PSA-916

Sonar Altimeter

User's Manual

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P/N 007217

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Preface

This User Manual provides complete instructions on using and maintaining the PSA-916 Sonar Altimeter. Please read it prior to deploying the equipment and keep it where it can provide a reference during setup and operation of the altimeter. This manual is divided into the following eight sections:

1   **Description**
2   **Specifications**
3   **Setup and Deployment**
4   **Theory of Operation**
5   **Packing List**
6   **Drawing List**
7   **Return Procedures**
8   **Warranty**

Proprietary Information

The information, description, and illustrations in this manual are the property of Teledyne Benthos, Inc. Materials may not be reproduced or disseminated without the prior written consent of Teledyne Benthos, Inc.

Changes

Teledyne Benthos, Inc. reserves the right to make changes to meet new specifications at any time without incurring any obligation to modify previously installed units. This manual is provided for informational and reference purposes only and is subject to change without notice.

Notes and Warnings

Where applicable, special notes and warnings are presented as follows:

| **NOTE:** | A reminder to check that certain criteria are met before proceeding further in a step or sequence. |

| ⚠️ **WARNING:** | A reminder that dangerous consequences could result if certain recommended procedures are not followed |

Table of Contents

1 Description

The PSA-916 Sonar Altimeter is a microprocessor-controlled, self-contained, underwater acoustic product. It generates a narrow beam acoustic signal and measures the travel time for the signal to bounce back from the target surface. The unit provides range data in both analog and digital formats for analysis and process control.

The PSA-916 Sonar Altimeter is the same as the standard PSA-916 Sonar Altimeter except it is housed in a corrosion-resistant pressure case. It is O-ring sealed and rated for operation in water depths up to 6,000 meters. The external 6-pin connector provides connections for external power source input, external key source/RS-232 input, analog, and RS-232 output.

PSA-916 Sonar Altimeter

Applications

The Model PSA-916 Sonar Altimeter with the built-in flexibility of its microprocessor design, cost-effectively meets a wide variety of sonar measurement applications with a single self-contained instrument.

The most common use of the Model PSA-916 Sonar Altimeter is for altitude measurement (height above bottom). Other uses include:

- Wave height measurement

- Obstacle avoidance

- Altitude of an ROV and other submersibles

- Surveying of shallow waters

- Sediment transport studies

2 Specifcations

TRANSMIT FREQUENCY:	200 kHz
TRANSMIT PULSE WIDTH:	250 microseconds
BEAM PATTERN:	14° conical
PULSE REPETITION RATE:	Selectable: Internal or External Internal - 5 pulses per second External - customer controlled rate, up to 5 pulses per second
RANGE:	100 meters full scale; 1.0 meter guaranteed minimum; 0.8 meter typical
ANALOG OUTPUT:	0 to 5 VDC
DIGITAL OUTPUT:	RS-232, baud rate 9600, 4800, 2400 or 1200, (user selectable)
RESOLUTION:	RS-232: 1 cm Analog: 2.5 cm
POWER REQUIREMENT:	6 to 24 VDC
CURRENT:	50 mA @ 15 VDC 100 mA @ 6 VDC
OPERATING DEPTH:	6,000 meters
CONNECTOR:	Part Number: Impulse XSG-6-BLC-3/4-16, or equivalent
MATING PIGTAIL:	Part Number: Impulse RMG-6-FS, or equivalent
DIMENSIONS:	2 1/4 in. OD x 9.38 in. long
WEIGHT:	In Air: 1.4 lb In Water: 0.8 lb

Configuration	Standard	FSI Mode	Custom
Description of Configuration			
Key (SW 1 & 2)	Internal	Internal	
Serial Output (SW 1 & 2)	Every Cycle	N/A	
Gain (SW 3)	High	High	
Under Range Detection (SW 4)	Disabled	Disabled	
Baud (SW 5 & 6)	9600	9600	
FSI Mode (SW 7)	Disabled	Enabled	
RS-232 Mode (SW 8)	Enabled	Enabled	
Dip Switches			
SW 1	OFF	OFF	
SW 2	ON	OFF	
SW 3	ON	ON	
SW 4	ON	ON	
SW 5	OFF	OFF	
SW 6	OFF	OFF	
SW 7	OFF	ON	
SW 8	OFF	OFF	
Jumpers			
JP1	Installed	Installed	
JP2	Installed	Installed	Installed
JP3	1-2 (RS-232 Out)	1-2 (RS-232 Out)	
JP4	1-2 (External Key In)	2-3 (RS-232 In)	

Configuration:
Standard   _____
FSI Mode   _____
Custom   _____

NOTE: The configuration is set by the dip switches. This page describes how the unit was configured when shipped to you. Any changes to the dip switches will change the configuration. Refer to Section 3.

