Cloning an ICOM OPC-172 Cable

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I've worked with the IC-901 radios and the IC-900 band modules for many years, but have not actually owned an IC-901 until recently. They are unique radios that feature expandable frequency coverage by way of add-on band modules. In the version that was generally available in the US, there are 6 add-on modules. The result of a full compliment of these modules is FM coverage on 10m, 6m, 220, 440, 1296, a pseudo-general coverage receiver, and CW/SSM/FM coverage on 2m.

Another feature that is unique is a remote-control head which has an optical fiber connection (required for the IC-900, optional for the IC-901). The EX-766 (which consists of a base and a remote module) is a 2-box accessory for the IC-901 that allows the control head, microphone, and speaker to be remote located – only the optical cable, ICOM part# OPC-172 (5m) or OPC-189 (20m), is needed to connect between the remote radio location and the operator control point. This allows the bulk of the radio to be mounted up to 65 feet from the remote controller, with no galvanic connections between the two (the remote controller needs a power supply of course, but it does not need to be referenced to the base-unit's power supply). Cool stuff.

What is really amazing is that this radio model was first introduced in the 1980's, making it an antique by some standards. Yet, it still has features that are difficult (if not impossible) to find in more modern radios. The radio and its accessories are still sought after by folks who know the model decades after being discontinued.

FO Cables Gone Wrong

The fiber-optic system designed by ICOM is relatively simple, and fairly robust in that it works, and they were able to accomplish the interface with proprietary circuits, which kept costs reasonable (for ICOM, at least). Unfortunately, they used proprietary circuits, cables, and connectors which meant that there is only one source for these items should repairs be required. Now that the IC-901 is long since discontinued, there is no hope at all of getting any of these proprietary components from the manufacturer.

In the case of the ICOM Fiber-Optic Interface, the OPC-172/189 cables form the weakest part of the system. These cables are fragile, and feature connectors that are profoundly proprietary. Good cables are invariably found connected to a working system, so if you need a cable, you have to find someone with an EX-766 or IC-900 that is willing to part with it for less than the GDP of most states. THEN, you end up orphaning the rest of an otherwise working system. Keeping the remaining electronics as spares is only of limited value, since the part that nearly always fails is the optical cable. So, the option of finding a spare optical cable is not a very realistic option.

The fragility of these cables is matched by the need for robustness in the environments that they would typically be installed within. Mostly intended for automobile installations (where RFI can be a difficult problem to solve due to the many looping constructs that can result from the close quarters between radio, operator, and antenna) the unprotected cable is ill-suited for such an environment. It features a relatively thin, plastic jacket, and has no flex-mitigation countermeasures. Without careful routing and protection against sharp edges (both of which abound in most vehicles) the optical cables will easily be degraded to the point of failure if not installed with great care.

As previously mentioned, the ICOM fiber-optic connectors are proprietary (see Figure 1), so you can't remove one, then snake the cable through a protective conduit and install a new connector because new connectors just aren't available. Splicing the fibers is "possible", but tricky and not a likely path to success. Thus, if a "conduit" protection scheme is desired, the ID of the conduit must be greater than the max OD of the optical connector. While rather small, these connectors are still about 0.6" wide, which makes for a very large conduit to protect a cable that is only about 0.17" wide. Thus, it is not likely that there are many installations where such a protection scheme might be practical.

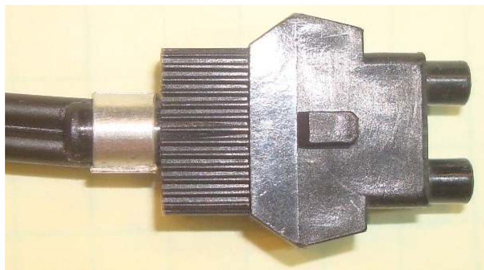


Figure 1. The ICOM fiber-optic cable connector

Then there are the cases where the optical cable is simply lost or forgotten. It is easy for me to imagine that someone who is selling a car with the IC-901 installed, may just rip out the radio, and leave the cables behind (they're just cables...easily replaced, right?). Then, later, they discover that the optical cables are not easily replaced, and the EX-766 becomes defunct for the lack of a flimsy piece of jacketed plastic.

