User Guide

HAB Cutter

Mechanical Release System

Balloon Ascent Technologies

The sky's not the limit; it's where we start.

The HAB Cutter™ is a light-weight self-contained mechanical release system for separating balloons, deploying instruments, dropping ballast, and other tasks that can be achieved by simply cutting a synthetic line.

- Cut synthetic line with a mechanical knife
- Wireless BLE and LoRa Interfaces
- Wired UART Interface
- Stand-alone watchdog timer activation option for termination redundancy

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Operating Specifications

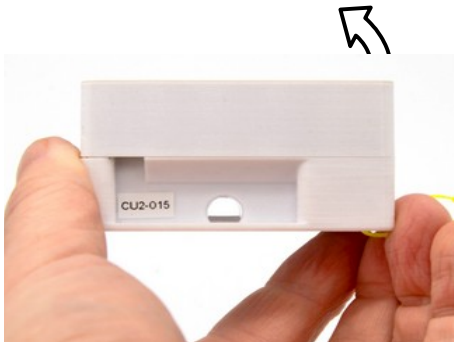
Parameter	**Min**	**Typical**	**Max**	**Unit**
Operating: Temperature	-60	-	60	°C
Operating: Battery Voltage	1	-	5.5	VDC
Line: Paracord Type (MIL-C-5040)	I	III	V	Type
Line: Tensile Strength	45	250	455	kg
Line: Tension on line to ensure proper cut	1		4400	N
Setting: Internal Heater Set-point	-60	-10	60	°C
Sensor: Internal Temperature	-55	-	125	°C
Mechanical: Mass (no Batteries)	-	55	-	g
Mechanical: Mass (2x L92 batteries)	-	15	-	g
Mechanical: Size (no foam enclosure)	48 x 68 x 35 mm			

Getting Started

The HAB Cutter is a reusable mechanical cutter designed to sever parachute cord (aka paracord). It is designed to slide over the paracord to be cut and held onto with a second small retention line.

The HAB Cutter has been proven to reliably terminate flights with payloads that range from 1 kg to 200 kg. It can also be used as ground-support equipment to remotely release anchor lines for larger zero-pressure balloon flights.

Unboxing



The HAB Cutter is shipped inside of its protective foam enclosure. Keep this foam, it will be used again during flight to both physically protect the HAB Cutter as well as thermally insulate it.

To open the foam enclosure gently pull the halves apart. Grab and lift one side of the top cover to access the batteries and power button.

Powering On

The HAB Cutter is turned on by pressing the primary power button down for 3 seconds. You will see the blue and a green indicator lights below the button start flashing.

Initial system charging takes about 40-60 seconds.

Pressing this button will turn the *HAB Cutter* on. Repeated pressing or constant pressing will have no impact on the *HAB Cutter* operation. It cannot turn off the HAB Cutter.

To shutdown the *HAB Cutter* remove its batteries or issue (**!cSD=Y**), the shutdown command. Note: the *HAB Cutter* will take a considerable time to fully shut-down once charged, even with the batteries removed—60+ seconds.

Connecting to the HAB Cutter

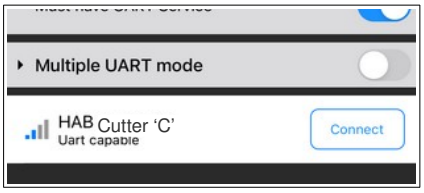
To get started, we'll focus on using the BLE communication link with the HAB Cutter. You will likely use this method during launch for inflation and verification.

Android *iOS*

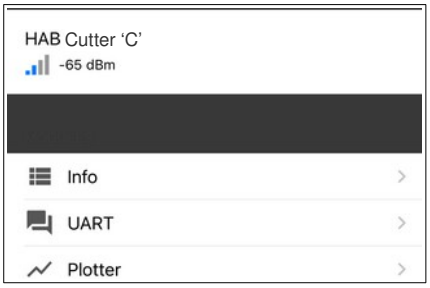
1) Connect via the Bluefruit Connect smartphone app. Use the QR Code links to download this app for Android and iOS smart phones.

2) Open the app. A list of one or more HAB Module devices will appear. Connect to the HAB Cutter ‘C’.

   Note: the ‘C’ in the device name will change to the ID you specify with the **`!cSI=__`** command.



3) Select the UART interface. A blank response window with an input field at the bottom will appear. You can type in the commands in the field at the bottom and the *HAB Cutter’s* responses will appear above.



4) Below is a command cheat-sheet for the HAB Cutter. It contains some of the more commonly used commands.

