efficiently implemented in the digital domain. The apparent contradiction is a consequence of several factors. First, digital circuits exhibit highly predictable and uniform performance. This in itself is a clear advantage, but it gives rise to a secondary advantage: no longer is there any need to use mechanical trims and expensive calibration procedures - and consequently the circuits are also immune to in-service shock and mis-adjustment. Third, the specific function can often be altered, either by simple mask programming, or by the use of ROMs or active control, unlike analog circuits which usually become functionally specific at high levels of integration. Not only does this advantage reduce the cost of altering the performance of a system, it opens the way to dynamic adaptation of the response. Fourth, once the signals are in digital form they are no longer (in principle, at least) subject to such analog imponderables as gain- and offset-drift, crosstalk and feedthrough, spurious responses, nonlinearities and random noise.

Whilst these are genuine advantages of digital signal processing, it must be added that the present situation is as much as anything a reflection of a popular modern philosophy, reinforced by educational policies which de-emphasize classical analog disciplines, often with the rationale that they are no longer of relevance. These factors have led a serious attrition in the number of designers capable of making significant contributions to analog design, and to a hardening of the view that digital implementations are unquestionably preferable and invariably superior.

The fact is, however, that there remain many functions which by their very nature must be performed by analog circuits. The need for competent design talent and process and product innovation is now evident and stretches far into the future. Indeed, there are signs of a resurgence of interest - even a renaissance - in analog techniques. Forecasts of business in linear ICs predict a continuance of the annual compound growth rate of 20%, with sales of \$8 billion by 1988, up from \$3 billion in 1983. (Source: Business Week, April 16, 1984). This potential has resulted in the formation of at least five recent start-ups in the U.S. Questions now needing attention are not so much a matter of whether analog techniques will survive the so-called Digital Revolution, but relate to optimum choices of technology, to design approaches and organizational streamlining, and in the long run to maintaining appropriate levels of analog emphasis in university curricula.

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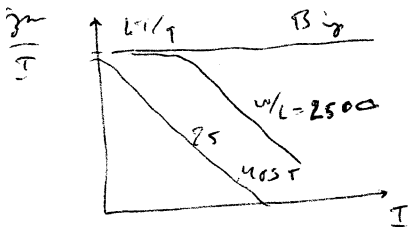
There is little doubt that MOS analog circuits have made great strides in recent years, largely as an outgrowth of work in universities where only MOS technology is available. Their appeal, however, is largely confined to those cases where the dominant chip function is digital, and the analog sections are included to support the main function in various ways. Their performance invariably falls far short of that which can be achieved using all-bipolar, or mixed bipolar and MOS (BiMOS), technologies. The choice of an MOS implementation is thus primarily a matter of pragmatism.

This paper will focus on advances in bipolar analog techniques, beginning with a discussion of some fundamental issues relating to the advantages of bipolar design, including new possibilities opened up by complementary processes, with particular emphasis on linear amplifiers of various types. The topic of D/A and A/D conversion will not be addressed in this paper. Later portions of the presentation will concentrate on nonlinear function synthesis using translinear techniques, and provide examples of powerful concurrent processing. It will also be shown that many of the advantages of digital processing, such as functional completeness with tight control of specifications, the elimination of the need for in-situ calibration, rapid re-configurability and so on, are becoming possible through the use new integrated components, laser-trimming techniques and fresh approaches. Indeed, the current design philosophy among leading suppliers of linear circuits, such as Analog Devices, is to provide complete, fully-calibrated microsystems which are as rugged and as easy to use as digital circuits.

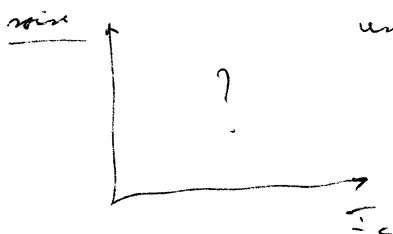
> IC market

Digital 57%

Linear 15%



most 4 terminal
Bip 3 terminal



Sys
8.4 Hz
?

GBW Sign 5539

Gen Purpose AD OP 37

△ Intermixing

3000

2000

tracking error

required in first group

now

AD 624

long - complementary process

△ Circuit: Meyer 1981

usually 0.1 Hz - 10 Hz

△ Bandson

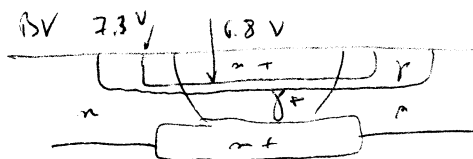
1.205

$V_{BE} = \dots$ Ref?

curvature correction

may give linear error

ok viable! + some problem



5 second
14 bits joint on R
6 bits joint

5 second

AD 639

8 AD - 80 AD

BiMOS 16 bit DAC

all trimming is
ratio metric!!

LT 121 8 ppm/°C