# Avcom SBS2 Beacon Receiver User Manual

This document applies to

SBS2 and RBR units

*manufactured after July 2019*

**Starting With These Serial Number Series:**

- SBS2Gxxxxx
- RBRGxxxxx

**Hardware Tracking Code:**

- HWTC 6/0 or later.

# SBS2-2150E-xxxx-B (Beacon Receiver Module)
# RBR-2150A (Rack Mount Beacon Receiver)

*User Manual - Version 1.0*

Contents

# Introduction

The Avcom Beacon Receiver (BR) is designed to identify and lock on to satellite tracking beacon signals in the L -Band range (actual range 950MHZ to 2150MHZ). The Avcom BR can track CW and moderately modulated BPSK beacons. The Avcom BR is appropriate for many antenna controller peaking and tracking algorithms. An analog signal strength output is provided as well as a digital lock indicator output. When using the API users can obtain all status and signal strength information via the API. The API can provide other information such as frequency drift.

Setup and control of the BR is via the Avcom GUI or the Avcom API. The unit can operate as a BR via interactive control or be set to run as a BR autonomously even after a system reset. The BR is built upon the Avcom SBS2 Spectrum Analyzer (SA). The user can switch between SA and BR modes.

The client application (Avcom GUI or user-built M&C built on Avcom API) can communicate with the BR via Ethernet or USB. For TCP/IP both static and DHCP IP addresses are supported.

# Functional Overview

When operating as a Spectrum Analyzer the SBS2-2150x operates much like previous Avcom products with a few differences. Additional features of the SBS2-2150x:

1.  Adjustable Video Bandwidth (VBW)
2.  The user can specify a variable number of sweep sample points
3.  There is a second band (9MHZ to 11MHZ) for monitoring 10MHZ reference signals
4.  Improved dynamic range
5.  A new API enabling reliable, higher quality integration
6.  Improved automatic device discovery (USB and Ethernet) in the Avcom GUI

The Beacon Receiver builds upon the Spectrum Analyzer feature set to provide a highly configurable beacon tracking receiver. The super-heterodyne tuner combined with the Resolution Bandwidth (RBW) filters and Digital Signal Processing (DSP) logic provide an efficient peak detection/tracking mechanism. Each application varies in terms of beacon strength, frequency drift, noise, and other factors. The Avcom BR gives the user great flexibility to optimize performance in each environment with a single hardware platform.

A quick overview of the BR operation follows. This assumes the Avcom GUI has already been installed and configured to connect to the SBS2-2150x which is covered in detail later in the document.

1.  Connect RF feed to SMA connector
2.  Connect USB or Ethernet
3.  Apply power to the SBS2-2150x
4.  Start the Avcom GUI
5.  Select the device to which you want to connect and press 'RUN' on the main window
6.  Open the Beacon Receiver configuration dialog (Config -> Beacon Receiver).
7.  In the dialog set the frequency, amplitude, and voltage slope parameters
8.  Press 'Run' on the dialog window

At this point the SBS2-2150x is operating in Beacon Receiver mode. The Beacon Receiver Control window remains open and the sweep display focuses on the configured beacon spectrum. The control window can be closed and re-opened at any time although it is a useful way to observe the state of the Beacon Receiver as it attempts to identify and lock on to a beacon signal.

The Beacon Receiver first attempts to acquire the beacon signal based on the parameters supplied. Once the beacon signal has been acquired (meeting the frequency, strength, and time user-supplied parameters) the Beacon Receiver will "lock" and at that point begin tracking the peak of the beacon. The peak may vary in amplitude and frequency drift. However,

the Beacon Receiver will stay locked to the peak of the beacon signal using that peak to determine changes in beacon power level.

The term "Acquire" is used to describe the state where the Beacon Receiver is attempting to find a beacon signal or has found a candidate signal.

The term "Tracking" is used to describe the state after a suitable beacon signal has been acquired and has persisted long enough to be considered not transient. At this point the Receiver is considered locked on to the signal and Tracking the signal.

It should be noted that the Beacon Receiver is driven by an independent high-priority program inside the SBS2-2150x. This assures the RF measurement, analysis, and output updates occur at a predictable, consistent rate. You may notice the GUI perform slower when the Beacon Receiver is active. This is normal in order to maintain the "real time" nature of the core Beacon Receiver function.

Once the Beacon Receiver is running the GUI can be stopped and the application closed without stopping the Beacon Receiver function.

