NOAA Technical Memorandum NESS 82

# THE GOES DATA COLLECTION SYSTEM

# PLATFORM ADDRESS CODE

Office of System Engineering
Washington, D.C.
October 1976

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ABSTRACT. This paper describes the theory and implementation methods involved with Data Collection Platform addressing. For the most part, this paper is intended to convey the GOES-DCS capabilities as they will exist after installation of the Data Collection System/Data Processing System (DCS/DPS) computer system (early CY 1977). It should be noted that the DCS design is evolutionary and will likely be modified to suit users' requirements. Therefore, the information contained herein should be treated as a timely design plan rather than a policy statement or requirements document.

## BACKGROUND

The GOES Data Collection System (GOES-DCS) is designed to collect a large variety of environmental data from virtually any location in the Western Hemisphere. The system is a data relay network consisting of thousands of individual data-gathering devices (or platforms) which can transmit their data to one of two Geostationary Operational Environmental Satellites (GOES). These platforms transmit their data in response to an interrogation or poll originating from a Command and Data Acquisition (CDA) Station located in Wallops Station, Virginia. Both the interrogation signal and the reply data are relayed between the platform and the CDA Station via GOES. A second type of platform initiates transmission to the CDA Station as scheduled by a timer or clock within the unit. These "self-timed" platforms do not require a receiver and, thus, do not use the interrogation signal from the CDA Station.

### The Platform Address Code

In an effort to expedite the cataloging and identification of data received by the GOES-DCS, as well as to implement the required polling procedure, a 31-bit code was adopted to identify (address) each platform uniquely.

The 31-bit BCH[1] code selected belongs to a class of cyclic codes discovered by Bose and Ray-Chaudhuri (1960) and Hocquengheim (1959),

[1] BCH coding is named for Bose, Ray-Chaudhuri, and Hocquengheim.

and has the following important properties:

1. All addresses (code words) have a minimum "hamming" distance of five; that is, no two addresses agree by more than 26 of the 31 bits. Therefore, the probability of transmitting an address assigned to one platform and having it be received as another platform's address is extremely low (0.000976 Pe, where Pe is the bit error rate (BER) of the channel).

2. The structure of the BCH code and its corresponding hamming distance provides the mechanism for error correction. It is possible, therefore, to correctly determine the intended platform address even though one, two or no bits had been corrupted in the transmission process. This has the effect of improving the channel's error rate significantly (at $10^{-5}$ BER, an uncoded address error rate would be about $2 \times 10^{-4}$, whereas coded the address error rate is about $10^{-12}$).

3. The code selected provides for $2^{21}$ (2,097,152) addresses out of a possible $2^{31}$ -- hence, the sometimes-used designation "21/31 BCH Code." This allocates a sufficient number of addresses for most GOES-DCS applications.

4. The implementation of the BCH code can be effected in a variety of ways. (See Appendix A.) NESS generates the platform addresses through the use of a matrix multiplication computer program. Through this program, a unique 21-bit sequence is multiplied by a 21 by 31-bit binary matrix, which results in a valid 21/31 BCH code word (fig.1). The code words produced are 31-bit sequences and are "systematic," that is, the first 21 bits are identical with the original 21 bits. Thus, all of the information contained within each code word is in the first 21 bits -- the remaining 10 bits are redundant or "check bits."

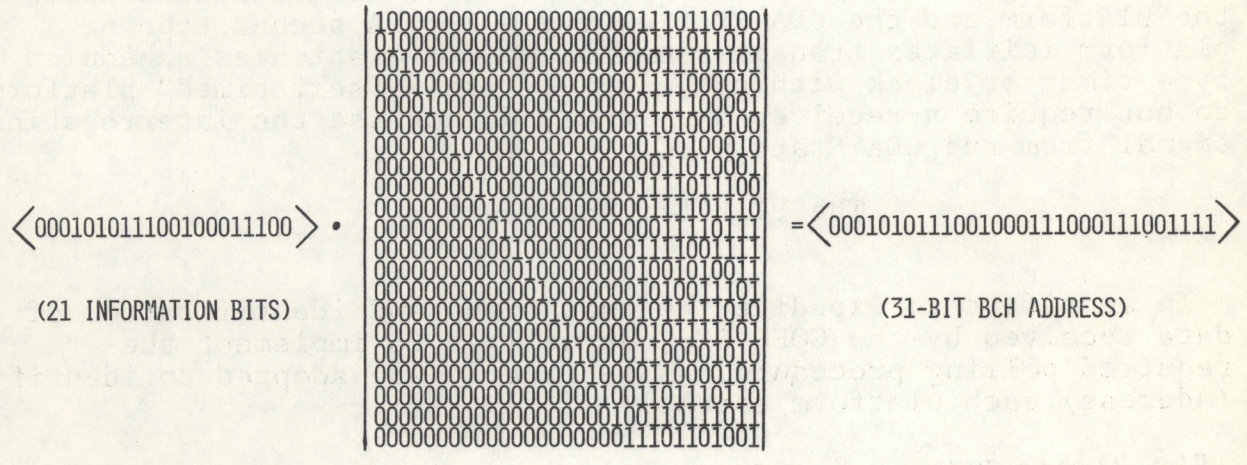
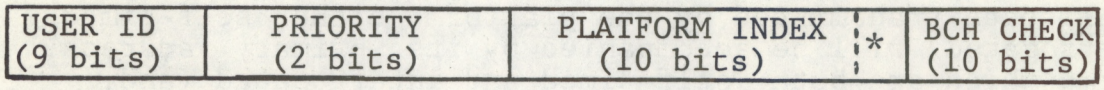



Figure 1. -- Generation of address by matrix multiplication

## Field Definition

As stated, the 21/31 BCH addresses consist of 21 information bits followed by 10 check bits. Although the primary use of the address is to uniquely identify a platform, an ordering or grouping of these addresses has been adopted to "encode" other descriptive information relating to the platform.

Figure 2 shows how the 31-bit addresses are internally coded. The 31 bits are divided into four fields consisting of a 9-bit user field, a 2-bit priority field, a 10-bit platform index field and the 10-bit check field.




Example: Address: 00010101110010001110001110011111
Meaning: USER: #43
PRIORITY: Operational
PLATFORM: #284 (primary)

*For platforms with both primary and secondary address, the 21st bit is a 0 and 1 respectively.

Figure 2.--Information fields within an address,

The 9-bit user field provides 512 possible sequences, which are used to identify up to 510 individual users of the GOES-DCS.

Two such sequences are reserved to designate command addresses (110011010) and a miscellaneous user group (000101011).

The 2-bit priority field specifies the priority associated with that platform: Emergency (01); operational (10); and experimental (11). The sequence "00" is unassigned.

The 10-bit platform index field is used to uniquely define the user's platform -- this assignment is generally left to the user's discretion. The last bit of the field ("the 21st bit") indicates whether the address is a "primary" (zero) or a "secondary" address for the platform; this bit is not interpreted by the GOES-DCS. The user may choose to assign one or two addresses, and thus accommodate 1024 or 512 platforms, respectively. The 10 bit check field contains the extra 10 bits generated by the matrix multiplication.

## USE OF THE 21/31 BCH CODE IN THE GOES-DCS

As described previously, the GOES-DCS makes use of the 21/31 BCH address in a variety of ways and for a multitude of purposes.

### Assumptions

To organize and, where necessary, to standardize the use of address codes, a number of assumptions were made in the system design:

1. As a minimum, every platform will be assigned a unique "primary" address. No two platforms would recognize or be associated with the same primary address.

2. All data transmitted by the platform, either self-timed or interrogated, will be accompanied by its primary address. Platforms which are both self-timed and interrogated (and, therefore, transmit on two different channels) should be identified by two different primary addresses, and will be considered as two platforms.

3. All interrogations which result in data being transmitted to the GOES-DCS (replies) will contain the primary address. Command sequences (described below) also begin with the primary address.

4. A unique secondary address may be assigned to individual platforms. Unlike the primary, the use of a secondary address is not mandatory; however, a number of system capabilities are available for use with platforms implementing secondary addresses. For platforms utilizing a secondary address, the 21st bit of the secondary address will always be a 1. Further the first 20 bits of the primary address will be identical to the first 20 bits of the secondary -- the 21st bit of the primary will always be a 0. This does not prevent primary addresses from having a 1 in the 21st bit; however, in such cases, secondary addresses, and those features associated with them are no longer available to that platform. See sections concerning command and test mode (reply-verify).

