NATO STANDARD

AOP-4547

DESIGN REQUIREMENTS FOR INDUCTIVE SETTING OF MEDIUM CALIBRE ELECTRONIC PROJECTILE FUZES

Edition A Version 1
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NORTH ATLANTIC TREATY ORGANIZATION

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NATO LETTER OF PROMULGATION

8 October 2019

1. The enclosed Allied Ordnance Publication AOP-4547, Edition A, Version 1, DESIGN REQUIREMENTS FOR INDUCTIVE SETTING OF MEDIUM CALIBRE ELECTRONIC PROJECTILE FUZES, which has been approved by the nations in the CNAD AMMUNITION SAFETY GROUP (CASG – AC/326), is promulgated herewith. The agreement of nations to use this publication is recorded in STANAG 4547.

2. AOP-4547, Edition A, Version 1, is effective upon receipt.

3.

4. This publication shall be handled in accordance with C-M(2002)60.

Zoltán GULYÁS
Brigadier General, HUNAF
Director, NATO Standardization Office

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RECORD OF RESERVATIONS

CHAPTER	RECORD OF RESERVATION BY NATIONS
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RECORD OF SPECIFIC RESERVATIONS

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TABLE OF CONTENTS

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CHAPTER 1 INTRODUCTION

1.1. REQUIREMENT TOPICS

Participating nations agree to comply with the requirements of this AOP. This AOP defines the following:

a. Inductive setting interface

b. Talk-forward message format

c. Talk-back message format (optional)

d. Fuze sensitivity to inductive signal

e. Inductive signal power levels

f. General physical layout

g. Functional requirements of the setter

h. Functional requirements of the fuze

1.2 DEFINITIONS AND ABBREVIATIONS

The definitions and acronyms of terms used in this AOP will be found in Annex A.

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CHAPTER 2 GENERAL

2.1. Electronic Fuzing is becoming more important in current and future developments. An autoset capability has been incorporated into modern large calibre fuzes (see STANAG 4369 and AOP-22 for details). The autoset capability is desired in medium calibre fuzes. To ensure interoperability between these fuzes and the NATO weapon systems, autosetting standards are required.

2.2. This AOP provides sufficient detail to define interchangeable message patterns. Design guidance intended to further promote interoperability will be defined in a future edition of this AOP. The inductive setting system will not degrade or circumvent fuze or weapon safety.

2.3. Interoperability with other fuzes and fuze setters is the responsibility of the development activity or nation. The developer of the fuze setter will be required to know the fuze specific parameters for those fuzes intended to be set with a setter designed to this AOP.

2.4. The influence of specific parameters and functional ID-codes is not restricted to the setter, they also have to be incorporated in fire control systems and command and control systems.

2.5. In a tactical situation the fuze is mounted on a projectile when presented to the setter. The setter receives information for the particular fire mission from the fire control system, and then sets the fuze through the inductive interface. The fuze has the option of repeating the message back through the inductive interface so that the setter can compare the two transmissions. Due to high rates of fire and minimal risk to the weapon system, the use of talkback is optional.

2.6. Figure 1 is a pictorial representation of a possible physical layout. It comprises a nose fuzed medium caliber projectile and a setter. This AOP places requirements on the inductive link utilizing the coil of wire located in each item. It depicts the setter's transmit coil, the fuze's receive coil, the magnetic coupling between the two, and a typical relative position. Multiple coil configurations are also acceptable.

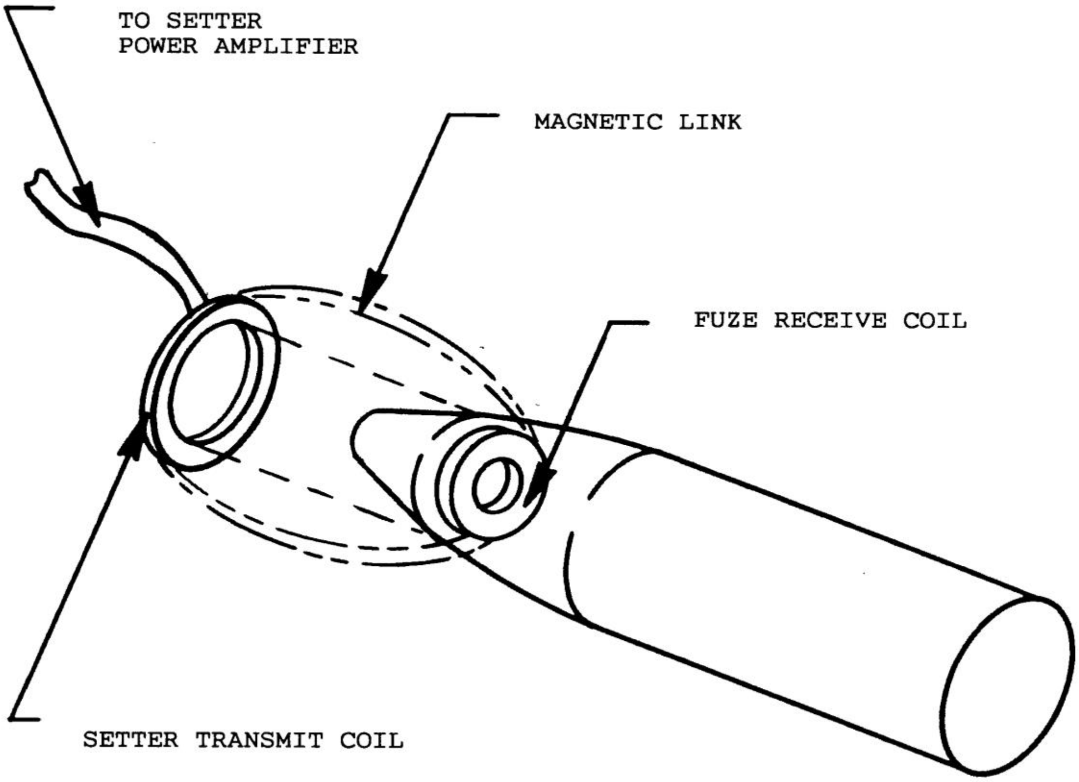

Figure 1. Inductive interface pictorial representation.

Note: The setter coil is shown separated from the fuze coil to show the magnetic link.

2.7. Communication structure comprises a power up period (PUP) and one or more fuze message windows (FMW). The timing diagram is illustrated in Figure 2.

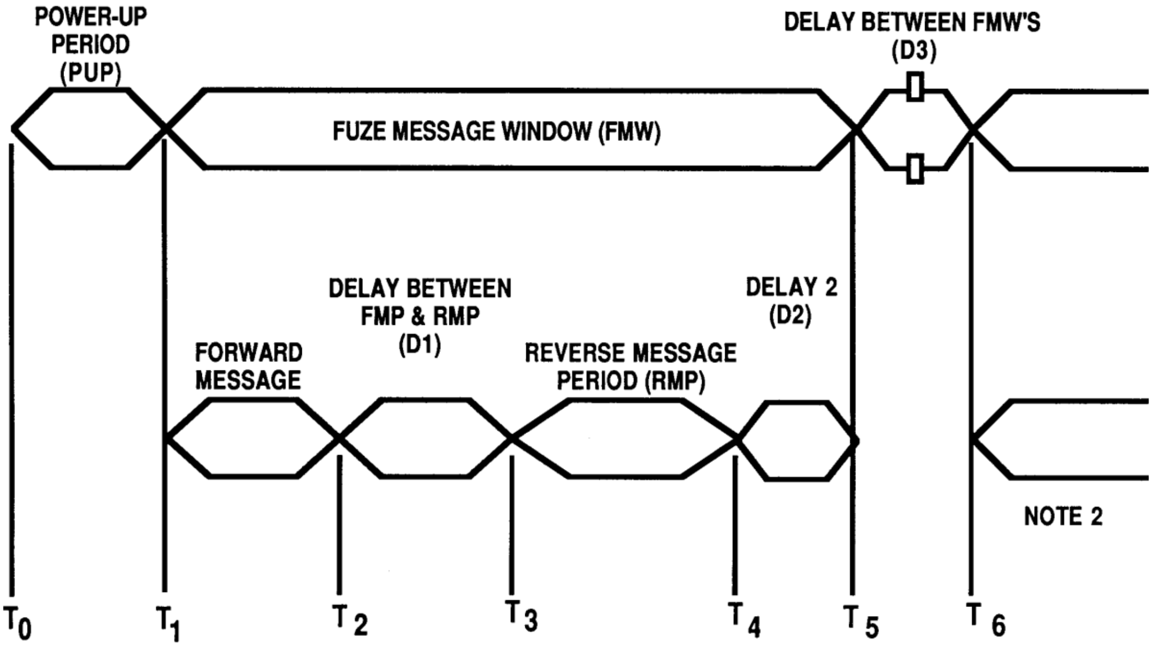

Figure 2. Inductive interface timing diagram

Notes:

1. T5 marks the end of communication and carrier turn-off for a FMW. T6 marks the beginning of carrier turn-on for either a single or a multiple FMW when another setting attempt or FMW is sent.
2. T1 through T6 sequence would be repeated for additional FMWs.
3. D1 and RMP (T2 through T4) apply only when talkback is utilized.