# Hardware Information

## Watchdog

If enabled, a watchdog timer will reset the Beacon Receiver if the main internal application becomes unresponsive. This is very helpful for the extremely rare case where some circumstances have caused a "healthy" system to stop. However, if you observe repeated unusual behavior such as output lines changing unexpectedly or the client application temporarily fails to get updates from the Beacon Receiver then the watchdog should be disabled. A subsequent lockup of the Beacon Receiver would then indicate an issue needing to be addressed.

## SBS2-2150x

For general SBS2-2150x hardware information please refer to the SBS2 Technical Manual.

The SBS2-2150x with the Beacon Receiver option is supplied with an additional cable for the beacon receiver outputs.

To aid in debugging, LEDs are provided which indicate power, Ethernet activity, USB activity, and CPU heartbeat (approximate 1 pulse per second).

## RBR-2150X

### Front Panel

The front panel has four LEDs. These indicate:

- Power

- Link to remote or local GUI

- Whether BR is running

- Whether BR is locked

### Rear Panel

The rear panel connectors are:

- Power (15 VDC)

- RF Input (950 – 2150 MHZ)

- DC Output (Beacon Receiver analog output, 0 – 10VDC)

- Ethernet (Remote Control)

- USB (Local Control)

- Beacon Status (DB-9)

    o Pin 1 – Ground

    o Pin 5 – Digital Lock Output

    o Pin 9 - Ground

# Software Information

The Avcom GUI v4 series or later can be downloaded from the Avcom FTP site. The GUI provides all needed configuration, control, and monitoring.

The Avcom API is written in POSIX-compliant 'C' language code. This API was designed to provide integrators with a robust and feature-rich method for reliable, predictable, and seamless system integration for antenna controllers and M&C software. The APIs are also ideal for custom standalone control, analysis, and data acquisition applications. The Avcom API is available free of cost via a simple license agreement. Binary versions for Windows and Linux x86 platforms are available. The source has been built for many OS/platforms by a number of customers with very little change required in most cases (IOS/iPhone/iPad, Linux/Arm, Linux/OMAP). In some cases a development framework requires a platform specific messaging API. The API is structured to also allow a "bring your own communication layer" approach.

The Avcom Beacon Receiver is designed to allow firmware updates over USB and Ethernet. An update would be applied using a PC-based command-line tool provided by Avcom along with the updated firmware. A future version of the GUI may include this feature. The Avcom API provides function calls to allow integrators to incorporate the firmware update procedure into their system software

# Detailed Operational Guide

In order for the Beacon Receiver to track a beacon signal a number of factors must align in terms of the signal environment versus the configuration settings. In general the following conditions must be met:

1) The signal is within the required frequency range
2) The signal is within the required strength range
3) Conditions 1 and 2 must both be met for a minimum length of time
4) Conditions 1 and 2 must both be met

Items 3 and 4 are not as redundant as they seem. Condition 3 requires the signal persist over time to demonstrate it is not some other transient spike or noise before the receiver declares beacon signal lock and begins tracking the signal. Condition 4 allows tracking to continue unless the signal has degraded or disappeared.

A Beacon Receiver usually does not work alone and is often paired with an antenna controller (which we can use as an example). This has the added dimensions of a closed-loop control system where the antenna speed, antenna tracking algorithm, the Beacon Receiver analog output slope, and the digital lock output are all related. Maybe it was easy to get it all working with the antenna set to its "slower than a snail" setting. However operational/mission requirements may dictate a much faster response time.

Avcom's intention is to provide a comprehensive set of parameters and functionality to help optimize performance across many applications. It is understood that the process can be frustrating. Avcom encourages customers to contact Avcom Engineering to discuss the specific application or issue. Quite often clarification of functionality can be a big help (and helps pinpoint documentation opportunities). In some cases a challenging application points out a good opportunity for new/modified Beacon Receiver functionality.

## Tracking Algorithm

The Tracking Algorithm determines the major functional mode for the receiver.

### Peak Following

This is the primary mode for tracking CW or moderately modulated beacons. It identifies a beacon within the set parameters and will lock to that signal. This is often used for validation of correct satellite and also peaking functions.

The receiver will retune to the peak of that signal as it varies gradually over the course of a day while keeping track of the frequency offset. The power returned for calculation of the analog output is the peak power.

