iFi iLink: USB>SPDIF converter

The iFi iLink Asynchronous USB-to-SPDIF converter/interface boasts the following specially-developed technologies:

1. Jitter Elimination Technology (JET®)
2. Dual-Level Outputs: Super® and Normal Digital Outputs
    - True-Balanced Drive
    - Transformer Coupled Outputs
    - Perfect Impedance Matching
3. Asynchronous USB to 24/192 kHz and beyond

Good things come to those who wait

High-Definition audio with low-jitter and exceptional sound quality from your PC is now a reality.

Yet those with a DAC which features only low-definition USB inputs or none at all need not feel left out. As long as they feature SPDIF inputs capable of high-definition audio, it is possible to enjoy the new high-definition audio formats.

This also goes for home theatre receivers which commonly feature an optical input.

Others have offered USB-to-SPDIF converters that offer High-Definition audio. At iFi we have not joined the rush to bring out some boxes for USB-to-SPDIF. Only now do we offer the iLink. We could have joined the clamor and produced another “me too” USB-to-SPDIF converter of generic real-world performance, but we choose not to.

To iFi, if something was worth doing at all, it was worth doing well and ideally, to the utmost. And our experience has been that while doing USB Audio at High-Definition audio rates is challenging and requires care and attention, transmitting High-Definition audio via SPDIF to most DAC's is altogether, more challenging.

The iLINK Solution – Benefitting from Trickle-Down AMR Technology

On the USB and software side of things, we use the proven Asynchronous USB solution as applied in the well-regarded iFi iDAC and its bigger brethren, the USD 5,000 AMR DP-777.

More info to be found here: http://amr-audio.co.uk/html/dp777_tech-papers_jitter.html

On the SPDIF side – we are bringing unique solutions and performance to the table. Again, based upon AMR's research into this area:

http://amr-audio.co.uk/html/dp777_tech-papers_spdif.html

192KHz/24Bit Full HD Audio USB Platform

CD audio operates with 44.1KHz sample rate and 16-Bit. This was considered adequate in the early 1980's.

In later years the limitations of the 1980's CD format were clearly recognised and since, formats with greater sampling rates and bit numbers have extended the fidelity of music recordings immeasurably.

Currently the highest standard that can be transmitted via SPDIF is 192KHz and 24Bit (we only consider formats that are international standards for music recordings).

This transmits over 6 times as much musical information as CD and nearly 30 times as much as the highest quality of MP3 and allows hitherto unknown levels of sound quality.

The iLink fully supports recordings up to 192KHz/24Bit and it allows the ultimate quality of the best modern recordings to be realised.

Let the iLINK unlock the full potential of your DAC.

In the next installment, the iLINK tech note 2 provides a detailed overview of each technological aspect making the iLINK such an atypical and high-performing USB>SPDIF converter.

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iLink – Talking Technologies

Jitter Elimination Technology (JET)

Many USB-to-SPDIF converters rely exclusively on the in-built SPDIF receiver's generic de-jitter circuitry which has virtually nil rejection of jitter at frequencies below 20KHz (this is also called baseband or audioband). Given this range is very much within the human audible range, this is quite a glaring weakness. Therefore, despite being fed a "perfect" signal, such a receiver is still capable of producing certain levels of jitter.

> For example, the Cirrus Logic CS8416 is capable of <50pS jitter at 96KHz sample rates, however this is only true if there is no jitter introduced by the music source (e.g. a computer or a CD transport) or in the actual SPDIF interface (cable, output etc.).
>
> If there is any jitter in the music source or interface at frequencies below 20KHz (in other words such jitter would be audible as it falls into the audible range), it is NOT filtered out at all, so the jitter from this receiver may be several nanoseconds(ns), for all we know, depending on the quality of the music source and SPDIF cable. The audible harshness is there for all to hear; edgy and harsh are two typical descriptors.

At iFi, this was simply not good enough. With only jitter in the upper frequencies suppressed, jitter in mid and lower frequencies remains free to do its worst.

The JET® technology in the iLink was developed based upon technologies suggested in 1972 by Matsushita et al in their paper "Jitter suppression by scrambling" (this long predates digital audio).

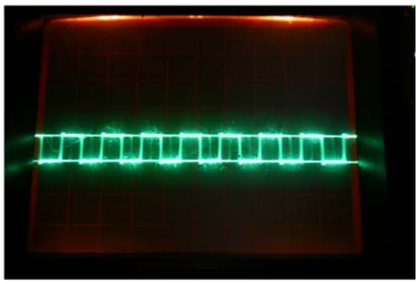
The JET® system shifts baseband (< 20KHz) jitter in the interface and receiver circuitry to much higher frequencies. To achieve this, one part of the complete circuit is the JET® System built into the iLINK, but the circuit is completed by the SPDIF cable and SPDIF Receiver. The SPDIF receiver's PLL acts as the actual jitter filter in conjunction with JET® system implemented in the iLink.

