OLED remote ATU display

N7DDC 100 7x7 OLED display ATU with remote control and display

One of our pet concerns is the use in the shack of what is commonly known as an Antenna Tuning Unit (ATU), (perhaps more correctly known as an Antenna Matching Unit (AMU)), rather than close to the antenna. We will use the usual abbreviation ATU in this article. In the days when an open wire feeder was much more prevalent, it made some sense to have the two wires entering the shack for connection to some form of ATU. These days with most antenna systems fed by coax, the best place for an AMU/ATU must surely be at the junction of the coax feed and the antenna itself. If, as is becoming common with many modern rigs having built-in ATUs, the ATU feeds the coax, then that coax itself also becomes part of the antenna system – which is not ideal in most situations. There is also likely to be more RF 'floating about' in the shack with an ATU close by.

The project described here takes an easily available auto-ATU (the N7DDC design **[1]**) and controls it remotely via simple interfaces. An advantage of the N7DDC design is that as standard, the internal firmware includes I²C display driving functions, giving much useful information about the state of the ATU tuning process. Normally, the connections between the ATU itself and its display should be kept quite short (in the order of a few tens of centimetres). This project includes robust line-driving of the display control signals such that the display can be driven effectively at much greater distances, theoretically perhaps up to hundreds of metres! The coax loss at such cable lengths, however, would probably preclude its use at those distances.

The concept

This article describes how to remotely control, at some distance, the N7DDC ATU from an Icom HF transceiver such as the IC-706MKIIG, IC-7400, IC-718, IC-756, IC-756PROII, IC-7000, IC-7100, IC-7300, IC-7610 and IC-9100, to mention just a few. Other makes may also be possible.

As mentioned earlier, the best place for any ATU is at the antenna end of the transmission line. 'Built in' ATUs or units that sit close to the transceiver rarely fall into that category, which means that they will not only tune the antenna but also the transmission line as well, resulting in loss of efficiency and quite often causing other problems in the shack. Over the years many antenna designs have appeared in *RadCom* and elsewhere featuring wire antennas of one description or another, all attempting to cover as many of the HF bands as possible.

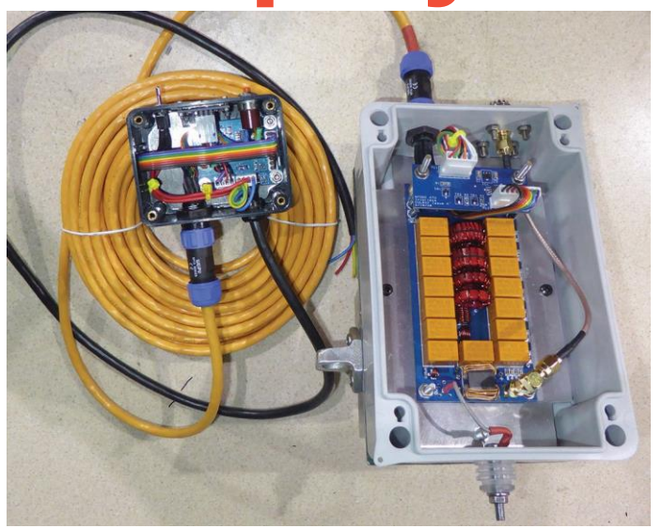

PHOTO 1: **General view of the completed indoor (left) and outdoor (right) units and interconnecting cable.**

At the very least, some sort of balun is used and quite often other matching devices are also employed. Usually, an ATU either in the rig or in the shack will be needed to cover all frequencies to reach maximum usefulness. The problem at the G4CXJ QTH is that the garden is small, permitting only a short end-fed wire with counterpoise and, originally, a 9:1 unun and a few metres of coax carrying the signals back to the shack. Optimising this arrangement, wire length and counterpoise, even with a good SWR meter, proved unsatisfactory as, simply, the internal Icom IC-7300 ATU would not tune Top Band or 80m and was also unhappy on other bands. The project here describes a method of tuning HF antennas (the above long wire for instance) with a remote ATU, dispensing with baluns and other tuning arrangements, thus promoting simplicity.

