DFRobot
SEN0366 Laser Rangefinder

User's Manual

DFRobot Community Property

This document contains material that is supplied by DFRobot and its user community. This information is intended for general public use.

PRELIMINARY

This is a work in progress. DFRobot community members are invited to submit corrections or additional information.

Version 0.01

November 18, 2024

Table of Contents

1 Introduction

1.1 Purpose of this document

This document serves as a User's Manual for the SEN0366 Laser Rangefinder, which is a product of DFRobot. This material is intended to guide the technical user during the design of application hardware and software components related to using this device.

1.2 Purpose of the SEN0366 Laser Rangefinder

The Infrared Laser Distance Sensor, SKU SEN0366, measures the distance between the device and most any object in the range of up to 50 to 80 meters. The distance limit is determined by the current precision setting of the instrument, ambient conditions, and reflectivity characteristics of the designated target object. This instrument connects with the user's equipment via a TTL/CMOS level serial connection that is suitable for a UART/USART operating at 9600 baud.

This product has proven to be reliable and accurate. It performs extremely well in its role.

1.3 Document Authority

This document was compiled from publicly available online documentation and information derived through experimentation. Existing documentation is not thorough or exhaustive, leaving the user with extensive guesswork and experimentation in order to make full use of this device. This document is an effort to ease the technical discovery burden of potential and existing users. The instrument is a worthy addition to the toolset available to hobbyists and engineers alike. Good documentation should help with widespread use of this device.

Given the point or origin, this document does not have any authority on its own. Empirical discoveries and source document guesswork is never as good as information provided directly from the engineers who created any device. The author hopes that this initial effort will be favorably regarded at DFRobot, enough that the engineering staff will open up to providing concrete answers to technical questions.

The user community is invited to help in the collection of this device's functional characteristics. An email address for submitting edits, suggestions, corrections, and new additions with be provided in the near future.

The author has worked in the embedded community since 1972. He authored a number of monitor/control systems, where it was often necessary to implement custom communications protocols. Numerous sensors and controls were designed by the author, each with connectivity requirements. It was necessary to fully document those works since they were utilized by large companies and government entities. The younger generations do not seem to be required to learn documentation skills. Maybe I can have some positive affect in that regard.

1.4 External References

Several external documents affect the conduct of this project or the compilation of this document. The following material provides references to substantiative material.

1.4.1 DFRobot Website Documentation

There is a substantial amount of material regarding the SEN0366 device on the seller's website. Rather than reproduce all of that here, links are provided so that readers may access that information directly. The

reason this new document exists, however, is because the available documentation is not technically complete in the vein of industry grade datasheets or documentation.

Infrared Laser Distance Sensor (50m/80m)

SEN0366 WIKI

SEN0366 Infrared Laser Distance Sensor Communications Protocol

1.4.2 Useful Reference Material

A number of computer related topics must be mastered in order have a complete understanding of the information in the current document. The following links have been provided to benefit the novice reader:

Binary Number System

Hexadecimal Number System

ASCII Encoding System

1.5 Document Status

This document is in a prerelease condition. It is currently undergoing research and compilation. Community comments, suggestions, corrections, and additional information are strongly solicited.

Once DFRobot provides definitive answers to missing details, replacing guesswork and empirical findings with stated facts, this manual will be extensively revised to eliminate its preliminary pleadings, complaints, and smart remarks. These will be replaced with as extensive hardware and software as can be gathered in one place.

The communications protocol will be the only topic initially described in this manual. This is because that information is desperately needed; and, the author prefers to limit document scope until DFRobot is willing to work with me to supply information not currently available in a complete form.

2 Introduction to the SEN0366 Communications Protocol

The SEN0366 Laser Rangefinder is a remarkably good instrument. It should enjoy extensive use throughout the user community. This device integrates with user equipment through the use of a TTL/CMOS level UART/USART serial connection. The communications protocol is a collection of rules and procedures which govern the format, content, and sequence of messages that are exchanged between the instrument and the user's system. Users must either master this protocol or obtain some externally written functional library in order to make use of this instrument.

This chapter establishes an initial understanding of the physical connection and message content. The external documents cover this material; however, some salient facts are omitted or blurred.