Command Overview

Format: **`!iSC=VAL`**

`!`	Commands start with !
`i`	Device ID (default ‘V’)
`S`	Subsystem (C, S, or R)
`C`	Command to carry out
`=VAL`	Value if applicable

ID can be changed with **`!cSI`**
Ex: **`!cSI=a`** sets ID to ‘A’.
Then **`!cSC`** becomes **`!aSC`**

Subsystems:
`C` – cutter subsystem
`S` – state subsystem
`R` – radio subsystem

Help Commands

`!i`	Recommended cmds
`!ic`	All cutter commands
`!is`	All state commands
`!ir`	All radio commands

Common Commands

`!cSC`	View sys. charge
`!cSV`	Battery voltage
`!cST`	Internal temp.
`!cSH`	Heater threshold
`!cSL`	Display cmd log
`!cSX`	System Status
`!cSW=90`	Term. Timer, 90 s
`!cCC`	Cut
`!cCO`	Open Cutter

Irrevocable Commands

`!cSZ=Y`	Terminate seq.
`!cSD=Y`	Shut down

Warning: the irrevocable commands will activate the backup burn-wire if backup power is on

Redundant Rigging

There are two different ways to

Indicator Lights

Primary Status Indicator – Green

The *HAB Cutter* has one green Primary Status Indicator. Possible blink patterns at 1 Hz are:

- **Pulsing** – Primary system is charging
- **Single** – Termination timer is enabled
- **Double** – Cutter currently active
- **Triple** – Cutter is currently active and moving
- **Quintuple** – Cutter error

The green Primary LED will flash briefly once every ~3 seconds to indicate it is powered on and operating correctly.

Communication Indicator – Blue

The *HAB Cutter* has one blue communication Indicator. Possible blink patterns are:

- **Brief flashes** at 1-3 Hz – indicates BLE advertising and awaiting first command since power-on
- **Single** brief flash – indicates command received
- **Off** – a command has been received since power-on

Control Interfaces

The *HAB Cutter* can be controlled by one or more of the following: Bluetooth Low Energy (BLE) radio, wired Universal Asynchronous Receive Transmit (UART) serial protocol, or LoRa radio. Commands are sent to the desired HAB module by specifying its identifier (ID) character—default is **'C'** for the HAB Cutter. This permits multiple devices to share the same communication method.

Bluetooth Low Energy Interface

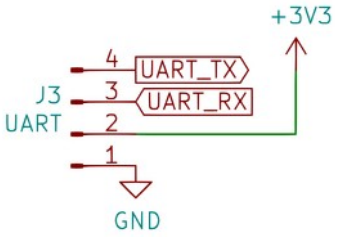
HAB Cutter uses the Nordic UART Service (NUS) for most Bluetooth communication, which enables the use of Adafruit's Bluefruit LE Connect App.

Android: https://play.google.com/store/apps/details?id=com.adafruit.bluefruit.le.connect

iOS: https://apps.apple.com/app/adafruit-bluefruit-le-connect/id830125974

Wired UART Interface

The HAB Cutter includes a terminal for a wired UART connection. It uses a 4-pin JST SH (1.0 mm pitch) connector with the following pin-out:



Pin 1 – GRN/WHT – Ground
Pin 2 – YELLOW – Power
Pin 3 – BLACK – Cutter Receives on this pin
Pin 4 – RED – Cutter Transmits on this pin

By default, messages are sent at 115,200 baud (user selectable), 8n1, at 3.3 VDC logic levels.

Power note: the available 3.3 VDC output is regulated, but should not be expected to source more than 20 mA. Use of it will impact expected battery life.

LoRa Radio Interface

The *HAB Cutter* has an integrated LoRa radio that can be used to send and receive communications to and from other modules on the balloon flight set to the same frequency, such as the flight computer.

The LoRa radio is based on a Semtech SX1262 chip which can be configured to operate in the 862-928 MHz frequency range over a distance of many meters. We recommend using the RadioLib library[1] on any flight computer that needs to connect with the HAB Cutter's LoRa radio.

The radio can be configured in 'gateway' or 'device' mode. As a 'gateway', the radio will echo commands to/from the other communication interfaces, permitting one HAB module to forward

1 The RadioLib library was developed by jgromes. GitHub: https://github.com/jgromes/RadioLib

commands to other HAB modules acting as as ‘devices’. With this, the LoRa radio network is self-contained, negating the need to add a custom LoRa radio module to the flight computer.

Refer to the **LoRa Radio** section for more details and a diagram of how to use LoRa ‘gateway’ functionality on flights with multiple HAB modules.

