



**Glen Kropuenske**  
Application Engineer  
1.800.736.2673 or  
1.605.339.0100  
<mailto:ae@sencore.com>  
<http://www.sencore.com>

## Understanding Digital Audio Interface Standards/Connections

Digital audio dates back to the 1980s. Today three serial interface standards coexist. The AES3 and AES3-id standards are used for professional digital audio and the S/PDIF standard for consumer use. Passive conversion between interface formats is possible, but can lead to incompatibilities. A thorough understanding of these formats and differences can help you be prepared if you experience problems.

This article explains the different interface formats, connectors and level differences. It further shows you how to analyze the interface signal VPP levels and to accurately convert between interface formats with the Sencore DigiPro.

### Professional — AES3 or AES/EBU

The professional digital audio interface (AES3 or AES/EBU) was authored by the Audio Engineering Society/European Broadcasting Union, the two organizations that created the first two-channel digital audio serial interface standard in 1985. Issued as AES3-1985, it was revised several times and is now the AES3-1992 (r1997) AES Recommended Practice for Digital Audio Engineering - Serial transmission format for two-channel linearly represented digital audio data.

Other standards institutes produced standard documents describing the same serial digital audio interface including:

- American National Standard: ANSI S4.40- 1992
- International standard, issued as IEC 60958-4

### Professional AES-3id

Another standard which evolved in the professional world was the AES-3id (commonly with no hyphen: AES3id). The standard evolved around the broadcast industry's desire to transport digital audio longer distances than permitted by a balanced 110 ohm line defined in the AES3 standard. For longer distances over a high frequency transmission line, unbalanced coax is superior to balanced lines due to the higher capacitance of twisted pair cable. This prompted a special subset to the AES standard or AES3-id.

This standard is the same format as AES3 but instead of using a 110  $\Omega$  balanced line, it specifies a 75  $\Omega$  unbalanced line using BNC connectors.

## Consumer

Among consumer digital audio products we find an interface standard with the acronym S/PDIF or SPDIF (Sony/Philips Digital Interface Format). While the basic digital structure is the same as professional standards AES3 and AES3id, differences exist in the connector and line voltage levels compared to the professional standards.

Other standards describing the same signal include:

International standard: IEC 60958-3 (same as professional version but different dash #)

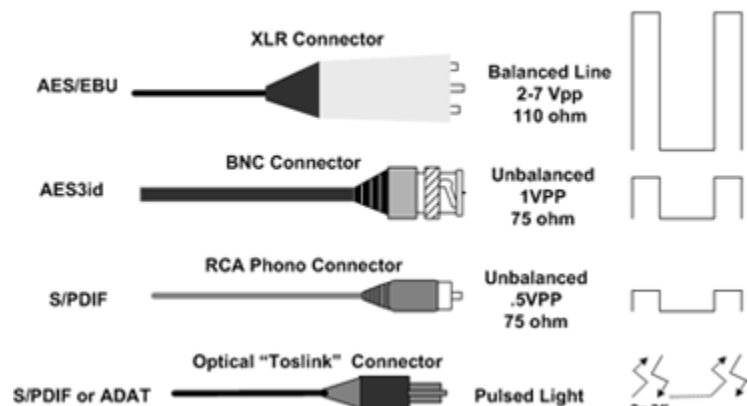
EIAJ (Electronic Industry Association Japan) standard: CP-1201 (renumbered CP-340).

*Side Note: Don't confuse S/PDIF with SDIF (no P). SDIF is an exclusive Sony digital system and is incompatible with S/PDIF.*

## Digital Audio Interface Connectors

The first thing you discover when working with digital audio signals is that the industry standard interfaces (AES3, AES3id or S/PDIF) each use different connectors. This makes it easy to recognize which interface standard is being used and what voltage levels should exist on that transmission line, but difficult when trying to interface between digital audio equipment.

### Digital Audio Interface Connectors/Level/Impedance



*Figure 1. Digital Audio Interface Connectors.*

The AES3 interface uses a balanced line of 110 ohms with XLR connectors on the cable. The transmission line voltage should range from 2-7VPP. An AES3id interface uses a 75 ohm coaxial cable with BNC connectors and a nominal transmission line voltage of 1 VPP. A SPDIF interface may use one of two possible connections. The two connectors used with a S/PDIF interface are the RCA coaxial connector and the optical (Toslink) connector.