2.1 UART/USART Electrical Connection

The following connectivity issues augment the seller's information:

1. The units are delivered with different wire colors. Use the pictorial that shows the wires connected to the rangefinder in order to verify/determine proper connections.
2. The rangefinder's TX wire connects to your UART's RX pin. Of course, the rangefinder's RX wire must connect to your TX pin.

3. Even though the communications facility is based upon multi-drop, or multi-point connectivity, fan out specifications were not provided. This specification must be supplied so that users know how many rangefinders can be connected in a single circuit.
4. Multiple rangefinder devices can be controlled and read over a single serial connection. The wires of each device are connected to the same point on the user's system, in parallel. There are electrical rules which govern this sort of connection; however, these are not provided in the supplier's documentation. Keep the length of connection "Tees" to a minimum, and use an oscilloscope to determine if termination resistors should be used to eliminate reflections in the signal.

2.2 Message Components

Messages to and from the laser rangefinder each consist of a series of bytes. Of course, UART/USARTS generally work with binary bytes; however, novice users tend to think only in terms of ASCII character content. It is necessary for the user to understand that these messages consist of binary 8-bit bytes that are strictly numeric in nature. Well, in the case of messages which transport distance measurements, those messages include ASCII strings of numeric characters. Since message content is a sequence of arbitrary binary values, it is useful to represent them in documentation or variable initializations using the two character hexadecimal format. Please consult the external references for those foundational topics.

Material that follows later in this text will describe the form and structure of the messages exchanged between the laser rangefinder and the applications computer. The following symbols will be used in those descriptions:

- **< > - A symbolic representation of a byte**. The space between the "<" and the ">" contain an abbreviation or name of the message field. Fields are shown in the sequence in which they appear in a message.
- **Two digit hexadecimal value.** These two digits represent the actual binary numeric value of the byte.
- **<ADDR> - Device address.** This byte selects the particular rangefinder device that is to be the recipient of the message. Each device in a parallel wiring plan must be assigned a unique address. An address must be in the range of 0x80 through 0xF9. Address 0xFA is a broadcast address to which all connected devices respond.
- **<GRP> - Command group.** This byte immediately follows the device address. It seems to designate a command class, or category.
- **<CMD> - Command function.** This byte follows the <GRP> byte. It designates the function or operation to be performed by the rangefinder.
- **<CS> - Message checksum.** This byte terminates the message and provides a means to validate the entire message. Assuming that SUM is the numeric sum of all of the preceding bytes in the message, CS = ~SUM + 1. (~ being the binary inversion operator)
- **<ERR> - Error indication.** This byte seems to provide indication of a specific error condition discovered while attempting to perform a command.
- **<ADJ> - Distance Adjustment.** This byte applies an adjustment of some sort to the measurement value. It is not clear at this time how this value is applied.
- **<INT> - Sample Interval**. This byte is used to set the sample rate of a rangefinder for those times is is operated in continuous mode.
- **<POS> - Select Zero Reference.** This byte is used to select either the front or rear face of the physical device to server as the reference for the measurement.
- **<FRQ> - Frequency**. This byte is included in the "Set Frequency" command without explanation.

- **<RES> - Measurement Resolution.** This byte specifies the resolution setting for measurements. Resolution is either 1.0 or 0.1 millimeters.
- **<AUTO> - Measurements upon power-up**. The byte specifies whether or not measurements are started automatically when power is applied to the device.

2.3 Command Messages

The rangefinder is made to do things by sending it a short stream of binary 8-bit values in a specific sequence. There seem to be two general forms of commands:

<ADDR> <GRP> <CMD> <CS>

This byte sequence carries no user specified content, and can actually be encoded is user software as a fixed array of bytes. Several of these are specified in DFRobot documents with the <ADDR> byte set to 0xFA, the broadcast address. It is not known at this time if these commands can be used with a specific <ADDR> designation.

<ADDR> <GRP> <CMD> <user option> <CS>

This command format includes a byte that specifies a user-defines option. Messages of this type are used to change settings within the rangefinder device. The actual numeric value of this byte depends on the specific command being send and the setting to be enforced. Issues with the <ADDR> field are the same as those previously raised.