Bryan Mussell, G4CXJ
Bryan@mussell.co.uk
Mike Stevens BSc, MIET, G8CUL/F4VRB
mikeg8cul@gmail.com

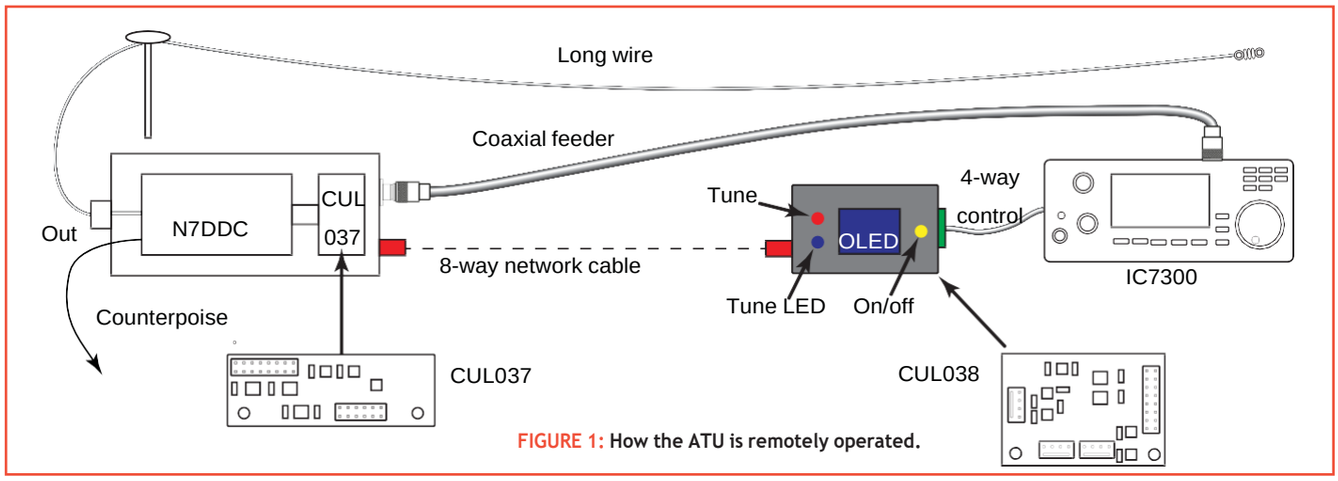

FIGURE 1: **How the ATU is remotely operated.**

PHOTO 2: General view of the shack unit (rig interface) front panel.

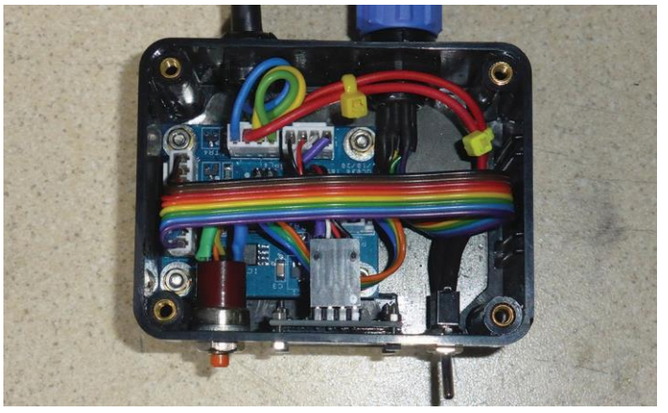

PHOTO 3: Completed CUL038 assembled in its box.

The N7DDC

By now, we suspect many amateurs will have heard of the N7DDC open source ATU-100 7x7 project from David Faintski, but if you have not, briefly, this is an auto tuner design released [1] with schematic, board layout and code, available to anyone to do with it as they will. Chinese manufacturers have taken up the build and a quick search on the internet will reveal quite a few suppliers with dozens of options from the bare PCB for a pound or two up to fully built and cased units at a little over £70, the latter being capable of running from a PP3 battery.