### Integrated Power

This is functionally similar to Peak Following. However, the power returned for calculation of the analog output is the calculated Integrated Bandwidth Power. This can be helpful for stronger signals with more aggressive modulation.

However, this mode does not provide a linear accurate response when the signal strength is less than 10 dB above the noise floor.

## Tuned Power Tracker

This mode can be helpful for certain cases:

1) There is no beacon on which to lock
2) Need for a simple method to measure signal power and generate a proportional analog signal
3) A high update rate for measuring signal power is needed

The Tuned Power Tracker (TPT) mode provides a way to measure the peak power of a slice of signal spectrum. If there is a signal with generally consistent average power level, this can be used to measure a portion of that signal and use that peak power level to drive the voltage calculation. This can then be used for antenna peaking operations. This mode does not provide retuning but measures a fixed "slice" of spectrum. The algorithm runs at 100 HZ providing 100 updates per second to the analog output. There are two TPT parameters: Bandwidth (slice size), and VBW (smoothing filter strength).

The following Beacon Receiver parameters are not used: Acquisition C/N0, Tracking C/N0, Acquisition Bandwidth, Tracking Bandwidth, Time To Lock, Reference Power Mode, Voltage Mode, Low Pass Filter, Update Rate, and Lock Output Polarity.

The client application can still obtain the digital version of power and voltage levels over the Ethernet or USB interface. Inside the receiver, real-time priority is given to assuring the measurement rate is consistently 100 Hz. Requests for data packets are lower priority and can't be guaranteed to be available at 100 HZ due to this fact and the numerous uncertainties of the network and connected hardware.

### TPT Bandwidth
TPT Bandwidth allows setting the TPT spectrum "slice" width from 3 kHz to 8 MHz in a few discrete steps. 3 kHz, 10 kHz, 30 kHz, 300 kHz, 1 MHZ, 2 MHZ, 4 MHZ, and 8 MHz

### TPT VBW
TPT VBW provides smoothing to the measured signal to help eliminate variations in the analog output. This low pass filter can be set to: 300 HZ, 3 kHz, 30 kHz, and 300 kHz.

## Frequency Settings

The frequency settings control where the Beacon Receiver will look for the beacon signal. This is done through three settings: Frequency, Acquisition Bandwidth, and Tracking Bandwidth. Combined these allow finding and tracking a beacon while accounting for the fact that beacons don't always seem to be at their published frequency.

## Band

Although the 10MHZ frequency band can be selected for the Beacon Receiver this is rarely used. Generally, this is set to L-Band for most applications.

## Frequency

This is the published official frequency of the beacon signal per the satellite operator

## Acquisition Bandwidth

The frequency span used to search for a beacon signal. Quite often many beacon signals appear frequency shifted which is why we must allow some deviation from the published frequency when trying to find a beacon. This defines how far the search will look on either side of *Frequency. So the total Acquisition Bandwidth is twice the value you enter on the screen.*

## Tracking Bandwidth

The approximate frequency span used to track an acquired beacon signal. Once the beacon has been acquired and the Beacon Receiver has "locked" on to the signal the tracking bandwidth is applied. The receiver sweep will be centered at the frequency where the beacon was acquired with a sweep span +/- (*Tracking Bandwidth* + 5kHz) from this frequency. During tracking, if the signal peak moves further than *Tracking Bandwidth* the receiver will exit beacon lock.

In most applications *the Acquisition Bandwidth* and *Tracking Bandwidth* can be set with *Tracking Bandwidth* set to 5 kHz less than *Acquisition Bandwidth*. Users of the beacon receiver can however tailor these to fit application needs.

*The total Tracking Bandwidth is twice the value you enter on the screen.*

## Notes on Bandwidth

In general, the lowest bandwidth values result in higher sensitivity and potentially earlier lock.

# Beacon Strength Settings

The beacon must have a discernable level of signal above the surrounding noise in order to definitively say it is a beacon signal. Likewise as the signal strength diminishes or noise increases there is a level at which we will no longer be able to discriminate between signal and noise. The settings are Acquisition C/N0 and Tracking C/N0. These are provided as separate settings to allow the user to implement a custom hysteresis for optimum stable operation in a given environment.

## Acquisition C/N0

Minimum signal strength required during search for beacon signal. This user parameter determines what level of signal above the noise is required to declare a beacon signal as strong enough to be considered acquired. C/N0 (Carrier to Noise Spectral Density) is the measurement used. A signal that has met or exceeded the Acquisition C/N0 and met the frequency criteria will be considered acquired. Assuming this signal remains for a sufficient time to prove it was not transient the Beacon Receiver will then enter lock and begin tracking.