2.8. Setter and fuze specific message and timing characteristics will be provided for each individual fuze by the item developer.

2.9. The communication format permits message error detection by the setter through the use of talkback. This optional feature is provided by the setter transmitting a message to the fuze, for the fuze to repeat the message back to the setter, and for the setter to compare the two transmissions.

The fuze may be programmed in two modes. The set mode is used to program inductively set fuzes at the launch platform in tactical situations. Use of this mode requires the operator or weapon system to recognize the identity of the fuze being set and requires the inductive fuze setter to know all of the timing and bit pattern requirements applicable to the fuze being set. The command mode which is optional can be used for functions such as fuze interrogation and fuze calibration. The setter will transform specified information transmitted to the operator into a form similar to that of the original fire mission data.

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CHAPTER 3 DETAILS OF AGREEMENT

3.1. The fuze physical layout shall include a coil of wire configured such that the magnetic field from the setter's coil will be sufficient to set the fuze, when mounted on the projectile and located in the tactical position. Rotation of the fuze about its axis shall not affect its interaction with any setter.

3.2. The setter physical layout shall include a coil of wire configured such that the setter can set the fuze when the fuze is mounted on the projectile and located in the tactical position. If a specified setter function is implemented by components physically located within the fire control system or other elements, then setter requirements specified by this AOP shall also apply to those components or elements.

3.3. The setter shall receive, from the operator or fire control system, the information necessary to set the fuze for the fire mission. The setter shall then, in a format appropriate for the fuze being set and the fire mission, transmit a complete message to the fuze. When the talkback feature is incorporated, the setter shall then: (a) detect the information returned by the fuze and compare it to the originally transmitted information, and (b) indicate to the operator or fire control system the status of the fuze.

3.4. The fuze shall receive a message from the setter in a format appropriate for the fuze and the target. The fuze shall then transmit a specified message to the setter when talkback is required. The fuze mission memory shall change as specified after receiving a valid message.

3.5. Communication between setter and fuze shall be accomplished by modulation of the carrier. Information conveyed via carrier modulation is implemented with mark and space phases for messages as specified. The setter modulates the carrier by energizing and de-energizing its coil. When talkback is enabled the fuze modulates the carrier by changing the impedance across its coil and thereby affects voltage and current in the setter coil. Message characteristics shall comply with the requirements in Annex B.

3.6. The values of certain fuze parameters associated with the inductive interface shall be selected by the development activity. The values selected shall be within the range permitted by this AOP for each such parameter. The development activity is responsible for parameter selections that are appropriate to support the interoperability requirements of the fuze. The development activity shall select fuze modes, time-of-flight (TOF), TOF format and associated fuze mode parameters, as appropriate. The development activity shall utilize the bit patterns and their significance as defined in Annex B.

3.7. This AOP defines two types of inductive setting systems. The first setting system is a digital system based on STANAG 4369. Digital message and general characteristics are provided in Annexes B and C. The second type of inductive setting system is an analog system. Analog message and general characteristics are provided in Annexes D and E. It is possible to design a single fuze setter which can accommodate both digital and analog setting techniques, however, the digital and analog systems use substantially different message characteristics and parameters.

3.8. The digital system utilizes an identification (ID) code based on fuze functionality and optionally permits talkback from the fuze to the fuze setter.

a. When the digital inductive system is employed the development activity shall request an identification (ID) code assignment from the custodian of this AOP. The ID code assignment will be based on fuze functions.

b. Requirements for general fuze parameters (digital) are given in Annexes B, C, and herein.

c. Fuze specific parameters will be provided by the fuze developers.

d. All fuzes shall be settable with repeated fuze message windows in accordance with Figure 2. Sequential forward messages may contain the same or different bit patterns.

e. All message timing parameters shall be in accordance with the specific requirements of the fuze to be set.

f. The ID code contains information about the fuze functional modes. However, a fuze shall be designed to default to a safe or to a reasonably effective alternative mode when it lacks the particular mode indicated by the forward message.

g. The ID code is eight bits long and is assigned based on fuze functions and capabilities.

h. The FMW shall contain a forward and, optionally, a reverse message with an ID code that is correct for the fuze to be set.

i. When talkback is implemented, the setter shall compare the forward message with the reverse message on a bit-for-bit basis in each FMW. If the bit-for-bit comparison fails, the setter may automatically make two more attempts to achieve a successful comparison before indicating a failure, in accordance with system requirements.

j. If the forward message is accepted by the fuze, then the reverse message data bit pattern (if talkback is incorporated) shall be identical to that of the forward message.

k. If the forward message is rejected by the fuze, then the reverse message data bit pattern shall be indicative of the fuze default mode.

3.9. The analog system does not have provision for an identification (ID) code but it can permit a form of talkback from the fuze to the fuze setter which would allow a setter to determine basic fuze type identification.

a. Requirements for general fuze parameters (analog) are given in Annex D and herein.

b. Fuze specific parameters will be provided by the fuze developer.

c. All fuzes shall update the mission memory based on the latest fuze message window.

d. The analog system requires that the setter know the fuze and fuze functions in advance of the setting cycle.

e. All message timing parameters shall be in accordance with the specific requirements of the fuze to be set.

f. The fuze shall be designed to default to a safe or to a reasonably effective alternative mode when it lacks the particular mode indicated by the forward message.

g. The setter shall compare the forward message with the reverse message when talkback is implemented. If the comparison fails, the setter may automatically make two more attempts to achieve a successful comparison before indicating a failure, in accordance with system requirements.

h. If the forward message is accepted by the fuze, then the reverse message data (if talkback is incorporated) shall be identical to that of the forward data.

i. If the forward message is rejected by the fuze, then the reverse message data (if talkback is incorporated) shall be indicative of the fuze default mode.

3.10. The fuze mission memory shall not be changed by a forward message before the acceptance or rejection of the message has been determined.

3.11. After receipt of a valid set mode message and a valid FMW, the fuze mission memory shall be changed to that of the current fire mission. The receipt of an invalid FMW shall cause the fuze to revert to the default mode.

3.12. After rejection of a set mode message, the fuze mission memory shall be changed to that of the fuze default mode.

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ANNEX A DEFINITIONS AND ABBREVATIONS

For the purposes of this AOP, the definitions, terms and acronyms herein shall apply.

1. Carrier. A magnetic field with sinusoidal waveform that is generated by the setter to support two-way information transmission between the setter and the fuze in accordance with this AOP.

2. Delay 1 (D1). The elapsed time between the FMP and the RMP is termed Delay 1. Delay 1 is used by the fuze to process the forward message and to prepare for talkback to the setter.

3. Delay 2 (D2). Delay 2 is the time interval between the end of the RMP and the end of the FMW. Delay 2 allows a fixed time duration for the FMW to be maintained.

4. Delay 3 (D3). Delay 3 is the time interval between FMW's. Delay 3 is used by both fuze and setter to prepare for the next FMW.

5. Digital Setting System. A method of programming the mode and time-of-flight information using a series of mark or space of the setter carrier at specified times to denote logical "1"s and "0"s.

6. Duty cycle. For a periodic waveform, the ratio of the mark phase to the total period of the waveform. It is expressed as a percentage. The space phase is that part of the waveform which is not mark phase.

