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March 1969

Brief 69-10070

NASA TECH BRIEF

Analysis of Magnetically-Controlled Processes in Pulse-Modulation Systems

An investigation has been made to establish simple analytic expressions applicable to the design of a class of pulse modulators in which the modulating signal controls the reset level of flux in a nonlinear magnetic core. Analysis was carried out in the reset-coordinate plane B_r, T_r by defining two constraints on the reset process; one imposed by the magnetic core itself, and the other which includes the circuitry external to the core. Expressions derived for modulator response, modulation sensitivity, and limit-cycle stability were applied to both pulse-width and pulse-rate modulator designs.

Basic character of modulator behavior was shown to depend on the relative magnitudes and algebraic signs of the circuit derivative dB_r/dT_r and the core derivative dB_r/dT_r. Modulator response was found to be oscillatory for designs in which $(dB_r/dT_r)/(dB_r/dT_r) < O$, and is monotonic for $(dB_r/dT_r)/(dB_r/dT_r) > O$. Modulator stability depends only on the magnitude of $(dB_r/dT_r)/(dB_r/dT_r)$. Discontinuities in the fundamental mode of operation or transitions to a subharmonic mode were shown to result from the onset of instability. The region of stable operation is extended and the modulator response made very fast for a design using constant reset time.

Results of the investigation show that modulator performance parameters can vary over a wide range in the region of normal operation, with a significant deterioration in response occurring as the threshold of instability is approached. Pulse-width modulator designs with both finite and infinite circuit derivatives were analyzed for operation under constant-voltage reset conditions. Essentially optimum modulator performance was obtained for operation under fixed-reset-time conditions (infinite circuit derivative). The results of the generalized analysis were also applied to a pulse-rate modulator operating under constant-current reset conditions. Both an analytical description of the magnetic core reset function and a graphic representation of an experimentally-derived characteristic were used in the analyses, thus illustrating the flexibility of the generalized approach.

Notes:

1. Performance parameters of each of the above modulator circuits were measured and compared with the theoretical and calculated values. In each case good agreement was obtained and the results of the generalized analysis thereby substantiated.
2. Documentation for the innovation is available from:

   Clearinghouse for Federal Scientific and Technical Information
   Springfield, Virginia 22151
   Price $3.00
   Reference: TSP69-10070

Patent status:

No patent action is contemplated by NASA.

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Category 01