3 Setup and Deployment

This section provides information on unpacking, installation and general operation of the PSA-916 Sonar Altimeter.

Unpacking and Disassembly

As with any sophisticated electronic equipment, Teledyne Benthos, Inc.'s products should be handled with a reasonable amount of care when unpacking, transporting or storing.

When shipped from the factory, the units are packed in weatherproof cartons. Every effort is made at the factory to pack the equipment so as to protect it during shipment and to minimize the effect of any mishandling.

Carefully inspect each instrument for physical damage as it is unpacked. Report any damage to the freight carrier and to the Teledyne Benthos, Inc. sales office. Store the shipping cartons and packing materials in a cool, dry place for later use in system transport.

The unit is shipped completely assembled and internally configured. Should an internal inspection be deemed necessary, the unit can be opened by turning the delrin closure ring counter-clockwise. The transducer and electronics should slide easily from the pressure case. Caution is advised as the electronics is connected to the interface connector at the opposite end of the pressure case.

NOTE: An O-ring seal is designed into the pressure case/end cap to protect the electronic components from moisture. A failure of these seals will result in the unit flooding and subsequent loss. Whenever the unit is disassembled, carefully inspect the O-rings for cracks, tears, and proper fit. Replace any damaged O-rings. The end cap O-ring grooves and housing O-ring mating faces should also be checked for tool marks or abrasions.

Prior to reassembling the unit, clean O-rings and O-ring surfaces, apply a coat of silicone lubricant to the O-rings. Reposition the internal components in the casing and tighten the closure ring, turning it in a clockwise fashion.

⚠️ **WARNING:** **DO NOT** apply excessive torque to the closure ring. Over-tightening of the closure ring could damage the ring and make any future disassembly difficult

If you suspect that there are items missing, or if you suspect that there has been any damage to the equipment, contact Teledyne Benthos, Inc. immediately.

Connection

The PSA-916 Sonar Altimeter outputs data and receives power through a 6 pin connector. The PSA-916 Sonar Altimeter is supplied with the mating pigtail and a dummy plug. Whenever the pigtail is not installed, install the dummy plug to protect the connector pins.
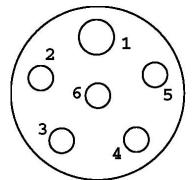
Connector Pin-out

The functional assignments of the six pin connector is as follows:

Pin Number	Function
1	RS-232 Input/External Key Input *
2	External power ground
3	RS-232 Output/Error Output†
4	Analog output
5	Analog output ground
6	External power (6 - 24V)

NOTE: **To select RS-232 Input install a jumper between JP4 pins 2 & 3. To select External Key Input install a jumper between JP4 pins 1 & 2.*

†To select RS-232 Output install a jumper between JP3 pins 1 & 2. To select Error Output install a jumper between JP3 pins 2 & 3.

Connector view, looking at the PSA-916 Sonar Altimeter

RS-232 Input/Output

The RS-232 communications port is set to the following parameters:

Baud:	1200,2400,4800, or 9600 user selectable
Number of Data Bits:	8
Number of Stop Bits:	1
Parity:	none

On power up the following banner message will be output:
"Benthos PSA-916 V1.2"

Where the number following the V is the firmware version. The serial output will be in the following format:

$$Rxx.xx<cr><lf>$$

where xx.xx can range from 0.80 to 99.99. If no echo was received the output will be R99.99E<cr><lf>. If an echo was missed or the value does not meet the averaging criteria then an "E" will be appended to the previous value. If under range detection is selected and the value is under range then a '<' will be appended to the data.

If the unit is not functioning correctly, "E1,<cr><lf>" will be output. If this occurs see section 4.4.3.