	AES3	AES3id	S/PDIF
<b>Interface</b>	Balanced	Unbalanced	Unbalanced
<b>Connector</b>	XLR-3	BNC	RCA
<b>Impedance</b>	110 ohms	75 ohms	75 ohms
<b>Output Level</b>	2-7 Vp-p	1.0 Vp-p	0.5 Vp-p
<b>Max Output</b>	7 Vp-p	1.2 Vp-p	0.6 Vp-p
<b>Max Current</b>	64 mA	1.6 mA	8 mA
<b>Min Input</b>	0.2 V	0.32 V	0.2 V
<b>Cable</b>	STP4	Coax	Coax
<b>Max Distance</b>	100 m	1000 m	10 m

*Figure 2. The technical differences and specifications of the AES3, AES3id, and S/PDIF digital audio interfaces.*

## Converting Between Digital Audio Formats

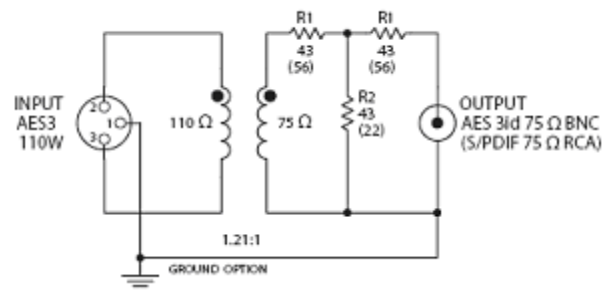
You can convert one digital audio electrical interface to another with a few passive parts. The passive components adapt the line VPP levels and impedances. You need to take caution to insure that the conversion, along with the transmission line or cable length, does not reduce the VPP transmission line level below a receiver's sensitivity, because loss of audio or intermittent locking can occur.

While passive adapters match levels and impedance, they do not alter the digital audio's channel status bit information. The bits in the channel status data tell which type of signal it is, professional (AES or AES3id) or consumer (S/PDIF) as well as further describing the digital audio signal's contents. Conversions set the stage for incompatibilities between the signal and digital audio equipment reliant on what's in the channel status bits. This is true even though a signal complies with its standard and even though other equipment seems to work OK with the same digital audio signal.

### AES3 to AES3id Passive Converter

A common conversion that is needed is between AES3 and AES3id. This can be accomplished with a transformer followed by a resistor attenuator circuit as shown in Figure 3. The transformer provides impedance matching, ground isolation, DC blocking, and short-circuit protection. A transformer with an appropriate turns ratio of 1.21:1 provides 110  $\Omega$  to 75  $\Omega$  impedance matching. A high frequency transformer to 12 MHz or more, designed for digital audio signals, is required to maintain the digital audio signal squarewave.

The resistor attenuator is a T-network with 75  $\Omega$ :75  $\Omega$  bi-directional attenuation. The transformer in combination with the attenuator reduces the average 4V on the AES line to approximately 1V output to feed AES3id inputs. If the resistor values in parentheses are used, the 4 V AES level is reduced to approximately 0.5 volts to feed a S/PDIF input.



*Figure 3. Circuit Diagram of AES3 to AES3id or S/PDIF converter.*

Several manufacturers have constructed digital audio AES3 to AES3id converters (similar to the circuit in Figure 3) and made them available so you don't have to construct the circuit yourself.

*Figure 4. AES3 to AES3id converter.*



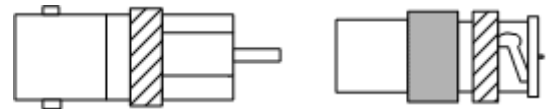
**CAUTION: These adapters can physically be connected backwards to seemingly adapt an AES3id (BNC) digital audio**

**to AES3 (XLR) digital audio. However, the resistive attenuator works the same because digital audio travels in either direction through the converter. Therefore, the AES3 output level is reduced well below the minimum 2V level. An adapter with only a transformer is recommended for this conversion.**

## AES3id to S/PDIF or S/PDIF to AES3id Conversion

These formats both are 75  $\Omega$ , so impedance matching is not necessary. All that is needed is to change the BNC connection to an RCA phono connection. In theory, for a proper level match, the line VPP on the AES3id (1V) should be reduced to the S/PDIF (0.5V) with a 6-dB pad (2:1 attenuator) to half the voltage. In most cases, the S/PDIF receiver easily tolerates the higher AES3id levels so this is not necessary.

You may feed a S/PDIF line into an AES3id input using a phono to BNC adapter since the impedance is the same. While the typical input level of 0.5V (S/PDIF) is marginal for an AES3id input (1V), receivers function properly down to their sensitivity level approaching 0.2V.



*Figure 5. Cable adapters to enable AES3id to S/PDIF or S/PDIF to AES3id conversions.*

**CAUTION: Do not use any resistor network or attenuator, such as using an AES3id to S/PDIF adapter/attenuator, as the S/PDIF signal is typically  $\frac{1}{2}$  of the normal level used with AES3id. Further attenuation would result in a severely reduced level.**

**Note:** AES3id is a professional interface format while S/PDIF is a consumer format. Differences in the Channel Status Bit coding can cause incompatibilities between digital audio equipment.

