BSM # 7785

SAGE DATA TRANSMISSION SYSTEMS

DESCRIPTION — GROUND-TO-GROUND DATA SYSTEMS

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1. GENERAL

1.01 With the exception of the long range and gap filler radars, practically all of the data processing units of the SAGE system that are located on the ground are interconnected and exchange information via the ground to ground data system. The data transported over this system include messages between direction centers, messages relating to weapons status and assignment and messages to interrogate the height finding radars.

2. GROUND TO GROUND DATA SYSTEM

2.01 The basic characteristics of the data generated in ground to ground data systems are as follows:

(a) Information is transmitted at the rate of 1300 bits per second. These data are arranged in the form of messages which are approximately 90 bits long. Messages are sent at a rate of approximately 15 per second. Each message contains five data words.

(b) Ground-to-ground data contain the usual three components; a start or synchronizing component, a data component and a timing component. The starting component only indicates the beginning of each message; indications of the starting points of the words in the message are not sent.

(c) There is a possibility that successive messages may have an informational relation to one another, however, this not likely to occur often. Most of the time the messages will not be related.

(d) The data words have error detection built in the message structure to the extent that each word in the message contains an odd parity check.

2.02 A portion of the messages sent over the ground to ground systems relate to actions or processes that are neither progressive nor repetitive. The message, therefore, does not contain information that is related to previous information that has been transmitted in the past nor will related information be transmitted in the future. ("Past" and "future" as used here denote time intervals in the order of minutes.) Furthermore the action or process to which the message relates will not be repeated. These conditions make it imperative that the message "get through" without error if at all possible, but, failing in this, that transmission errors be always detected. To this end not only does each word of each message have a parity check applied to it but, in addition, the whole message is "interleaved" to guard against multiple errors.

2.03 The interleaving technique is shown in Fig. 1 applied to a message that consists of one start bit and fifteen information bits. The information is arranged in the form of three data words each four bits in length. Each word concludes with a fifth bit that carries the parity. The incident message is shown at the top of the illustration - the waveshape is not drawn but the bits are indicated by letters and subscripts. Thus 1_1 is the first bit of word 1 and 1_2 is the first bit of word 2 and so on. The parity bits are indicated by "P" and a subscript. At the sending end this word is read into a storage matrix, word 1 first, then word 2 and finally word 3. After "read in" the bits are arranged in the storage matrix as shown. The bits are read out vertically to the line transmission gear; the resultant message is shown as the "incident line message" in the center of the figure. It will be noted that the message structure is now such that the words have lost their identity. At the receiving end of the circuit the message is read into and out of a storage matrix again and restored to its original structure.

2.04 This interleaving technique affords protection against multiple errors that might otherwise not be detected by a simple parity check. This is illustrated in Fig. 2 which compares the effect of multiple transmission errors on two identical messages, one of which has been interleaved before line transmission. The incident message is shown at the top of the page; it is composed of three words, each four bits in length. Each word has its associated parity bit thus its total length, information plus parity, is five bits. The nomenclature used is the same as before, that is, 1_1 is the first bit of word 1 and so on. The parity bits are indicated by P_1, P_2, and P_3. A combination of marks and spaces has been assumed for each word as shown.

2.05 It is assumed that odd parity is applied to each word, therefore, the total number of marks in each word, including the parity bit is always an odd number. In word 1, for example, bits 1_1 and 4_1 are marking, as is the parity bit, so the total number of marks is 3. This holds for words 2 and 3 although different bits are marking. The messages on the line are shown in the third line down; the interleaved message is on the right. A noise burst has been assumed in the same time position in each column, that is, the third and fourth bits following the sync pulse. The effect of this noise is to introduce errors, these two bits which were formerly spacing have now become marking due to the noise voltage superimposed on the signal. This is shown in the fifth line where the errors are indicated by "E."

2.06 The interleaved message must be read in and out of storage ("unscrambled"), before the parity can be checked. After the "read out" it should be noted that the original two successive errors now appear as single errors in two separate words. An erroneous mark now appears in the second bit of word 1 and the first bit of word 3. Application of the parity check results in a failure of parity for words 1 and 3 since each now has an even number of marks (4). The parity will be verified for word 2 since this has an odd number of marks (3).

