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## **AESQbox**

### **Operational Detail**

#### **1.0 System Operation**

##### **1.1 System Theory of Operation**

The AESQbox is designed to provide a portable means of testing various aspects of AES-3 and S/PDIF digital audio systems. It is able to generate AES-3 or S/PDIF output signals over a sample frequency range from 32kHz to 192kHz.

Audio sources available for the signal generator/transmitter function include a built-in microphone, a pair of tone generators (one for the left channel, the other for the right), or an external line-level stereo audio source, such as a portable MP-3 player, CD player, or computer sound card.

The AESQbox also functions as an AES-3 or S/PDIF receiver. It is capable of receiving sample frequencies from 32kHz to 192kHz, and provides for monitoring the audio content via a built-in speaker or line/headphone output jack.

Connectors are provided for S/PDIF in (BNC female), AES-3 in (XLR female), S/PDIF out (BNC female), AES-3 out (XLR male), line-level audio in (1/8" TRS female), line-level/headphone out (1/8" TRS female) and external power (5.5mm x 2.1mm coaxial jack).

Power source may be a 6 volt DC "wall wart" or four "AA" cells. Other external power may be used provided the DC voltage never exceeds 10 VDC or sinks below 3.5 VDC. Peak power requirement is 7.5 Watts. Average power requirement is 1.5 Watts. The largest factor in power draw is the setting of the speaker volume, the second largest is the line output level and the load on it. Recommended headphone impedance is between 32 and 100 ohms.

##### **1.2 Indicators, Controls, and Interfaces Description**

###### **1.2.1 LED Indicators**

There are a total of twelve LED indicators used on the AESQBox. They are grouped functionally and described in the paragraphs below.

###### **2.2.1.1 Power Indicator**

The Power Indicator LED is directly above the Power Control switch, and is illuminated when the Power switch is ON. The Power LED is connected to the primary power source, so it serves as an indicator of the state of the power supply (especially when powered by batteries). It will dim as the

batteries lose power, thus giving an indication of remaining battery life.

#### 2.2.1.2 Input Sample Rate Indicators

The Input Sample Rate Indicators are seven LEDs are in a row along the top of the unit. Only one will be illuminated at a time, except during the Power-On Self-Test. The sample rates that they indicate are (from left to right) 32kHz, 44.1kHz, 48kHz, 88.2kHz, 96kHz, 176.4kHz, and 192kHz. When locked to an input digital audio source these LEDs indicate the detected sample rate.

#### 2.2.1.3 Fault Indicator

The single LED below the row of seven is the multi-function Fault indicator. If it illuminated steadily, a hardware fault has been detected. If it is flashing slowly (at about a half-second rate), either the unit is locked to a signal but can't determine the sample rate, or if the unit is in Loopback (Cable Test) mode, the output sample rate does not match the input sample rate. If flashing rapidly (at about a quarter-second rate), the input is locked to a signal that is not a PCM (pulse-code modulation, or audio bit stream) signal. This signal could be a data stream or a DTS-CD stream.

#### 2.2.1.4 Clip Indicators

The two LEDs directly below the Mode switch are Clip detection indicators for the Left and Right input channels; the LED on the left is for the Left channel; the LED on the right is for the Right channel. These LEDs will start flashing dimly when the signal is about 4dB below digital full-scale, and will illuminate steadily when the signal is about 1dB below digital full-scale.

#### 2.2.1.5 Input Signal Lock Indicator

The single LED to the right of the Sample Rate Select switch is the Input Signal Lock indicator. It will illuminate whenever the AES-3 or S/PDIF input signal is locked by the digital receiver.

### 2.2.2 Control Potentiometers

#### 2.2.2.1 Line/Headphone Output Level Control

The Line/Headphone Output Level Control is the leftmost of the three control knobs. It controls the analog audio level present on the Line/Headphone Output 1/8" TRS jack.

#### 2.2.2.2 Speaker Level Control

The Speaker Level Control is the center knob. It adjusts the output level of the built-in speaker.

#### 2.2.2.3 Analog Input Level Control

The Analog Input Level Control is the rightmost knob of the three. It controls the level presented to the Analog-to-Digital

Converter analog input. All three of the possible analog inputs (microphone, tone oscillators, and auxiliary input) are affected by this control. This control is used in conjunction with the Clip Indicators, and is typically adjusted for a level where the Clip Indicators only occasionally flash on.

## 2.2.3 Control Switches

### 2.2.3.1 Power Switch

The Power Switch is located between the Headphone/Line Output Level Control and the Speaker Level Control, and directly under the Power Indicator. When the switch toggle is toward the left, power is off; when to the right, power is on.