Error Output

This output is useful for indicating the validity of the data whenever the analog output is the source of range output. This line will be a logic 1 (5 volts) whenever no echo was detected in the last range interrogation cycle. Essentially this line is high whenever it would be necessary to output an E on the serial output. This line also goes high if error condition E1 occurs. If this line is low it can be assumed that the altimeter is functioning normally and the analog output is valid.

Analog Output

The analog output ranges from 0 VDC to 4.98 VDC, which represents 0.00 to 99.99 meters. Note that if no echo is received, the output will go to full scale (4.98 VDC).

External Key

This line is used to tell the PSA-916 Sonar Altimeter to take a range reading. The altimeter looks for a transition from a logic 1 (5 volts) to a logic 0 (0 volts). Once the transition is detected the altimeter will take a range reading and wait 200 ms before looking for the next transition. Thus the minimum time between key pulses is 200 ms. However, there is no maximum limit to the time between key pulses. Note that the analog value will be valid 200 ms after sending the external key.

FSI Mode

In FSI mode the unit acquires range information once every 200 ms, but only reports the range data over the RS-232 output after receiving a #Z through the RS-232 input.

Configuration

There are eight switches which determine the mode of operation. The different combinations are listed in the table below.

DIP SWITCHES - All dip switch changes will take affect immediately, except for the baud rate. To change baud rate the unit must be reset (i.e. cycle power).

Description	SW1	SW2	SW3	SW4	SW5	SW6	SW7	SW8
Test mode - see section 4.4	ON	ON						
External key - 200 ms min. between keys	ON	OFF						
Internal key - serial out every depth cycle	OFF	ON						
Internal key -serial out every fifth depth cycle	OFF	OFF						
More gain			ON					
Less gain			OFF					
Disable under-range detection				ON				
Under-range detection (if range is less than 0.8, then output is '0.8<')				OFF				
1200 baud (rep rate may be > 200 ms)					ON	ON		
2400 baud					ON	OFF		
4800 baud					OFF	ON		
9600 baud					OFF	OFF		
RS-232 off								ON
RS-232 on								OFF
FSI mode disabled							OFF	
FSI mode enabled							ON	

Predeployment

Always test the altimeter immediately before deployment to ensure that the unit can transmit and receive acoustic signals and that the system parameters are correctly set.

NOTE: Always test the operation of each PSA-916 Sonar Altimeter as a stand-alone instrument before integrating it into another system.

Teledyne Benthos, Inc. recommends that an in-air test be performed followed by a short range in-water test prior to the actual deployment.

A major source of problems with acoustic equipment is that the transducer is not clean and acoustic signals are masked. We strongly recommend that prior to each deployment that the user clean the exterior of the pressure casing and transducer with fresh water and a mild detergent. **Do not use glass cleaner**.

To perform the in-air test:

- Turn the altimeter ON by applying power.

- Verify that the RS-232 output is 99.99E and that the analog output is 4.98V. Note that if under-range detection is enabled, verify the RS-232 output is'0.8<' and the analog output is 39.8 mv.

- If under-range detection is not enabled, tap on transducer face with a finger, and verify that the RS-232 and analog output changes.

If the in-air test was successfully completed, proceed to an in-water test. Make sure the transducer is well below the keel of the boat and away from prop wash and noise. A test tank or barrel filled with water can be used provided the water depth is at least three feet.

Deployment

Once you are confident that the unit is operating properly on its own, you can then integrate it with other instrumentation used in your application.

If acoustic energy generated by other instruments is strong enough, it can adversely affect PSA-916 Sonar Altimeter operation, even if the acoustic output of the other instrumentation is at different frequencies. You may have to relocate or reposition the PSA-916 Sonar Altimeter to achieve reliable results.

Make sure sources of noise and turbulence such as the boat propeller and ROV thruster motors are not between the altimeter and the target surface, and that they are well away from the transducer.

Securely fasten the PSA-916 Sonar Altimeter to its platform, vehicle or instrument package, making sure there are no obstructions between the transducer face and the intended target. When mounting be sure the anodized finish is not scratched or gouged by clamps, bolts, etc.

If the unit is mounted on an underwater vehicle, be sure that the sound beam path is perpendicular to the horizontal flying position of the vehicle. Note that excessive pitch or roll motion will influence the PSA-916 Sonar Altimeter range measurement. The PSA-916 Sonar Altimeter radiation pattern is 14°.