Operation

Rigging

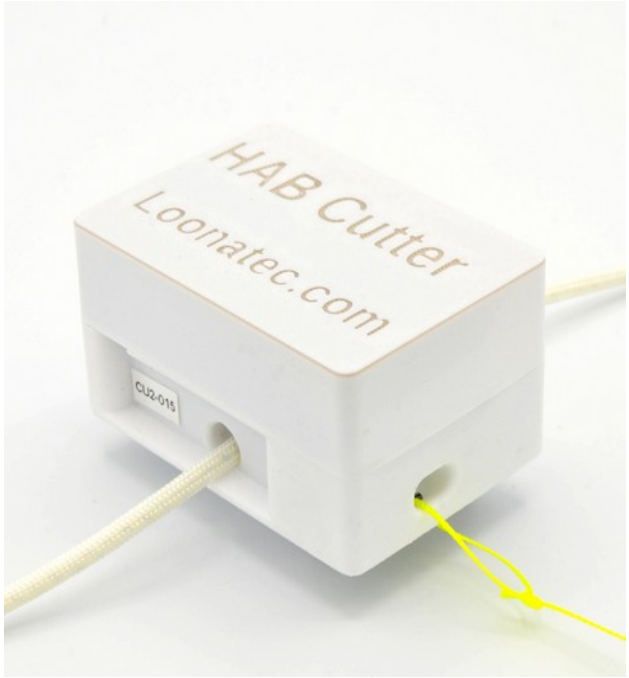
1) Open *HAB Cutter* by grasping and lightly pinching the lid and lifting up (see arrow)
2) Insert two new batteries
3) If blade is down (shown raised in photos):
    1. Turn on by pressing power-on button for 3 seconds
    2. Connect via BLE with smart phone
    3. Send **`!cCO`** command to open (raise) the cutting blade
    4. Turn off with **`!cSD=Y`** command
4) Thread line to be cut through the circular tube (white 550 paracord in photo)
5) Attach retaining line (yellow line in photo) to attach *HAB Cutter* to flight train for retention after cut

Power-On

6) Press the power-on button for 3 seconds
7) Connect with BLE, LoRa, or UART
8) Verify that blue BLE LED turns off

Cutter Activation

9) Cut line with **`!cCC`** command
10) Or start termination timer with **`!cSW=x`**



Manual Cutter Operation

The *HAB Cutter's* line cutter can be controlled via the **`!cCC`** (cut) and **`!cCO`** (open) commands.

Example:

`!cCO` Open the line cutter mechanism to permit the rigging of a new line to be cut.

`!cCC` Activate the line cutter mechanism to cut the rigging line. It takes the *HAB Cutter* approximately 18 seconds to complete the cutting routine. An immediate acknowledgment message will be send as well as completion message once the routine is done.

Termination Timer

The termination timer will count down from the initial time specified and terminate the flight when it reaches zero. Resetting, or feeding the timer, will restart the countdown to the initial time specified. This timer can be used to ensure that the flight is terminated if something happens to the flight computer or the LoRa radio link (ex RF jamming).

We recommend programming the flight computer to send the **`!cSX`** command frequently to both check on the *HAB Cutter's* status and to feed the termination timer. We recommend sending this command at an interval of approximately one-third the termination timer's initial time specified so that a failure to receive the command and feed the timer must happen 3 times in a row before the flight is automatically terminated.

Example: start termination timer, feed once (restarts the timer from the previous value), re-enable once (restarts the timer from a new value), then stop feeding:

`!cSW=120` Start the timer counting down from 120 seconds

… can wait up to 119 seconds …

`!cSW=F` Feed the timer, restarting the countdown from the prior setting of 120s

… can wait up to 119 seconds …

`!cSW=30` Reset the timer, starting the countdown from new time of 30 seconds

… wait 30 seconds for time to expire …

Resulting activation sequence:

1. *HAB Cutter* issues the **`!cSZ=Y`** command to itself
2. Termination message sent out via BLE/LoRa/UART
3. Termination sequence is activated

Terminate Sequence

The *HAB Cutter's* line cutter is repeatedly activated when the Terminate command is called. It runs through the **`!cCC`** (cut) sequence every 60 seconds until canceled or the batteries are consumed.

The Terminate command can either be called directly by the user via the **`!cSZ=Y`** command, or by an expiring Termination Timer.

The Terminate command is canceled by calling the **`!cCO`** (open) command.

Non-Volatile Cutter Parameters

Most of the *HAB Cutter's* parameters are saved in non-volatile memory. The value is not effected by powering the *HAB Cutter* off, so values can be configured in advance of launch. See the **Commands** section for which parameters are saved to non-volatile memory.