5. At most only two addresses (primary and secondary) will be assigned to any individual platform.

6. The 21/31 BCH addresses may be represented in two ways. First, the address may be expressed in binary form (e.g., 000101011100100011100011100111l1, in which case, the bits will be designated left-to-right in order of transmission (i.e., in this example, a 0 is transmitted first and a 1 last). Second, the address may be represented in hexadecimal notation by separating the binary sequence into groups of four -- with a 0

added to the end of the 31-bit sequence to make it come out even. For the example given in Figure 2, the address would represent "15C8E39E" in hexadecimal.

## Address Assignment

Platform addresses are assigned by NESS on a user-by-user basis. For each user having, or likely to have, a large number of platforms, a block of 4096 21/31 BCH code words (1024 possible addresses) is reserved. All addresses for a given user have the same first nine bits. The tenth and eleventh bits are reserved to indicate the priority of the individual platform (01-emergency, 10-operations, 11-experimental and 00-unassigned); the rationale for the assignment of priority is not discussed herein.

The remaining ten "information" bits of the BCH address are reserved for assignment to specific platforms by the user (and conveyed to NESS prior to platform activation). The 1024 possible BCH addresses available to each user will generally be assigned in pairs (one primary and one secondary) providing for up to 512 platforms -- 1024 platforms can be accommodated if secondary addresses are not required. Factors to be considered in choosing not to implement secondary addresses include future requirements for single command functions or reply-verify (test mode) uses. Users implementing exclusively self-timed platforms should consider the reservation of secondary addresses if there is a future possibility of adding or replacing platforms with the interrogated type. In addition, the availability of low-cost, field-portable interrogation receivers will, in the future, make it possible for a technician to "check out" platforms during field installation effectively and expeditiously by using the test mode.

A platform is uniquely determined by the user and the platform index fields; therefore, no two platforms may have identical user and platform index fields regardless of priority.

## INTERROGATIONS

The polling or interrogating capability of the GOES-DCS is implemented by the use of primary addresses. Figure 3 shows the data format used on the two 468 MHz[2] interrogate channels.

[2]Specifically 468.825 MHz for the Western GOES and 468.8375 MHz for the Eastern GOES.

| BCH ADDRESS (31 bits) | TIME CODE (4 bits) | MLS (15 bits) | BCH ADDRESS (31 bits) | TIME CODE (4 bits) |
|---|---|---|---|---|

Figure 3.--Interrogate link data format

This format consists of repetitive sequences of: a Time-Code[3] (4 bits); a Maximal-Length Sequence (MLS) Frame Sync (15 bits - 100010011010111); and a 21/31 BCH address. An interrogation of a platform is effected by the transmission (once) of the platform's primary address. Every transmission from the CDA of a platform's primary address (self-timed platforms excluded) is expected to produce a reply. Conversely, no message is expected (or permitted) from a platform unless the primary address is transmitted from the CDA (except from self-timed or emergency platforms). Specifically, transmission of the secondary address to the platform should not produce a response. Not only does the GOES-DCS expect a message every time a primary address is transmitted, the system expects this message to begin immediately after the address is sent. (See section on platform replies.)

Error-correcting properties of the 21/31 BCH code can and generally should be used for interrogating. Specifically, a platform should recognize its own primary address in spite of one or two errors, and should respond with a reply using its correct address.

## PLATFORM REPLIES

Data transmitted by platforms to the GOES-DCS are called "replies" and may be triggered by the receipt of an interrogation or by self-initiation. The transmission format illustrated below (fig. 4) consists of: five seconds of carrier (nominal); 2.5 seconds of alternating 1/0 data bits; 15 bits of MLS frame sync; the primary address; data formatted in ASCII (8 bits per character, odd parity); and three ASCII EOT characters. All reply data must use the platform's primary address.

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[3]See Cateora, Davis, and Hansen (1976).

| CARRIER (5 sec nom.) | ALTERNATING 1/0 (2.5 sec nom.) | MLS (15 bits) | PRIMARY ADDRESS (31 bits) |
|---|---|---|---|

| DATA (ASCII, odd parity) (8 x N bits) | 3 EOT CHARACTERS (24 bits) |
|---|---|

Figure 4.--DCS platform reply format.

Replies to interrogation are expected to begin immediately after the address is received by the platform. Specifically, the platform's reply is expected to complete transmission of its address within 11 seconds after it received its address on the interrogate link. (Note: Both addresses are the same primary address.) This specification is necessary so that the GOES-DCS can efficiently schedule future messages for that channel. This scheduling is based on the ability to accurately predict the channel occupation time for each interrogation.

Data received by the GOES-DCS is time-stamped (or tagged) when the address portion of the reply is received at the CDA Station.

The GOES-DCS currently does not provide for full error correction if the address in the reply is corrupted; the computer will provide for address correction only if the platform had been scheduled. If the received address is within two bits of the address expected, the message will be routed to the user with the correct address. If the received address differs by more than two bits, the user will be told, but the message will be delivered uncorrected.

## COMMANDING

The transmission of data over the interrogate channel, which elicits a change in platform status, configuration, or operating mode is referred to as a command. The GOES-DCS supports the commanding of platforms in two ways:

### Single Address Commanding

The simplest method of commanding involves the use of a platform secondary address and provides the capability for only one command. A platform designed for this purpose,therefore, monitors the interrogation channel for two addresses: its primary, after which it is always expected to reply; or its secondary, after which it is expected to perform its command function and not reply. As with interrogations, secondary address commanding can be implemented to permit up to two errors. This is optional, however, since some users may insist that their commands be received perfectly.

Since replies are not expected from secondary addresses, command verification (the ability to see that the command was received properly) is not implicit in this technique.

## Two Address Commanding

A second and more generalized approach to commanding through the GOES-DCS is by the use of two addresses transmitted sequentially. The first address sent is the platform's primary address and the second address is a valid 21/31 code word beginning with a unique user ID (110011010). This second address, sometimes referred to as the command data word, may be any one of 4096 different BCH addresses. The use of one special user ID exclusively for commanding makes it impossible to transmit a platform address inadvertently. The priority field associated with other addresses is not contained within the command data word -- rather, the remaining 12 information bits are variables making possible the 4096 different commands.

Figure 5 shows a typical data stream on the interrogate channel containing a two-word command. As indicated, platform 15C353B8 which is to be commanded must first recognize its own primary address , then examine the next address to determine whether it is a command data word. If the second address is a command data word (identified by 110011010), the platform should take the appropriate action; if the second address is not a command data word, the platform should simply reply with its normal-length message. Whether commanding or not, the platform must respond with a normal-length message after receiving its primary address. Multiple commands, if required, will necessitate the transmission of another pair of addresses (the primary) and the next command data word. The GOES-DCS supports commanding on an individual basis. Successive commands (pairs) are not possible since the system will not send a primary address for that platform (or any other platform on that channel) until after the first platform's reply message has been completed. Strings of more than one command data word will not be supported.

## Comments on the Use of Commands

The capability to command platforms can be used in a variety of ways, which are left to the user's own imagination or the platform's sophistication. The way in which these 4097 possible commands (single and double word) are to be interpreted is defined on an individual platform basis and the GOES-DCS is "blind" to the effect these commands have on the platform. The implications of this fact are considerable when one considers the types of commands