### 2.2.3.2 Speaker Monitor A/B Switch

The Speaker Monitor A/B Switch is located directly below the 44.1kHz Sample Rate LED, and controls which of the two available audio channels (Channel A, or left; and Channel B, or right) is presented to the speaker from monitoring. Switch toggle to the left selects the left ("A") channel, and to the right selects the right ("B") channel.

### 2.2.3.3 Analog Input Source Select Switch

The Analog Input Source Select Switch is below and to the right of the Speaker Monitor Switch. It controls which of the three possible analog input sources will be transmitted as digital AES-3 or S/PDIF. If the switch toggle is to the left, the microphone input is selected, if in the center, the auxiliary input is selected, and if to the right, the tone oscillators are selected.

### 2.2.3.4 Operating Mode Select Switch

The Operating Mode Select Switch is directly to the left of the Speaker Monitor Switch and directly under the 176.4kHz Sample Rate LED. Its function is to select the desired operating mode. When the switch toggle is to the left, "Cable Test" ("Loopback") mode is selected, when in the center, "Normal" or "In/Out" mode is selected, and when to the right, "Pass-Thru" mode is selected.

### 2.2.3.5 Output Sample Rate Select Switch

The Output Sample Rate Select Switch is directly to the right of the Analog Input Level Control and directly to the left of the Input Signal Lock Indicator. It controls, under some circumstances, the sample rate of the digital audio transmission. When the switch toggle is to the left, a sample rate of 48kHz is selected, when in the center, 96kHz is selected, and when to the right, 192kHz is selected.

## 2.2.4 Interface Connectors

### 2.2.4.1 External Power Input Jack

The External Power Jack is found on the left uppermost corner on the side of the unit. It is a 5.5mm x 2.1mm standard coaxial power connector. The center contact on this connector is positive, the barrel contact is negative. A 6VDC 1000mA plug-in power supply with the correct mating connector is supplied with the unit when it is desired to not operate the unit off of battery power.

#### 2.2.4.2 Line/Headphone Output Jack

The Line/Headphone Output Jack is located between the External Power Input Jack and the Auxiliary Input Jack on the left side of the unit. It provides a high-quality analog version of any digital audio source that is received by the AESQbox. Peak output level is +4dB, and the output is capable of driving headphones from 32 ohms to 100 ohms impedance. The output level is controlled by the Line/Headphone Output Level control. This output is a standard unbalanced 1/8" TRS (Tip-Ring-Sleeve) female jack with the left channel connected to the tip, the right to the ring, and the sleeve to common.

#### 2.2.4.3 Auxiliary Analog Input Jack

The Auxiliary Analog Input Jack is located at the bottom corner of the left side of the unit. It allows the operator to connect any analog source, such as a portable MP-3 player, CD player, radio, or any similar device to the AESQbox. This input then may be converted to AES-3 or S/PDIF format and transmitted as a digital audio signal. The maximum level into this input is +4dB. The Analog Input Level Control can compensate for variations in the source level. This input is a standard unbalanced 1/8" TRS (Tip-Ring-Sleeve) female jack with the left channel connected to the tip, the right to the ring, and the sleeve to common.

#### 2.2.4.4 S/PDIF Digital Input Jack

The S/PDIF Digital Input Jack is a standard BNC female coaxial connector, and is located on the upper right side of the unit. It accepts standard S/PDIF digital audio signals over 75 ohm coaxial cable, such as RG-6/U. Input levels may be as high as 5V p-p and as low as 250mV p-p. Input sample rates may range from 32kHz to 192kHz.

#### 2.2.4.5 AES Digital Input Jack

The AES Digital Input Jack is a standard female XLR connector, and is located just below the S/PDIF Digital Input Jack on the right side of the unit. It accepts standard AES-3 digital audio signals over 110 ohm balanced shielded cable, such as Belden 1800F or Belden 1696A. Input levels may be as high as 5V p-p and as low as 250mV p-p. Input sample rates may range from 32kHz to 192kHz. Standard pin connections are used with this connector: pin 1 is the shield

ground, pin 2 is the positive input, and pin 3 is the negative input.

#### 2.2.4.6 AES Digital Output Jack

The AES Digital Output Jack is a standard male XLR connector, and is located just below the AES Digital Input Jack on the right side of the unit. It outputs standard AES-3 digital audio signals over 110 ohm balanced shielded cable, such as Belden 1800F or Belden 1696A. Output level is 5V p-p. Output sample rates may range from 32kHz to 192kHz, depending upon operating mode. Standard pin connections are used with this connector: pin 1 is the shield ground, pin 2 is the positive input, and pin 3 is the negative input.

#### 2.2.4.4 S/PDIF Digital Output Jack

The S/PDIF Digital Output Jack is a standard BNC female coaxial connector, and is located on the lower right side of the unit. It outputs standard S/PDIF digital audio signals over 75 ohm coaxial cable, such as RG-6/U. Output sample rates may range from 32kHz to 192kHz, depending upon operating mode.