7. Forward message. The message transmitted from the setter to the fuze in any fuze message window.

8. Forward message period (FMP). The time required to transmit a forward message. It is the product of the number of bits in the forward message. It is the reciprocal of the forward message bit rate.

9. Fuze default mode. A functional mode of operation that the fuze specification defines if an improperly set fuze is fired.

10. Fuze message window (FMW). A fixed time comprising of the forward message period, Delay 1, the reverse message period, and Delay 2.

11. Fuze mission memory. That part of the fuze which remembers the setting information for a fire mission after the inductive setting process is completed.

12. Fuze-specific parameters. The bit pattern and timing parameters identified for a particular type of fuze. These are determined by the fuze developer.

13. Identification code (ID). The eight-bit code is determined by available fuze modes. A single ID code is generally associated with particular functional modes, missions, and fuze-specific parameters.

14. Inductive fuze setter. A device which utilizes an inductive interface to exchange data with an inductively settable fuze in compliance with this AOP. The fuze setter may interpret the significance of individual data bits received and display the interpreted information to the operator or fire control system.

15. Inductive interface. The characteristics that control the interaction of an inductive fuze setter with an inductively settable fuze, in accordance with this AOP.

16. Inductively settable fuze. A fuze that can be set with an inductive fuze setter using the inductive interface.

17. Mark phase. A period of time when the carrier is suppressed or turned off to communicate information. It is a period of time when there is the absence of carrier.

18. Mission message. The mission message is composed of the data bits which identify fuze function and provides fuze function-specific information. The mission message is composed of one or more FMWs.

19. Power-up period (PUP). A prescribed period of time during which the inductive fuze setter energizes, with a sinusoidal waveform magnetic field, the physical space between the setter and the fuze. This period permits an inductively settable fuze to absorb sufficient energy from the magnetic field to operate necessary fuze circuits.

20. Reverse message. The message transmitted from the fuze to the setter in any fuze message window.

21. Reverse message period (RMP). The time interval during which an inductively settable fuze transmits a reverse message to the fuze setter. It is the product of the number of bits in the reverse message and the reciprocal of the reverse message bit rate.

22. Space phase. A period when the carrier is turned on to communicate information. It is the period of time where there is the presence of the carrier.

23. Valid message. A message that contains the correct number of FMWs transmitted in the correct order.

ANNEX B MESSAGE CHARACTERISTICS: DIGITAL

1. The setter controls the energizing of its coil. After the PUP, the setter transmits a forward message and then continues energizing its coil through the end of the communication. If more than one FMW is used such as for continuous setting, then there will be a delay (termed D3) between each FMW. The setter terminates the carrier within D3 after the end of the last FMW.

2. A forward message consists of a sequence of bits transmitted by the setter. The forward message bit rate is specified in Table B-1. Identification of logic 1's and 0's is based on the duty cycle of the waveform measured. Mark is represented by absence of carrier. A space is represented by presence of carrier. Figures B-1 and B-2 illustrate waveforms associated with forward message bits.

3. A reverse message consists of a sequence of bits transmitted by the fuze. The reverse message bit rate is controlled by the fuze and will be within the range specified in Table C-1. Identification of logic 1's and 0's is based on the duty cycle of the waveform. Mark is represented by varying the impedance "shorting cycle" across the fuze receive coil at a frequency (subcarrier) of 16 times the bit rate. The impedance reduction cycle is synchronized to the start of the mark period. Space is represented by restoring the impedance across the fuze receive coil. Figure B-3 illustrates waveforms associated with reverse message bits.

4. General inductive setting parameters are specified in Table B-1.

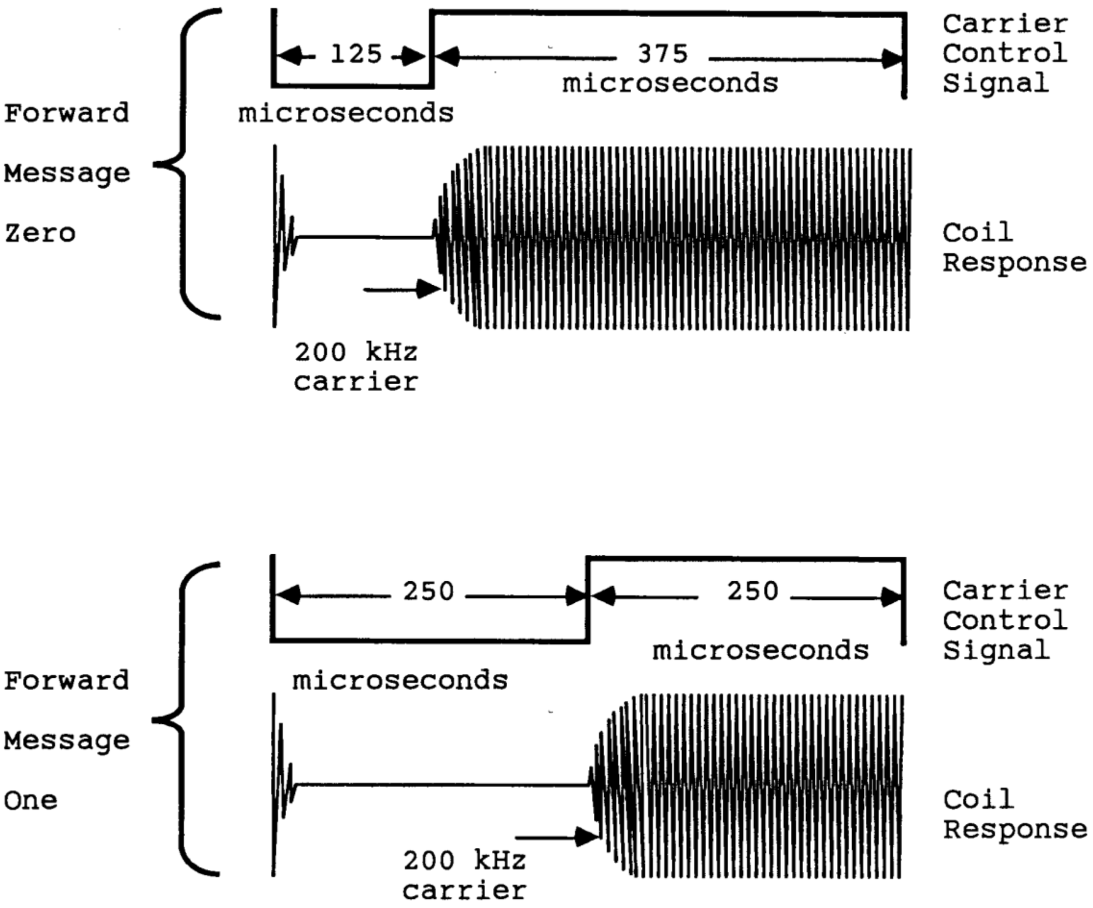
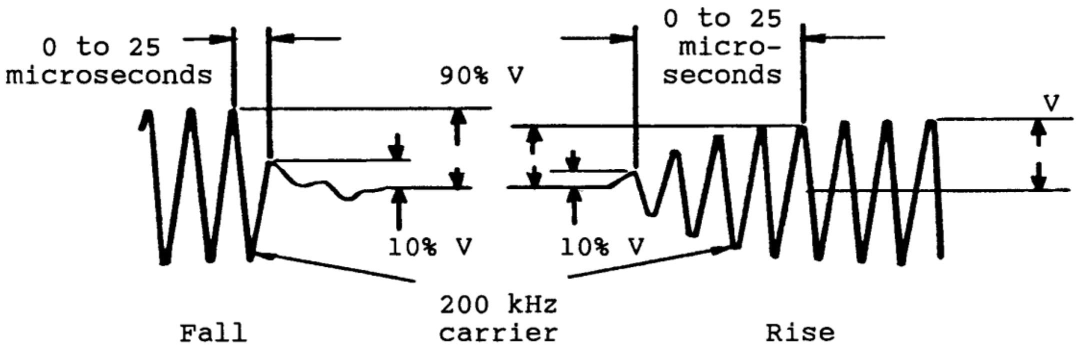
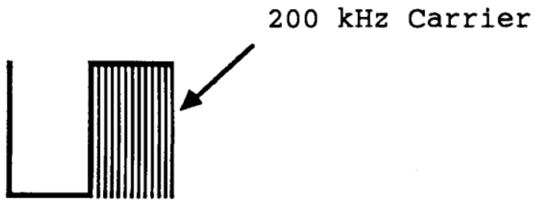