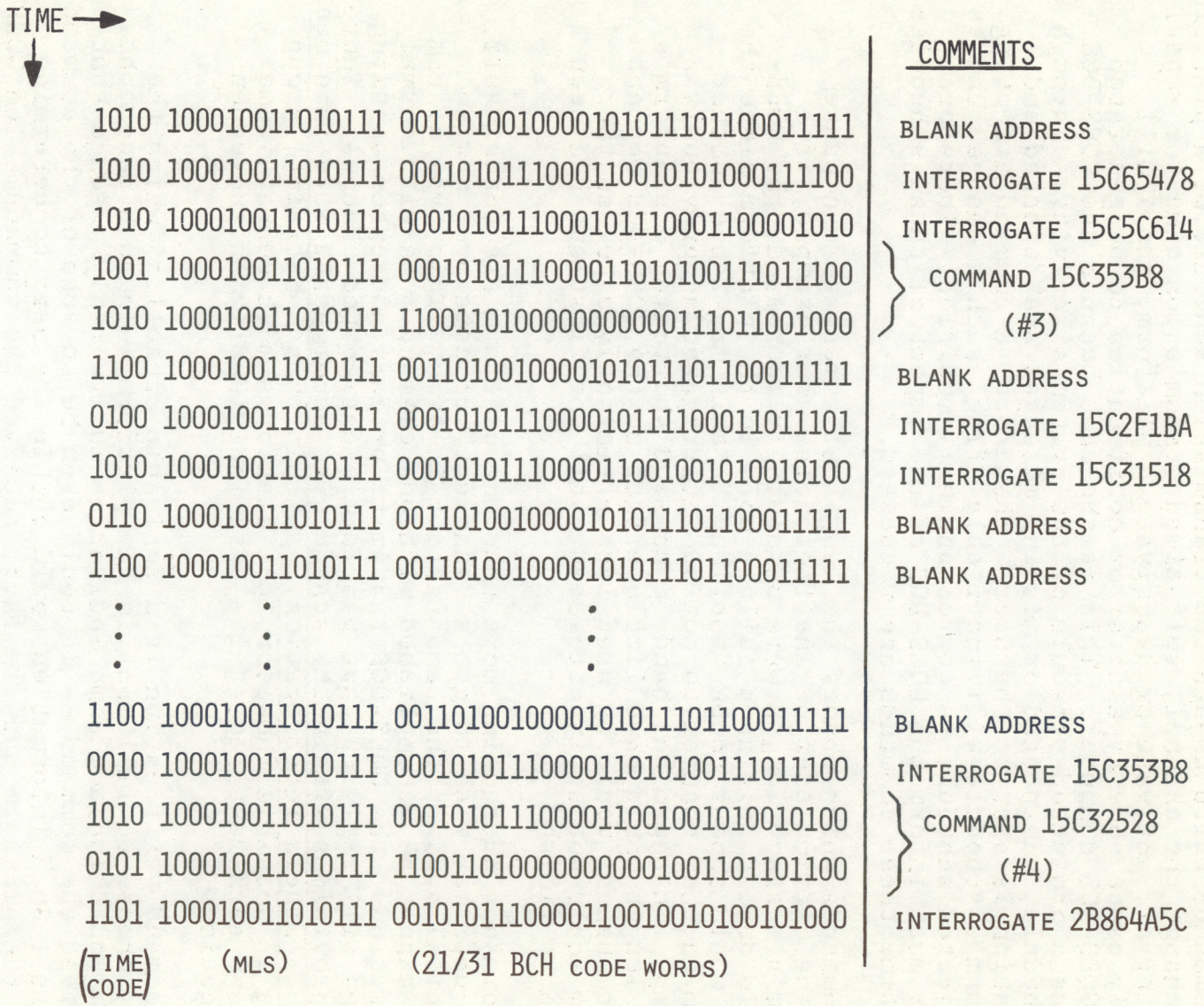


Figure 5.--Example of interrogate channel data containing commands.

likely to be sent. For example:

1. Commands which change the transmission schedule of a platform (i.e., change the channel, self-timed transmission time for repetition interval, activate or deactivate a platform, etc.) will generally cause some type of error notification to be generated by the GOES-DCS computer. This is the case because the GOES-DCS maintains a projected schedule of the system's activity. Through this schedule, unexpected or missing messages are detected and a notification is sent to the user. Therefore, a command affecting a platform's schedule will inevitably flag such a change, unless the projected schedule is correspondingly modified. Therefore, the user must inform the GOES-DCS of the impact of these schedules at the time these commands are requested.[4]

2. Commands which change the length of a message can cause scheduling difficulties or inefficiencies. For example, if a platform's message length were unknowingly increased, the GOES-DCS would detect this as a failure mode in the platform since the message would appear to be "too long;" this may cause another platform on that channel to not be interrogated as previously scheduled. On the other hand, a command shortening a platform's message length would have little effect on the GOES-DCS, except that the channel would be used less efficiently since another platform would not be interrogated until the first one had been expected to finish.

3. Commands addressing more than one platform are conceivable, where a user may wish to get a "snapshot" of data over a wide geographical area at the same instant in time. This type of commanding cannot be accomplished with one command. As with normal interrogations, the GOES-DCS transmits primary addresses assuming a message will reply on that platform's designated channel. There are no provisions within the schedule to accommodate more than one reply to a single interrogation. Within this constraint, group sampling is possible, however, the platforms must contain some memory and each must report its data individually on subsequent interrogations.

4. Command verification is a desirable capability which the user may choose to implement in his platform. In such case, the platform would include some indication in its reply message that it received the command -- it could even be an echo of the command data word. Such information would enable the user to determine whether the platform had, in fact, received the command. The GOES-DCS does not inspect messages for a verification; the user must perform this check after the message is subsequently disseminated. Note: The current design of the GOES-DCS does not support

[4]At present, neither commanding nor the associated rescheduling is automated beyond a manual operator function.

re-commanding in the event of a missed or bad reply -- it will be reinterrogated a user-specified number of times; however, the command data word will not be included.

5. It is conceivable that some requirements may indicate a need for commands which are to be separated by a fixed amount of time -- one command to start a measurement and one to stop it. Such commands should be avoided, where possible, since the dynamic scheduling properties of the GOES-DCS (which tries to accommodate many channels, not just one) cannot guarantee a rigid spacing between interrogations (or commands). Such requirements can be satisfied by providing the platform with memory that will always provide data for the last fixed measurement interval, or by transmitting a command which specifies the measurement interval and then holding the data until a subsequent interrogation.
Note: Emergency schedules which supersede normal scheduling activities could provide a greater level of regularity between interrogations; however, absolute spacing still cannot be guaranteed.

6. The occurrence of errors on the interrogate link is possible, but not likely except in marginal-link situations. Users should consider whether commands should be executed in the presence of errors. This capability (to correct command word errors) could affect the reliability of the platform and would most certainly increase its complexity. It is recommended that the platform respond to the primary address with a message whether or not it, or the command data word, contains an error.

## TEST MODE (REPLY/VERIFY)

The principle use for the secondary address is for the test, or reply-verify mode. This function is provided by the GOES-DCS for use in situations where it is necessary for a platform to be told by the system that a previously reply had been received without errors. This function is described as a "mode" because the GOES-DCS will provide the service only if previously instructed to do so; any or all platforms may be supported. The GOES-DCS supports the test mode in the following manner: As a message is received at the CDA Station, it is checked for parity errors. If the message contains no errors (up to the first EOT character) and the platform is in the "test mode", that platform's secondary address will be transmitted on the interrogate channel. If, on the other hand, the message contains one or more errors, the secondary address will not be sent.

This mode of operation can be used with either self-timed or interrogated platforms, whether or not the reply message was scheduled. In the latter case, however, the secondary address will generally be delayed by an additional minute, since the system must determine whether or not this platform was in the test mode. The test or

reply/verify mode can be used in a number of ways:

1. As the name implies, the test mode feature may be used as an aid in the field testing of radio sets (platforms). For example, a user could notify NESS that a particular platform was to be installed or serviced in the near future, and request the platforms be put in the test mode. Later, when a technician is at the field site checking out the platform, he could trigger a transmission, (either manually or by waiting for an interrogation) and wait for subsequent reception of that platform's secondary address. All current commercially available interrogatable radio sets (April 1976 and earlier) effect a relay contact closure when the secondary address is received. These contacts could be connected to a light, logic probe or other device to act as a signal. A receipt of this secondary address in the test mode goes a long way toward assuring that the platform will work operationally since the entire data path, including data formatting, will have been tested. To be most effective, several "shots" should be possible; this can be arranged with NESS through prior scheduling. It is important that the field technician be aware of the schedule for his platform's channel to prevent inadvertent interference to other platforms. In the case of interrogated platforms, the best procedure is to schedule additional interrogations and not self-initiate. For self-timed platforms, the technician can be given a test schedule from NESS for the channel(s) involved.

2. The test mode described above can be used with self-timed as well as interrogated platforms. Since self-timed platforms do not generally have receivers built into them, the technician must bring one with him. Through the use of a diplexer, the existing antenna can probably be used. A useful addition to such a receiver design is a time-code decoder which can provide the technician a very accurate time reference for setting the platform's timer.

3. Platforms being used as message relay terminals (such as teletypes or tape-reading devices) may find the reply/verify function useful. Such applications, involving manual preparation of messages, will find the "message received" feedback of the test mode to be good human engineering. An operator at such a terminal appreciates knowing the message has been properly received.

4. Platforms designed with data storage sufficient to ride out even severe GOES-DCS outages may find the reply/verify mode useful. Such designs, with storage, have the inherent problem of not being able to discern whether any given interrogation is a request for new or old data (the GOES-DCS reinterrogates platforms if messages are bad or not received; these platforms cannot determine whether to re-send the old data or not). Use of the reply/verify mode permits such platforms to know whether the previous block was received by simply interpreting the secondary address as an acknowledgement of the previous message.