## Tracking C/N0

Minimum signal strength required while tracking a beacon signal. This user parameter determines what level of signal above the noise is required to continue tracking a locked beacon signal. C/N0 (Carrier to Noise Spectral Density) is the measurement used. In the event the signal C/N0 level drops below the Tracking C/N0 the Beacon Receiver is no longer locked on the beacon signal and the Receiver will begin looking for a signal to acquire. This should be equal to or less than the Acquisition C/N0.

## Notes for Acquisition and Tracking C/N0 Levels

For maximum sensitivity and earliest lock set both C/N0 settings to their lowest settings.

In noisy environments these settings can be useful to establish levels for stable operation free from false locks on noise signals.

It should be noted that any signal with less than 3dB signal-to-noise ratio will not be considered for acquisition. Also, any tracked signal that drops below 2 dB signal-to-noise ratio will cause loss of lock and the Receiver will begin looking to acquire a signal once again

In general the ability to acquire and track the very lowest C/N0 signal is driven by using a reasonably small bandwidth. The details of the relationship are discussed below.

NOTE: Units prior to firmware version 1.9 may have the Acquisition C/N0 and Tracking C/N0 set to 70 as a default. This will generally cause the Beacon Receiver to never lock unless these values are changed.

# Bandwidth vs. Sensitivity vs. Sample Rate

The Beacon Receiver is designed to use the minimal number of sample points when sweeping a frequency range. This optimizes the time required and CPU cycles used for a sweep. This assures adequate resources are available to maintain the real time constraint of 10 samples per second plus allow some capacity to handle client requests. Each frequency sample point in a sweep requires time to tune to a new frequency, time for the tuner to settle, and CPU time to collect. Once all sweep points are collected time is required to perform DSP filtering, evaluate the results and update the various beacon receiver outputs and indicators.

The Beacon Receiver is designed to use the lowest RBW filter possible in order to reduce the noise component of the sampled signal for improved sensitivity.

Although the bandwidth is adjustable, a tradeoff is that larger bandwidths require  the use of wider RBW filters in order to keep the number of sweep points relatively low.

Summary:

| Displayed Bandwidth Setting (GUI Settings, API) | Total Bandwidth | RBW Filter Used | Min C/N0 |
|---|---|---|---|
| 5 kHz - 37 kHz | 10 kHz – 72 kHz | 3 kHz | 40 dB-Hz |
| 38 kHz – 92 kHz | 76 kHz – 184 kHz | 10 kHz | 44 dB-Hz |
| 94 kHz – 375 kHz | 188 kHz - 750 kHz | 30 kHz | 48 dB-Hz |

# Setting Output Voltage Relationship to RF Power Level

When the BR is locked it can provide an analog output voltage that is proportional to the RF power level (in dBm) of the beacon. The way the voltage varies based on power level will need to be tailored for each application. In order to establish the way in which the voltage will change with respect to the RF power level of the beacon signal there are user settings provided to set the Voltage Slope, Reference Voltage, and the Reference Power. All three are related so a brief description of each will be followed by an example that shows the relationship.

## Voltage Slope

The Voltage Slope determines how many volts the output will change for a corresponding 1dB change in beacon signal power. For instance, a slope of 0.5 V/dB indicates that the voltage output increases by 0.5V for each 1dB increase in beacon signal power. When voltage slope is negative then the output voltage will decrease when beacon signal power increases. The default value for slope is 0.5V/dB.

## Reference Voltage

Reference Voltage is the starting or reference point for determining output voltage. This is the voltage that will be output when the beacon signal power is equal to the Reference Power Level which is discussed next. The Reference Voltage default value is 5.0V which is the midpoint of the analog output range.

## Reference Power

Reference Power is the beacon signal power level that will produce an output voltage equal to the Reference Voltage. The difference between the Reference Power and the actual beacon signal power is used along with Voltage Slope to determine how much the output voltage should vary from the Reference Voltage.

## Reference Power Mode: FIXED

The Reference Power Mode of FIXED uses a user-supplied, fixed power level as a reference.