During the power-on sequence, the non-volatile memory is verified and then loaded. If the memory is found to be corrupted then it is reformatted and default values are loaded. This is indicated by the green STATUS indicator flashing the rapid, continuous error pattern. This error state will be cleared the next time the unit is powered on.

System Measurements

Every thirty (30) seconds while powered on, the *HAB Cutter* will measure the battery voltage, system charge, and internal temperature.

If the temperature measurement is below the set heater threshold the battery heater will be enabled, or disabled if the temperature is above it. The heater threshold is the temperature where the heater will be turned on or off. It is -10 °C by default, and can be changed using **`!cSH=__`**

Command Logging

HAB Cutter has a circular log that saves the last approximately 800 entries in non-volatile memory. Events that are recorded include:

- Incoming commands
- Command responses
- Bluetooth connection events

Consumables

Batteries

The *HAB Cutter* has been designed to use primary lithium batteries in the 'AAA' size. The Lithium/Iron Disulfide (Li/FeS2) chemistry has proven to work well, even at the low temperatures experienced on balloon flights. Possible suppliers of these batteries include:

- Energizer Ultimate Lithium L92 AAA Battery

While the *HAB Cutter* will operate on standard alkaline batteries, it is strongly recommended against using them during flight due to their poor performance at cold.

Line

The *HAB Cutter's* mechanical cutter has been designed to cut the following types of MIL-C-5040 Paracord:

- Type I (100 lbs, 45 kg tensile strength)
- Type II (400 lbs, 180 kg tensile strength)
- Type III (550 lbs, 250 kg tensile strength) aka 550 paracord, with 7 inner strands
- Type IV (750 lbs, 340 kg tensile strength) aka 750 paracord, with 11 inner strands
- Type V(1000 lbs, 455 kg tensile strength) aka 1000 paracord, with 14 inner strands

Trustworthy paracord can be purchased from suppliers such as Para Gear and Atwood Rope. Much of the 550 paracord sold by sites like Amazon and eBay are not made to specification and lack the prerequisite number of inner strands, changing the line's break-strength.

The HAB Cutter is capable of cutting other synthetic line, but ground-testing should be conducted to confirm that the line is reliably cut.

Note: the paracord is usually completely cut through, but occasionally a thread may be remain uncut. Ensure at least 1 N of force is present on the cut line to ensure any remaining threads are pulled free and the line separates. For force-free separation of light loads use a HAB Cutter instead.

Knife Blade

The *HAB Cutter's* mechanical cutter relies on a sharp knife blade to cut the synthetic line. It is possible to replace this blade should it become dull. Please contact support for more information.

Commands

The *HAB Cutter* uses the same commands for both the BLE, UART, and LoRa interfaces. All commands and responses are in easy-to-read ASCII text and follow predefined formats with searchable characters to aid with parsing.

Command Format

Commands follow the following format: **`!iSC=VAL`**

"**!**" (0x21) denotes a new command start. All commands will start with "**`!`**"

"***i***" is the ID (A-Z) of the device that will receive the command. This can be any letter except "**i**" itself, which is used for special help commands. By default, it is set to "**C**".

"**S**" is the subsystem name. Valid options are C, S, or R.

"**C**" is the subsystem's command that will be carried out.

"**=**" (0x3D) is only required when there is a VAL associated with the command.

"**VAL**" is the optional command value

Notes: no termination character is required, commands are not case-sensitive with a few exceptions

Example command: **`!ash=-10`** → `ID=A, Subsystem=S, Command=H, VAL=-10`

Result: tells device with ID = "a" to set its heater threshold to -10 °C

Response Format

Responses use the following format: **`[iSC, VAL] Description (unit)`**

"**[]**" (0x5B & 0x5D) enclose the command and it's formal response

"***iSC***" repeats the command that was received, displayed all uppercase

"**,**" (0x2C) separates the command from its value

"**VAL**" is the command response value

"**`Description`**" and if applicable "**`(unit)`**" help a human operator understand the response

Help Commands

These help commands do not follow the typical format, and will respond with information for the user rather than performing a task.

CMD	Description	Reply
!i	Command Cheat Sheet	`Displays recommended commands for basic HAB Cutter functions`
!ic	Cutting Commands List	`Displays all available cutting commands`
!is	State Commands List	`Displays all available State commands`
!ir	Radio Commands List	`Displays all available LoRa radio commands`
!?	Launch Final Checklist	`Displays a launch checklist to complete before releasing balloon`

Cutting Commands

This is a list of commands to control the HAB Cutter's Cutting functions. These use the subsystem identifier "**C**".