5. Some requirements may suggest that a platform should not fully execute a command unless it has been verified by the GOES-DCS. In this case, the secondary address could be considered the execute command. The command verification, in this case, is not an inspection of the message contents, but rather a check that the message was received and was without parity errors.

## EMERGENCY OPERATION

An "emergency" functionally pertaining to the GOES-DCS is any situation during which platforms must be interrogated and the data disseminated as soon as possible. One method for triggering an emergency interrogation schedule is by the receipt of a message (by the GOES-DCS) from a platform transmitting on an "emergency channel." Such platforms are able to determine when an emergency situation exists and are programmed to initiate a spontaneous, or alert, transmission (sometimes called "thresholding").

Since these emergency channels are shared among all such platforms and are used only in emergency situations, they are sometimes called "random access" channels. Use of these channels differs somewhat from the normal operations scenario. When a platform senses an alarm condition for which an emergency message should be scheduled, it begins transmitting on the emergency channel. The message transmitted consists of a standard reply using its primary address but with no data. Transmissions are to be repeated every 15 to 20 minutes -- this is necessary because statistically there is a possibility that two such platforms could transmit at the same time on the same channel. The GOES-DCS computer will receive the message and, after determining this unexpected message was on an emergency channel, it will schedule a number of future interrogations. The platform initiating the emergency schedule will always be reinterrogated on its primary address. This interrogation serves two purposes. First, it provides sensor data from that platform to be transmitted on its normal channel (not an emergency channel). Second, this interrogation serves as an acknowlegement that the GOES-DCS recognized the alarm situation and the platform should stop further transmissions on the emergency channel.

Since the emergency schedule is prepared especially for the emergency condition, commands may also be included (either one or two word types). Whether or not commands are to be sent, the thresholding platform must adhere to all address and channel usage conventions previously defined.

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## APPENDIX A: ADDRESS GENERATION AND DECODING SCHEMES

The BCH code is a binary cyclic code which may be generated as the product of two polynomials:

$$F(x) = g(x)\ q(x)$$

where g(x) is a generator polynomial of degree of n-k, [$g(x) = a_0 + a_1 x + a_2 x^2 + \ldots a_{n-k}x^{n-k}$] q(x) is an information polynomial of degree k-1 [$q(x) = b_0 + b_1 x + \ldots b_{k-1}x^{k-1}$] and F(x) is the code polynomial of degree n-1 [$F(x) = C_0 + C_1x + C_2x2 + \ldots C_{n-1}\ x^{n-1}$]. Therefore, any sequence of k information bits may be represented as a polynomial which, when multiplied by a specific generator polynomial, will yield a valid code word of n bits.

The 21/31 BCH code used in the GOES-DCS utilizes a generator polynomial of $1 + x + x^2 + x^4 + x^5 + x^7 + x^{10}$ and all arithmetic is modulo-2 binary ($0 \cdot 0 = 0$, $0 \cdot 1 = 0$, $1 \cdot 1 = 1$, $0 + 0 = 0$, $0 + 1 = 1$, $1 + 1 = 0$).

In specific, a sequence of 21 information bits may be expressed as a polynomial and when multiplied by g(x) will yield a polynomial whose coefficients are the 31-bit code word. For example, the binary sequence 000111010000101010010 can be written as $x^3 + x^4 + x^5 + x^7 + x^{12} + x^{14} + x^{16} + x^{19}$. When multiplied by g(x) the result is $x^3 + x^5 + x^7 + x^8 + x^9 + x^{12} + x^{16} + x^{17} + x^{19} + x^{21} + x^{22} + x^{29}$ or, 0001010111001000110101100000010 (= 15C8D604) -- a code word.

This multiplication can also be expressed as a matrix multiplication:

$$F = Q \cdot G$$

Where F is [$c_0, c_1, c_2, \ldots, c_{n-1}$], Q is [$b_0, b_1, b_2, \ldots, b_{k-1}$], and G is a 21 by 31 matrix (fig. 6).

G =

| |
|---|
| 1110111010010000000000000000000 |
| 0111011101001000000000000000000 |
| 0011101110100100000000000000000 |
| 0001110111010010000000000000000 |
| 0000111011101001000000000000000 |
| 0000011101110100100000000000000 |
| 0000001110111010010000000000000 |
| 0000000111011101001000000000000 |
| 0000000011101110100100000000000 |
| 0000000001110111010010000000000 |
| 0000000000111011101001000000000 |
| 0000000000011101110100100000000 |
| 0000000000001110111010010000000 |
| 0000000000000111011101001000000 |
| 0000000000000011101110100100000 |
| 0000000000000001110111010010000 |
| 0000000000000000111011101001000 |
| 0000000000000000011101110100100 |
| 0000000000000000001110111010010 |
| 0000000000000000000111011101001 |

Figure 6.-- 21 x 31 matrix.

By virtue of two properties of cyclic codes, namely, that the set of all possible code words is a group closed under addition (i.e., the sum of two code words is another code word) and that any code word shifted to the right or left (with rotation) is also a valid code word, it is possible to construct an "equivalent" generator matrix which is systematic (fig. 7).

$G^* =$

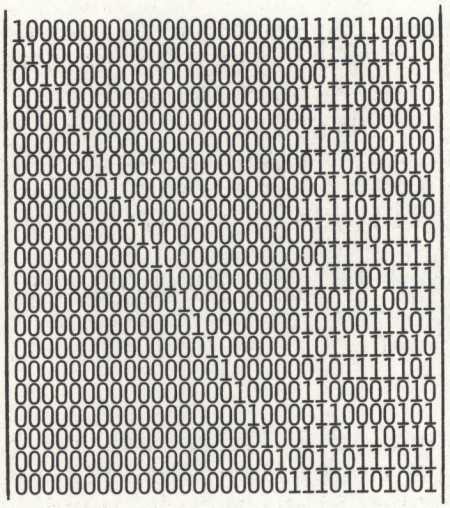


Figure 7.--Systematic 21/31 BCH generator matrix.

Thus, for any valid code word generated by G, the same code word can be generated by G* utilizing an information vector identical to the first 21 bits of that code word. G* is the matrix used to generate the 21/31 BCH addresses for the GOES-DCS.

## Error Detection

All code words may be considered as the product of g(x) and some information polynomial q(x). Conversely, any valid code word polynomial divided by g(x) will yield the original information polynomial q(x) with zero remainder. Thus, it can be shown that any received sequence (expressed as a polynomial) divided by g(x) will yield a polynomial with zero remainder if, and only if the sequence is a code word. Further, all detectable errors will yield a non-zero remainder.

For the 21/31 binary BCH code utilized by the GOES-DCS, this division can be implemented by the following digital switching circuit (fig. 8):

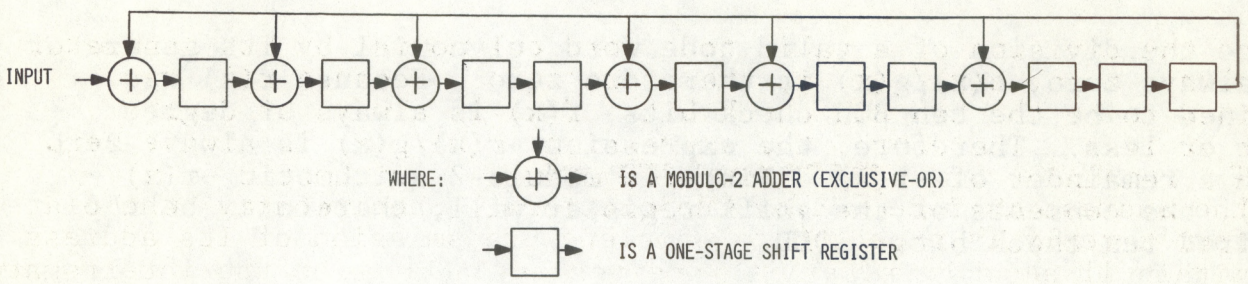


Figure 8.--BCH codework error detector.

In this simple implementation, each bit of the received code word ($C_0C_1C_2...$) is shifted into the circuit at the input. After the first ten shifts the quotient starts shifting out at the right. After 31 shifts, the division is complete and the remainder is contained within the ten storage registers. If the received code word does not contain an error (detectable) the contents of all the registers will be zero. If an error had occurred, at least one register will be non-zero.