## Reference Power Mode: AUTO

The Reference Power AUTO feature does not use a pre-determined, fixed power level as a reference. This feature, when selected, will set the Reference Power at the time the beacon receiver locks onto the beacon signal. The Reference Power is set to the current beacon signal power level at the time of lock. The AUTO feature will determine a new Reference Power each time beacon lock is achieved. This can be useful only relative signal strength is all that is required to achieve peaking/tracking operation.

This feature allows for greater flexibility in environments where beacon levels have a high degree of variation. This variation can be over time, ground position, weather or in switching between satellites. This feature may allow flexibility with less tailoring. If determination of a fixed Reference Power for all operating situations proves difficult consider using AUTO mode.

In specific applications using this mode it can be advantageous to "re-center" the beacon receiver output to maximize range. This can be accomplished by first peaking the antenna in AUTO mode. Once this is done the beacon receiver can be briefly be disabled and then enabled to reset the beacon receiver to reacquire the beacon signal, obtain lock, and set the  Reference Power level to the beacon power level of the freshly peaked antenna.

# Other Settings

The beacon must have a discernable of signal above the surrounding noise in order to definitively say it is a beacon signal. Likewise as the signal strength diminishes or noise increases there is a level at which we will no longer be able to discriminate between signal and noise. The settings are Acquisition C/N0 and Tracking C/N0.

## Lock Output Polarity

The digital lock indicator can assert either voltage-high or voltage-low when a lock condition occurs. If this output is not used polarity can be set to "None"

## Time-To-Lock

After a signal has been acquired it must persist as a valid signal for at least "Time To Lock" in order for the Receiver to be considered locked on to the signal after which the Receiver begins tracking the beacon signal.

## Watchdog Enable

When enabled a system reboot will be triggered if the system stops responding internally.

## Voltage Mode

This determines how the Beacon Receiver sets the analog output voltage when it is no longer locked on a beacon. The three options are:

1) ZERO: Set analog output to zero (0) volts
2) STOP: Set analog output to the last voltage calculated when the received was locked
3) CONTINUE: Set the analog output voltage proportional to the power level and according to the Voltage Reference, Power Reference, and Voltage Slope based on the power level detected at the configured Frequency. This can be useful for some applications like uplink power control. Be aware that tracking a signal level that has not met the criteria for beacon lock may be subject to noise floor variations or other signals.

## Update Rate

Applies to Tracking Algorithms: Peak Following & Integrated Power

The Beacon Receiver update rate defaults to 10 HZ. Optionally, it can be changed to 25 HZ

## Run On Boot

Have the Beacon Receiver run automatically after system startup, power interruption, or watchdog reset. When enabled this causes the Beacon Receiver to start running when the Beacon Receiver is first powered up or reset (e.g., by watchdog). [feature available in API and in GUI versions 4.0rc20 and later]
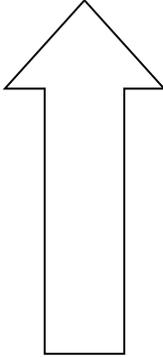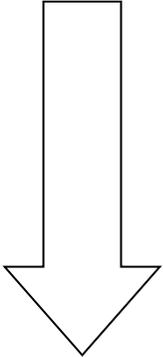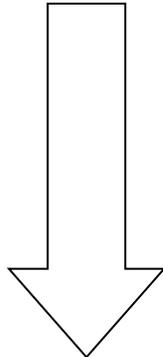
## Reference Level (input attenuation)

Similar to the Spectrum Analyzer, the Reference Level can be set. The Beacon Receiver default is -40dBm (minimal attenuation). For stronger input signals the Reference Level can be changed to provide a max level of 0dBm on the power scale [feature available in API 1.4 (production release) and in GUI versions 4.0 (production release) and later].

## Noise Filter Selection

The Beacon Receiver uses two digital low-pass filters which concurrently act to reduce the effects of noise as it analyzes signal energy at specific frequency points (similar in concept to a video bandwidth filter on a spectrum analyzer). The default filter is 0.5 Hz and requires 2 seconds (1/0.5 Hz) to settle. This effectively limits the lowest Time-To-lock to 2 seconds. This works well when challenged with a noisy LNB and a weak beacon.