Thus the JET® enables the SPDIF receiver to operate at its optimum level of performance; *effective* jitter elimination *throughout the whole of the frequency range*.

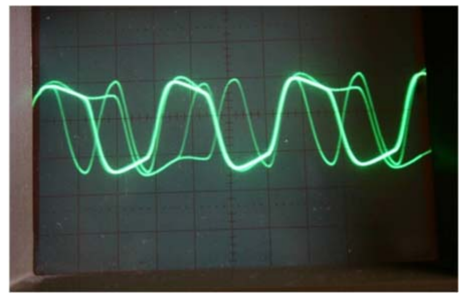
The Super Digital Output

There are a few "textbook" circuits for digital outputs that have been re-hashed by many designers that use a "cookie cutter" approach to design. These circuits usually work, in a fashion, yet many have significant drawbacks. The results they produce are far from those that should be observed with a high-grade SPDIF output:

A perfect SPDIF signal:

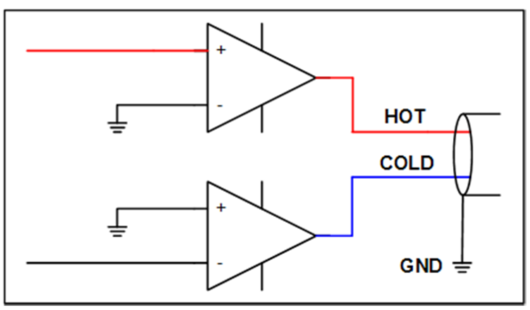


Common SPDIF signal from commercial USB-to-SPDIF converter:



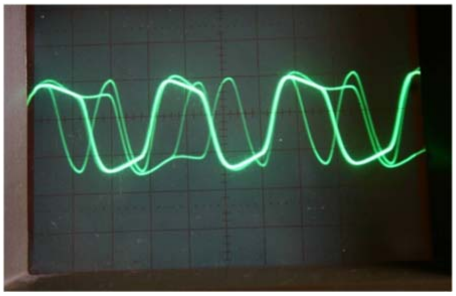
I. True Balanced Drive

First, loading the output of a logic circuit will cause signal-related noise on the power supplies, which cause jitter. The solution used in the iLink is to use True Balanced Drive. With True Balanced Drive, we remove the signal-dependent modulation of the power supply and jitter to the point of being totally eliminated.

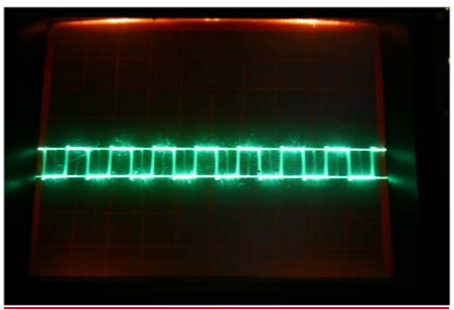


II. Transformer Coupled Outputs

Second, while it is common to use transformers to isolate digital signals, the usual cookie cutter circuits tend to severely restrict rise-time. Isolation is desirable to break ground loops and can prevent jitter as well, yet poor implementation will compromise signal integrity so severely that jitter is actually vastly increased, instead of reduced. Most transformer-coupled SPDIF outputs look like this, which is far from ideal:



The iLink does use transformers to isolate signals, yet it operates them rather unconventionally; in a way that produces a rapid rise-time from the transformers used yet leaves transformer-less outputs in the shade.



III. Inside and Out, Perfecting the Impedance Match

Thirdly, the SPDIF connection system was originally derived from video connection technology. Yes, SPDIF's roots lay in an analogue (not digital) transmission system.

As such it is a system based on matched characteristic impedances (75 Ohm) and failure to do so will introduce so-called reflections (think of them like ripples of the main wave reflected from the walls of a canal with a passing ship/boat) which can increase jitter.

Despite using RCA sockets (which technically speaking violate the 75 Ohm rule, we chose them because of their user-friendliness) yet we have still attained an excellent impedance match. Why? Because we designed and analysed the whole as opposed to just a section. This is achieved by carefully applying correct layout and design principles end-to-end. Few 75 Ohm BNC implementations we have come across in digital audio have been well-matched to 75 Ohm once inside the equipment.

Why no BNC connector?

There is no '75 Ohm BNC' magic. PCB traces that do not correctly match 75 Ohm or wires that do not correctly match 75 Ohm after the socket create a by far greater break in correct impedance matching, even though nominally, 75 Ohm BNC connectors are used.