This simple code word checker may be used whenever it is necessary to determine if an error has occurred in an address. Platforms utilizing a large number of command addresses may find this circuit less complicated than a direct compare with all possible addresses. NOTE: This circuit does not indicate the number of errors contained within a received code word, but merely whether one or more errors exist.

Address Generation Utilizing a Shift Register Circuit

The circuit shown in Figure 8 can also be used to generate the ten BCH checkbits from the 21 information bits. In this case, however, the 21 information bits are clocked into the circuit followed by ten 0's. After the 31st clock, the contents of the shift register will contain the ten check bits.

A justification for this implementation is very straightforward. As before, any valid BCH 31-bit code word can be expressed as a polynomial c(x) Further, consider a new polynomial, r(x), which is defined to be the ten check bits of c(x). Thus, the expression C(x) - r(x) represents the sequence of information bits (the code is systematic) followed by ten 0's. Recalling that the circuit

in Figure 8 is a polynomial divider, the division of c(x) - r(x) by g(x) can be expresses as follows:

$$\frac{c(x) - r(x)}{g(x)} = \frac{c(x)}{g(x)} - \frac{r(x)}{g(x)}$$

Since the division of a valid code word polynomial by its generator is always zero, c(x)/g(x) is therefore zero. Because r(x) was defined to be the ten BCH check bits, r(x) is always of degree nine or less. Therefore, the expression -r(x)/g(x) is always zero with a remainder of -r(x). Since in modulo-2 arithmetic -r(x) = r(x), the contents of the shift register will, therefore, be the desired ten check bits. QED.

## Secondary Address Determination

A secondary platform address is defined to have the same first 20 bits as a primary address, with the 21st bit a 1 rather than a 0. By inspection of the generator matrix G*, it can be seen that a 1 in the 21st bit of the input vector I will cause only the 21st, 22nd, 23rd, 25th, 26th, 28th, and 31st bits to differ. Thus, the secondary address can be calculated from the primary address by adding (modulo-2) the sequence 00000000000000000011101101001. Since modulo-2 addition and subtraction are the same, a primary address can be calculated from a secondary by exactly the same procedure.

## Appendix B: 4096 COMMAND DATA WORDS

The next eight pages contain a computer printout of 4096 command data words.

COMMAND DATA WORDS

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0- | CD000034 | CD000EE6 | CD001342 | CD001D90 | CD0026D8 | CD00280A | CD0035AE | CD003B7C | CD00433E | CD004DEC |
| 1- | CD005048 | CD005E9A | CD0065D2 | CD006B00 | CD0076A4 | CD007876 | CD008620 | CD0088F2 | CD009556 | CD009B84 |
| 2- | CD00A0CC | CD00AE1E | CD00B38A | CD00BD68 | CD00C52A | CD00CBF8 | CD00D65C | CD00D88E | CD00E3C6 | CD00ED14 |
| 3- | CD00F0B0 | CD00FE62 | CD0102CE | CD010C1C | CD0111B8 | CD011F6A | CD012422 | CD012AF0 | CD013754 | CD013986 |
| 4- | CD0141C4 | CD014F16 | CD0152B2 | CD015C60 | CD016728 | CD0169FA | CD01745E | CD017A8C | CD0184DA | CD018A08 |
| 5- | CD0197AC | CD01997E | CD01A236 | CD01ACE4 | CD01B140 | CD01BF92 | CD01C7D0 | CD01C902 | CD01D4A6 | CD01DA74 |
| 6- | CD01E13C | CD01EFEE | CD01F24A | CD01FC98 | CD0205C0 | CD020B12 | CD0216B6 | CD021864 | CD02232C | CD022DFE |
| 7- | CD02305A | CD023E88 | CD0246CA | CD024818 | CD0255BC | CD025B6E | CD026026 | CD026EF4 | CD027350 | CD027D82 |
| 8- | CD0283D4 | CD028D06 | CD0290A2 | CD029E70 | CD02A538 | CD02ABEA | CD02B64E | CD02B89C | CD02C0DE | CD02CE0C |
| 9- | CD02D3A8 | CD02DD7A | CD02E632 | CD02E8E0 | CD02F544 | CD02FB96 | CD03073A | CD0309E8 | CD03144C | CD031A9E |
| 10- | CD0321D6 | CD032F04 | CD0332A0 | CD033C72 | CD034430 | CD034AE2 | CD035746 | CD035994 | CD0362DC | CD036C0E |
| 11- | CD0371AA | CD037F78 | CD03812E | CD038FFC | CD039258 | CD039C8A | CD03A7C2 | CD03A910 | CD03B4B4 | CD03BA66 |
| 12- | CD03C224 | CD03CCF6 | CD03D152 | CD03DF80 | CD03E4C8 | CD03EA1A | CD03F7BE | CD03F96C | CD04050E | CD040BDC |
| 13- | CD041678 | CD0418AA | CD0423E2 | CD042D30 | CD043094 | CD043E46 | CD044604 | CD0448D6 | CD045572 | CD045BA0 |
| 14- | CD0460E8 | CD046E3A | CD04739E | CD047D4C | CD04831A | CD048DC8 | CD04906C | CD049EBE | CD04A5F6 | CD04AB24 |
| 15- | CD04B680 | CD04B852 | CD04C010 | CD04CEC2 | CD04D366 | CD04DDB4 | CD04E6FC | CD04E82E | CD04F58A | CD04FB58 |
| 16- | CD0507F4 | CD050926 | CD051482 | CD051A50 | CD052118 | CD052FCA | CD05326E | CD053CBC | CD0544FE | CD054A2C |