Make sure the altimeter is attached to the bottom of the ROV so that it is not affected by echoes from the skids.

In applications using multiple altimeters within each others range, their transmissions should be externally triggered to avoid crosstalk between the units.

The sound beam pattern is an important consideration. The pattern consists of the main beam and small side lobes stemming from it. Certain conditions may cause range errors from side-lobe reflections.

- A strong acoustic reflector close to the instrument reflects a side-lobe signal before the main beam echo is received.

- When using a towed vehicle to measure depth, a steep slope reflects the side lobe before the main beam is reflected by the bottom directly below the instrument.

- The side lobe reflects off the bottom before a main beam aimed diagonally at the seabed.

Maintenance

If you exercise reasonable care, your Teledyne Benthos, Inc. products should provide you with years of reliable service.

To ensure an even greater level of reliability, Teledyne Benthos, Inc. recommends that you take a few preventive maintenance measures and that you contact Teledyne Benthos, Inc. early in your efforts to troubleshoot an altimeter malfunction. We have found that most problems are related to the acoustic environment and can be solved with applications planning and pre-deployment testing.
The following steps will help you maintain protection against damage to the altimeter.

When you retrieve the unit at the completion of a project, follow these preventive maintenance procedures:

▪ Turn the unit OFF by unplugging the mating connector.

▪ Clean the exterior of the pressure casing and transducer with fresh water and a mild detergent. **DO NOT USE GLASS CLEANER**.

NOTE: It is important to clean the transducer face so that film does not build up on the transducer face and attenuate acoustic signals.

▪ Dry the unit with a cloth.

▪ Inspect the transducer and the exterior of the casing for signs of wear and damage.

▪ Clean the connector on the unit using a lint free alcohol wipe.

▪ Lubricate the connector O-ring mating surface with a light coat of silicone and place the protective dummy plug on the connector.

▪ Store the unit, in its original packing case, in a cool, dry place.

▪ Teledyne Benthos, Inc. recommends that the O-rings in this unit be inspected after every deployment and changed if there is any sign of wear or damage. Otherwise, O-rings should be changed every two years per manufacturer recommendations.

<u>Size</u>
2-125 Transducer O-ring
2-029 Transducer Housing O-ring

4 Theory of Operation

This section describes the operation of the PSA-916 Sonar Altimeter. DO NOT ATTEMPT REPAIR of the PSA-916 Sonar Altimeter unless you are a trained electronics technician. For help with any questions about using or maintaining the instrument, contact your local Teledyne Benthos, Inc. representative, or call Teledyne Benthos, Inc. Customer Service at 508-563-1000.

Operating Principle

The PSA-916 Sonar Altimeter determines the round trip time for a sound pulse to travel from the transducer through the water, reflecting off a surface and returning to the transducer. Since the speed of sound is known, the altimeter can determine the range utilizing this equation:

$$R = 1/2 \ (Cs)(t +/- \Delta t)$$

Where:

    Cs - the speed of sound in meters per second
    t - the total round-trip travel time in seconds
    R - range in meters

The nominal speed of sound is 1,500 meters per second in water, and is used by the PSA-916 Sonar Altimeter. Note that the speed of sound is affected by temperature, salinity, and pressure.

The Δt factor is the jitter or the ability of the detectors to accurately determine the presence or absence of a pulse. Jitter is a function of operating frequency, system bandwidth and signal to noise ratio. In the PSA-916 Sonar Altimeter Δt is approximately 5 microseconds or approximately +/-0.4 cm total distance. Since the total travel time is divided by two in the above formula, the jitter error is +/-0.2 cm.

Board Level Description

Power Supply

The input power can range from 6 to 24 volts, and is diode protected by CR1 to prevent reverse polarity. The power supply regulates the input power to 5 VDC and 12 VDC.

Transmitter

The microprocessor generates a key pulse putting the transceiver into the transmit mode for the duration of the pulse. A train of 1 µs pulses is output from the transceiver at the oscillator frequency of 200 kHz, which are later stretched to 1.8 µs pulses. These pulses are then boosted to drive the transducer with a sinusoidal 200 kHz burst lasting for the duration of the key pulse.