CMD	VAL	Description	Reply	Non-Volatile
!CCC		Cutter Cut Command	`[CCC, CUT-1] Starting Cut` → Immediate ACK `[CCC, CUT-2] Done Cutting` → ~20 sec later, once cut is done	
!CCE[2]		External Trigger → Query	`[CCE, n] EXT State`	
	0	External Trigger → Set to OFF		
	1	External Trigger → Set to RISING		
	2	External Trigger → Set to FALLING		
!CCM		Cutter Motor Direction → Query	`[CCM, NORM ? REV] Motor Direction`	X
	0	Cutter Motor Direction → Set to reversed		
	1	Cutter Motor Direction → Set to normal		
!CCO		Cutter Open Command	`[CCS, OPEN] Opening`	

2 The External Trigger command is present on the HAB Cutter but it does not have the necessary connector to be used on v2 hardware.

System Commands

Below is a list of commands to control the HAB Cutter's state functions. These use the subsystem "**S**".

CMD	VAL	Description	Reply	Non-Volatile
!CSA[3]		AUX Output → Query	`[CSA, n] AUX State`	
	0	AUX Output → Set, low output		
	1	AUX Output → Set, high output		
!CSC		System Charge → Query Percentage	`[CSC,52] System Charge (%)`	
	T	System Charge → Query Time to Charged	`[CSC,303] Time to charge (s)`	
	V	System Charge → Query Voltage	`[CSC,2.23] System Charge (V)`	
!CSD	**Y**	Shutdown	`[CSD,SHTDWN] Shutdown` `[CSD,ERROR] Use "iSD=Y" to shutdown`	
!CSE		UART<->BLE Comm Echo → Query	`[CSE, ENBL ? DSBL] Comm Echo`	X
	D	UART<->BLE Comm Echo → Set to OFF		
	1	UART<->BLE Comm Echo → Set to ON		
!CSF		Display Settings	Returns multiple lines of text indicating Serial #, Sensors, and Parameters	
!CSG		Seconds since power-on	`[CSG, 45.24] Seconds Powered-On`	
!CSH		Heater Set Threshold → Query	`[CSH,-10] Heater Threshold (C)` → Default is -10 C	
	10	Heater Set Threshold → Set (°C)	`[CSH,10] Heater Threshold (C)`	
!CSI	**B**	Device Identification Letter → Set (A-Z)	`[BSI,B] Device ID` → If ID set to B `[CSI,ERROR] 'I' Reserved` → Cannot set to I	X
!CSL		Displays Log `(Cannot transmit over LoRa)`	Returns multiple lines of text with past commands `[CSL,ERROR] E=enable, D=disable, C=clear`	X
	C	Clear Log	`Log Cleared!` `[CSL,ERROR] Use "iSL=C" to clear log`	

3 The AUX state command is present on the HAB Cutter but it does not have the necessary AUX connector to be used on v2 hardware.

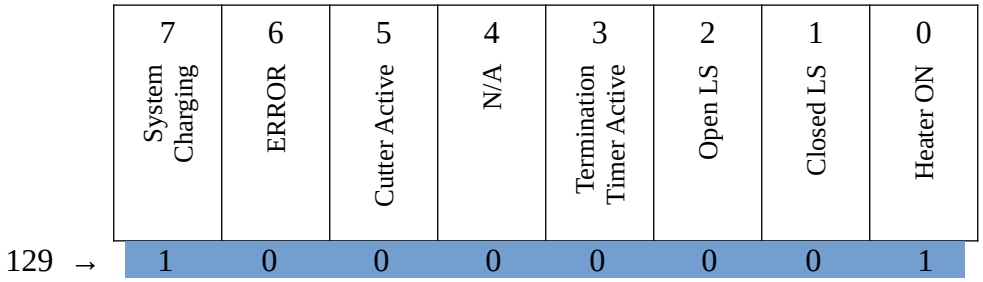
	D	Disable Logging	`[CSL,DSBL] System Event Logging`	
	E	Enable Logging	`[CSL,ENBL] System Event Logging`	
!CST		Internal Temperature → Query	`[CST, 22.7] Temperature (C)`	
!CSU		UART Baud Rate → Query	`[CSU, 115200] UART Baud Rate`	X
	1200	UART Baud Rate → Set	`[CSU, 1200] UART Baud Rate` `[CSU, ERROR] UART Baud range: 1,200 to 115,200`	
!CSV		Battery Voltage → Query	`[CSV, 2.78] Battery (V)`	
!CSW		Termination Timer→ Query	`[CSW,-1] Term. Timer Inactive` `[CSW,n] Term. Timer Remaining (s)`	
	D	Termination Timer→ Disable	`[CSW,-1] Term. Timer Disabled` `[CSW,ERROR] Failed to stop Timer`	
	F	Termination Timer→ Feed	`[CSW,n] Term. Time Remaining (s)` `[CSW,ERROR] Term. Timer not Fed`	
	60	Termination Timer→ Set	`[CSW,n] Term. Timer Enabled/Feed (s)` `[CSW,ERROR] Term. Timer invalid interval (1-4000000 s)`	
!CSX		System Status → Query	`[CSW,n,n,n] STV`	
!CSZ	**Y**	Start Termination Sequence	`[CSZ,TERM] Termination initiated` `[CSZ,ERROR] Use "iSZ=Y" to terminate`	