| 17- | CD055788 | CD05595A | CD056212 | CD056CC0 | CD057164 | CD057FB6 | CD0581E0 | CD058F32 | CD059296 | CD059C44 |
| 18- | CD05A70C | CD05A9DE | CD05B47A | CD05BAA8 | CD05C2EA | CD05CC38 | CD05D19C | CD05DF4E | CD05E406 | CD05EAD4 |
| 19- | CD05F770 | CD05F9A2 | CD0600FA | CD060E28 | CD06138C | CD061D5E | CD062616 | CD0628C4 | CD063560 | CD063BB2 |
| 20- | CD0643F0 | CD064D22 | CD065086 | CD065E54 | CD06651C | CD066BCE | CD06766A | CD0678B8 | CD0686EE | CD06883C |
| 21- | CD069598 | CD069B4A | CD06A002 | CD06AED0 | CD06B374 | CD06BDA6 | CD06C5E4 | CD06CB36 | CD06D692 | CD06D840 |
| 22- | CD06E308 | CD06EDDA | CD06F07E | CD06FEAC | CD070200 | CD070CD2 | CD071176 | CD071FA4 | CD0724EC | CD072A3E |
| 23- | CD07379A | CD073948 | CD07410A | CD074FD8 | CD07527C | CD075CAE | CD0767E6 | CD076934 | CD077490 | CD077A42 |
| 24- | CD078414 | CD078AC6 | CD079762 | CD0799B0 | CD07A2F8 | CD07AC2A | CD07B18E | CD07BF5C | CD07C71E | CD07C9CC |
| 25- | CD07D468 | CD07DABA | CD07E1F2 | CD07EF20 | CD07F284 | CD07FC56 | CD080492 | CD080A40 | CD0817E4 | CD081936 |
| 26- | CD08227E | CD082CAC | CD083108 | CD083FDA | CD084798 | CD08494A | CD0854EE | CD085A3C | CD086174 | CD086FA6 |
| 27- | CD087202 | CD087CD0 | CD088286 | CD088C54 | CD0891F0 | CD089F22 | CD08A46A | CD08AAB8 | CD08B71C | CD08B9CE |
| 28- | CD08C18C | CD08CF5E | CD08D2FA | CD08DC28 | CD08E760 | CD08E9B2 | CD08F416 | CD08FAC4 | CD090668 | CD0908BA |
| 29- | CD09151E | CD091BCC | CD092084 | CD092E56 | CD0933F2 | CD093D20 | CD094562 | CD0948B0 | CD095614 | CD0958C6 |
| 30- | CD09638E | CD096D5C | CD0970F8 | CD097E2A | CD09807C | CD098EAE | CD09930A | CD099DD8 | CD09A690 | CD09A842 |
| 31- | CD09B5E6 | CD09BB34 | CD09C376 | CD09CDA4 | CD09D000 | CD09DED2 | CD09E59A | CD09EB48 | CD09F6EC | CD09F83E |
| 32- | CD0A0166 | CD0A0FB4 | CD0A1210 | CD0A1CC2 | CD0A278A | CD0A2958 | CD0A34FC | CD0A3A2E | CD0A426C | CD0A4CBE |
| 33- | CD0A511A | CD0A5FC8 | CD0A6480 | CD0A6A52 | CD0A77F6 | CD0A7924 | CD0A8772 | CD0A89A0 | CD0A9404 | CD0A9AD6 |
| 34- | CD0AA19E | CD0AAF4C | CD0AB2E8 | CD0ABC3A | CD0AC478 | CD0ACAAA | CD0AD70E | CD0AD9DC | CD0AE294 | CD0AEC46 |
| 35- | CD0AF1E2 | CD0AFF30 | CD0B039C | CD0B0D4E | CD0B10EA | CD0B1E38 | CD0B2570 | CD0B2BA2 | CD0B3606 | CD0B38D4 |
| 36- | CD0B4096 | CD0B4E44 | CD0B53E0 | CD0B5D32 | CD0B667A | CD0B68A8 | CD0B750C | CD0B7BDE | CD0B8588 | CD0B8B5A |
| 37- | CD0B96FE | CD0B982C | CD0BA364 | CD0BADB6 | CD0BB012 | CD0BBEC0 | CD0BC682 | CD0BC850 | CD0BD5F4 | CD0BDB26 |
| 38- | CD0BE06E | CD0BEEBC | CD0BF318 | CD0BFDCA | CD0C01A8 | CD0C0F7A | CD0C12DE | CD0C1C0C | CD0C2744 | CD0C2996 |
| 39- | CD0C3432 | CD0C3AE0 | CD0C42A2 | CD0C4C70 | CD0C51D4 | CD0C5F06 | CD0C644E | CD0C6A9C | CD0C7738 | CD0C79EA |
| 40- | CD0C87BC | CD0C896E | CD0C94CA | CD0C9A18 | CD0CA150 | CD0CAF82 | CD0CB226 | CD0CBCF4 | CD0CC4B6 | CD0CCA64 |
| 41- | CD0CD7C0 | CD0CD912 | CD0CE25A | CD0CEC88 | CD0CF12C | CD0CFFFE | CD0D0352 | CD0D0D80 | CD0D1024 | CD0D1EF6 |
| 42- | CD0D25BE | CD0D2B6C | CD0D36C8 | CD0D381A | CD0D4058 | CD0D4E8A | CD0D532E | CD0D5DFC | CD0D66B4 | CD0D6866 |
| 43- | CD0D75C2 | CD0D7B10 | CD0D8546 | CD0D8B94 | CD0D9630 | CD0D98E2 | CD0DA3AA | CD0DAD78 | CD0DB0DC | CD0DBE0E |
| 44- | CD0DC64C | CD0DC89E | CD0DD53A | CD0DDBE8 | CD0DE0A0 | CD0DEE72 | CD0DF3D6 | CD0DFD04 | CD0E045C | CD0E0A8E |
| 45- | CD0E172A | CD0E19F8 | CD0E22B0 | CD0E2C62 | CD0E31C6 | CD0E3F14 | CD0E4756 | CD0E4984 | CD0E5420 | CD0E5AF2 |
| 46- | CD0E61BA | CD0E6F68 | CD0E72CC | CD0E7C1E | CD0E8248 | CD0E8C9A | CD0E913E | CD0E9FEC | CD0EA4A4 | CD0EAA76 |
| 47- | CD0EB7D2 | CD0EB900 | CD0EC142 | CD0ECF90 | CD0ED234 | CD0EDCE6 | CD0EE7AE | CD0EE97C | CD0EF4D8 | CD0EFA0A |
| 48- | CD0F06A6 | CD0F0874 | CD0F15D0 | CD0F1B02 | CD0F204A | CD0F2E98 | CD0F333C | CD0F3DEE | CD0F45AC | CD0F4B7E |
| 49- | CD0F56DA | CD0F5808 | CD0F6340 | CD0F6D92 | CD0F7036 | CD0F7EE4 | CD0F80B2 | CD0F8E60 | CD0F93C4 | CD0F9D16 |
| 50- | CD0FA65E | CD0FA88C | CD0FB528 | CD0FBBFA | CD0FC3B8 | CD0FCD6A | CD0FD0CE | CD0FDE1C | CD0FE554 | CD0FEB86 |
| 51- | CD0FF622 | CD0FF8F0 | CD1007AA | CD100978 | CD1014DC | CD101A0E | CD102146 | CD102F94 | CD103230 | CD103CE2 |
| 52- | CD1044A0 | CD104A72 | CD1057D6 | CD105904 | CD10624C | CD106C9E | CD10713A | CD107FE8 | CD10818E | CD108F6C |
| 53- | CD1092C8 | CD109C1A | CD10A752 | CD10A980 | CD10B424 | CD10BAF6 | CD10C2B4 | CD10CC66 | CD10D1C2 | CD10DF10 |
| 54- | CD10E458 | CD10EA8A | CD10F72E | CD10F9FC | CD110550 | CD110B82 | CD111626 | CD1118F4 | CD11238C | CD112D6E |