The N7DDC iteration chosen here is based on a low-priced kit comprising a partially built board. The processor is pre-programmed and soldered on the board, together with a few SM devices. The rest of the assembly, including coil winding etc is left to the constructor. From some suppliers it comes complete with a small OLED display that delivers information on power, SWR, antenna efficiency, L and C values (as determined by the tune process). The diminutive display means that a 'head unit' can be constructed that, although fairly small, is nevertheless bright enough to read in full daylight, giving the operator very useful information on the antenna's performance in real time using the built-in antenna bridge and firmware. The key to the whole project is the useful information, that is not normally available, which helps monitor antenna performance and even aids antenna improvements. It should be pointed out at this stage, that in spite of this articles title, it is possible to use other, say, larger displays if required. Indeed, some kits are available with displays other than the OLED. The built in N7DDC firmware is configurable for some other types without difficulty, although a programming facility is required. Configuration details are readily available. Building the N7DDC ATU is not covered here. It is easy to construct, test and is well documented on the internet. No changes were made by the authors to either the N7DDC hardware design or the firmware as supplied.

Having decided to place the ATU remotely at the end of the coax, which at the G4CXJ QTH means at the top of a 6m steel pole, a couple of problems had to be solved. Provision had to be made to supply the ATU with 12V, with some means of controlling it (via tuner control signals) and getting the information sent by the ATU back to the OLED display in the shack.

In this article we describe how the ATU can be remotely controlled and the display driven using two interface boards carrying the information between the display and ATU via screened Ethernet cable. The N7DDC design is incredibly configurable and can even be wired to enable the rig Tune control to configure the ATU at the frequency in use. **Figure 1** shows how the ATU is remotely operated.

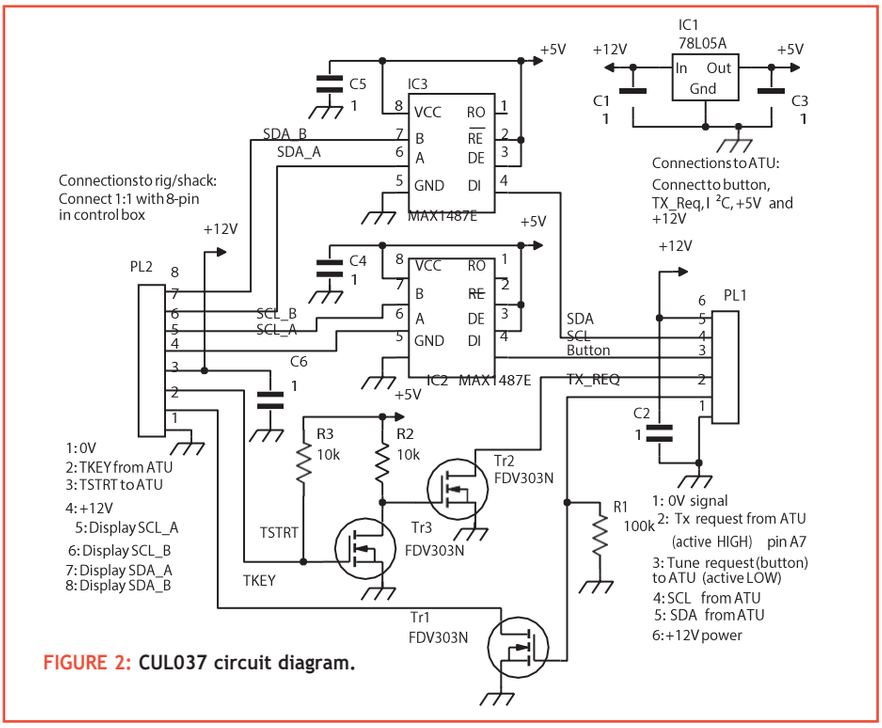

FIGURE 2: CUL037 circuit diagram.

