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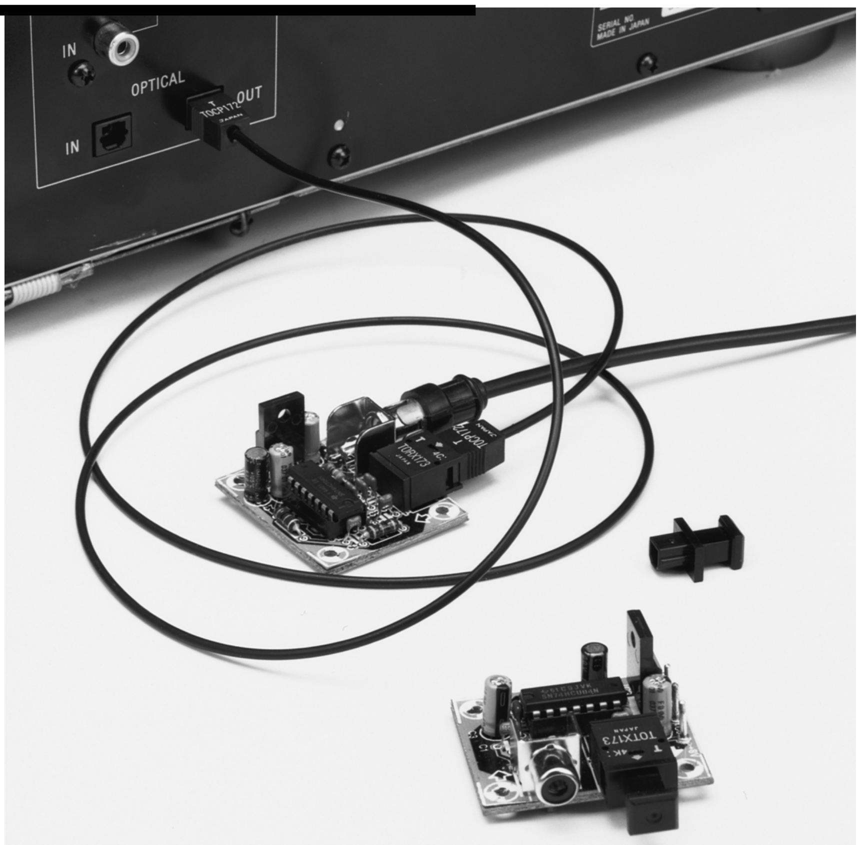
opto-to-coaxial audio converter

converts digital outputs

Most audio equipment produced in the past five to ten years has digital inputs and outputs. It is a pity, though, that there are two standards: optical and coaxial, and not all equipment has both. Fortunately, the connection difficulties that may ensue are easily resolved by the use of the adaptor described in this article. This enables any optical output to be converted into a coaxial one or vice versa.

Design by T. Giesberts



THE PROBLEM

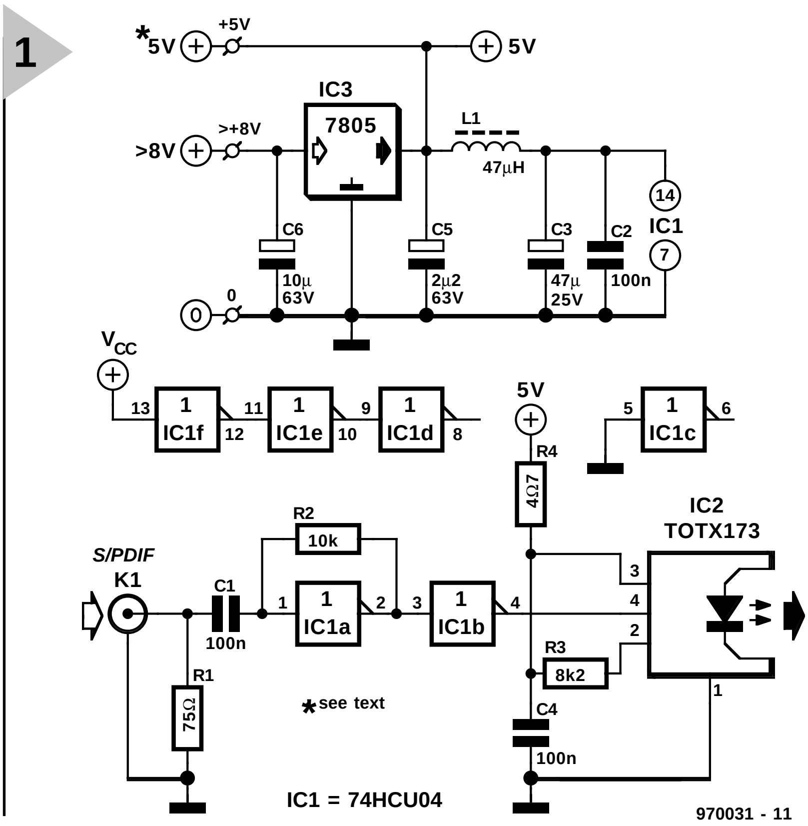
Connection difficulties are frequent phenomena in the audio world. In the beginning there was the DIN (Deutsche Industrie Normen = German Industrial Standards) standard. Within a very short time, there were a number of variants on this: a five-pole plug does not fit into a three-way socket; 180° plugs and 240° sockets are not compatible either. And let's not even talk about the seven-way plugs and four-way square DIN connectors. The result of this was a thriving market in adaptors.