Whatever happened with the optical cable for the first EX-766 that I obtained, it was long gone by the time I came into possession of the system. It had all of the pieces one might need, except the optical cable. After a protracted search, examining the mating connector on the interface units and the connectors of a myriad of available fiber-optic connectors, I concluded that the ICOM connector was profoundly proprietary. Nothing really even came close in the off-the shelf offerings.

I considered my options: try to build a cable connector that will mate to the optical transceiver connector, or bypass the fiber-optic transceivers with copper-based ones. The ICOM system uses a duplex fiber with one light-path direction for each fiber (one fiber sends data to the remote, and the other receives data from the remote). The transceiver modules have one TX and one RX, so a twisted pair driver/receiver at each end should be able to transfer the data that was intended for optical transmission. The thought of trying to duplicate an optical connector with none handy to examine made me realize that this task was destined for many cut-and-try iterations – this made the twisted pair option seem preferable.

The twisted-pair idea had great appeal because the speeds involved are in the Mb/s range (not 10's or 100's of Mb/s) so the speed isn't a huge concern and there are a lot of different line-driver options that would support up to hundreds of feet of transmission capability at these speeds (I didn't foresee needing that, but it is nice to have overkill) and CAT-5 cable is plentiful and relatively cheap. I just needed the time to pull it together.

Fast-forward a couple of years. I never got around to attempting a twisted pair solution. However, I obtained a second IC-901 with yet another EX-766. This time, the stars aligned in a way that is a rarity for me. The newly acquired EX-766 came with not one, but TWO optical cables. One was the OPC-172, which is the standard, 5m cable, and the other was the OPC-189, the 20m “monster” cable that ICOM offered as an accessory. I no longer needed to worry about engineering a twisted pair transceiving system, I could now remote mount the base radio in my attic (or, actually, my upstairs closet) and have the control head and mic downstairs in my office all using the original ICOM cabling. Plus, I had an extra cable. That is, until I decided to put the other IC-901 in my car.

A Simple Problem

I like the IC-901, in spite of its shortcomings - and there are a few: The control head operation is archaic, the base unit is a bear to troubleshoot, and with several modules and the EX-766 all attached, the stack-up is mechanically tedious to manage (although it **is** one sturdy radio). One of the quirks that can be irritating is that you can’t switch between optical interface and wired interface without removing the front cover of the IC-901 base unit. If you only need to work on the modules, this is an added complication that takes a considerable effort in disassembly (then re-assembly) to address. So for an IC-901 with the EX-766, it would be helpful to have a spare optical cable so that the system can be relocated to a workbench for service without having to reconfigure the radio. I suddenly felt the pain of being “fresh out” of OPC-172/189 cables. For those with an IC-900, there is no “wired” option. It is optical cable or nothing.

This brought me back to the original conundrum of needing to conjure an OPC-172 cable from essentially nothing. Only this time, I had an original article to provide important details needed to produce a copy of that funky, proprietary, ICOM optical cable – I had SOMETHING. I also had something else – something just as good: a friend with a 3D printer. Some free advice: if you have a friend with a 3D printer, make sure that they REMAIN friends with you.