2.4 Reply Messages

With the exception of the “Single Measurement” command, all commands respond to the control host with a reply message which provides execution status and sometimes data. There are two general formats for reply messages and additional formats for supplying distance readings. The two general reply formats are briefly described here while the data carriers are described in the chapter for message descriptions.

<ADDR> <GRP> [<CMD> | 0x80] <CS>

A message in this form acknowledges the command message it just received. It is almost an echo of the original command; however, 0x80 is OR’d into the original <CMD> byte. Of course, the <CS> is also computed specific to the reply. It remains a four byte message.

Replies to messages bearing a <user option> field are in this format since the data field is not included in the reply.

A specific example of such a message for consideration is a “Control Laser On/Off” command directed to device 0x82:

Hex: 82 06 05 01 72
Bin: 10000010 00000110 00000101 00000001 01110010

The reply to this message showing success would be:

Hex: 82 05 85 01 F3
Bin: 10000010 0000110 10000101 00000001 11110011

<ADDR> [<GRP> | 0x80] [<CMD> | 0x80] <ERR> <CS>

A message in this form acknowledges the receipt of a command; however, it also signals that the command was rejected due to some error related to the command. Both the <GRP> and <CMD> bytes are OR’d with 0x80 when returned in this reply. It is a five byte message.

NOTE: *There are irregularities between commands which lead the author to believe that the documentation contains errors or that there are unusual irregularities among commands. Experiments are in order in order to determine which.*

2.5 Ambiguities of <ADDR> and 0xFA Broadcast

Several commands in DFRobot documentation are shown with the broadcast address 0xFA in the <ADDR> field. It is not clear whether or not these commands will respond to a specific address. It would be a shame if these commands will only respond to the broadcast address. The author plans to test this behavior.

Broadcast messages should not respond to the host processor lest numerous simultaneous replies become electrically mixed on a parallel circuit. All reply messages will be lost and TX hardware will physically suffer from the collision. It does appear that replies are made to broadcast commands. The author will test for this. Refrain from sending a broadcast message to which a reply is returned when operating multiple rangefinders on a single circuit.

3 Detailed Message Descriptions

This chapter contains detailed descriptions of each command/reply message pair. These descriptions will surely undergo revision once the aforementioned issues have been clarified.

The bytes in each message are shown either as a <symbol> or as a two character hexadecimal number. Each byte is separated in the manuscript by a single space. That space is NOT included in the binary message. Each message is the indicated sequence of bytes with no other formatting or padding in the actual message.

3.1 Read Parameter

This command may be issued in order to retrieve mostly unspecified values from a rangefinder. Effort will be expended to discover and publish the nature and format of the information contained in the reply.

CMD: FA 06 01 FF

REPLY: FA 06 81 <ADDR> xx xx xx … <CS>
No other than the device's assigned address, no other detail was supplied.

ERROR: No error is detected.

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.2 Read Machine Number

This command provides the serial number of the rangefinder device. The value in the reply message is a 16 byte ASCII string.

CMD: FA 06 04 FC

REPLY: FA 06 84 dddddddddddddddd <CS>
The 'd' characters above each represent one byte in a sixteen byte printable serial number. The content of this string is unspecified.

ERROR: No error is detected.

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.3 Set Address

Use this command to set the individual address of a rangefinder. The value delivered by this command becomes the <ADDR> byte of subsequent commands directed to that specific device. Be sure that only one rangefinder is connected to the host when the command is issued. It is cumbersome to have all of the connected devices respond to commands intended for a single unit.

CMD: FA 04 01 <ADDR> <CS>

REPLY: FA 01 81 81
The command succeeded by assigning <ADDR> to the device.

ERROR: FA 84 81 02 FF.
The 02 byte is probably and error code meaning “invalid address”.

NOTES: Perhaps this command will work with a specific device address rather than just broadcast. In that case one could leave multiple devices connected at a time. Be careful to avoid assigning the same address to more than one rangefinder.

3.4 Revise Distance

This command is used to adjust something related to the distance measurement. What is adjusted and how the adjustment is applied remain unknown at this time. Efforts will be made to discover and document whatever happens as a result of using this command.

CMD: FA 04 06 {+|-} <ADJ> FF
Use byte 0x2B (‘+’) or 0x2D (‘-‘) in this command to indicate adjustment polarity. The valid numeric range of this value is currently unspecified.