After the DIN era, there came the phono socket era. Once this had established itself, there was a period of relatively calm – until the advent of 'personal audio'. On this small equipment there was no space to fit standard phono sockets for the line outputs and so the 3 mm mini jack was born. And again, an adaptor was required if such a Walkman™ or Discman™ had to be connected to another piece of audio equipment.

It seems that history will repeat itself in respect of the connectors on modern audio equipment. From day one it was the case that where exchange of digital signals took place, there were two standards: one working with electrical pulses and the other with light pulses. In itself, that is, of course, no problem as long as both types of connector are fitted on all audio equipment. And that is mani-

** S/PDIF = Sony/Philips Digital Interface Format – the consumer version of the AES/EBU standard. This standard was devised by the American Audio Engineering Society and the European Broadcasting Union to define the signal format, electrical characteristics and connectors to be used for digital interfaces between professional audio products.*

Figure 1. A coaxial-to-optical converter basically needs only an amplifier, a buffer and a Toslink™ sender.



festly not happening. It is true that there is equipment on the market that has both, but the majority has not.

THE SOLUTION

Two converters are described that remedy the connection problem. They are easy to build and put paid to any interface problem between digital inputs and outputs.

One of the designs converts electrical signals into optical ones and the other does exactly the opposite. Both designs are based on the well-known Toslink™ modules. These compact converters may be built into the relevant audio equipment or they may be constructed as stand-alone units.

If the converter is built into the audio equipment, its power may be derived from that equipment. If used as stand-alone unit, the unit derives power from a mains adaptor.

FROM COAX TO OPTO

The circuit of the electrical-to-optical converter (EOC) is shown in the diagram of **Figure 1**. It is a straightforward design.

The S/PDIF* signal input to K_1 has a peak-to-peak value of about 0.5 V and is applied across 75 Ω terminating resistor R_1. This signal is amplified first by IC_{1a} and then by IC_{1b}, whereupon it has a peak-to-peak value of 5 V (HC level). The design of the amplifiers prevents any clipping taking place.

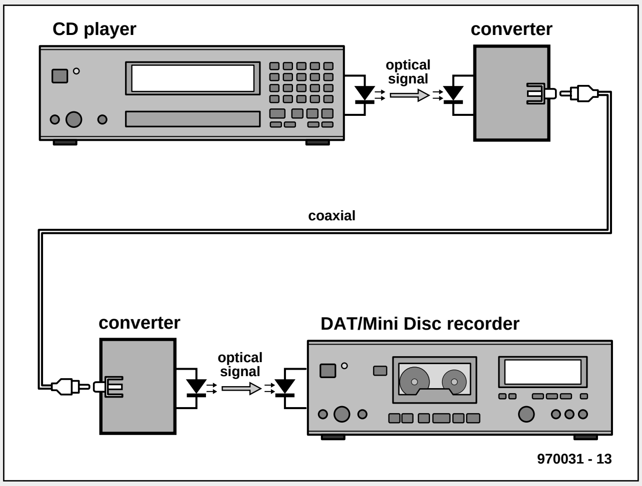
The supply to IC_{1a} is ½V_{cc} because of resistor R_2. Any input offset is blocked by C_1. This capacitor also prevents the operating point of IC_{1a} being affected by R_1.

The output of IC_{2b} is applied to IC_2, a Toslink™ sender, in which the actual conversion from electrical to optical signal takes place.

