

Word Clock Synchronization - Why and When You Need It

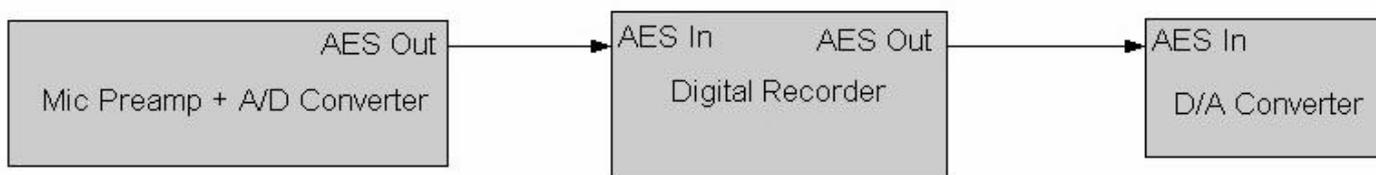
Produced by Transamerica Audio Group, Inc.
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Imagine a band with a drummer who can keep good time. The drummer sets the beat, everyone follows along, and they sound good. But suppose each band member has a metronome and listened to that rather than the drummer. Even if everyone set his metronome to the same tempo and tried to start it as soon as the drummer hits the first downbeat, human reaction times vary - they won't all click at the same time. Furthermore, the metronomes may not be perfectly calibrated or perfectly stable, so after a couple of minutes, they'll start to drift further apart. This will become one very sloppy band.

Like a band, all digital components need an accurate clock to keep the data stepping through at a constant rate. This is the Word Clock and nearly all devices have one built in. When two or more digital devices are interconnected, it's important that their clocks be synchronized. If the clocks get out of step, the receiver may lose or misread a bit, resulting in a click, noise, or muting.

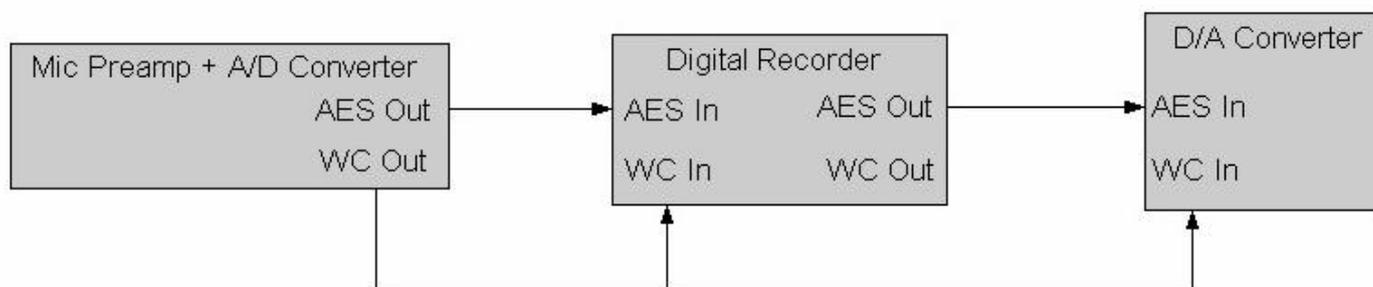
Simple systems consisting of two devices, for example a digital-to-analog (D/A) converter connected to the digital output of a DAW, can be self-synchronizing. The IEC and AES specifications for digital interfaces require that the receiver have the capability to synchronize its clock to an incoming data stream. There's usually a switch to select between the internal clock and the digital input. Set it properly and things will work fine. The Alesis ADAT™ optical interface ("lightpipe") specification has provisions for extracting the clock signal from the incoming data stream but it's not required and not all devices offer this feature.

But what if you have more than two digital devices connected together?



The recorder can synchronize its clock to the mic preamp and the D/A converter can sync to the recorder output. This will work for recording and playback, but since data out of the recorder may not be in sync with the data coming in due to internal processing delays, some problems may occur when monitoring the output of the D/A converter while recording.