Figure B-1. Forward message: bit general characteristics

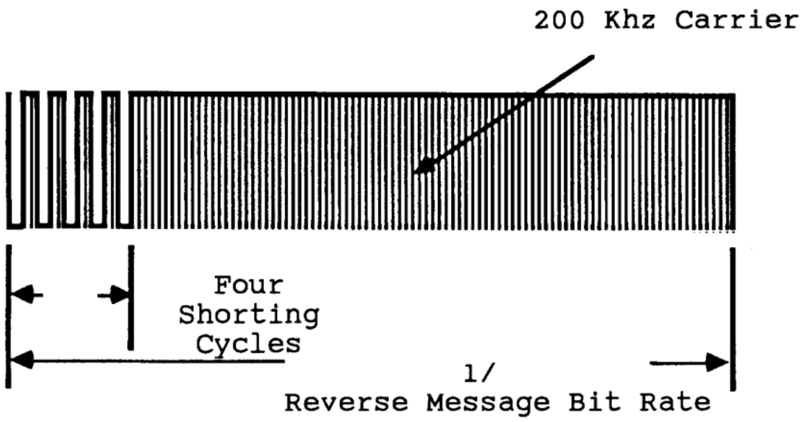


Note: Waveform measured across the Standard Fuze coil.

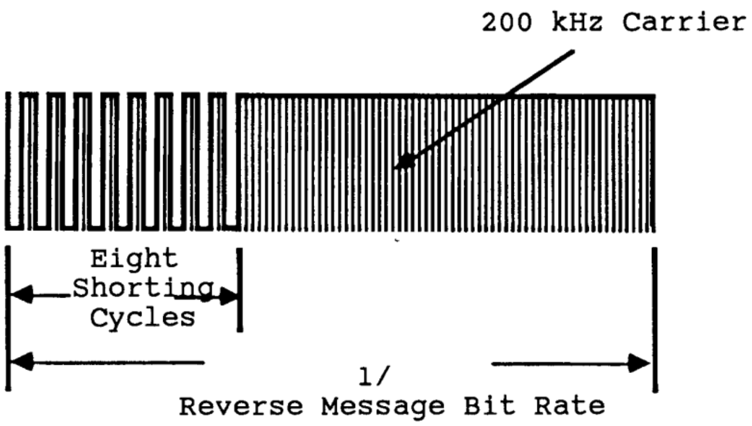
Figure B-2. Forward message: bit rise time and fall time characteristics.



a. Single shorting cycle



b. Reverse message "0"



c. Reverse message "1"

Figure B-3. Reverse message: fuze coil bit characteristics.

PARAMETER	VALUE	UNITS	REFERENCE
FMW	40 +/- 5	ms	Figure 2
D1	5	ms	Figure 2
D2	3.76 to 22.62	ms	Figure 2
D3	5 maximum	ms	Figure 2
Carrier Frequency	200 +/- 0.02	kHz	
Forward Message			
Bit Rate	2000 +/- 10	bits/s	Figure B-1
rise time (mark-to-space)	25 max	μs	Figure B-2
fall time (space-to-mark)	25 max	μs	Figure B-2
logic 0 mark	125 +/- 25	μs	Figure B-1
logic 0 space	375 +/- 25	μs	Figure B-1
logic 1 mark	250 +/- 25	μs	Figure B-1
logic 1 space	250 +/- 25	μs	Figure B-1
Reverse Message			Figure B-3
reverse message bit rate	3125	bits/s	
shorting cycle frequency	16 x bit rate	Hz	Annex C
shorting cycle phase	start with short		Figure B-3
shorting duty cycle	50 +/- 5	percent	
shorting cycle logic 0	4	cycles	Figure B-3
shorting cycle logic 1	8	cycles	Figure B-3

Table B-1. General Inductive Setting Parameters

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ANNEX C FUZE-SPECIFIC PARAMETERS: DIGITAL

1. The bits in an FMP shall comprise eight ID bits followed by up to 24 data bits. The maximum number of bits in a FMP shall be 32.

   a. Eight ID bits shall precede the data bits in both the FMP and the RMP.

   b. The number of data bits in one FMW for any fuze shall be no more than 24 data bits for talkforward (FMP) and, if used, 24 data bits for talkback (RMP).

   c. Fuzes may utilize fewer than 32 bits in each FMW.

2. The digital communication sequence begins with a 5 millisecond Power-up period followed by a forward message period. The FMP is from 3.76 to 22.68 milliseconds in duration depending on the number of bits (9 to 32) and is followed by Delay 1. Delay 1 is fixed at 5 milliseconds and is followed by the reverse message period. The reverse message period lasts from 2.88 to 10.24 milliseconds depending on the number of bits (9 to 32). Delay 2 completes the fuze message word. It maintains a fixed fuze message word duration of 40 milliseconds. The digital communication sequence is shown in Figure C-1.

3. The ID bits indicate available modes and also whether the fuze is in the command mode or the set mode. An ID bit pattern of all "0"s programs the fuze to accept the data bits as a command such as interrogate (all data bit "1"s). Otherwise the fuze is in the set mode. The ID and data bit patterns and their significance are shown in Figures C-2, C-3 and C-4.

4. The data bits are organized into six four-bit groups beginning with the mode and followed by the time-of-flight information. The time information is grouped into five digits beginning with tens and ending with thousandths. Each digit is made of four bits encoded using the Binary Coded Decimal (BCD) format as shown in Figure C-4. Only values of 0 through 9 are used for the time information digits. The others may be used for special purposes.

5. Fuzes may utilize the setter carrier to derive the subcarrier. The subcarrier frequency will be one-fourth the frequency of the carrier. The subcarrier may be generated by the fuze by dividing the carrier by four or by utilizing an independent at the discretion of the fuze developer.

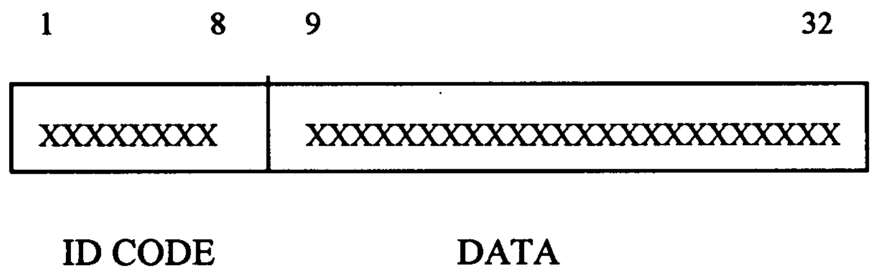
6. Fuze-specific parameters are specified in Table C-1. Additional fuze parameters, as necessary will be provided by the fuze developer.

PUP	FMP	D1	TALKBACK	D2
5 msec	4.5 to 16 msec	5 msec	2.88 to 10.24 msec	3.76 to 22.62 msec

Figure C-1. Inductive Word Format.

Notes:

1. Bits 1 through 8 are used for the ID code which also indicates the available fuze modes.
2. When bits 1 through 8 are all "0"s then the fuze is being sent a command. The command for interrogation has all "1"s for data bits 9 through 32.



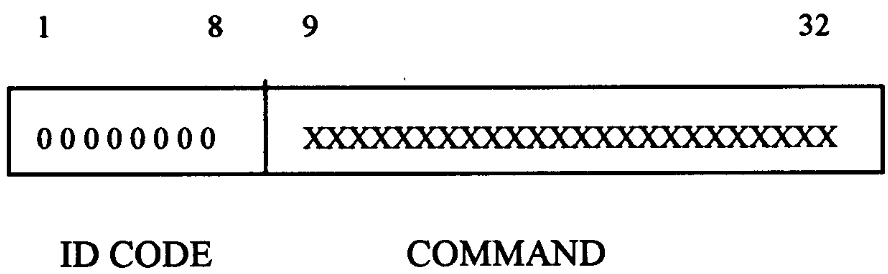


Figure C-2. Forward and reverse message format.