REPLY: FA 04 8B 77.
This reply breaks pattern. Other replies would make one expect FA 04 86 7C. The behavior will be verified.

ERROR: FA 84 8B 01 F6.
This reply breaks pattern. Other replies make one expect FA 84 86 01 FB. The behavior will be verified.

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.5 Set Data Return Interval

This command sets the time interval between successive readings. This value sets the sample rate used when a rangefinder is in continuous mode. It is not clear how this value is used. It may set an interval between samples, in which case the time units are unspecified. Perhaps it sets the number of samples per second. Only the Shadow knows.

CMD: FA 04 05 <INT> <CS>
The nature of the <INT> byte is not clearly specified. Perhaps this can be resolved through experimentation.

REPLY: FA 04 85 7D

ERROR: FA 84 85 01 FC

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.6 Select Measurement Starting Point

The physical position on the rangefinder that is used as the starting "zero" reference can be either the face of the device where the laser beam exits or the face on the opposite side. Use this command to select the desired reference point.

CMD: FA 04 08 <POS> <CS>
01 sets the zero to the front (top), 00 sets the rear (tail). Front/top and rear/tail may not be properly interpreted.

REPLY: FA 04 88 7A

ERROR: FA 84 88 01 F9

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.7 Set Frequency

This command sets the frequency of something. Confusion exists between this command and the command described in 3.5, above. The difference between these two commands must be resolved, followed by a complete understanding of the setting values.

CMD: FA 04 0A <FRQ> <CS>
Valid settings for <FRQ> seem to be 0, 5, 10, and 20 decimal. (00 05 0A 14) No explanation of these values has been provided.

REPLY: FA 04 8A 78

ERROR: FA 84 8A 01 F7
Perhaps this indicates that the specified <FRQ> was not one of the listed values.

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.8 Set Resolution

Use this command to set the resolution of each reading. The unit can deliver readings with either 1.0 or 0.1 millimeter resolution.

CMD: FA 04 0C <RES> <CS>
A <RES> value of 01 sets 1mm resolution, 02 sets 0.1mm resolution.

REPLY: FA 04 8C 76

ERROR: FA 84 8C 01 F5
The command was rejected, probably because the <RES> value was not either 01 or 02.

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.9 Set Measurement Auto-Start

This command is used to enable and disable automatic startup of streaming measurements. When enabled, a rangefinder device will begin outputting measurement reading messages following the application of power.

Do not use this command with a broadcast address when multiple devices are connected.

CMD: FA 04 0D <AUTO> <CS>
The <AUTO> field is 00 to disable auto-start, 01 to enable.

REPLY: FA 04 8D 75

ERROR: FA 84 8D 01 F4
The <AUTO> field is not as expected.

NOTES: Perhaps this command will work with a specific device address rather than just broadcast.

3.10 Take Single Measurement

Issue this command to cause all connected devices to make a single measurement, storing it internally. The idea is to take readings at all sensors at the same time. Always use the broadcast address because it makes no sense to use this command when only one rangefinder is connected in the circuit.

Readings taken as a result of this command are retrieved from individual rangefinders through the use of the "Read Cache" command.

CMD: FA 06 06 FA

REPLY: This command does not reply. That really aught to be the policy for all commands to a broadcast address.

ERROR: This command does not reply.

3.11 Read Cache

Use this command to retrieve the measurements that were taken following a "Take Single Measurement" command (06 01). Issue this command to each rangefinder connected to the system, each with its own assigned address. It makes no sense to use this command using the broadcast address.

CMD: <ADDR> 06 07 <CS>

REPLY: When the device is set to 1.0mm resolution:
<ADDR> 06 87 ddd.ddd <CS>
When the device is set for 0.1mm resolution:
<ADDR> 06 87 ddd.dddd <CS>

The 'd' characters represent a single numeric digit, expressed as a single ASCII byte. The numeric string including the decimal point is a printable string. These bytes are embedded in the message in the same manner as all other bytes.

Since DFRobot's documentation indicates that the reply is actually the same as when the "Single Measurement" command is used, the 87 byte is in confusion with an 82 byte in that position. Efforts will be made to disambiguate this discrepancy.