System Status Message Details:

Description: This message is intended to be called regularly to check on the *HAB Cutter's* status AND keep the termination timer fed, if it is enabled. It combines together the following commands: **`!cST`**, **`!cSV`**, **`!cSW=F`**, and provides the same information that the green status indicator is currently displaying.

It is recommended to send the **`!cSX`** command at an interval below one third of the termination timer's interval to ensure the timer is fed even if occasional connection issues occur. The command itself returns the decimal-value of a bit-mapped Status Field as well as the module's internal temperature and battery voltage.

Status Field: A decimal number converted from binary. Convert it back to interpret



Temperature Field: Board temperature in degrees C, zero decimal places

Voltage Field: Battery voltage in volts, two decimal places

Example: [CSX,129,16,5.03] STV

The returned decimal value of 130 converts to binary 0b10000001. These digits correspond to the characteristics in the bitmap.

System power is charging, cutter heating system is on, other characteristics are off

Board temperature is 16 °C

Battery voltage is 5.03 VDC

LoRa Radio Commands

This is a list of commands to control the HAB Cutter's LoRa Radio functions. These use the subsystem "**R**".

CMD	VAL	Description	Reply	Non-Volatile
!CRA		Preamble Setting → Query	`[CRA, n] Preamble length` → Default is 8	X
	6 to 65535	Preamble Setting → Set		
!CRB		Bandwidth Setting → Query	`[CRB, n] Bandwidth` → Default is 125	X
	7.8 to 500	Bandwidth Setting → Set		
!CRC		Coding Rate Setting → Query	`[CRC, n] Coding rate` → Default is 7	X
	5 to 8	Coding Rate Setting → Set		
!CRE		Echo Setting → Query	`[CRE, n] Radio Echo Setting` → Default is Device	X
	D	Echo Setting → Set as 'Device'		
	G	Echo Setting → Set as 'Gateway'		
	0-255	Echo Setting → Set bit mask manually		
!CRF		Carrier Frequency Setting → Query	`[CRF,n] Carrier Frequency` → Default is 915 in US → Set to ~865 in EU	X
	862.0 to 928.0	Carrier Frequency Setting → Set		
!CRG		Gain Setting → Query	`[CRG, n] Gain`	X
	0 = AGC	Gain Setting → Set		
!CRN		Latest Signal to Noise Ratio	`[CRN, n] SNR (dB)`	
!CRO	**0**	Turn Radio Module OFF	`[CRR, ON] Radio State` → Default is ON	*if other setting later set
	1	Turn Radio Module ON	`[CRR, OFF] Radio State`	
!CRP		Output Power Level Setting → Query	`[CRP, n] Output Power` → Default is 2	X
	-17 to 22	Output Power Level Setting → Set		
!CRR		Latest RSSI Value	`[CRR, n] RSSI (dBm)`	

!CRS		Spreading Factor Setting → Query	`[CRS, n] Spreading Factor` → Default is 9	X
	6 to 12	Spreading Factor Setting → Set		
!CRW[4]		Sync Word Setting → Query (default = 0x12)	`[CRW, n] Sync Word (dec)` → Default is 18	X
	≤ 8 bytes	Sync Word Setting → Set		

4 The Sync Word is displayed in HEX during the boot sequence but set in DEC by the RW command. It can also be up to 8 bytes in length but ≥2 bytes has not been tested yet.

Unprompted Messages

The *HAB Cutter* normally only sends information after a command is issued. Below are the exceptions.

Cutting Complete

The *HAB Cutter* will transmit a message when the cutting cycle is complete.

```
[CCC,CUT-2] Done Cutting
```

Terminate Sequence Completion

The following command is issued when the *HAB Cutter* starts its termination sequence

```
[CSZ,TERM] Termination initiated
[CCC,CUT-1] Starting Cut
[CCC,CUT-2] Done Cutting
...
```

Termination Timer

The following command is issued if the *HAB Cutter's* termination timer expires

```
[CSZ,TERM] Termination initiated
```

LoRa Message Information

The *HAB Cutter* currently displays a line of information each time it echos a LoRa interface message to/from the BLE and UART interfaces:

```
<LORA> RSSI: val, SNR: val                    for SX1262
```

Note: These LoRa messages should be considered deprecated and expected to be removed in future firmware versions.