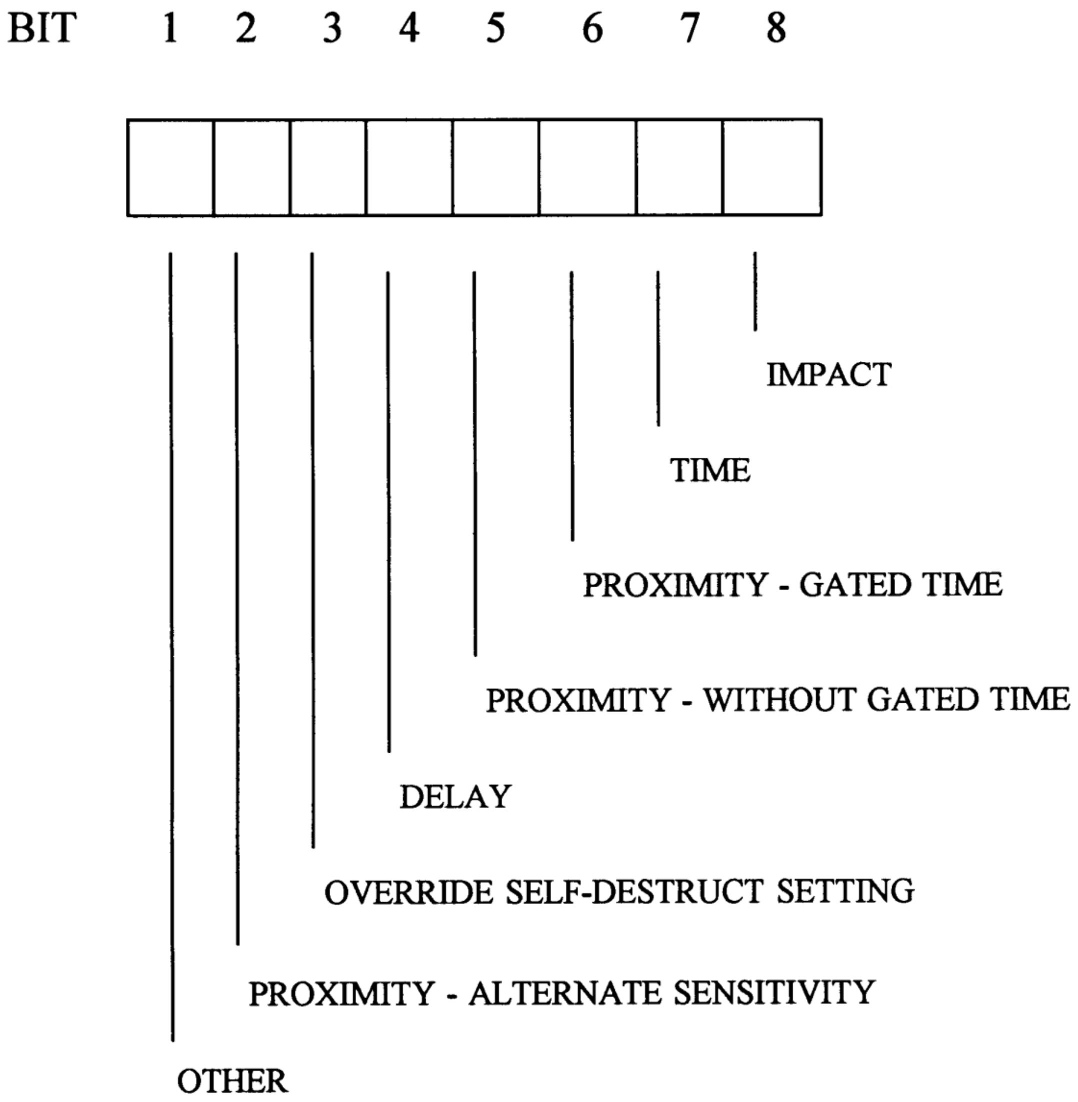


Figure C-3. ID Code Significance.

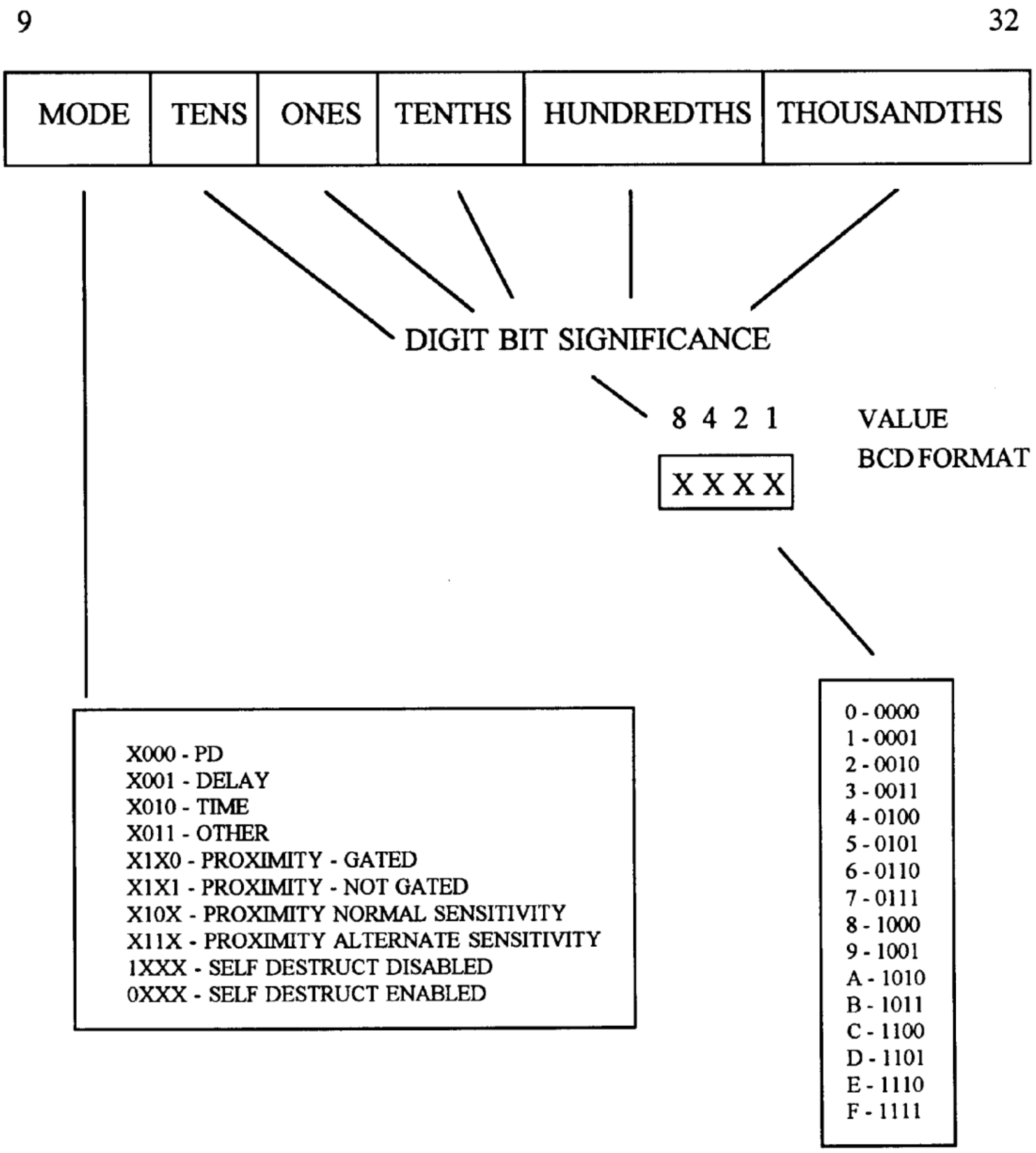


Figure C-4. Data Bit Significance

PARAMETER	VALUE	UNITS	REFERENCE
Carrier frequency	200 +/- 0.02	kHz	Figure B-1
PUP	5	ms	Figure C-1
D1	5	ms	Figure C-1
D2	NOTE 1	ms	Figure C-1
D3	5 maximum	ms	Note 4
ID bits	eight ID bits		Figure C-2
Data bits	1 to 24	number	Figure C-2
FMP	4.5 to 16	ms	Figure 2
Reverse message bit rate	3125	bits/s	Figure B-3
RMP	NOTE 3	ms	Figure 2
FMW	40.00	ms	Figure C-1
FMW number	1	number	
Subcarrier frequency	carrier / 4	Hz	

Table C-1. Fuze-specific Parameters

NOTES:

1. D2 is given by FMW minus (FMP plus D1 plus RMP) and may be any non-negative value corresponding to permitted values of FMW, FMP, D1, and RMP.

