Is the Golden Age of Analog circuit Design Over?

My answer:

Yes, the golden age of pure analog circuit design is over.

But, the golden age of mixed signal technology is coming.

Some important works might be done in pure analog circuit design. Performance increases in basic analog circuits. However, many important progresses will be accomplished by the mixed signal technology.
### Current role of analog technology

The current major role of analog is to sustain digital technologies.

Digital communications, networkings, broadcastings, recordings, displays, etc.

Gb Ethernet

**Diagram:**

- **Analog circuit:**
  - Variable Gain Amp.
  - Analog Filter
  - A to D Converter
  - Side-stream Descramber & Trellis, Viterbi Symbol Encoder

- **Digital circuit:**
  - Pulse Shaping
  - Slicer
  - DFE
  - Clock Recovery
  - Side-stream Descramber & Trellis, Viterbi decoder
  - Voltage Controlled Oscillator
  - Clock Recovery
  - 3-NEXT Canceller
  - Echo Canceller

DVD recording

**Diagram:**

- **Analog circuit:**
  - Data In (Erroneous)
  - Voltage Controlled Oscillator
  - Clock Recovery
  - Viterbi Error Correction

- **Digital circuit:**
  - Data Out
  - Variable Gain Amp.
  - Analog Filter
  - A to D Converter
  - Digital FIR Filter

Data Out (No error)

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All systems will be integrated on mixed signal SoCs

“Global system design and optimization over digital and analog”

must be the most important works for the designer. The performance of SoC depends on it, greatly.

Corroboration: Digital and analog  System and circuit

Global optimization: digital and analog

Mixed signal SoC can integrate full DVD system


"Global system design and optimization over digital and analog" must be the most important works for the designer. The performance of SoC depends on it, greatly.
Analog issue in mixed signal SoC

If analog area can not be scaled along with digital, Chip cost will increase.

Analog should be scaled!
Otherwise, can’t be integrated.

Only the essential analog will survive

Digital calibration realized drastic power and area saving!

Y. Cong and R. L. Geiger, ISSCC 2003

Area: 1/50
Pd: 1/20

14b 100MS/s DAC
1.5V, 17mW, 0.1mm², 0.13um

Y. Cong and R. L. Geiger, ISSCC 2003

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Digital give us the breakthrough of analog circuit

Static accuracy: digital calibration  
Dynamic accuracy: timing adjustment

High speed conv.: parallelism  
DLL  
timing adjustment

8bit, 20GHz, ADC

Noise limitation

\[ V_n^2 = \frac{kT}{C} \quad \text{Conventional} \]

\[ V_n^2 = \frac{kT}{C} \cdot \frac{1}{M} \quad \text{Over sampling} \]

M: over sampling ratio

Enable low voltage operation

1.2V Dual-mode WCDMA/GPRS ΣΔ Modulator

GPRS: 82dB, WCDMA: 70dB

0.13umCMOS, Pd=3mW

K. Paulton, et al., ISSCC 2003

A. Dezzani and E. Andre, ISSCC 2003
Mixed signal egg

Analog helps digital (digital network and storage…). Next step is digital should help analog.

Mixed signal egg (Analog yolk and white with digital shell)

- Digital shell
  - Sustain the analog egg.
  - Calibration and adjustment,
  - Digital filtering

- Analog yolk and white
  - Delicious and nutritious

- But, very delicate and fancy
Golden age designers for analog circuits will be over

New golden designers age are expected

They can work in;

- Digital technology and analog technology
- System, circuit, and device
- Electromagnetism as well as conventional circuit theory
Progress in A/D converter; video-rate 10b ADC

ADC is a key for mixed signal technology. We have reduced the cost and power of ADC drastically;

Power consumption: 1/2,000
Price: 1/200,000

1980 1982 1993 Now
Conventional product World 1st Monolithic World lowest power SoC Core

<table>
<thead>
<tr>
<th>Board Level (Disc.+Bip)</th>
<th>Bipolar (3um)</th>
<th>CMOS (1.2um)</th>
<th>CMOS (0.15um)</th>
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<td>20W</td>
<td>2W</td>
<td>30mW</td>
<td>10mW</td>
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<td>$ 800</td>
<td>$ 2.00</td>
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Our developed. Our developed.

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Progress in high-speed ADC

High speed ADC has reduced its power and area down to be embedded.

World fastest 6b ADC
6b, 1GHz ADC
2W,
1.5um Bipolar

ISSCC 2000
World fastest CMOS ADC
6b, 800MHz ADC
400mW, 2mm²
0.25umCMOS

ISSCC 2002
World lowest Pd HS ADC
7b, 400MHz ADC
50mW, 0.3mm²
0.18umCMOS