The interface boards

Tune control and display data is handled by two interface boards: CUL037, mounted at the remote, ATU-end and CUL038 at the head, rig-end. **Figure 2** shows the circuit diagram of the CUL037 remote board.

Four connections and +12V/GND are required for the N7DDC ATU board. These other connections are SDA and SCL (the I²C signals for the display), Button and TX_REQ for the ATU control. The I²C signals cannot

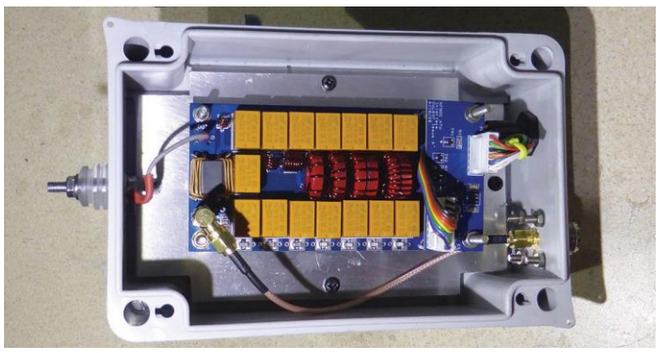

PHOTO 4: **CUL037 mounted in the IP67 box complete with the ATU itself.**

be connected directly to the display over large distances, so require a robust line-driving method. This is achieved by using some RS422 drivers. RS422 is a differential line drive system that can run at high speeds over great distances, typically 1500m or more. This should be perfectly adequate for this application! The chosen device, the MAX1487, is an RS485 transceiver but here it is hard-wired in drive mode, thus using it in an RS422 only mode. Being a differential drive system and using screened twisted-pair cable, any far-field interference should be dramatically reduced. No interference issues have yet been detected with this system in use. The two ATU control signals are just 'Button' (to initiate the tuning process) and TX_REQ (from the ATU to request some RF power from the radio). These signals are buffered using N-channel MOSFETS, FDV303N devices being shown as they were available. Just about any N-channel device will do, as the voltages and current demands are low. Both the CUL037 and CUL038 boards are laid out for SOT23 surface mount devices.

The four signals, two of which are now in differential mode, are connected to the shack-end head unit using standard screened network cable via PL2. IC2 and IC3 have the usual supply decoupling capacitors. Local power at +5V is provided by a 5V regulator IC1. The tune sequence is as follows:

- TSTRT signal is pulled low
- ATU starts the tuning process and pulls down the TX_REQ signal
- Radio switches to CW and produces low power RF signal (about 5-10W)
- When the ATU has finished the tune process, the TX_REQ signal is released
- Radio switches back to receive and to the original transmission mode.

The TSTRT signal can either come directly from the radio or from a manually operated push button in the head unit. My personal preference is to use a manual push button, as my experience is that the radio will attempt to tune every time a band change is done. I would far rather it was directly under my control, only tuning when I want it to. The head unit board allows either method.

Figure 3 shows the circuit diagram of the head-end board CUL038. This small board uses the same MAX1487 as used on the ATU end interface board but hard-wired for receive mode only. The two I²C signals in differential mode, SDA and SCL from PL2 are converted from RS422 back to standard TTL-type signals by the MAX1487. The display is connected to PL3 which provides the I²C signals, power and GND.