COMMAND DATA WORDS

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| 55- | CD1130CA | CD113E18 | CD11465A | CD114888 | CD11552C | CD1158FE | CD1160B6 | CD116E64 | CD1173C0 | CD117D12 |
| 56- | CD118344 | CD118D96 | CD119032 | CD119EE0 | CD11A5A8 | CD11AB7A | CD11B6DE | CD11B80C | CD11C04E | CD11CE9C |
| 57- | CD11D338 | CD11DDEA | CD11E6A2 | CD11E870 | CD11F5D4 | CD11FB06 | CD12025E | CD120C8C | CD121128 | CD121FFA |
| 58- | CD1224B2 | CD122A60 | CD1237C4 | CD123916 | CD124154 | CD124F86 | CD125222 | CD125CF0 | CD1267B8 | CD12696A |
| 59- | CD1274CE | CD127A1C | CD12844A | CD128A98 | CD12973C | CD1299EE | CD12A2A6 | CD12AC74 | CD12B1D0 | CD12BF02 |
| 60- | CD12C740 | CD12C992 | CD12D436 | CD12DAE4 | CD12E1AC | CD12EF7E | CD12F2DA | CD12FC08 | CD1300A4 | CD130E76 |
| 61- | CD1313D2 | CD131D00 | CD132648 | CD13289A | CD13353E | CD133BEC | CD1343AE | CD134D7C | CD1350D8 | CD135E0A |
| 62- | CD136542 | CD136B90 | CD137634 | CD1378E6 | CD1386B0 | CD138862 | CD1395C6 | CD139B14 | CD13A05C | CD13AE8E |
| 63- | CD13B32A | CD13BDF8 | CD13C5BA | CD13CB68 | CD13D6CC | CD13D81E | CD13E356 | CD13ED84 | CD13F020 | CD13FEF2 |
| 64- | CD140290 | CD140C42 | CD1411E6 | CD141F34 | CD14247C | CD142AAE | CD14370A | CD1439D8 | CD14419A | CD144F48 |
| 65- | CD1452EC | CD145C3E | CD146776 | CD1469A4 | CD147400 | CD147AD2 | CD148484 | CD148A56 | CD1497F2 | CD149920 |
| 66- | CD14A268 | CD14ACBA | CD14B11E | CD14BFCC | CD14C78E | CD14C95C | CD14D4F8 | CD14DA2A | CD14E162 | CD14EFB0 |
| 67- | CD14F214 | CD14FCC6 | CD15006A | CD150EB8 | CD15131C | CD151DCE | CD152686 | CD152854 | CD1535F0 | CD153B22 |
| 68- | CD154360 | CD154DB2 | CD155016 | CD155EC4 | CD15658C | CD156B5E | CD1576FA | CD157828 | CD15867E | CD1588AC |
| 69- | CD159508 | CD159BDA | CD15A092 | CD15AE40 | CD15B3E4 | CD15BD36 | CD15C574 | CD15CBA6 | CD15D602 | CD15D8D0 |
| 70- | CD15E398 | CD15ED4A | CD15F0EE | CD15FE3C | CD160764 | CD1609B6 | CD161412 | CD161AC0 | CD162188 | CD162F5A |
| 71- | CD1632FE | CD163C2C | CD16446E | CD164ABC | CD165718 | CD1659CA | CD166282 | CD166C50 | CD1671F4 | CD167F26 |
| 72- | CD168170 | CD168FA2 | CD169206 | CD169CD4 | CD16A79C | CD16A94E | CD16B4EA | CD16BA38 | CD16C27A | CD16CCA8 |
| 73- | CD16D10C | CD16DFDE | CD16E496 | CD16EA44 | CD16F7E0 | CD16F932 | CD17059E | CD1708 4C | CD1716E8 | CD17183A |
| 74- | CD172372 | CD172DA0 | CD173004 | CD173ED6 | CD174694 | CD174846 | CD1755E2 | CD175B30 | CD176078 | CD176EAA |
| 75- | CD17730E | CD177DDC | CD17838A | CD178D58 | CD1790FC | CD179E2E | CD17A566 | CD17ABB4 | CD17B610 | CD17B8C2 |
| 76- | CD17C080 | CD17CE52 | CD17D3F6 | CD17DD24 | CD17E66C | CD17E8BE | CD17F51A | CD17FBC8 | CD18030C | CD180DDE |
| 77- | CD18107A | CD181EA8 | CD1825E0 | CD182B32 | CD183696 | CD183844 | CD184006 | CD184ED4 | CD185370 | CD185DA2 |
| 78- | CD1866EA | CD186838 | CD18759C | CD187B4E | CD188518 | CD188BCA | CD18966E | CD1898BC | CD18A3F4 | CD18AD26 |
| 79- | CD18B082 | CD18BE50 | CD18C612 | CD18C8C0 | CD18D564 | CD18DBB6 | CD18E0FE | CD18EE2C | CD18F388 | CD18FD5A |
| 80- | CD1901F6 | CD190F24 | CD191280 | CD191C52 | CD19271A | CD1929C8 | CD19346C | CD193ABE | CD1942FC | CD194C2E |
| 81- | CD19518A | CD195F58 | CD196410 | CD196AC2 | CD197766 | CD1979B4 | CD1987E2 | CD198930 | CD199494 | CD199A46 |
| 82- | CD19A10E | CD19AFDC | CD19B278 | CD19BCAA | CD19C4E8 | CD19CA3A | CD19D79E | CD19D94C | CD19E204 | CD19ECD6 |
| 83- | CD19F172 | CD19FFA0 | CD1A06F8 | CD1A082A | CD1A158E | CD1A1B5C | CD1A2014 | CD1A2EC6 | CD1A3362 | CD1A3DB0 |
| 84- | CD1A45F2 | CD1A4B20 | CD1A5684 | CD1A5856 | CD1A631E | CD1A6DCC | CD1A7068 | CD1A7EBA | CD1A80EC | CD1A8E3E |
| 85- | CD1A939A | CD1A9D48 | CD1AA600 | CD1AA8D2 | CD1AB576 | CD1ABBA4 | CD1AC3E6 | CD1ACD34 | CD1AD090 | CD1ADE42 |
| 86- | CD1AE50A | CD1AEBD8 | CD1AF67C | CD1AF8AE | CD1B0402 | CD1B0AD0 | CD1B1774 | CD1B19A6 | CD1B22EE | CD1B2C3C |
| 87- | CD1B3198 | CD1B3F4A | CD1B4708 | CD1B49DA | CD1B547E | CD1B5AAC | CD1B61E4 | CD1B6F36 | CD1B7292 | CD1B7C40 |
| 88- | CD1B8216 | CD1B8CC4 | CD1B9160 | CD1B9FB2 | CD1BA4FA | CD1BAA28 | CD1BB78C | CD1BB95E | CD1BC11C | CD1BCFCE |
| 89- | CD1BD26A | CD1BDCB8 | CD1BE7F0 | CD1BE922 | CD1BF486 | CD1BFA54 | CD1C0636 | CD1C08E4 | CD1C1540 | CD1C1B92 |
| 90- | CD1C20DA | CD1C2E08 | CD1C33AC | CD1C3D7E | CD1C453C | CD1C4BEE | CD1C564A | CD1C5898 | CD1C63D0 | CD1C6D02 |
| 91- | CD1C70A6 | CD1C7E74 | CD1C8022 | CD1C8EF0 | CD1C9354 | CD1C9D86 | CD1CA6CE | CD1CA81C | CD1CB5B8 | CD1CB86A |
| 92- | CD1CC328 | CD1CCDFA | CD1CD05E | CD1CDE8C | CD1CE5C4 | CD1CEB16 | CD1CF6B2 | CD1CF860 | CD1D04CC | CD1D0A1E |
| 93- | CD1D17BA | CD1D1968 | CD1D2220 | CD1D2CF2 | CD1D3156 | CD1D3F84 | CD1D47C6 | CD1D4914 | CD1D54B0 | CD1D5A62 |
| 94- | CD1D612A | CD1D6FF8 | CD1D725C | CD1D7C8E | CD1D82D8 | CD1D8C0A | CD1D91AE | CD1D9F7C | CD1DA434 | CD1DAAE6 |
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| 96- | CD1E03C2 | CD1E0D10 | CD1E10B4 | CD1E1E66 | CD1E252E | CD1E2BFC | CD1E3658 | CD1E388A | CD1E40C8 | CD1E4E1A |
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| 100- | CD1F4232 | CD1F4CE0 | CD1F5144 | CD1F5F96 | CD1F64DE | CD1F6A0C | CD1F77A8 | CD1F797A | CD1F872C | CD1F89FE |
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| 102- | CD1FE2CA | CD1FEC18 | CD1FF18C | CD1FFF6E | CD2001DA | CD200F08 | CD2012AC | CD201C7E | CD202736 | CD2029E4 |
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| 106- | CD2125CC | CD212B1E | CD2136BA | CD213868 | CD21402A | CD214EF8 | CD21535C | CD215D8E | CD2166C6 | CD216814 |
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| 108- | CD21C63E | CD21C8EC | CD21D548 | CD21DB9A | CD21E0D2 | CD21EE00 | CD21F3A4 | CD21FD76 | CD22042E | CD220AFC |
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| 112- | CD2306D4 | CD230806 | CD2315A2 | CD231B70 | CD232038 | CD232EEA | CD23334E | CD233D9C | CD2345DE | CD234B0C |
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| 122- | CD2627F8 | CD26292A | CD26348E | CD263A5C | CD26421E | CD264CCC | CD265168 | CD265FBA | CD2664F2 | CD266A20 |
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| 124- | CD26C40A | CD26CAD8 | CD26D77C | CD26D9AE | CD26E2E6 | CD26EC34 | CD26F190 | CD26FF42 | CD2703EE | CD270D3C |
| 125- | CD271098 | CD271E4A | CD272502 | CD272BD0 | CD273674 | CD2738A6 | CD2740E4 | CD274E36 | CD275392 | CD275D40 |
| 126- | CD276608 | CD2768DA | CD27757E | CD277BAC | CD2785FA | CD278B28 | CD27968C | CD27985E | CD27A316 | CD27ADC4 |
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| 130- | CD28A584 | CD28AB56 | CD28B6F2 | CD28B820 | CD28C062 | CD28CEB0 | CD28D314 | CD28DDC6 | CD28E68E | CD28E85C |
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| 132- | CD29448C | CD294A5E | CD2957FA | CD295928 | CD296260 | CD296CB2 | CD297116 | CD297FC4 | CD298192 | CD298F40 |