If a faster response time is required (e.g. rapid transportable antenna deployment) the user can select a higher frequency low-pass filter. This will reduce the effective minimum Time-To-Lock. In the previously mentioned example it could allow faster antenna motion during deployment to locate the beacon quicker.

| Filter (Hz) | Recommended Minimum Time-To-Lock (ms) | Noise Environment (RF) | Acquisition Speed | Effective Smoothing of Outputs |
|---|---|---|---|---|
| 0.25 | 4000 | Higher Noise Resistance | Slower | Less Ripple |
| 0.5 | 2000 | | | |
| 1.0 | 1000 | | | |
| 1.5 | 700 | | | |
| 2.0 | 500 | | | |
| 2.5 | 400 | | | |
| 3.0 | 300 | Lower Noise Resistance | Faster | More Ripple |

Systems requiring fast acquisition will sometimes perform a rough acquisition using high speed antenna motion with a higher frequency filter. The antenna system switched to low speed mode and to a lower filter for final or periodic peaking. When using a higher frequency filter in a noisy environment care should be given to setting the Acquisition C/N0 to an appropriate level to avoid false lock conditions.
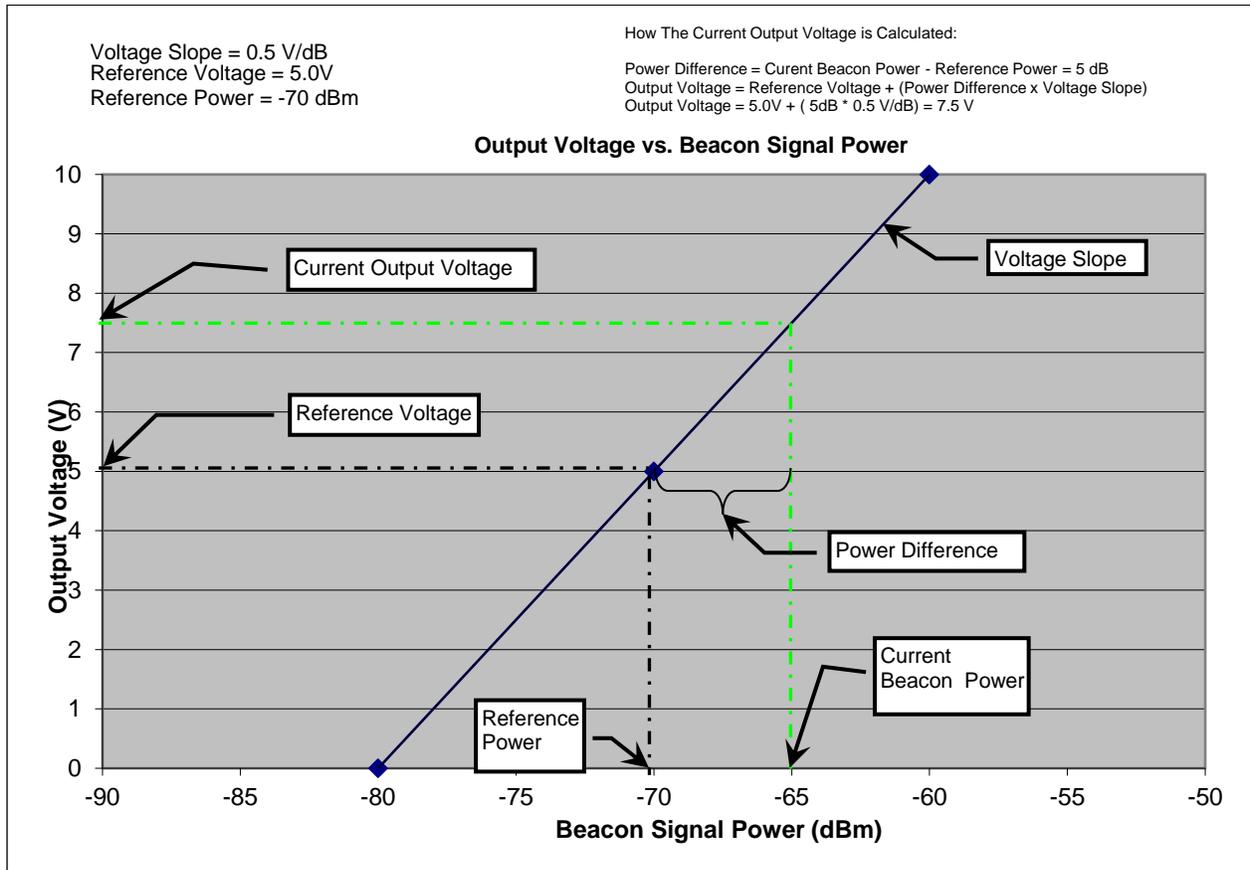
## *Beacon Receiver Output Cable (SBS2-2150E)*