Power-On UART Message

At power-on, the *HAB Cutter* will transmit an introductory message over the hardware UART interface that includes basic parameters. This information can also be accessed by sending the **!cSF** command.

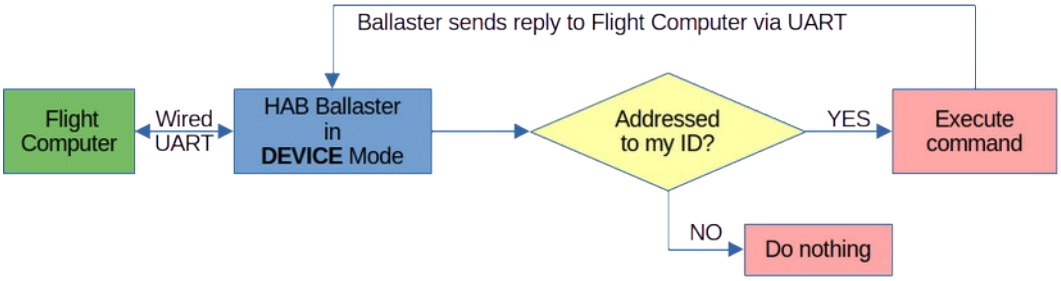
```
--------- HAB Cutter, rev 2.1 ---------
  SERIAL NO   : XXXXXXXXXXXXXXX
  FIRMWARE    : Jun  4 2026
------------ Settings ------------
  ID CHARACTER: C
  HTR SET PNT : -10 (C)
  COMM ECHO   : ENBL
  ...
  ...
---------- Loonatec.com ----------
```

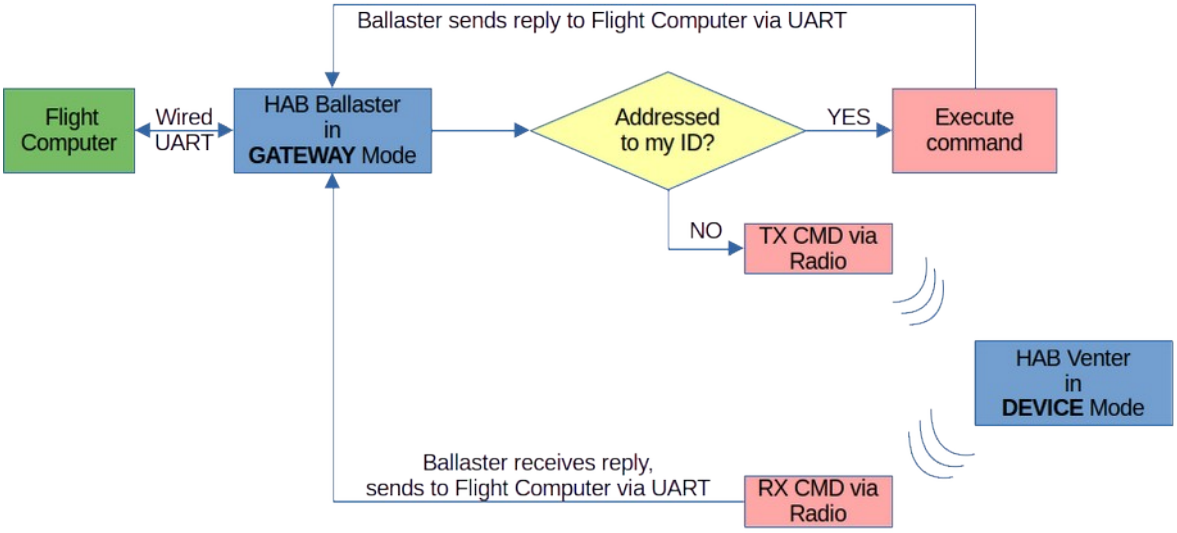
LoRa Radio

The HAB Cutter, and other HAB modules, can be controlled through messages sent over LoRa radio on the same frequency. All HAB modules receive the messages sent at that frequency so it is essential that each device has a different ID.

If the flight computer does not have LoRa radio capabilities, then it can be connected via wired-UART to a HAB module configured to LoRa 'gateway' mode. This gateway unit will then bi-directionally echo commands to/from the flight computers UART interface and its LoRa radio. Only one HAB module at a time should be set to 'gateway' mode in order to prevent endless command echoing.