## Analyzing the VPP of any Digital Audio Interface Signal

The level or volts peak-to-peak of the digital signal on the transmission line is often reduced by improper output circuits, improper interface conversions, and long or defective cables. Reduced levels make it difficult for receivers to lock and maintain lock to the incoming digital signal. The Sencore DA795 Digital Audio Analyzer can measure the transmission line VPP levels of the digital audio signal to identify problems and help isolate causes.

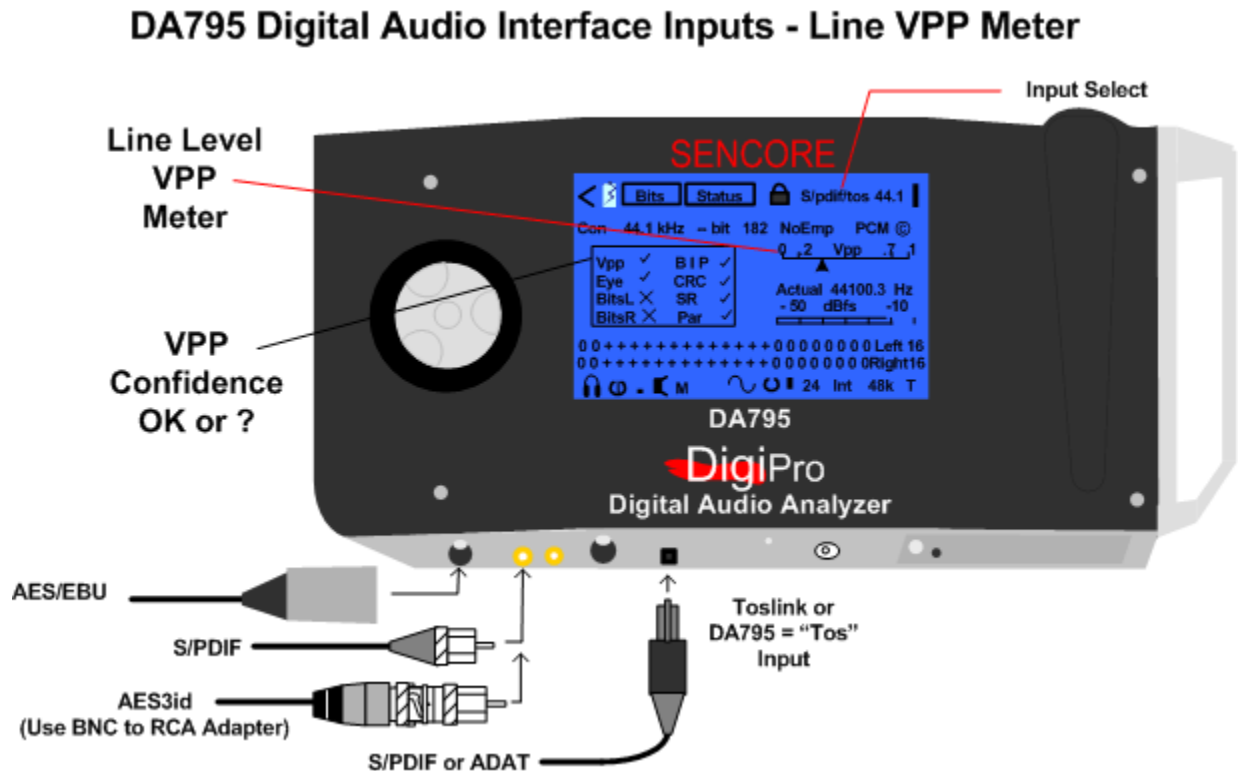
Measurement involves interfacing the different standard signals to the analyzer and selecting the input to be measured. The Sencore DA795 includes AES/EBU, S/PDIF and Toslink inputs. The AES3id standard is measured using the S/PDIF input through the use of a BNC to RCA phono adapter. The input signal is selected in the upper right field of the STATUS screen on the DA795 for measurement.

The Bitstream Analyzer VPP meter section of the STATUS display monitors the VPP level of the digital signal on the input selected. Two indicators are included on the STATUS screen of

the Bitstream Analyzer. The line scale is marked with an arrow indicating the VPP on the input. A VPP confidence indicator in the box at the left shows a check mark when the level is within the normal range and an X when the level is not normal.