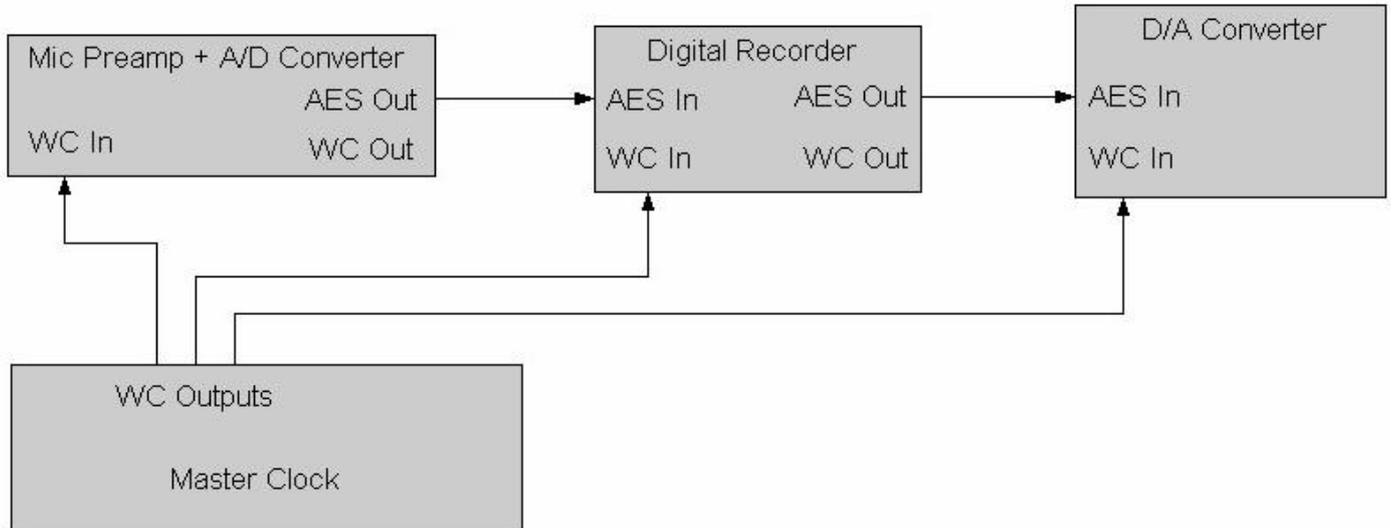
A better solution, if the appropriate word clock inputs and outputs are available, is to choose one device as the word clock master for the other devices.



In this configuration, the preamp's word clock output is connected to the word clock input of both the recorder and D/A converter. This keeps everything in sync, but there's a potential problem.

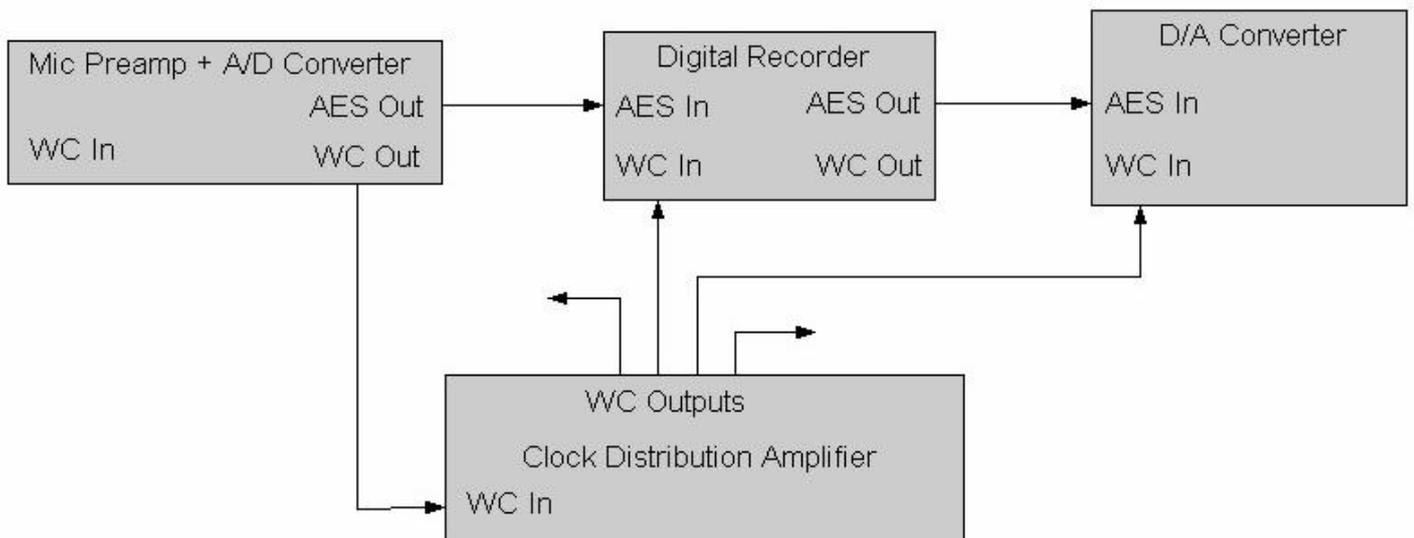
In order to preserve the waveform of the clock signal, it's important to terminate the word clock source with the proper impedance. Most word clock inputs have a built-in 75Ω terminator to correctly terminate a word clock output. However, connecting two terminated inputs to a single output doubles the termination load on the word clock master. This can change the shape of the clock waveform, and also reduces the amplitude of the clock signal, often to a level too low for the receiver to capture, resulting in a loss of synchronization. In this configuration, it's necessary to remove the termination on the recorder's word clock input – easy if there's a termination on/off switch, more difficult if an internal modification is required.