The circuit is powered by a supply line that is regulated by IC_3. Choke L_1, resistor R_4 and capacitors C_2–C_4 ensure adequate decoupling of the supply line. More about the supply later.

Long(ish) optical link

The converters described in this article may also be used for another purpose that has nothing to do with connection problems. It is a known fact that optical links suffer from a slight drawback: in practical use their length is very limited. This means that when it is desired to link two units that have only optical connectors over a distance of a few metres (10 feet or so) there is a little problem. However, the use of two converters makes the link possible. To do this, connect a converter to each of the two audio units via a short optical cable and link the converters via a standard, screened coaxial cable (see illustration). It may seem rather a long way around the problem, but it works well.



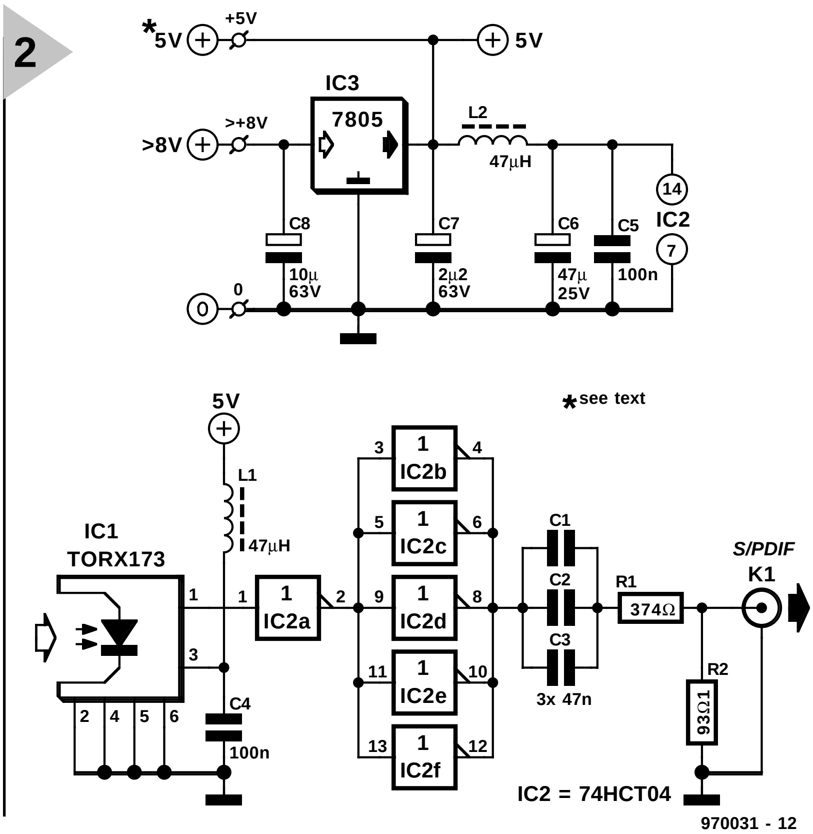


Figure 2. An optical-to-coaxial converter needs a Toslink™ receiver and not much more. A potential divider ensures the correct level of the output signal and the value of the output impedance.

Parts list

COAX-TO-OPTO CONVERTER

Resistors:
R_1 = 75 Ω
R_2 = 10 kΩ
R_3 = 8.2 kΩ
R_4 = 4.7 Ω

Capacitors:
C_1, C_2, C_4 = 100 nF ceramic, pitch 5 mm
C_3 = 47 µF, 25 V, radial
C_5 = 2.2 µF, 63 V, radial
C_6 = 10 µF, 63 V, radial

Integrated circuits:
IC_1 = 74HCU04
IC_2 = TOTX173 (Toshiba)
IC_3 = 7805

Miscellaneous:
L_1 = 47 µH (standard available)
K_1 = audio connector for board mounting
PCB Order no. 970031 (see Readers' services towards end of this issue)

OPTO-TO-COAX CONVERTER

Resistors:
R_1 = 374 Ω, 1%
R_2 = 93.1 Ω, 1%

Capacitors:
C_1–C_3 = 47 nF, ceramic, pitch 5 mm
C_4, C_5 = 100 nF, ceramic, pitch 5 mm
C_6 = 47 µF, 25 V, radial
C_7 = 2.2 µF, 63 V, radial
C_8 = 10 µF, 63 V, radial

Integrated circuits:
IC_1 = TORX173 (Toshiba)
IC_2 = 74HCT04
IC_3 = 7805

Miscellaneous:
L_1, L_2 = 47 µH (standard available)
K_1 = audio connector for board mounting
PCB Order no. 970031 (see Readers' services towards end of this issue

FROM OPTO TO COAX

The circuit of the optical-to-electrical converter (OEC) is shown in the diagram of **Figure 2**. Like its sister circuit, it is a straightforward design.