The ATU control signals TSTRT and TX_REQ are each double

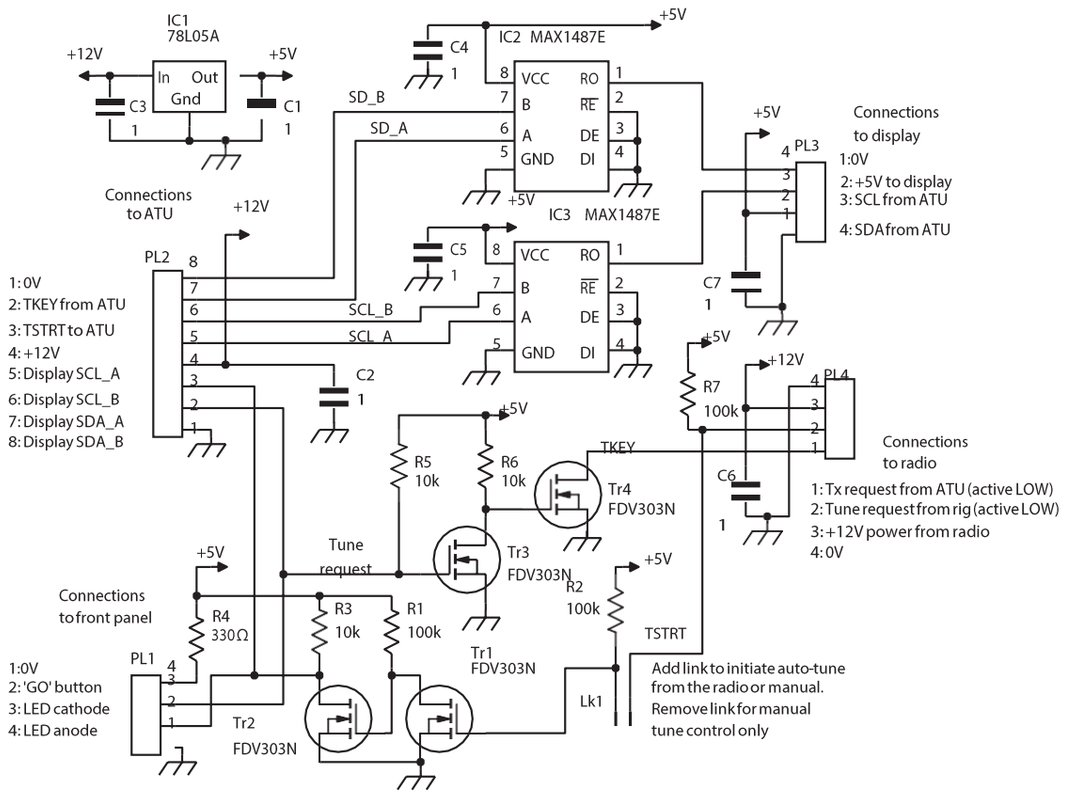

FIGURE 3: **Circuit diagram of the head-end board CUL038.**

TABLE 1: Interconnecting cable details.

Signal	CUL037 PL2, CUL038 PL2	External connector pin	Wire
0V/GND	1	1	Pair one_A
TKEY from ATU	2	2	Pair two_A
TSTRT to ATU	3	3	Pair two_B
+12V	4	4	Pair one_B
SCL_A	5	5	Pair three_A
SCL_B	6	6	Pair three_B
SDA_A	7	7	Pair four_A
SDA_B	8	8	Pair four_B
0V/GND	-	9	Cable screen (connect to PL2 pin 1)

TABLE 2: Suggested connectors for enclosures and cable.

Connector	Where used	CPC stock code	RS stock code
9-pin fixed socket	Rig-end head unit	CN21348	207-0648
9-pin fixed plug	ATU-end IP65 enclosure	CN21341	207-0645
9-pin free plug	Interface cable, rig-end	CN21313	207-0629
9-pin free socket	Interface cable, ATU-end	CN21320	207-0633

TABLE 3: Efficiency found using different wire lengths (see text).

Band	20m wire	31m wire
160m	20%	63%
80m	50%	35%
40m	13%	55%
30m	50%	40%
20m	35%	35%
17m	40%	40%
15m	13%	40%
12m	40%	40%
10m	40%	40%

buffered by N-channel MOSFETS that serve to protect the radio interface from excess signals on the twisted pair cable from the ATU. Again, FDV303N devices are shown but many other N-channel MOSFETS would be suitable. Power at +5V is derived from the +12V feed to the ATU, regulated by IC1.