| 133- | CD2992E4 | CD299C36 | CD29A77E | CD29A9AC | CD29B408 | CD29BADA | CD29C298 | CD29CC4A | CD29D1EE | CD29DF3C |
| 134- | CD29E474 | CD29EAA6 | CD29F702 | CD29F9D0 | CD2A0088 | CD2A0E5A | CD2A13FE | CD2A1D2C | CD2A2664 | CD2A28B6 |
| 135- | CD2A3512 | CD2A3BC0 | CD2A4382 | CD2A4D50 | CD2A50F4 | CD2A5E26 | CD2A656E | CD2A6B8C | CD2A7618 | CD2A78CA |
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| 138- | CD2B249E | CD2B2A4C | CD2B37E8 | CD2B393A | CD2B4178 | CD2B4FAA | CD2B520E | CD2B5CDC | CD2B6794 | CD2B6946 |
| 139- | CD2B74E2 | CD2B7A30 | CD2B8466 | CD2B8AB4 | CD2B9710 | CD2B99C2 | CD2BA28A | CD2BAC58 | CD2BB1FC | CD2B8F2E |
| 140- | CD2BC76C | CD2BC9BE | CD2BD41A | CD2BDAC8 | CD2BE180 | CD2BEF52 | CD2BF2F6 | CD2BFC24 | CD2C0046 | CD2C0E94 |
| 141- | CD2C1330 | CD2C1DE2 | CD2C26AA | CD2C2878 | CD2C35DC | CD2C3B0E | CD2C434C | CD2C4D9E | CD2C503A | CD2C5EE8 |
| 142- | CD2C65A0 | CD2C6B72 | CD2C76D6 | CD2C7804 | CD2C8652 | CD2C8880 | CD2C9524 | CD2C9BF6 | CD2CA0BE | CD2CAE6C |
| 143- | CD2CB3C8 | CD2C8D1A | CD2CC558 | CD2CCB8A | CD2CD62E | CD2CD8FC | CD2CE3B4 | CD2CED66 | CD2CF0C2 | CD2CFE10 |
| 144- | CD2D02BC | CD2D0C6E | CD2D11CA | CD2D1F18 | CD2D2450 | CD2D2A82 | CD2D3726 | CD2D39F4 | CD2D41B6 | CD2D4F64 |
| 145- | CD2D52C0 | CD2D5C12 | CD2D675A | CD2D6988 | CD2D742C | CD2D7AFE | CD2D84A8 | CD2D8A7A | CD2D97DE | CD2D990C |
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| 148- | CD2E46B8 | CD2E486A | CD2E55CE | CD2E5B1C | CD2E6054 | CD2E6E86 | CD2E7322 | CD2E7DF0 | CD2E83A6 | CD2E8D74 |
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| 150- | CD2EE640 | CD2EE892 | CD2EF536 | CD2EFBE4 | CD2F0748 | CD2F099A | CD2F143E | CD2F1AEC | CD2F21A4 | CD2F2F76 |
| 151- | CD2F32D2 | CD2F3C00 | CD2F4442 | CD2F4A90 | CD2F5734 | CD2F59E6 | CD2F62AE | CD2F6C7C | CD2F71D8 | CD2F7F0A |
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| 155- | CD3070D4 | CD307E06 | CD308050 | CD308E82 | CD309326 | CD309DF4 | CD30A6BC | CD30A86E | CD30B5CA | CD30BB18 |
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| 157- | CD3117C8 | CD31191A | CD312252 | CD312C80 | CD313124 | CD313FF6 | CD3147B4 | CD314966 | CD3154C2 | CD315A10 |
| 158- | CD316158 | CD316F8A | CD31722E | CD317CFC | CD3182AA | CD318C78 | CD3191DC | CD319F0E | CD31A446 | CD31AA94 |
| 159- | CD31B730 | CD31B9E2 | CD31C1A0 | CD31CF72 | CD31D2D6 | CD31DC04 | CD31E74C | CD31E99E | CD31F43A | CD31FAE8 |
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| 161- | CD3253CC | CD325D1E | CD326656 | CD326884 | CD327520 | CD327BF2 | CD3285A4 | CD328B76 | CD32296D2 | CD329800 |
| 162- | CD32A348 | CD32AD9A | CD32B03E | CD32BEEC | CD32C6AE | CD32C87C | CD32D5D8 | CD32DB0A | CD32E042 | CD32EE90 |
| 163- | CD32F334 | CD32FDE6 | CD33014A | CD330F98 | CD33123C | CD331CEE | CD3327A6 | CD332974 | CD3334D0 | CD333A02 |
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| 167- | CD3436E4 | CD343836 | CD344074 | CD344EA6 | CD345302 | CD345DD0 | CD346698 | CD34684A | CD3475EE | CD347B3C |
| 168- | CD34856A | CD3488B8 | CD34961C | CD3498CE | CD34A386 | CD34AD54 | CD34B0F0 | CD34BE22 | CD34C660 | CD34C8B2 |
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| 175- | CD368504 | CD368BD6 | CD36C394 | CD36CD46 | CD36D0E2 | CD36DE30 | CD36E578 | CD36EBAA | CD36F60E | CD36F8DC |
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| 177- | CD37540C | CD375ADE | CD376196 | CD376F44 | CD3772E0 | CD377C32 | CD378264 | CD378CB6 | CD379112 | CD379FC0 |
| 178- | CD37A488 | CD37AA5A | CD37B7FE | CD37B92C | CD37C16E | CD37CFBC | CD37D218 | CD37DCCA | CD37E782 | CD37E950 |
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| 184- | CD39860C | CD3988DE | CD39957A | CD399BA8 | CD39A0E0 | CD39AE32 | CD39B396 | CD39BD44 | CD39C506 | CD39C8D4 |
| 185- | CD39D670 | CD39D8A2 | CD39E3EA | CD39ED38 | CD39F09C | CD39FE4E | CD3A0716 | CD3A09C4 | CD3A1460 | CD3A1AB2 |
| 186- | CD3A21FA | CD3A2F28 | CD3A328C | CD3A3C5E | CD3A441C | CD3A4ACE | CD3A576A | CD3A59B8 | CD3A62F0 | CD3A6C22 |
| 187- | CD3A7186 | CD3A7F54 | CD3A8102 | CD3A8FD0 | CD3A9274 | CD3A9CA6 | CD3AA7EE | CD3AA93C | CD3AB498 | CD3ABA4A |
| 188- | CD3AC208 | CD3ACCDA | CD3AD17E | CD3ADFAC | CD3AE4E4 | CD3AEA36 | CD3AF792 | CD3AF940 | CD3B05EC | CD3B0B3E |
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| 190- | CD3B600A | CD3B6ED8 | CD3B737C | CD3B7DAE | CD3B83F8 | CD3B8D2A | CD3B908E | CD3B9E5C | CD3BA514 | CD3BABC6 |
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| 199- | CD3E37B6 | CD3E3964 | CD3E4126 | CD3E4FF4 | CD3E5250 | CD3E5C82 | CD3E67CA | CD3E6918 | CD3E748C | CD3E7A6E |
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| 202- | CD3F263A | CD3F28E8 | CD3F354C | CD3F3B9E | CD3F43DC | CD3F4D0E | CD3F50AA | CD3F5E78 | CD3F6530 | CD3F6BE2 |
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| 210- | CD41A1EA | CD41AF38 | CD41B29C | CD41BC4E | CD41C40C | CD41CADE | CD41D77A | CD41D9A8 | CD41E2E0 | CD41EC32 |
| 211- | CD41F196 | CD41FF44 | CD42061C | CD4208CE | CD42156A | CD4218B8 | CD4220F0 | CD422E22 | CD423386 | CD423D54 |
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| 215- | CD43317C | CD433FAE | CD4347EC | CD43493E | CD43549A | CD435A48 | CD436100 | CD436FD2 | CD437276 | CD437CA4 |
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| 217- | CD43D28E | CD43DC5C | CD43E714 | CD43E9C6 | CD43F462 | CD43FAB0 | CD4406D2 | CD440800 | CD4415A4 | CD441B76 |
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| 396- | CD7BC32E | CD7BCDFC | CD7BD058 | CD7BDE8A | CD7BE5C2 | CD7BEB10 | CD7BF6B4 | CD7BF866 | CD7C0404 | CD7C0AD6 |
| 397- | CD7C1772 | CD7C19A0 | CD7C22E8 | CD7C2C3A | CD7C319E | CD7C3F4C | CD7C470E | CD7C49DC | CD7C5478 | CD7C5AAA |
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| 400- | CD7D06FE | CD7D082C | CD7D1588 | CD7D1B5A | CD7D2012 | CD7D2EC0 | CD7D3364 | CD7D3D86 | CD7D45F4 | CD7D4B26 |
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| 403- | CD7DF67A | CD7DF8A8 | CD7E01F0 | CD7E0F22 | CD7E1286 | CD7E1C54 | CD7E271C | CD7E29CE | CD7E346A | CD7E3AB8 |
| 404- | CD7E42FA | CD7E4C28 | CD7E518C | CD7E5F5E | CD7E6416 | CD7E6AC4 | CD7E7760 | CD7E79B2 | CD7E87E4 | CD7E8936 |
| 405- | CD7E9492 | CD7E9A40 | CD7EA108 | CD7EAFDA | CD7EB27E | CD7EBCAC | CD7EC4EE | CD7ECA3C | CD7ED798 | CD7ED94A |
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| 407- | CD7F3690 | CD7F3842 | CD7F4000 | CD7F4ED2 | CD7F5376 | CD7F5DA4 | CD7F66EC | CD7F683E | CD7F759A | CD7F7B48 |
| 408- | CD7F851E | CD7F8BCC | CD7F9668 | CD7F98BA | CD7FA3F2 | CD7FAD20 | CD7FB084 | CD7FBE56 | CD7FC614 | CD7FC8C6 |
| 409- | CD7FD562 | CD7FDBB0 | CD7FE0F8 | CD7FEE2A | CD7FF38E | CD7FFD5C | | | | |

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