Receiver

The transmit pulse and any received echoes are input to the receiver through a transmit/receive network. The receive signal is attenuated during transmit and during the first few milliseconds of the receive cycle, when the returned echoes are likely to be the strongest. Once the transceiver senses the receive signal, it goes through a high gain amplifier, and uses the same circuitry as the transmitter, so the receiver and transmitter are always tuned to the same frequency.

Microcontroller

The microcontroller provides the system timing and computing power operating a crystal controlled clock frequency of 12 MHz and is initialized via a power reset when power is applied. The microcontroller also generates the error output and sends data to the 12-bit digital to analog converter for the analog output and the RS-232 driver.

Firmware Description

Main Program

The program generates the key pulse, which causes a 200 kHz burst to be transmitted as described in section 4.2.2. The transmission is detected by interrupt 1, which starts a 1µs timer. If the transmission is not detected, the program will output "E1" on the RS-232 output. The program then waits 133 ms for an echo. Once an echo is received, it stops the timer, and calculates the range. If no echo is received, the timer is stopped and the range is assumed to be 99.99 meters. The range is then sent to the RS-232 and Analog outputs, and the error output is set or cleared as required. If in internal Key mode the microcontroller will wait 200 ms from the previous key before sending another key pulse, thus starting the whole cycle over again. If in external Key mode, the microcontroller will wait for a low going pulse on the key In input, before sending the next key pulse.

Averaging Algorithm

A moving weighted average is used. Each new range is given a weight of 25%, while the previous value is given a weight of 75%. In addition if the new range differs significantly from the old range then the new range will be skipped and the old range will be used. Note that the algorithm will not skip more than two consecutive ranges. If two consecutive ranges have been skipped, then the next new range will be used. Note that if a range is skipped then an "E" is appended to the data and the error output is goes to a logic '1' (5VDC).

Diagnostics

Analog output

The analog output can be tested by using the DIP switches to put the altimeter in test mode. The following table shows the dip switch settings and the corresponding analog output.
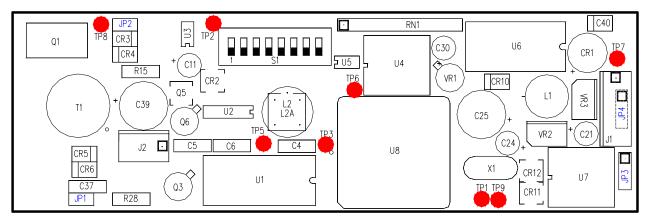
SW1	SW2	SW3	SW4	SW5	OUTPUT	SERIAL OUTPUT
ON	ON	ON	ON	ON	0 Volts	Analog out - 0V
ON	ON	ON	ON	OFF	1 Volt	Analog out = 1V
ON	ON	ON	OFF	ON	2 Volts	Analog out = 2V
ON	ON	ON	OFF	OFF	3 Volts	Analog out = 3V
ON	ON	OFF	ON	ON	4 Volts	Analog out = 4V
ON	ON	OFF	ON	OFF	5 Volts	Analog out = 5V
ON	ON	OFF	OFF	ON	Teledyne Benthos, Inc. Use	
ON	ON	OFF	OFF	OFF	Teledyne Benthos, Inc. Use	

WARNING: Do not set to the " Teledyne Benthos Use" position, or damage may result.

Test Points:

TP1   Detector: normally a logic 1 (5 VDC), whenever a transmission or a received echo is detected the line goes to a logic 0 (0 VDC) for the duration of the detection.

TP2   Transmit Pulse: normally a logic 1 (12 VDC). During transmit a train of 1.8 µs pulses at the transmit frequency.

TP3   Oscillator during Transmit cycle, and amplified output of the receiver. Note that the scope capacitance will alter the signal.

TP5   Transmitter Key: Normally 0 VDC, during transmit it is at 0.6 VDC lasting for 250 µs.

