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NASA TECH BRIEF

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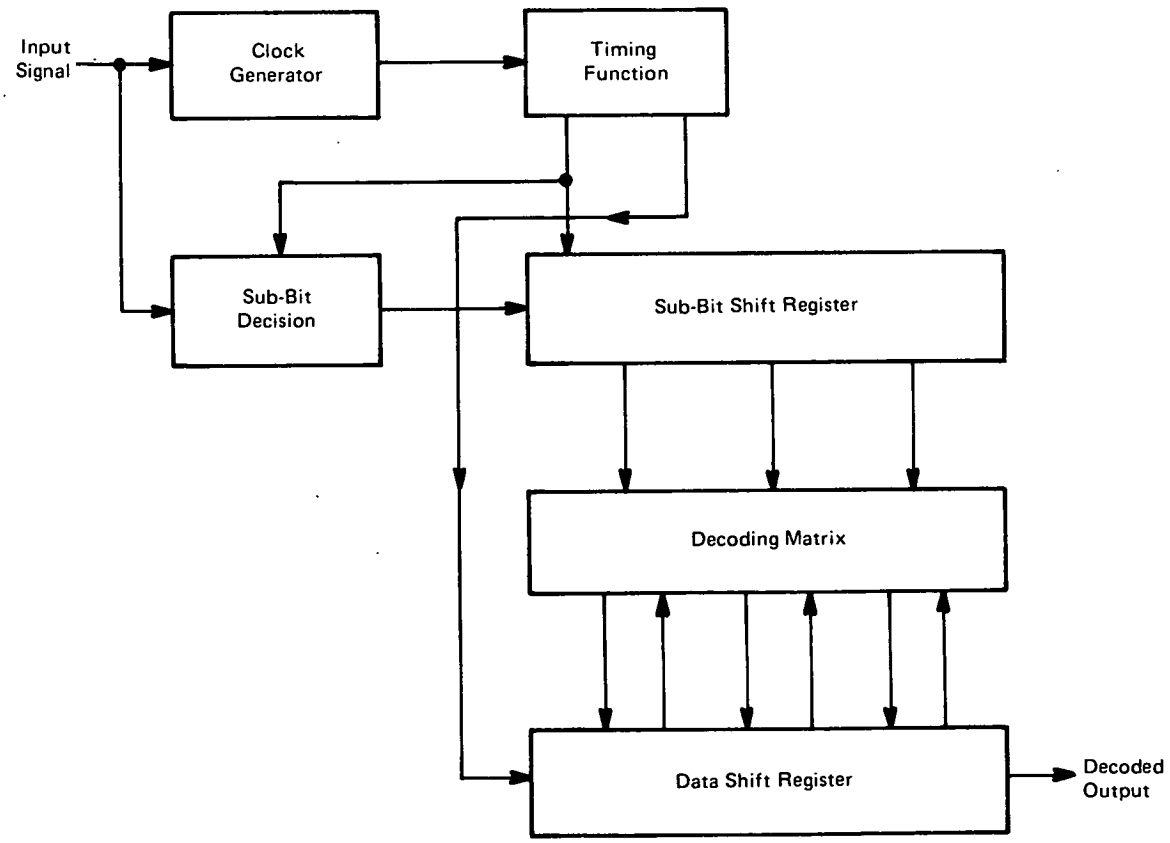
An Improved Learning Decoder

The problem:

Theory shows that improved performance of information transmission systems could be obtained if the pulse code modulation data are again coded prior to transmission. However, coded systems which offer better performances than those of the uncoded ones fall far short of Shannon's theoretical limit. The existing techniques use decoders which provide very low data capability and offer only slight improvement over uncoded systems in spite of extreme complexity. They also fail to decode signals at a relatively high signal-to-noise ratio compared to the expected thresholds and fail to recover and decode properly after a loss of signal.

The solution:

A learning decoder was developed which operates at the system data rate without limiting the data rate. The decoder is much simpler than those in existence, operates near Shannon's channel capacity, and automatically recovers operation after a loss of signal.



(continued overleaf)

How it's done:

The basic functions of the decoder are shown in the figure. An input signal is required to provide the sub-bit stream which is to be decoded. This signal is usually obtained from a receiver which has detected the signal from a distant signal source. The bit rate is determined by the clock generator which provides a time reference for the equipment operation. In the usual uncoded telemetry system, a device called a bit synchronizer is used to generate the clock and may be used as the clock generator for the learning decoder. The basic timing functions in the learning decoder are produced by the timing function; specifically, the sub-bit rate is used in the control of the sub-bit decision circuit and to shift the sub-bits stored in the sub-bit shift register. The sub-bit timing is also used to determine the information or data bit rate in the timing function and used to shift the data stored in the data shift register. A sub-bit decision circuit is similar to the data regeneration used in commercial bit synchronizers.

The incoming signal is analyzed sub-bit by sub-bit and regenerated. The regenerated signal is shifted through the sub-bit shift register and is used in the decoding process while it is stored in this register. The heart of the decoder is the decoding matrix which utilizes both the sub-bits in the sub-bit shift register and the data bits in the data bit shift register. The decoding matrix enters data into the data shift register and also corrects data bits which may be in error. The output of the decoder is the decoded signal.

The decoder performance was analyzed for operation at a signal-to-noise ratio of 2.5 dB with the noise measured in the data bandwidth. The signal-to-noise ratio for the received sub-bits was then -2.28 dB.

The results are as follows:

$(S/N)_b$ = 1.77 dB
T_b = 1.88 dB
$P_e(b)$ = 0.03
$P_c(b)$ = 0.97
$(S/N)_s$ = 0.60 dB
T_s = 1.08 dB
$P_e(s)$ = 0.14
$P_c(s)$ = 0.86

where: $(S/N)_b$ and $(S/N)_s$ are the bit and the sub-bit signal-to-noise power ratios, respectively.

T_b and T_s are the decision thresholds for the data bit and sub-bit error probabilities, respectively.

$P_e(b)$ and $P_e(s)$ are the respective probabilities of a bit and sub-bit error from the decision element.

$P_c(b)$ and $P_c(s)$ are the respective probabilities of a correct bit and sub-bit from the decision element.

Simulation of a rate 1/5 code provided normal operation at a signal-to-noise ratio of 3.5 dB (with the noise measured in the data bandwidth) for 1000 data bits. However, long test runs have not been performed.

Note:

Requests for further information may be directed to:
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Patent status:

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning non-exclusive or exclusive license for its commercial development should be addressed to:
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