2. FMP is given by the number of forward message bits divided by the forward message bit rate.

3. RMP is given by the number of reverse message bits divided by the reverse message bit rate.

4. Delay 3 will not generally be required since Delay 2 and PUP may provide the necessary delay between FMWs.

ANNEX D MESSAGE CHARACTERISTICS: ANALOG

1. The setter controls the energizing of its coil. The setter transmits data by energizing and de-energizing its coil for specific periods of time in accordance with Figure D-1.

2. A forward message consists of a period during which the carrier is turned on then off and then on by the setter. The first carrier on period is 10 milliseconds to provide a power-up period for the fuze. The subsequent time that the carrier is turned off indicates fuze mode (Proximity-gated time, Proximity-no gated time, Proximity sensitivity, Override self-destruct setting, Time, Point Detonation, Delay, and other) in accordance with Figure D-2. During the next period the carrier is turned on for up to 40 milliseconds to indicate the time-of-flight. The carrier is turned on proportionately 1 millisecond for every 200 milliseconds of the time-of-flight setting in accordance with Figure D-3. The carrier is then turned off for 200 microseconds to mark the end of the talkforward message (Delay 1).

3. After the forward message period is concluded the setter carrier is turned on for 41.4 milliseconds to enable the fuze to communicate with the setter (talkback), if that feature is incorporated.

4. A reverse message consists of the fuze mode followed by time-of-flight information in accordance with Figure D-4. The fuze transmits this information by shorting and unshorting its coil at the subcarrier frequency for a period equal to that for the mode in accordance with Figure E-1. The fuze stops communicating to the setter for 200 microseconds and then indicates time-of-flight information by shorting and unshorting its receive coil at the subcarrier rate for the duration indicative of the time-of-flight in accordance with Figure E-2. The subcarrier frequency is the carrier frequency divided by four.

5. General inductive setting parameters are specified in Table D-1.

	PUP	FORWARD MESSAGE PERIOD			REVERSE MESSAGE PERIOD	
		MODE	TIME OF FLIGHT	DELAY 1		DELAY 2
	10	0.2 to 1.0	0.01 to 40.0	0.2	41.4	5.0
SETTER CARRIER	ON	OFF	ON	OFF	ON	OFF