Example: A HAB Ballaster is set to 'gateway'. It will execute commands addressed to **!b** and echo commands addressed to other IDs. Sending a command such as **!vST** will be transmitted by the HAB Ballaster's LoRa radio to the HAB Venter. The HAB Venter's reply will be received by the HAB Ballaster and sent on to the Flight Computer via the UART connection.





LoRa Settings & Effects

Below is a simplified overview of the basic LoRa and its chirp spread spectrum modulation settings.

Bandwidth

The bandwidth is the frequency range each chirp covers. Decreasing this value increases the data rate, lowers transmit power consumption, but requires better oscillator tolerances between units. Frequency tolerances are typically ±25 % of this bandwidth to maintain a packet error rate below 10 %.

Spreading Factor

The spreading factor is the number of RF chirps per symbol (encoded 4-bit data packet). Increasing this value makes the data more resistant to noise but lowers the data rate.

Coding Rate

The coding rate is the total number of bits in encoded symbol—4-bit data packet plus bits added as a forward error correction. Increasing this value increases reliably while decreasing the data rate.

Sync Word

The sync word can be used to isolate groups of LoRa devices. For instance if more HAB modules are installed on a flight train than device IDs (A-Z) permit then two groups, each with their own ‘gateway’ HAB module, could be created by using different sync words. Note that there are some restrictions on valid sync words, for instance 0x34 is reserved for LoRaWAN.

Power

This is the transmit power level, in decibel-milliwatts. Its range spans transmit powers of approx 20 uW (-17 dBm) to 150 mW (22 dBm).

Preamble

The preamble is used to detect the start of a data packet. It is the number of symbols that a long constant chirp is transmitted prior to data being sent to alert and allow the receive to achieve lock. Increasing this value increases the time on air.

Gain

A value of 0 will permit the LoRa radio to use automatic gain control. In most circumstances this is best.

State

This is an internal bit-mask value that controls the following:

0. Transmit Enabled → Enable LoRa TX echoing from BLE/UART

1. Receive Enabled → Enable LoRa RX echoing to BLE/UART
2. Send Reply Messages → TX device reply messages over LoRa
3. Forward Other Messages → TX received messages over LoRa
4. Forward My Messages → Also TX messages that match device ID over LoRa
5. Forward Reply Messages → Also TX reply messages that match device ID over LoRa

There are two preset options for State:

- Device → State = 7 → Tx & Rx enabled, send reply messages
- Gateway → State = 15 → Tx & Rx enabled, send reply messages, and forward other messages

Note: some care and experimentation with these settings may be required to avoid creating an echo chamber between multiple modules.

Additional LoRa Resources

See: https://www.semtech.com/products/wireless-rf/lora-tranceivers/sx1262#download-resources

LoRa Country Restrictions

Frequencies, transmit power, and duration restrictions vary from country-to-country. Below are the basic restrictions of two common regions.

Region	North America	Europe
ISM Band	902-928 MHz	863-870 MHz
Regulated by	FCC	ETSI
TX Restriction	400ms tx time	Generally 1% tx duty-cycle
Payload sizes	11 – 242 bytes	51 – 242 bytes
Spreading factors	7 – 10	7 – 12
Data rates	1 – 12.5 kbps	0.3 – 5.5 kbps
Max transmit power	21 dBm	Generally 14 dBm

Spreading Factor & Bandwidth	Transmit Data rate	Maximum Payload Size	
		North America	Europe
SF_8 500kHz(AT+SENDH)	12.5 kbps	242 bytes	-
SF_7 125kHz	5.47 kbps	242 bytes	242 bytes
SF_8 125kHz	3.125 kbps	129 bytes	242 bytes
SF_9 125kHz	1.76 kbps	53 bytes	115 bytes
SF_10 125kHz	0.98 kbps	11 bytes	51 bytes
SF_11 125kHz	0.44 kbps	-	51 bytes
SF_12 125kHz	0.25 kbps	-	51 bytes

From Differences Between North America & Europe

Note: All HAB Module messages are ≤ 50 bytes with the exception of displaying the system log (**!cSL**) which can only be transmitted over the BLE or UART interfaces.

Safety Precautions and Recommendations

Regulatory

Always adhere to the regulations governing high-altitude ballooning applicable in the country of operation. In the United States, high-altitude balloon flights are governed by “FAA Part 101”.

Always adhere to the regulations governing radio transmissions applicable in the country of operation. In the United States, radio transmissions are governed by “FCC Part 15” ISM regulations.

Falling Payload Hazard

Always clear the launch area prior to launch. While unlikely, balloon or line failure after release may result in a falling payload impacting the ground before the parachute fully deploys.