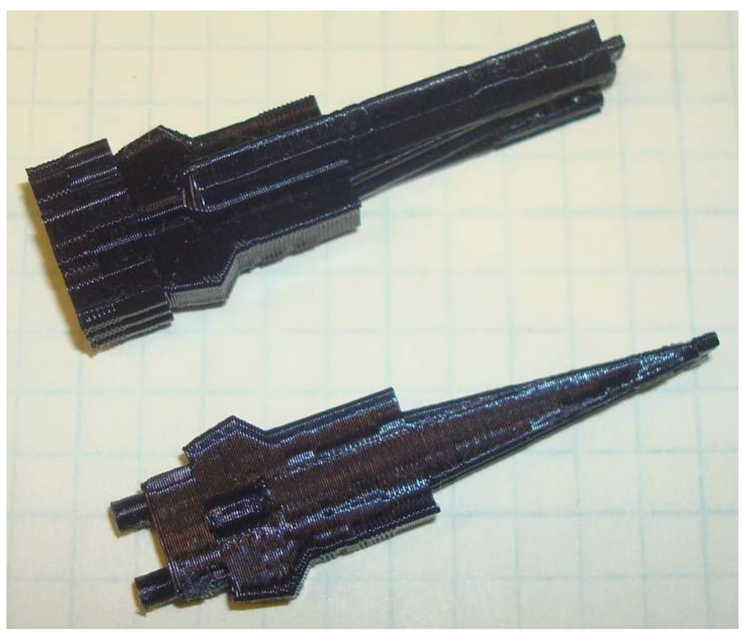


Figure 2. 3D printed “clone” of the ICOM optical connector. At top: the housing with printed support structures. At bottom: the housing after clean-up.

After some hand-sketches and a flurry of e-mails, my friend had produced a CAD drawing that I was happy with. He then set out to transfer this to the 3D printer. After a few hours of printing, the part of Figure 2 emerged. This particular print platform can print vertical holes, but its precision in diameter is typically wanting. Thus, I had to chase-out the holes that were intended for the fiber and the jacket (no big deal, really, but a bit of care was required). Some support structure removal and general clean-up were also needed. However, in short order, I was able to mate the off-the-shelf optical cable that I had purchased to the brand new connector housing. Oh, yes, and it also fit the mating EX-766 optical connector (this is kind of important as well).

I had to search a bit for optical cable. The ICOM cable uses a relatively large-bore fiber. I haven't cut into one yet, so I am not sure of the dimensions. It appears that the terminated ends are flared somewhat (likely by a thermal process) but it is difficult to tell without destructive forensics. However, I found a Broadcom offering that featured a 0.04" diameter fiber. In quantity, the duplex cables are less than $2/m, but I didn't want to invest in 100m of cable. So, I got one of their terminated cables (and simply discarded the un-needed terminations) that was 5m long. This was a cost of just under $4/m (about double the bulk price) but overall, less than $20. The optical targets are typical LED form-factors (something like T-1) with a built-in lens. If the fiber is aligned reasonably close to the target, it should work adequately.

After determining that the optical transceiver modules were identical between the base and remote unit, I was then able to determine that the connection needed to be a crossover cable. Thus, the fibers needed to swap places between the cable ends. A bright lamp is all that was needed to identify the fibers and make sure they were inserted into the correct openings. Some lacing cord, a bit of clear epoxy, and some trimming and polishing finished the job. There is likely an approved "optical-grade" epoxy that is generally recommended for FO termination, but for this application, I don't expect that to be an issue. There are also official "polishing kits" but I just used 2000 grit sandpaper and got adequate results.

Since I was applying the connectors to the fiber-optic cable, I could use a protective conduit that was of a more reasonable size than what would normally be required. Thus, I was able to use some ¼" air-hose for the task. This will protect the optical cable from scuffing and cutting and will also help maintain the minimum bend-radius of the optical cable as it snakes through the car installation.

The Same, But BETTER

Comparing figures 1 and 2 it is easy to see that the 3D printed housing is rather different than the original ICOM version. The portion of the connector that mates to the optical transceiver is basically identical, but the cable end of the housing is extended and has a considerable "tail". Since I don't have any crimp tools or materials for fiber-optic cables, I opted to modify the original strain relief design to accommodate the materials and techniques that I have available: lacing cord. The taper of the tail allows the duplex fibers to gradually converge, and the rubber-like consistency of the fiber jacket allows the lacing cord to grip quite well. Figure 3 illustrates the final configuration with a portion of the air hose "conduit" shown.