Figure D-1. Setter Carrier Control

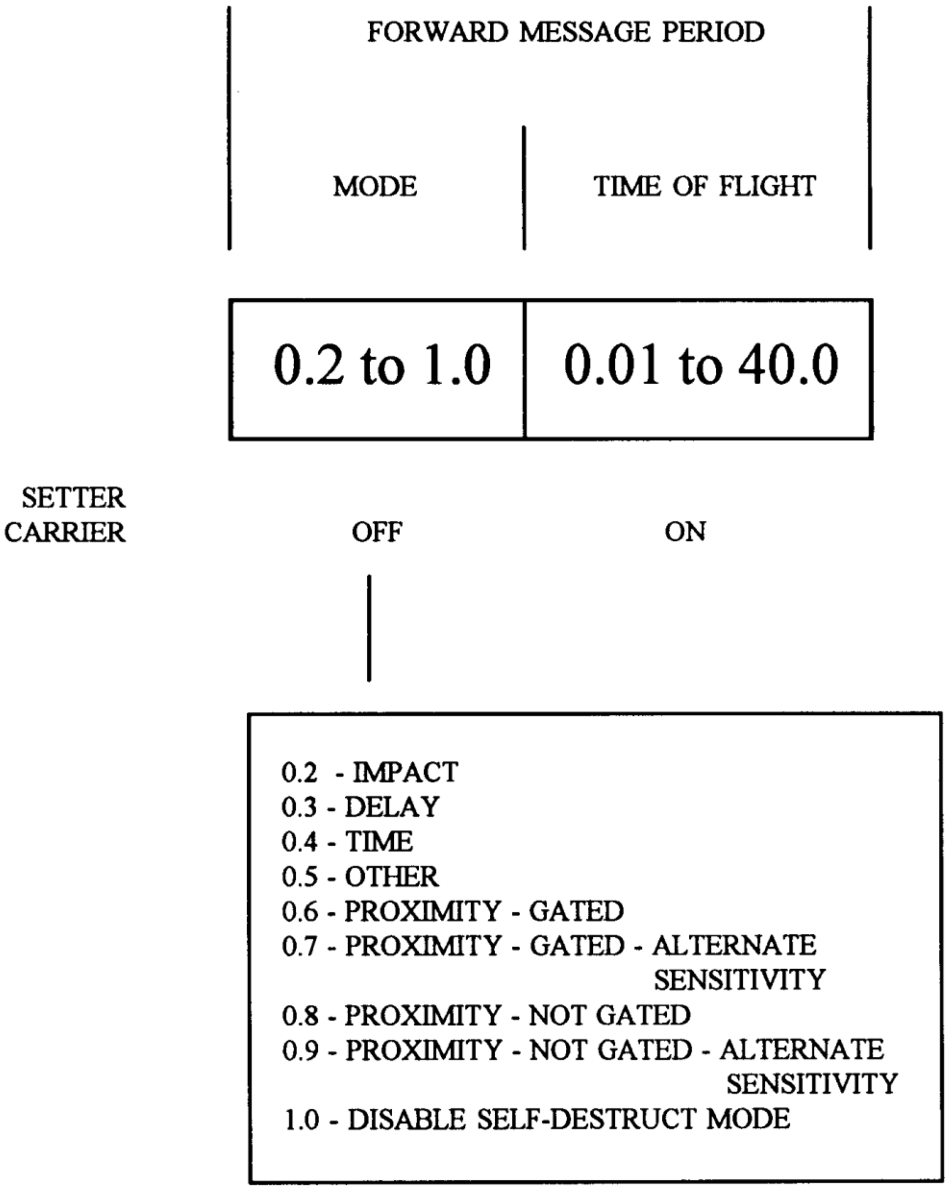


Figure D-2. Forward Message: mode

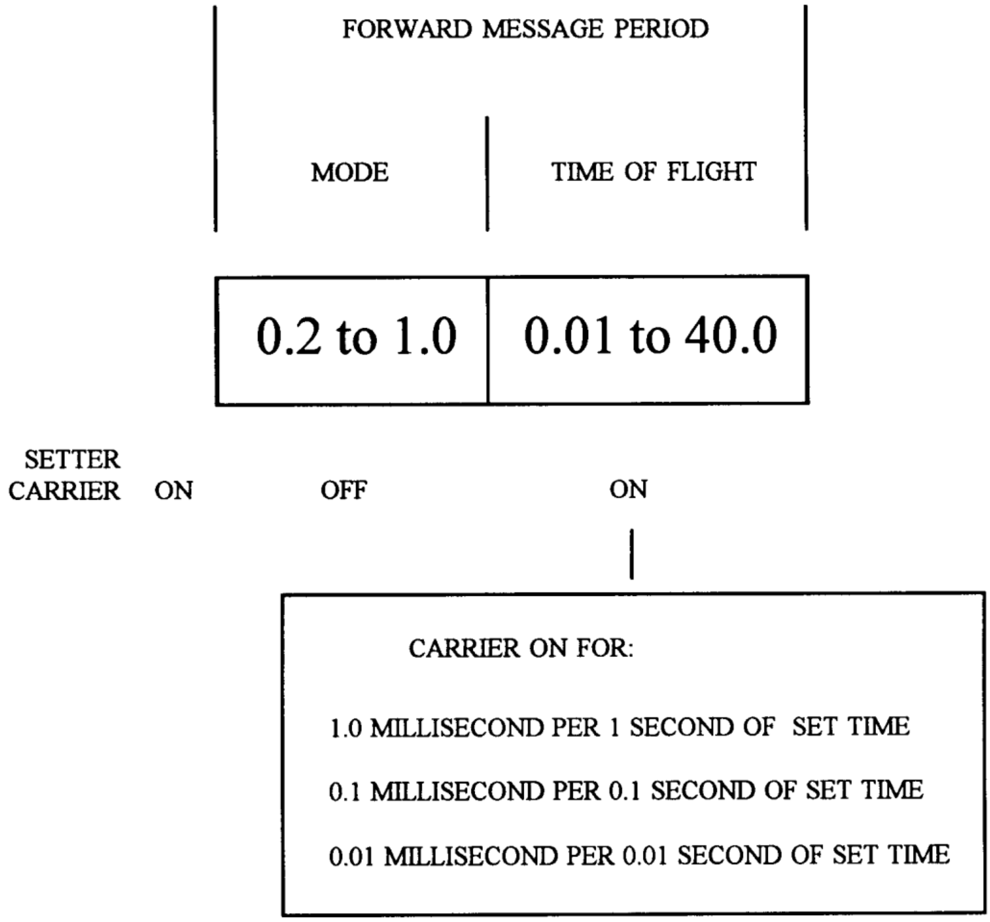


Figure D-3. Forward Message: time-of-flight

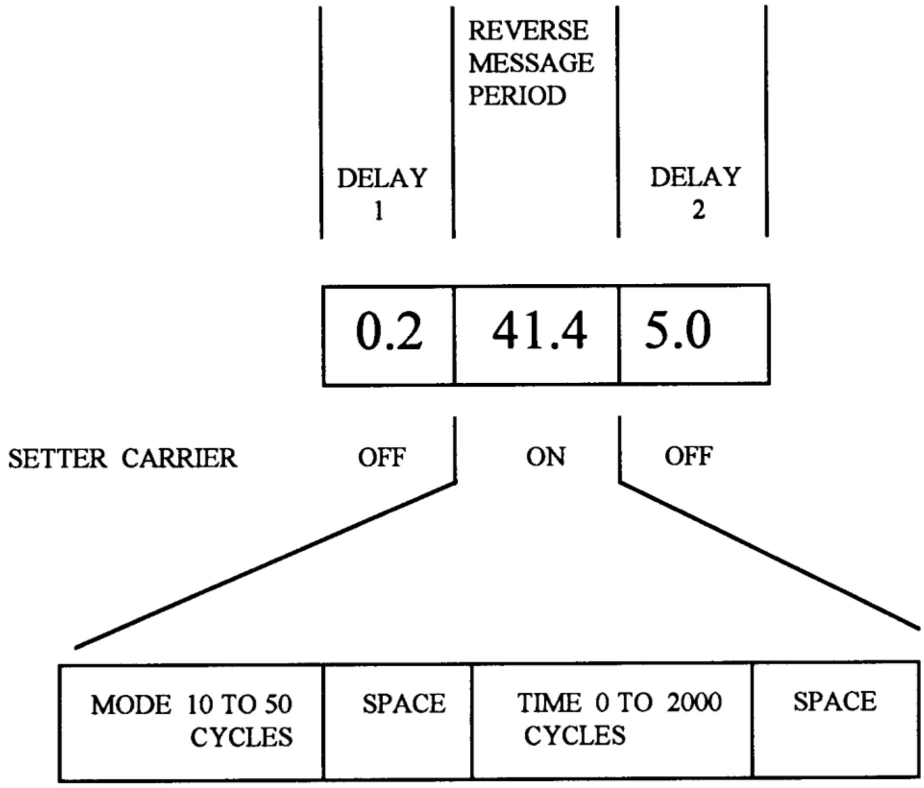


Figure D-4. Reverse Message Period.

PARAMETER	VALUE	UNITS	REFERENCE
FMW	56.81 to 97.6	ms	Figure D-1
D1	0.2 +/- 0.05	ms	Figure D-1
D2	5.0 +/- 0.1	ms	Figure D-1
D3	5.0 +/- 0.1	ms	Note 1
Carrier frequency	200 +/- 0.05	kHz	
Forward message period	0.21 to 41.0	ms	Figure D-1
Mode	0.2 to 1.0	ms	Figure D-2
Time-of-flight	0.01 to 40.0	ms	Figure D-3
Subcarrier frequency	50 +/- 0.05	kHz	carrier / 4
Reverse message period	41.4 +/- 0.1	ms	Figure D-4
Reverse message mode	10 to 50	cycles	Figure E-1
Reverse message TOF	0 to 2,000	cycles	Figure E-2
Shorting cycle phase	start with short		Figure B-3
Shorting duty cycle	50 +/- 5	percent	

Table D-1. General Inductive Setting Parameters - Analog

Note:
The Power-up period (PUP) in the analog system serves the same function as of Delay 3 in the digital system. Therefore, there is no specific Delay 3 required for the analog system. The fuze shall be designed to store the setting information for the period of time equal to the total of the PUP, Delay 2, and Delay 3 or 20 milliseconds.

ANNEX E FUZE-SPECIFIC PARAMETERS: ANALOG

1. The FMP is comprised of two distinct portions: mode and time-of-flight (TOF) data. The mode is transmitted by suppressing the setter carrier for 200 to 1000 microseconds. Modes have been defined for 100 microsecond intervals of the carrier suppression. The fuze will respond to carrier suppression intervals from 0.2 to 1.0 milliseconds in accordance with the following:

0.2 - Impact.
0.3 - Delay.
0.4 - Time.
0.5 - Other.
0.6 - Proximity with turn-on (gated) time.
0.7 - Proximity with gated time and alternate sensitivity.
0.8 - Proximity without gated time.
0.9 - Proximity with alternate sensitivity but without gated time.
1.0 - Disable self-destruct mode.

2. The TOF data is transmitted to the fuze by turning the carrier on for between 0.01 to 40 milliseconds to proportionately select time-of-flights between 0.060 and 8 seconds. The minimum defined setting increment is 0.001 second.

3. The setter carrier is suppressed for 200 microseconds (Delay 1) to terminate the TOF transmission.

4. The fuze utilizes a subcarrier to talkback data to the setter. Fuzes may utilize the setter carrier to derive the subcarrier. The subcarrier frequency will be one fourth the frequency of the carrier. The subcarrier may be generated by the fuze by dividing the carrier by four or by utilizing an independent oscillator at the discretion of the fuze developer. The setter carrier is on during the entire reverse message (talkback) period. The fuze reverse message communication timing is shown in Figures E-1 and E-2. The modes are shown in Figure E-1 and the time-of-flight information is shown in Figure E-2.

5. The fuze reverse message (talkback) period follows Delay 1 and is made of four parts. During this interval, the fuze subcarrier is utilized to send mode and TOF data to the setter. The fuze initiates talkback by sending mode data to the setter. The mode is communicated by sending from 10 to 50 subcarrier cycles as follows:

10 - Impact
15 – Delay
20 - Time
25 - Other
30 - Proximity with turn-on (gated) time.
35 - Proximity with gated time and alternate sensitivity.
40 - Proximity without gated time.
45 - Proximity with alternate sensitivity but without gated time.
50 - Disable self-destruct mode.

6. After the mode data is sent the fuze stops sending subcarrier cycles for 200 microseconds. The subcarrier suppression provides a space between mode and TOF data transmissions and the TOF data transmission and the delay 2. The second space effectively allows for any overall timing error up to 200 microseconds

7. The TOF information is conveyed imprecisely through subcarrier cycles. Due to physical limitations the talkback time accuracy can only approach 4 milliseconds at best. However, the fire control systems used in medium calibre systems seldom have any mechanism for handling talkback error. The operator would only be concerned with significant setting problems such as incorrect modes/rounds. The time talkback would provide general feedback on setter-fuze operation which could be analyzed at a depot or during training/testing. The time setting is talked back to the setter using numbers of subcarrier cycles from 0 to 2000 cycles. Fifty subcarrier cycles would be transmitted for every second of set time up to 8 seconds. Five subcarrier cycles would be transmitted for every 0.02 second of set time.