The input signal is applied to IC_1, a Toslink™ receiver. Provided that the level of the optical signal is sufficient, the output of IC_1 is at TTL level (low = 0.5 V high = 3 V). This means that amplification is not necessary in this circuit, so that IC_1 is followed by buffer IC_{2a}. The five remaining inverters in IC_2 are paralleled to function as the output stage. The output signal is applied to K_1 via coupling capacitors C_1–C_3 and potential divider R_1-R_2.

The potential divider has two meet two criteria. The first is that, provided the output is correctly terminated into 75 Ω, the output voltage level does not exceed 0.5 V. The second is that the output impedance must be 75 Ω to prevent any mismatch. Consequently, the values of the two resistors are fairly low and this means that the output stage has to provide a relatively large current. This, in turn, is the reason that the five inverters in IC_2 are connected in parallel.

Asymmetric loading of the output stage is prevented by a.c. coupling.

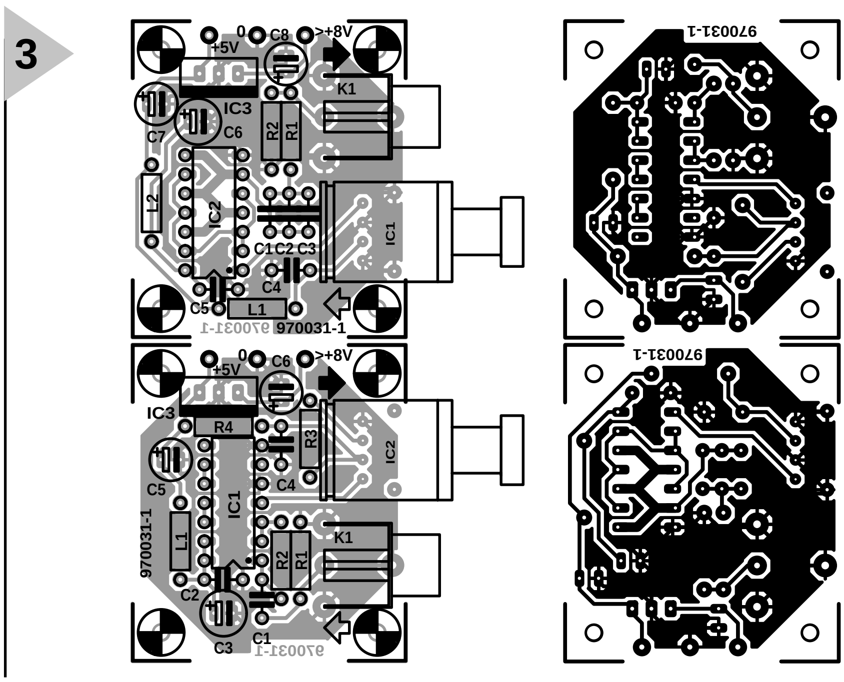


Figure 3. The printed-circuit boards for the two converters are manufactured as one.

This is effected by three capacitors connected in parallel so as to reduce the series resistance.

The power line is decoupled by chokes L_1 and L_2 and capacitors C_4–C_6.

POWER SUPPLY

As mentioned earlier, power may be derived from the relevant audio equipment into which the converters may be built, but it may also be provided by a discrete unit.

It is, of course, better to use a discrete power supply, since it being derived from the audio unit may give rise to hum and earth loops. In that case, it may even be necessary to use an output transformer to keep the various earths separated.

A discrete power supply is simply obtained from a mains adaptor whose output may be 8–35 V. Since the converters already have a regulator on board, and they draw a current of only a few milliamperes, the demands on the adaptor are small.

If the two converters are fitted in one and the same case, just one mains adaptor will do, otherwise each will need its own, of course. If only one mains adaptor is used, the regulator may be omitted from one of the boards and the +5 V and 0 terminals on the two boards interlinked. Again, take care that earth loops do not arise.

CONSTRUCTION

The converters are best built on the printed-circuit board shown in **Figure 3**. Note that this needs to be cut into two before any work is done.

