LOG-RATIO BEAM POSITION MONITORING AT 425 MHz*

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Abstract

A logarithmic-ratio beam position monitoring circuit has been designed, based on a monolithic logarithmic-amplifier integrated circuit that provides 70 dB of gain over the 100-MHz to 500-MHz frequency range. Log-ratio circuits previously reported operate at frequencies below 100 MHz [1, 2, 3]. Operation at higher accelerator bunching frequencies previously required down-conversion to an intermediate frequency in the 20 to 100 MHz range. This new circuit offers the possibility of position measurement without down conversion.

Introduction

Logarithmic-ratio processing of beam position monitor (BPM) signals is currently under investigation at several Laboratories. The technique, which has been described in four publications [1, 2, 3, 4], is attractive because it provides the most linear response across the aperture of a cylindrical BPM probe as compared to difference-over-sum and amplitude-modulation to phase-modulation (AM/PM) processing [4].

The first monolithic logarithmic amplifier applied to this application was the Analog Devices Model AD640, having a frequency range of 20 to 100 MHz [1, 2, 3]. Many accelerator bunching frequencies are above this range and down conversion is required to obtain a suitable intermediate frequency below 100 MHz.

SL3522A Logarithmic Amplifier

In 1990, the Plessey Semiconductor Company introduced the SL3522A, a 70-dB logarithmic amplifier having a frequency range of 100 to 500 MHz. This device is a successive detection logarithmic/limiting, monolithic amplifier that produces a Log/Lin characteristic for input signals between +6 and -64 dBm with a linearity of ±1 dB.

Comprising the circuit are six stages of 12-dB gain each, seven detector stages, a limiting rf output buffer and a video output amplifier. For the log-ratio circuit application the rf output buffer is disabled.

Fig. 1 shows a typical transfer characteristic of an amplifier operating at 425 MHz. Ideally, the plot should be a straight line, but in reality the line deviates by about 5% from a straight line fit between -10 and -50 dBm. This compares to a 1% deviation exhibited by a typical AD640 operating at 60 MHz [1, 2]. This deviation from linearity is a principle source of error in the log-ratio application.

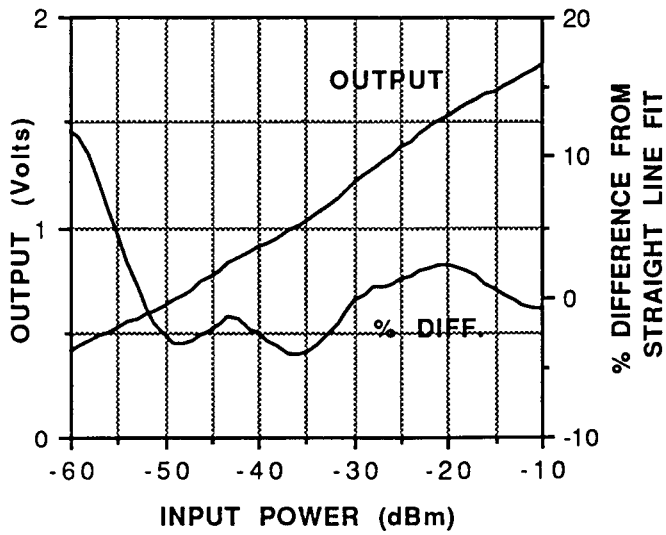

Fig. 1 Transfer curve for the SL3522A operating at 425 MHz.

The Log-Ratio Circuit

A block diagram of the log-ratio beam position monitor circuit is shown in Fig. 2. Two SL3522A amplifiers are used with their filtered outputs applied to a differencing amplifier that produces a beam-position signal proportional to log (A/B).

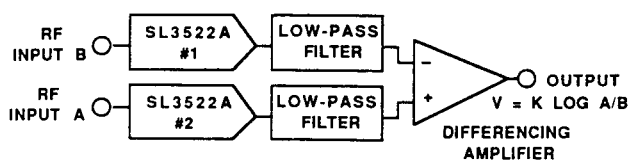

Fig. 2 The log-ratio circuit block diagram.