ERROR: <ADDR> 06 87 ERR---dd <CS>
The 'd' characters represent bytes containing numeric ASCII digits. There is no explanation regarding the content or meaning of these digits. The composite string consists of a sequence of bytes containing the ASCII characters shown above. These characters are included in the message with no other formatting, taking their own place like the rest of the bytes.

Unless an oversight in the DFRobot documentation, the 06 byte is not set to 86 when an error is reported. This is a break from pattern. Perhaps the command is not in error but the measurement wasn't performed. Additionally, the 87 byte would be 82 in the reply to a single measurement command. The actual form of this reply needs to be discovered.

3.12 Single Measurement

This command solicits a single reading from the designated rangefinder. Do not use the broadcast address with this command when operating multiple devices in the circuit. The designated rangefinder takes one reading and sends that value in a reply.

CMD: <ADDR> 06 02 <CS>

REPLY: When the device is set to 1.0mm resolution:
<ADDR> 06 82 ddd.ddd <CS>
When the device is set for 0.1mm resolution:
<ADDR> 06 82 ddd.dddd <CS>

The 'd' characters represent a single numeric digit, expressed as a single ASCII byte. The numeric string including the decimal point is a printable string. These bytes are embedded in the message in the same manner as all other bytes.

ERROR: <ADDR> 06 82 ERR---dd <CS>
The 'd' characters represent bytes containing numeric ASCII digits. There is no explanation regarding the content or meaning of these digits. The composite string consists of a sequence of bytes containing the ASCII characters shown above. These characters are included in the message with no other formatting, taking their own place like the rest of the bytes.

3.13 Continuous Measurement

Issue this command to cause the rangefinder to send reading messages continuously without the need for intervening commands. Do not use the broadcast address with this command when operating multiple devices in the circuit. The measurement is performed at the currently set resolution.

This time interval between measurements is set by using the either the "Set Frequency" or maybe the "Set data return interval" command. It seems the purpose of those two commands needs to be resolved experimentally.

The means to exit continuous run mode is not currently documented.

CMD: <ADDR> 06 03 <CS>

REPLY: When the device is set to 1.0mm resolution:
<ADDR> 06 82 ddd.ddd <CS>
When the device is set for 0.1mm resolution:
<ADDR> 06 82 ddd.dddd <CS>

The 'd' characters represent a single numeric digit, expressed as a single ASCII byte. The numeric string including the decimal point is a printable string. These bytes are embedded in the message in the same manner as all other bytes.

ERROR: <ADDR> 06 83 ERR---dd <CS>

The 'd' characters represent bytes containing numeric ASCII digits. There is no explanation regarding the content or meaning of these digits. The composite string consists of a sequence of bytes containing the ASCII characters shown above. These characters are included in the message with no other formatting, taking their own place like the rest of the bytes.

3.14 Control Laser On/Off

This command is used to turn the laser on or off. It seems would be useful to use this command with the broadcast address; however, that is not specified in DFRobot documentation. Obviously, the rangefinder's microcontroller remains awake following an "off" setting.

CMD: <ADDR> 06 05 <CS>

REPLY: <ADDR> 06 85 01 <CS>

The 01 byte breaks the reply pattern. The documentation does not indicate what this value means; however, the error reply does contain a different value in that position.

ERROR: <ADDR> 06 85 00 <CS>

This reply breaks pattern in two ways. First, the 06 is usually returned as 86. Second, the 00 byte is usually 01 to indicate an error.

3.15 Shut Down

Use this command to shut the rangefinder down. The difference between this command and the "Control Laser Off" command is not explained. How to wake the device from this command is also not mentioned. Assuming this command is not "The Kiss of Death", the ability to use the broadcast address would be fortuitous. Of course, that isn't documented either.

CMD: <ADDR> 04 02 <CS>

REPLY: It seems that there is no reply, just an uncertain coma.

ERROR: It seems that no error is detected.

Revision Control

This section contains information that controls the revision status of the document. Revisions in whole number form, such as 1.00, are approved documents. Numbers to the right of the decimal point indicate that the document is undergoing revision.

Revision History

Revision	Date	Description
0.01		Initial document creation.