2.07 Application of the parity check to the message on the left, however, which is not interleaved, does not pick up the errors. Both errors are in word 1 and the net result is that this word has erroneous marks (2nd and 3rd bits), but the total number of marks in it is still odd. The parity will, therefore, be verified and the erroneous word passed to the data using apparatus.

2.08 This interleaving technique increases the efficiency of the simple parity check enormously since by it (in the example shown), successive errors up to three in number will be detected. A penalty is incurred, however, in that more of the message is lost in the presence of errors when the message is interleaved. Thus in Fig. 2 only one word is wrong in the straight transmission while two words are lost in the interleaved method. This is distinctly a secondary consideration in ground-to-ground data systems, however, since here accuracy considerations are paramount.

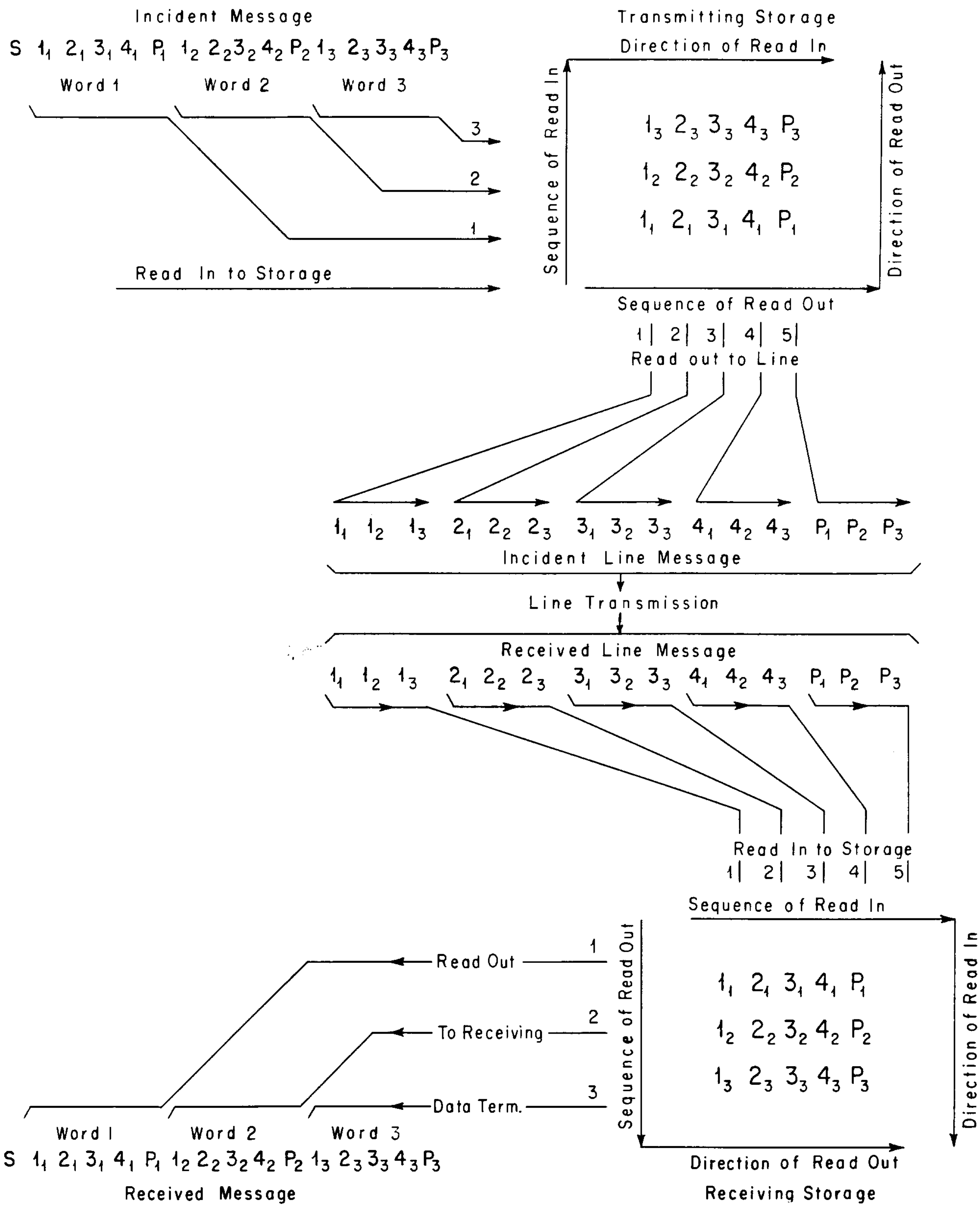

Fig. 1 - Interleaving Technique

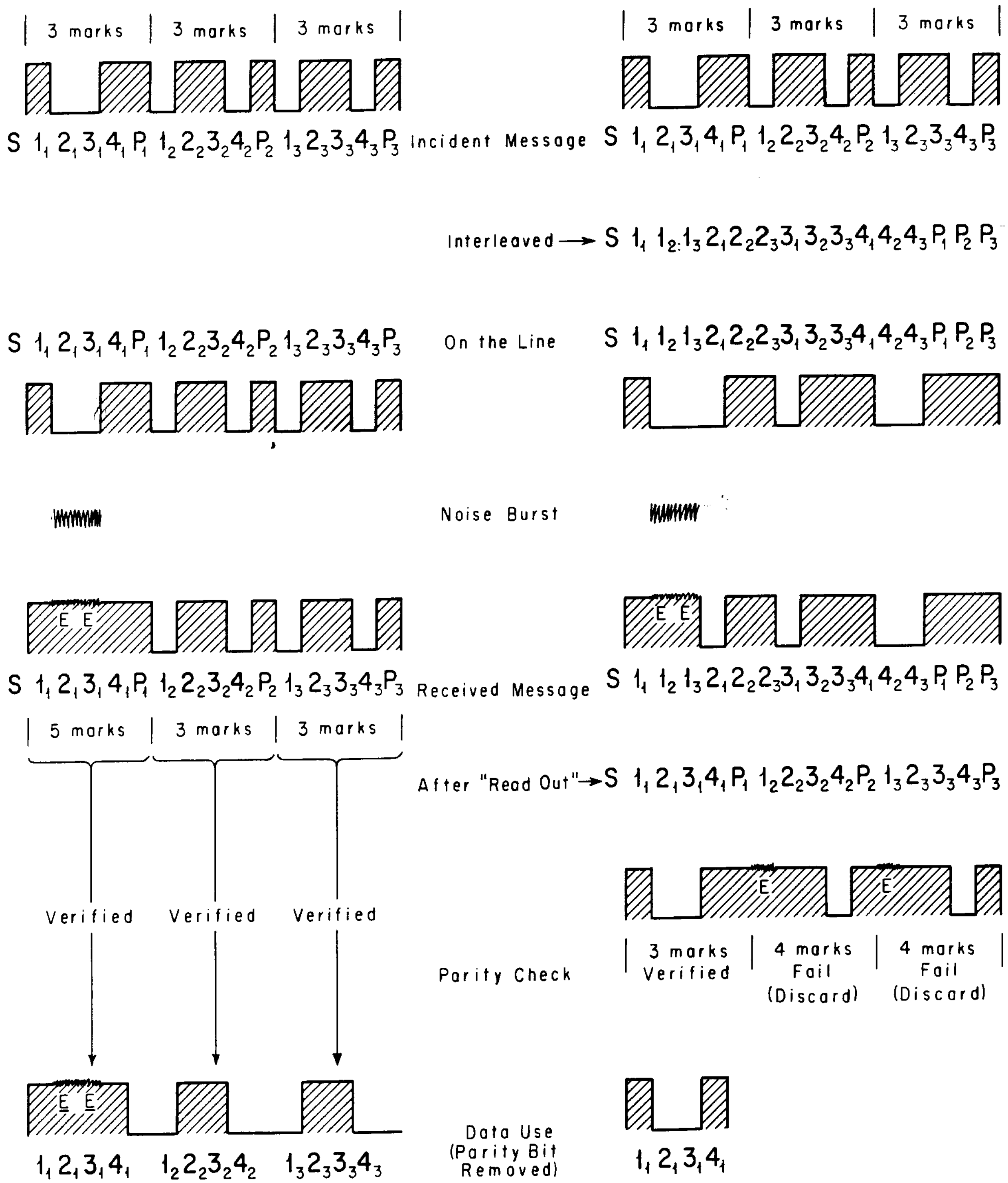

Fig. 2 - Error Detection