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The response of this circuit to 425-MHz rf input signals is illustrated by Fig. 3. The sinusoidal variations are attributed to the successive approximation circuit technique used for achieving the logarithmic response in the amplifiers and to the deviation of the transfer curves from the ideal straight line.

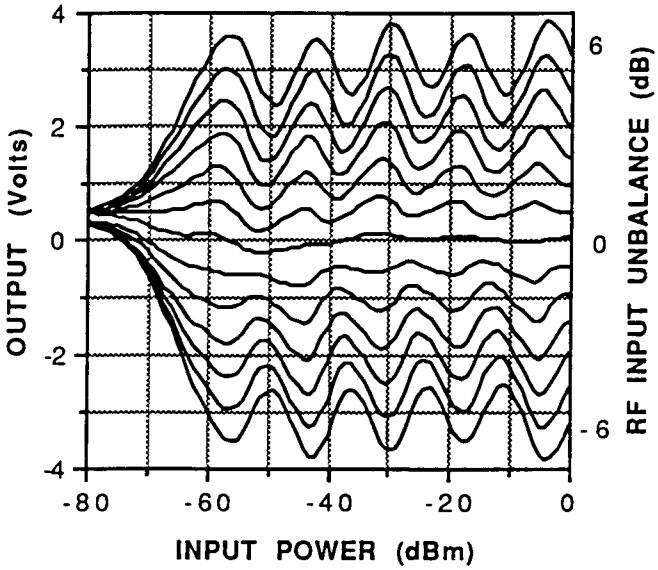

Fig. 3 Response curves of the log-ratio circuit operating at 425 MHz.

A plot of peak-to-peak error versus beam position is shown in Fig. 4 for a cylindrical probe having a subtended angle of 45 degrees. The error ranges from 2% at the center of the probe to approximately 8% at 0.2 of the probe radius.

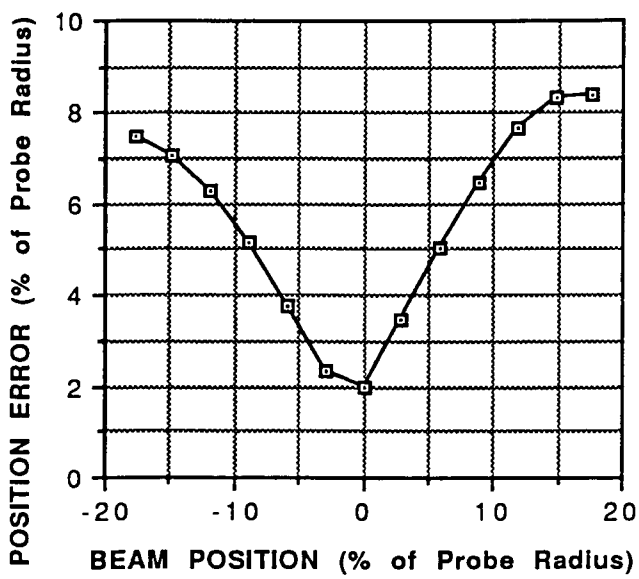

Fig. 4 Peak-to-peak error versus beam position.

Log-Ratio Compared to AM/PM Processing

An ideal system for measuring beam position should provide data that is independent of beam intensity over several decades of beam current. In general, the AM/PM system comes closest to this ideal because limiters are available that are phase matched over three or more decades of input signal voltage [5]. However, the maximum useful frequency limit is about 50 MHz. AM/PM systems operating above 100 MHz are generally limited to one or two decades of beam current and the measurements are sensitive to the beam current intensity.

Although the measurement accuracy of this log-ratio circuit is substantially worse than the AM/PM technique with down conversion, the device is usable at 425 MHz and it operates over six decades of rf-input power. AM/PM circuits are essentially unusable for this frequency and power range. The log-ratio technique is immediately adaptable to beam centering applications and the cost is about one-fifth that of AM/PM equipment. Log-ratio processing will become more viable as improved logarithmic amplifiers are designed by the semiconductor industry.

REFERENCES

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