When measuring an AES3id interface input, the DA795 uses the S/PDIF input and VPP measurement scale. A manual interpretation of the VPP level is required. The level should be near 1VPP or full scale

**Note:** The VPP meter is not active with the Toslink input since light is not voltage related.

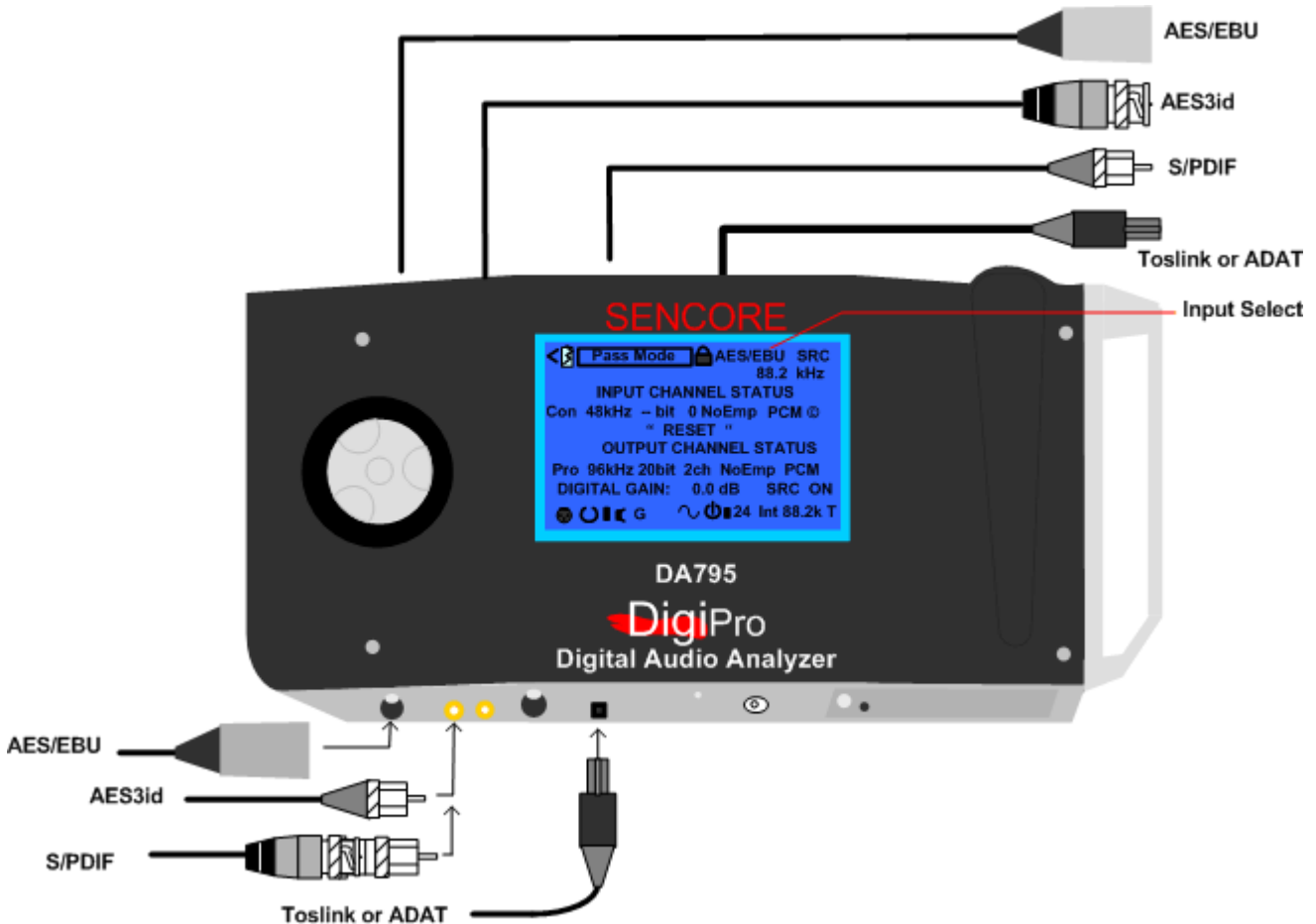


*Figure 6. The DigiPro selects and analyzes all signal interface formats. A VPP meter shows the digital signal level on the cable.*

## Changing Interface Formats with the DA795 PASS MODE.

The DA795 can serve as a signal interface converter when your output format does not match the needed input format. You can virtually change any of the input formats to any of the output formats (See figure 7). Convert AES/EBU, S/PDIF Coax and Toslink, or ADAT optical format digital audio streams to any other format.

When troubleshooting, use the pass mode converter to test the different digital audio inputs of the equipment. In emergencies when subbing for digital audio equipment with incompatible interface formats, use the DA795 to make the needed conversion.



*Figure 7. The Pass Mode function of the Sencore DA795 can change the digital audio signal interface format, audio sample rate, channel status bit information, digital audio level and improve jitter.*

The Sencore DigiPro can solve mysterious digital audio problems including those caused by interface problems. For additional information on digital audio and the Sencore DA795, visit the DA795 product page or call 1-800-736-2673.