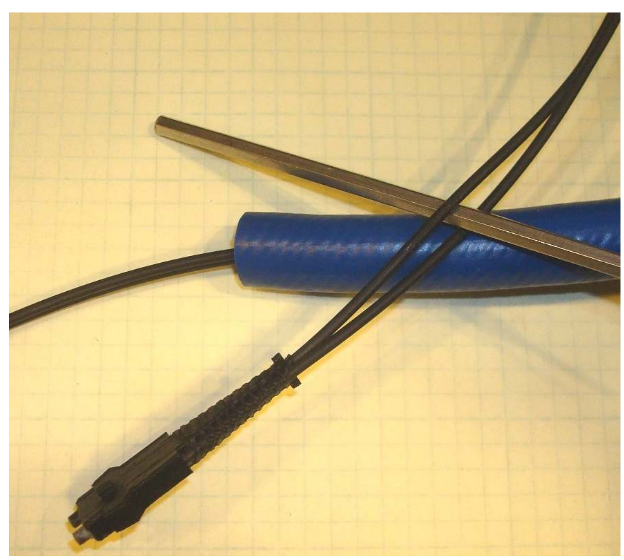
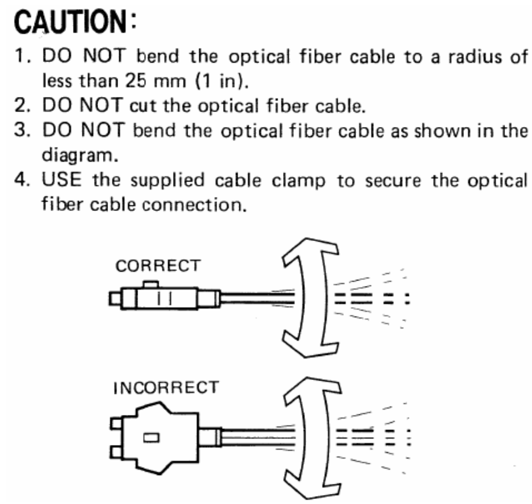


Figure 3. 3D housing mated to the FO cable and air-hose protective "conduit".

Figure 3 also illustrates an embellishment that I wish I could take credit for, but must admit that this is how the Broadcom cable was supplied. As can be seen in the photo, the fibers are separated for about 3” from the end of the housing. At first I thought it to be rather “ratty” to have the fibers separated in this way, but after thinking about it for a moment, the genius of the separated fibers was suddenly obvious - it represents an important improvement over the termination method employed by the original ICOM cable. The side-to side motion described in Figure 4 as “Incorrect” is not desirable for the original ICOM cable because this movement exerts powerful tension and compression forces on the optical fibers (they are joined together all the way to the housing on the original ICOM cables) and can cause the fibers to fracture quickly if such forces are exerted over just a relatively small number of iterations.


CAUTION:

1. DO NOT bend the optical fiber cable to a radius of less than 25 mm (1 in).
2. DO NOT cut the optical fiber cable.
3. DO NOT bend the optical fiber cable as shown in the diagram.
4. USE the supplied cable clamp to secure the optical fiber cable connection.

Figure 4. Excerpt from IC-901 operating manual regarding optical cable handling.

However, by slitting the duplex jacket so that the fibers are separated for 3 or 4 inches from the connector housing, there is no longer a side-to-side motion to be concerned about – the fibers simply behave as separate entities near the housing interface. This is actually an idea that can be employed with the original ICOM optical cables providing that it is done carefully.

Problem SOLVED

The most astounding result of all this is that the resulting cable actually works. I now have a way to produce new replacement cables for the optical connection between my radios and have the freedom to cut-to-length, provide over-jacket protection, or any of the other things we take for granted when we route “wires” using connectors that are readily available. All that it cost was about $19 for a 5m fiber-optic cable, and lunch for my friend with the 3D printer.

I wish to acknowledge the contributions of Brent Hatcher for his time and effort at the helm of his 3D printer. Happy lunch!

References

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