By understanding the whole picture, rather than focusing on a single, specific factor, we are able to get far better performance by optimising the *whole* signal path. We minimise the break in correct impedance strictly to the actual connector that is in effect a few millimeter by placing correct termination direct BELOW the RCA socket, not several centimeters away, connected by poorly impedance matched wires or traces. Thus convenience and performance are both served best, even with the more ubiquitous RCA in the path.

Is there a way to measure impedance?

Yes, but not easily nor cheaply. We have come across 'technical' claims that when they see a product endowed with a BNC connector, it has 'good' impedance matching and vice versa. Further, they have attempted to measure this. Well, unless one can afford the US$20k for a Time Domain Reflectometer, one will struggle to accurately measure the impedance of a product. And no, a multimeter set to ohms will not measure impedance! (yes, this was suggested to us by a 'cable manufacturer').

Source: eetimes.com

The 'High' and 'Low' of Super Digital Output

At iFi, we like to 'research the heck out of the tech'. Rather than just taking the receiver at face value, we have rigorously analysed each and every facet of the technology and the components. For the latter, one can surmise that there are two distinct, 'high' and 'low' types of SPDIF receiver chips.

SUPER® Digital Output

The Highs – AKM, Cirrus Logic and others

Most (~90%) industry standard SPDIF receiver chips (e.g. AKM, Cirrus Logic) are designed for Pro-Audio use, i.e. AES/EBU receivers. As such, they require around 5V SPDIF signals for optimum operation. Even though these receivers do lock reliably at SPDIF levels of 0.5V, it is worth noting that lower level SPDIF signals increase jitter.

In other words, AKM/Cirrus Logic Chips are optimised for AES/EBU input (5V), and perform best with such higher-level signals. They handle Standard SPDIF (0.5V) lower-level signals rather less well.

The Lows – Wolfson Micro, older Philips and Pioneer

On the other hand, other receivers (~10%) are optimised for lower-level SPDIF signals (Wolfson Micro, older Philips & Pioneer) and need the best low-level SPDIF (0.3-1V) signal possible. Greater signal levels will overload the receivers and increase jitter. So for these receivers it is critical to get the level right.

Hence one ideally needs two distinct signal levels; depending on the receiver and implementation. Switching SPDIF levels directly on the output is possible, but would have been too much of a compromise as switches will severely compromise impedance matching at SPDIF frequencies.

For the iLink we use two distinct outputs instead, duplicating everything, the reclocking, the balanced output drive and the coupling transformers. Other than signal levels, both outputs are identical and of the maximum design quality we known to apply. To us, the extra cost was justified by the end sonics.

Getting the most from your iLink

It is hard to work out by looking at a DAC which receiver is used. It is best to try both level options and to select the one that provides better sound quality, neither output will cause damage. No changes to the DAC itself are required; simply connect one or the other output and listen: one will produce the best sound.

We recommend to keep the SPDIF cable after the iLink as short as possible (best <12" long) as with longer cables incorrect impedances can cause reflections of the signal in the cable that will cause additional jitter, though the design of the iLink minimises this to the very best of its ability.

Not all DAC's will benefit from JET® and in some rare cases high sample rates may not be able to lock if JET® is enabled. However for most mainstream SPDIF Receivers (especially the Cirrus Logic / AKM ones in standard implementations) JET® can offer a major improvement in sound quality.

Real world examples

Example I

So, for example, for a DAC that uses "datasheet" implementation of Cirrus Logic receivers (80% of the DACs out there) and RCA connections, the best configuration in our experience is:

- High-Level output;
- JET® enabled; and
- Shortest possible SPDIF cable "tail" (such as the one supplied with the iLink).

Example II

On the other hand, with something like the Mark Levinson #36 or the AMR DP-777 it is best to use:

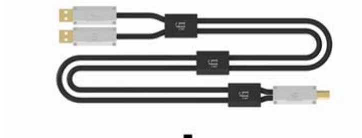
- Normal level output;
- JET® enabled;
- BNC input on the DAC;
- BNC cable with the supplied RCA to BNC adapter on the iLink.
- The cable length will be fairly uncritical, as long as the cable correctly implements the 75 Ohm required characteristic.

However it is always worth trying all options and selecting the configuration that works best in *your* system and with *your* actual DAC; the right selection for all features is the one that sounds best to *your* ears.

Ultimate Performance

iLink + iUSB Power + Gemini Dual-Headed USB cable

When operated as supplied, directly from the PC’s USB Port, the iLink offers exceptional levels of performance. Yet for an even more exalted performance than that offered by the iLink connected directly to your computer source, add the iFi iUSB Power which is quieter than batteries for a clean, pure USB power supply (sold separately).



For ultimate performance, complete the system by adding the iFi Gemini Dual-Headed USB cable (sold separately) between the iLink and iUSB Power. Thus removing the noise from the PC's USB port and eliminating the crosstalk between power lines and data in the USB cable. This configuration elevates the iLink's performance to even more sublime heights making just about unassailable.