Completing the boards is straightforward provided the usual sequence is followed: start with the resistors and capacitors, followed by the chokes and integrated circuits. Do not use sockets for the ICs. The Toslink™ modules and audio connectors may be soldered directly to the board.

When the board has been completed give it a good going-over to check that all connections are good, that the polarity of capacitors has been observed and that the ICs are fitted correctly. Note that the heat-conducting side of IC_3 is indicated by a small white square. **Figure 4** shows the completed prototype.

The enclosure(s) used depend on the application of the converters. If they are used permanently for one purpose only, the quality of the enclosure is not very important. If they are used for many purposes, a rather more robust case is necessary.

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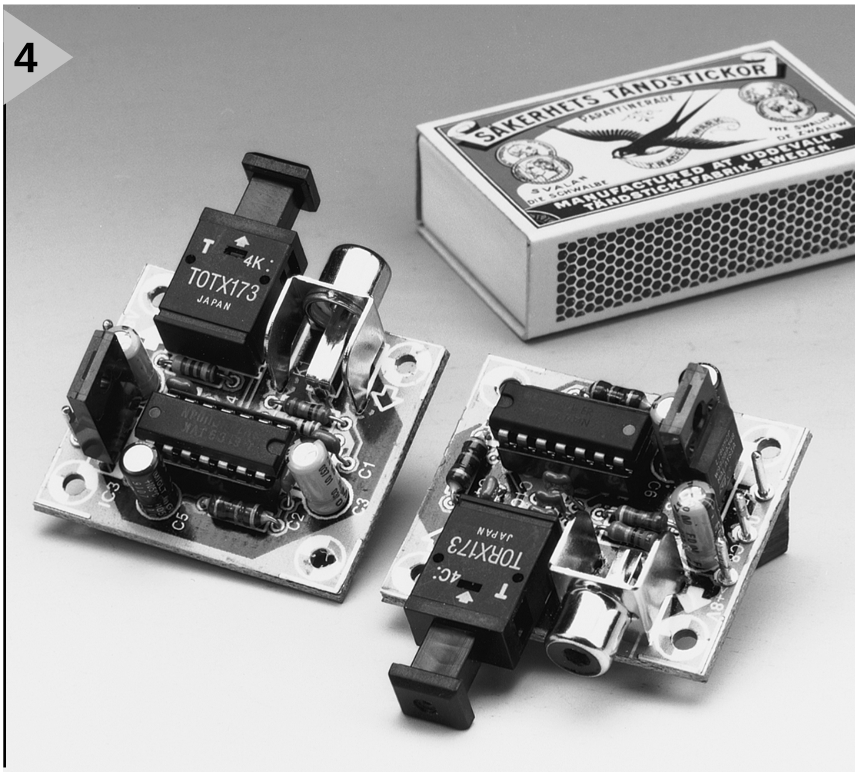

Figure 4. Completed prototype boards.

In passing ...

Since the late 1970s, many new consumer technologies have promised (threatened?) to transform our lives. Yet, the only really successful one has been that of the compact disk – CD – introduced by Sony and Philips in 1982; most of the other designer dreams have not come true. Why? There are several reasons: the new technology may not have filled a market need; or it may not have delivered what it promised; or maybe it was just too expensive.

Venture capitalists, of which the USA has many, but Europe, alas, has hardly any, have a rule of thumb, known as the ×10 rule, which helps them decide which new technology to back. Basically, the rule makes them ask themselves the question: "Will the consumer think the new device or equipment is so much better (ten times) than what it is replacing that it justifies the change?"

In retrospect it seems, therefore, that digital audio tape (DAT), introduced by Sony and Philips in 1987, in spite of its advantages over both the CD and standard audio cassettes, did not pass the rule. It is now only found in specialist niches. Production has been discontinued.

Then, in 1992, Philips introduced the digital compact cassette (DCC) and Sony the mini disc. The DCC has been a total flop and the mini disc is today only moderately successful in Japan (although Sony is still promoting it hard in Europe).

Another memorable flop is the videophone, first demonstrated in the USA in the 1960s: production models did not appear until the late 1980s (in Japan). By 1990, fewer than 100,000 had been sold world-wide; it is no longer in production anywhere. Perhaps it will be revived when the telephone and computer will begin to work together efficiently (which they do not as yet).

Robots, at least the general-purpose type, have disappointed, too. They have not taken over the routine chores of our lives as was promised (foreseen by many) all those years ago. Unlike the DAT and DCC, however, they will be reborn, but not until well into the 21st century.

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