8. The fuze completes the reverse message period by suppressing its subcarrier transmission for a minimum of 200 microseconds. The fuze does not bcarrier again until another reverse message period.

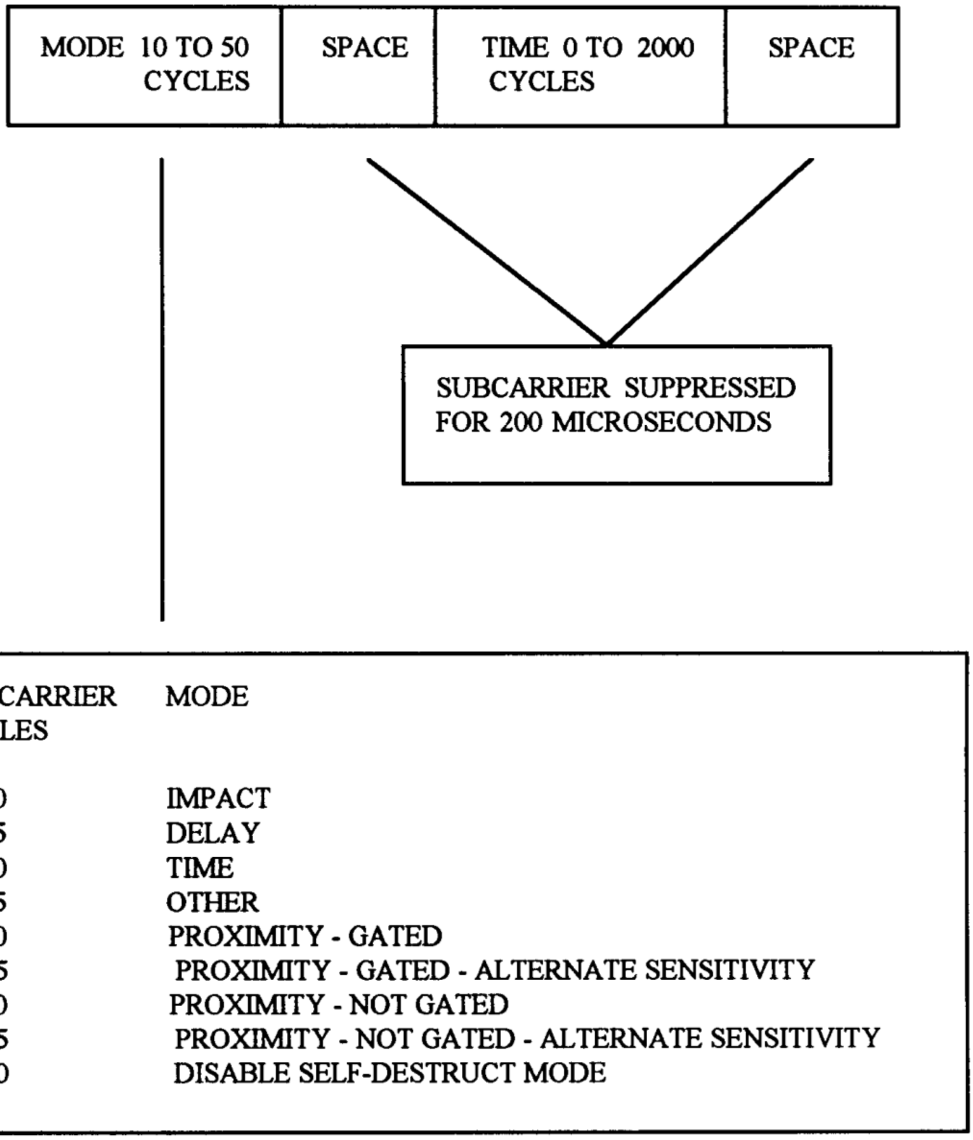


Figure E-1. Reverse Message Period: Mode

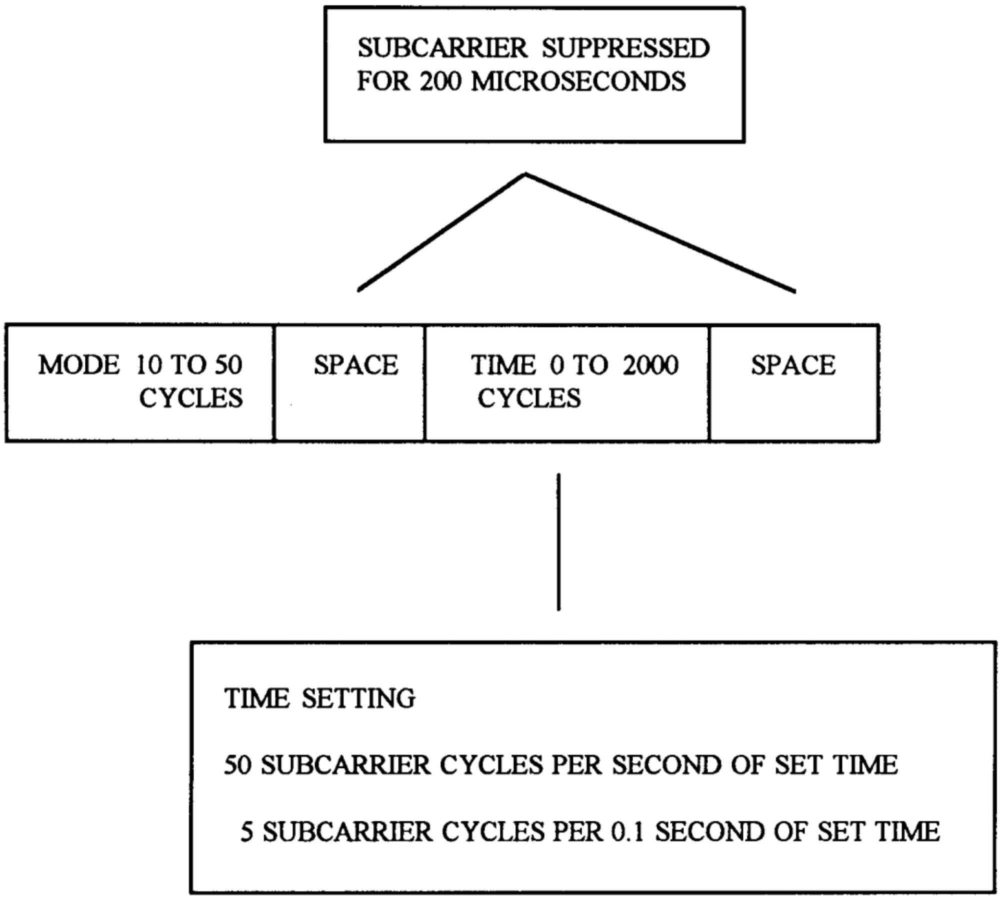


Figure E-2. Reverse Message Period: time-of-flight

PARAMETER	VALUE	UNITS	REFERENCE
Carrier frequency	200 +/- 0.02	kHz	Figure B-2
PUP	10 +/- 5	ms	Figure D-1
D1	0.2 +/- 0.05	ms	Figure D-1
D2	5 +/- 0.1	ms	Figure D-1
FMP	0.21 to 41.0	ms	Figure D-1
RMP	41.4 +/- 0.1	ms	Figure D-4
mode	10 to 50	cycles	Figure E-1
time-of-flight	0 to 2,000	cycles	Figure E-2
Subcarrier pause	0.2 +/- 0.05	ms	Figure E-1
Subcarrier frequency	carrier / 4	Hz	

Table E-1. Fuze-specific Parameters – Analog

NOTES:

1. The Power-up period (PUP) in the analog system serves the same function as of Delay 3 in the digital system. Therefore, there is no specific Delay 3 in the analog system.

2. The forward message mode is selected by carrier suppression after the PUP from 200 to 1000 microseconds in 100 microsecond increments. The reverse message mode is communicated by the number of subcarrier cycles in accordance with Figure E-1.

3. The forward message time is programmed by the carrier duration after the mode. The time setting is proportional to the carrier duration. The reverse message time setting is communicated by the number of subcarrier cycles after the pause in accordance with Figure E-2.

AOP-4547(A)(1)