TP6   2.5 VDC

TP7   Analog Output
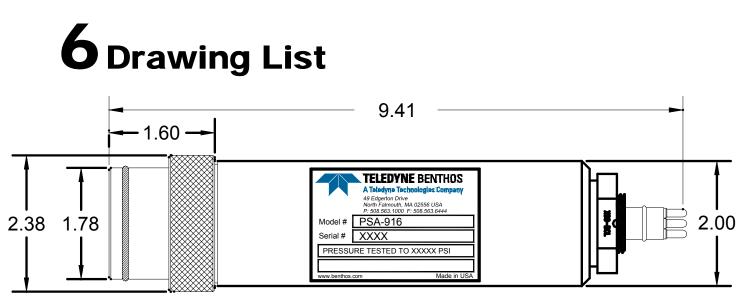
TP8   12 VDC

TP9   5 VDC
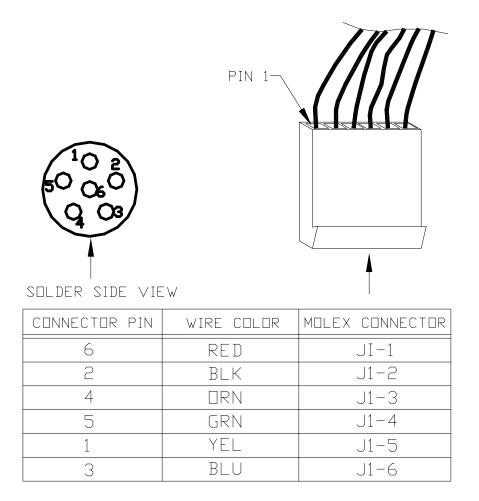
Top side view of PCB assembly

Error Message

If Error message E1 is continuously output, it means the receiver is unable to detect the transmission of the transmitter. Check that Jumper JP1 is installed, and that the ground wire from the end cap to J2 is connected. Otherwise the most likely source of the failure is something within the transceiver circuitry. Contact Teledyne Benthos, Inc. for repair information or refer to Section 7 Return Procedures in this User's Manual.

5 Packing List

Item	Qty	Part No.	Manufacturer	Description
1	1	—	Teledyne Benthos, Inc.	PSA-916 Sonar Altimeter-Top Assembly
2	1	RMG-6-FS	Impulse, or equivalent	Connector, 6 pin, pigtail
3	1	RMG-6-FSD-HP	Impulse, or equivalent	Connector, 6 pin, dummy
4	1	007217	Teledyne Benthos, Inc.	Manual, PSA-916 Sonar Altimeter
5	2	G-FLS-P-F	Impulse, or equivalent	Locking Sleeve-Female

6 Drawing List

PSA-916 Outline Drawing

PIN 1

SOLDER SIDE VIEW

CONNECTOR PIN	WIRE COLOR	MOLEX CONNECTOR
6	RED	JI-1
2	BLK	J1-2
4	ORN	J1-3
5	GRN	J1-4
1	YEL	J1-5
3	BLU	J1-6

PSA-916 Pinout Drawing

7 Return Procedures

If you need to return an PSA-916 Sonar Altimeter for warranty service, contact Teledyne Benthos, Inc. for a **Return Material Authorization (RMA)** number and shipping instructions.

Teledyne Benthos, Inc.
Tel: 508-563-1000
Fax: 508-563-6444
e-mail: sales@benthos.com

You will need to provide the following information to receive a **Return Material Authorization (RMA):**

- **Reason for return**

- **Number of altimeters to be returned**

- **Serial number of each unit**

- **Shipping method, if applicable**

NOTE: Do not ship an altimeter without a **Return Material Authorization.**

8 Warranty

LIMITED WARRANTY. Teledyne Benthos, Inc. warrants that the products sold hereunder shall be free from defects in materials and workmanship under normal use and service when correctly installed, used and maintained for a period of 12 months from date of shipment from Teledyne Benthos, Inc. Purchaser's receipt of any product delivered hereunder shall be an unqualified acceptance of and a waiver by Purchaser of the right of Purchaser to make a claim with respect to such product unless Purchaser gives Teledyne Benthos, Inc. notice of any claim within 12 months after the receipt of such product. This warranty is limited to repair or replacement of the said product at Teledyne Benthos, Inc. plant in North Falmouth, Massachusetts, providing the product was not abused or operated other than in accordance with the Teledyne Benthos, Inc. instruction manuals. Since all Teledyne Benthos, Inc. oceanographic instruments are pressure tested to rated depth prior to shipment, Teledyne Benthos, Inc. does not assume responsibility for any damage due to leakage or implosion. Teledyne Benthos, Inc. reserves the right to modify its warranty at any time, in its sole discretion. THIS LIMITED WARRANTY IS NOT TRANSFERABLE.

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