The best solution is to feed each device's word clock input from a separate output of a master word clock generator such as the Drawmer M-Clock series.



This assures that everything will be in accurate synchronization. The more devices that a system has, the more important it is to use a single clock source for everything.

An alternative is to use one of the devices as the word clock master, and use a word clock distribution amplifier such as the Drawmer D-Clock.



The distribution amplifier buffers the clock source and provides multiple outputs to the other devices in the system.

Which approach is best? It depends on the complexity of your system and the quality of your existing or planned components. Study the features and feel free to consult with our system experts for a recommendation.

Clock Accuracy

The more accurate the clock frequency is, the more accurate the sample rate, which in turn determines the accuracy of the pitch of the recorded or reproduced audio. Accuracy is usually expressed in parts per million. The Audio Engineering Society Standard AES11-2003, defines a Grade 1 clock as one with a long term accuracy of ± 1 PPM. The frequency of a Grade 1 clock at 44.1 kHz will fall between 44.0999559 and 44.1000441 kHz. At 96 kHz, ± 1 PPM represents a range of 95.999904 to 96.000096 kHz.

A Grade 1 clock is suitable for synchronizing a multi-studio facility but can also be used in stand-alone equipment. A Grade 2 clock has a long term accuracy of ± 10 PPM and is generally considered adequate for synchronizing equipment in a single-studio facility.

Will An External Clock Make My System Sound Better?

There is anecdotal evidence of this, and theory that predicts that it may be possible. People have installed an external word clock and have reported an apparent sonic improvement, generally described as more open and less harsh. This is surely a good thing, but how much difference, if any, that you'll observe with your own system is dependent on the quality of the clock in your existing equipment.

The improvement heard when using an external clock may be a result of a reduction in jitter. Jitter is a short term clock frequency variation which results in frequency modulation of the audio signal. The modulation causes sidebands which are not harmonically related to the original signal frequency and are therefore a form of distortion. What primarily determines the audibility of the effect of jitter is not the amplitude (that's limited to 1 PPM in a Grade 1 clock) but rather, the frequency spectrum of the jitter.

If the jitter is a result of a poorly filtered power supply, it will be predominantly 60 or 120 Hz, which will create sidebands 60 or 120 Hz away from the recorded frequency. If the jitter is 1 kHz, the resulting sidebands will be 1 kHz away from the recorded frequency, putting them in the range where the ear is most sensitive. If the jitter is 10 kHz, the sidebands will be quite out of audible range.

While the word "jitter" suggests randomness, most of it isn't random. There are specific things in the clock circuit design that cause it, and jitter can be minimized with proper design. In addition, techniques for shaping the jitter spectrum in ways similar to dither noise shaping can move the jitter sidebands into a range where they're less audible. In a perfect world, the clock designer knows the characteristics of the phase lock loop (PLL) frequency stabilization circuitry in the A/D or D/A converter and can optimize the jitter for minimal effect. In a high quality converter, the internal clocking system is designed for the most effective jitter suppression.

When introducing an external clock signal, the clock's jitter characteristics may improve the performance of the converter if it's a good match for the PLL, but because of the variations in design, there's no guarantee of this. For this reason, while no word clock manufacturer will deny that his clock makes a system sound better, synchronization is its primary purpose and better sound, if achieved, is a nice benefit. On the other hand, a well designed converter won't be degraded when synchronized to a good quality external clock.

When adding an external word clock to a system, you should listen critically to a wide range of material to determine the effect, if any, of the clock on each A/D and D/A converter. It may be advantageous, for example, to use the A/D converter's word clock as the system master when recording if that's how the converter sounds best. When mixing or mastering, the back end of the system might sound best with the external word clock.

Most word clock generators can also function as a distribution amplifier. By connecting the word clock output of the A/D converter to the master clock's external word clock input, with the press of a button, the A/D clock can become the master clock for the system without swapping cables for operations where this is the optimum configuration.