#### 2.2.5 Miscellaneous (Battery Compartment)

The Battery Compartment is located on the left side of the unit below the External Power, Headphone/Line Output, and Auxiliary Input Jacks. It accepts four "AA" alkaline cells.

### 2.4 Operating Modes

There are three operating modes available with the AESQbox: In/Out (or Normal) mode, Pass-Thru mode, and Cable Test (or Loopback) mode. Each of these modes is described in detail in the following paragraphs.

#### 2.4.1 In/Out (Normal) Mode

In/Out, or Normal mode, is the mode that will most often be used, and is entered by placing the Mode Select switch in its center position. The internal digital receiver will lock to any received useable AES-3 or S/PDIF signals. The detected sample rate will be displayed and the Lock To Input indicator will also illuminate. The digital audio is decoded and presented to both the speaker and the Headphone/Line output jack. At the same time, whatever audio input source is selected will be converted to digital format and output from the digital output jacks. If a digital input signal is present and locked, the digital output sample rate will mimic the input sample rate, and the output sample rate switch has no effect. This feature allows a greater number of possible sample rates to be output while using a single crystal-controlled frequency source. If there is no digital input present, the output sample rate will be that selected by the sample rate select switch. In this mode, if an input signal is present but its sample rate cannot be determined, the Fault indicator will flash on and off at a rate of about once every  $\frac{1}{4}$  second.

#### 2.4.2 Pass-Thru Mode

Pass-Thru mode is used when it is desired to listen to a digital audio signal without interrupting its destination, essentially acting as a wiretap. The signal is input to the digital receiver, decoded, fed to both the digital-to-analog converter and the digital transmitter, and re-broadcast without passing through the analog domain. To use this mode, the mode switch is set to the rightmost position, the signal source cable is connected to one of the digital input connectors, and the signal destination cable is connected to one of the digital output connectors. If the input signal is not yet present, all the sample rate indicators will be off, and no digital output will be present. When the input signal is present, the appropriate sample rate indicator will illuminate as well as the Lock indicator, and the input signal will be present on the digital output connector. The input signal in analog format is available at the speaker and the headphone/line output jack. Any analog input sources are ignored, as well as the output sample rate select switch.

### 2.4.3 Cable Test (Loopback) Mode

Cable Test, or Loopback mode drives the digital output independently of the digital input. The selected audio input is driven out of the digital output at the sample rate selected by the sample rate select switch. If a cable is connected (either S/PDIF coax or an AES-3 XLR) between the inputs and outputs, the digital input will lock to the output, the Sample Rate indicators will display the detected sample rate, and the selected audio source will be heard over the speaker or the headphone/line output. A unique feature of this mode is that whatever digital input is received will be locked and presented as audio regardless of the output settings- but if the input and output sample rates do not match, the Fault indicator will flash on and off at a rate of about  $\frac{1}{4}$  second.

When using this mode as a cable test, three different sample rates may be selected: 48kHz, 96kHz, and 192kHz. To determine if the cable has high-frequency problems, select the highest sample rate. If the digital receiver is able to lock to the signal at the other end of the cable, chances are that the cable is good. If the cable has integrity problems, it could be that it may not lock at a rate of 192kHz, but may lock at a lower sample rate (this has been tried and verified in the lab).

Cable test also provides an excellent means of performing an end-to-end test of the AESQbox itself. Connecting a short cable between the input and output allows the operator to test the functionality of the microphone, tone generator, auxiliary input, speaker, headphone line output, sample rate select switch, speaker switch, audio input select switch, and the three level controls. Cable test mode can also allow the unit to serve as an analog audio amplifier for a weak line input signal.

## 2.5 Startup Sequence and Fault Modes

When initially powered on, the AESQbox runs through an initialization and diagnostic sequence. During this sequence, all the indicators under digital control (the sample rate indicators, Fault indicator and Lock indicator) will sequence on one at a time, then all will flash on and off twice. When this sequence is done, whatever mode happens to be selected at the time will be entered, and the AESQbox will then proceed to operate as detailed above.

The three analog indicators (power indicator and Clip indicators) do not participate in the sequence as above, since they are not under the control of the AESQbox microcontroller. The Power indicator follows the status of the Power switch, and the Clip indicators may flash on once briefly at power-on, but then follow the level of the audio input.

The AESQbox supports three types of fault annunciations. If the Fault indicator is steadily illuminated, a hardware fault has been detected. If the indicator flashes slowly (about a  $\frac{1}{4}$  second rate), it means either that the input sample rate cannot be determined (in Normal or Pass-Thru modes), or that the digital input sample rate does not match the output sample rate (in Cable Test mode). If the indicator flashes quickly (about a  $\frac{1}{8}$  second rate), it means that the digital input signal is a non-PCM format, and cannot be decoded as audio.