The subsequent TSTRT and TKEY signals thus produced interface very easily into the modern Icom ATU system, producing a simple automatic tune process. It should also be adaptable to other brands without too much difficulty.

PL1 connects to a LED and a push buttonon the front of the head unit box. The LED is illuminated during the tune process and the push button when connected to 0V can be used to manually initiate tuning. Alternatively, with the link LK1 made, the tune start signal can come direct from the radio – but remember the proviso mentioned earlier. LK1 can be removed to only allow manual tune initiation.

Connection between the head unit (rig interface) and the ATU is made using standard, screened network twisted pair cable which is readily available and inexpensive. This type of cable consists of four twisted pairs with a suitable overall screen. Two of the twisted pairs are used in the 'normal' differential drive mode while the other two are used for power and ground(one pair) and the two control signals (the other pair). Neither of these really needs to be twisted pair cables but two twisted pairs are free in the network cable so are used for these signals.

The pairs should be connected as shown in **Table 1**. Suitable connectors are also shown in **Table 2**. These connectors are rated at IP68 which should withstand the most inclement weather and are also inexpensive. Part numbers from two suppliers are shown and although it appears the connectors do not come from the same manufacturer they do seem similar (although different colours) and mate OK. Many other connector types would be suitable, depending on what is available in your junk box.

The build

Clearly the first task is to make sure the N7DDC module is fully functional (it has a built-in test facility). After the ATU itself is shown to be functional the interface boards can be tested.

In the prototype shown in **Photo 2**, the head unit (rig interface) was constructed with its PCB in a small ABS box with lid (EN81778 from CPC), which is small enough to fit comfortably on top of a Bird Model 43. To give the unit some weight and to makesure that it was fixed securely, the PCB was mounted on a piece of 5mm steel at the bottom of the enclosure, as seen in **Photo 3**. Most components for both interface boards are available from CPC and similar sources.

In order to keep the boards compact surface mount devices (SMD) are used throughout. Nevertheless, construction is fairly easy using the boards customed designed for this project.

The ATU-end board CUL037 is shownin **Photo 4**. Mounting hole spacing for the CUL037 PCB match those of the N7DDC board as it is intended to be mounted above it, easing construction with plenty of space using an IP65 polypropylene enclosure (EN82324 from CPC).

Connection to the rig (in this case any of the plethora of Icom models mentioned earlier) is, apart from the RF coax, only through the head unit via a short length of four core cable and is made by a four pin Molex 1490 series connector that can easily be moved from one Icom rig to another in seconds. These connectors with their associated pins are available from Farnell (order code 143207 for the housing and 2063727 for the pins). These are crimp type pins but can easily be soldered.

In practice

Of course, the basic N7DDC ATU in the shack will show the readings previously mentioned on the OLED display but they will take into account the feeder and making physical adjustments to the antennae may not yield the results expected.

In a test at the G4CXJ QTH, using the remote ATU, 11m was added to the existing long wire, initially to determine whether the results on one's favourite band couldbe improved upon but also to see if those results agreed with the generally accepted wire lengths shown in many publications. In both cases the N7DDC ATU was used and the display readings for efficiency are shown in **Table 3**.

In this case transmission on the 40m band achieved the sought-after improvement, and perhaps unsurprisingly, receive signals were also enhanced. Although not entirely text-book results, Table 3 does show that with the aid of this ATU upgrade, accurate antenna tuning can be achieved without considerable effort or even more importantly unknowingly destroying effectiveness on one's other favourite bands.

This project uses professionally designed custom boards for each end of the display data link. The authors are happy to provide these boards and perhaps other parts and, of course, advice to anyone who wishes to experiment along the lines shown in this article. Please feel free to contact the authors for more information.

Websearch

[1] https://github.com/Dfinitski/N7DDC-ATU-100-mini-and-extended-boards