The Avcom Beacon Receiver is supplied with a length of 4-wire cable that is unterminated on one end and has a 6-pin connector on the other. These wires supply the following outputs:
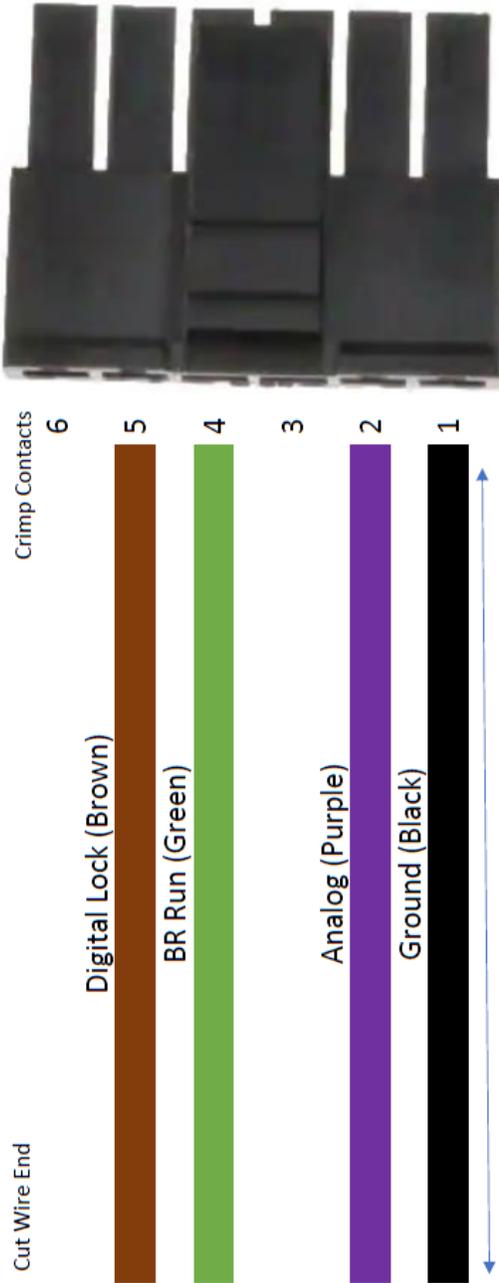
| Circuit | SBS2 | Function |
|---|---|---|
| Digital Lock (Brown) | H3-Pin 5<br>Output: 0VDC to 3.3VDC<br>Vo(L) = 0.01 VDC (Imax=15mA)<br>Vo(H) = 3.28 VDC (Imax=0.3mA) | The meaning of each level is defined by the Digital Lock Polarity setting. |
| BR Run (Green) | H3-Pin 4<br>Output: 0VDC to 3.3VDC<br>Vo(L) = 0.01 VDC (Imax=15mA)<br>Vo(H) = 3.28 VDC (Imax=0.3mA) | This line is set HIGH when the beacon receiver is running. |
| Analog Out (purple) | H3-Pin 2<br>Output: 0VDC to 10VDC<br>15 mA max | Signal strength indication based on user-parameters. When Beacon Receiver is not locked this is set based on the Voltage Mode setting. |
| Ground (black) | H3-Pin 1 | Chassis and power ground. |

H3-Pin 6 is a weak 3.3VDC supply and not recommended for customer use at this time as it is unprotected and incorrect use will result in internal damage.

H3-Pin 3 is an unassigned digital input/output and is not used at this time.

NOTE: Starting in August 2019, SBS2 uses a new series of connectors. The same physical position is retained going forward although the pin numbers are reversed if compared to the earlier generation of product. The numbers referenced here are for the current connectors (Molex) which differs from how the previous connector supplier numbered pins. The different families of connectors are not compatible and there is no chance of erroneous connection. See Avcom Product Change Notice PCN-2019-001 v2.

## CA 000026
## Assembly Drawing

| Crimp Tool | Molex |
| --- | --- |
| Crimp Contact | Molex 043030-0002 (x4) |
| 6 pin Receptacle | Molex 43645-0600 |

Crimp Contacts

6
5
4
3
2
1

Cut Wire End

Digital Lock (Brown)

BR Run (Green)

Analog (Purple)

Ground (Black)

36" (915 cm)

Tie the wires with one nylon wire tie at 2" from connector

Rev 1

06/09/2020

Beacon Receiver Cable