<u>The</u> <u>MFJ-1026</u>

by Mark Connelly

The MFJ-1026 is described as a “Deluxe Noise Cancelling Signal Enhancer” by its manufacturer MFJ Enterprises, Inc. (see company addresses on page **Error! Bookmark not defined.**), but DXers will recognize the MFJ-1026 as a “phasing unit”. The list price is US $179.95, and it offers the ability to null interference, whether from electrical noise sources or actual transmitters. This is accomplished by creating a 180-degree phase shift between two antennas that are presenting equal-amplitude “pest” signals that cover desired DX. It contains amplifiers and therefore requires a 12-volt DC supply at 150 mA. There is a similar model, MFJ-1025, which does not have the built-in whip / preamplifier option which sells for about $20 less.

A little bit of phasing unit history is in order here. Phasing units have been around for a long time, but most of these have been homebrew models built by a few dedicated DXers. In the 1960’s, I built some hit-or-miss L-C-R tuners / combiners to use at my Menotomy Rocks Park antenna farm and by the early ‘70s I had one of Gordon Nelson’s boxes up and running ahead of my R-390A. Master Trans-Atlantic DXer Bill Bailey was also using a Nelson-built box at the time and 160 meter hams such as Victor Misek were also experimenting with phasing circuits for steerable nulls. Producing a null in the opposite direction of a peak turned out to be a big advantage over loops, especially in hearing European stations here in the Boston area with the New York City (and other) “pests” off the back of the beam. In the early ‘80s, Gerry Thomas took a bold step beyond L-C-R units into broadband phasing with his delay-line-based Phase One (see IRCA reprint A73). His research led to my DL-1, DL-2, and DCP-2 models, which are described in IRCA reprints A134 and A141, while in the U.K., Graham Maynard became well known for the units he built.

As the 1990’s opened, there was still very little in the way of commercially available hardware despite the fact that many of the serious international DXers were using the homebrew units both at home and on Beverage DXpeditions to hear exotic stations that could not have been logged any other way. A device called the S.E.M. QRM Eliminator had minimal promotion and little market penetration. It used a tapped delay-line in a circuit similar to Gerry Thomas’s Phase One.

By 1993 (I think), the JPS ANC-4 model came onto the scene. In a trend that has followed all of the commercial units, advertising pointed out that elimination of local electrical noise was the primary use. One channel of the ANC-4, therefore, was a very high-gain stage driven by a short “noise gathering” whip. This arrangement didn’t seem particularly well suited to the DXer’s more common objective of using two similar fairly-low-noise good-gain outdoor antennas to phase together in order to remove co-channel (or adjacent channel) interfering <u>stations</u> rather than <u>noise</u>. Noise was often easily discarded by using noise-reducing balun transformers with “quiet grounds”. This idea, promoted by Dallas Lankford, Nick Hall-Patch, and others, can get electrical noise out of the equation even ahead of the phaser, leaving it with the considerably more interesting job of removing dominant stations. A few DXers got ANC-4’s, but the unit was prone to overload on its so-called “noise” channel and nulls seemed to be hit-or-miss because of sometimes-inadequate level- balancing and phase-adjusting range. Demand for homebrew units continued unabated as both Al Merriman and I can testify.

In 1997, the MFJ-1026 made a big splash because it was the first widely available commercially produced antenna-phasing unit that can be made to work for medium wave DXers. I say “can be made to work” because some modifications must be made to the stock version unit available at the time of this writing. The long and the short of it is that the brochure advertising the unit claims performance “down to VLF”, customarily taken to be 10 kHz or so, but several E-mail communications with MFJ personnel indicated that the unit comes equipped with high-pass input filtering designed to attenuate frequencies below the 160 meter ham band. Measurements taken here indicate losses of 8 dB at 1600 kHz and 27 dB at 530 kHz. By the time you get down to the European longwave broadcast band, it introduces 35 dB of loss. Aside from the insertion loss, inadequate phase shifting range on lower frequencies was encountered in some situations. Oscilloscope testing showed approximate phase shift ranges as low as 65° at 200 kHz, though by 2000 kHz the range is 169°. With the SW3 Phase Normal / Invert switch of the MFJ-1026, dependable nulls could be produced if the R16 phase range control gave 180 degrees of adjustment. It turns out that if you can easily swap the two inputs, a phase shift adjustment range of as little as 90 degrees will produce nulls.

Fortunately the modifications that have to be made to give the MFJ-1026 competent performance from 300 to 1800 kHz are quite simple. The MFJ-1026 schematic is shown on
page 12 of the instruction manual supplied with the unit, and the circuit board is well marked with the component designators.

Modification 1 will increase sensitivity below 2 MHz:

- Remove L3, L4, R26 (main input channel); L5, L6, R27 (auxiliary input channel)
- Change C8 and C16 from 680 pF to .01 μF

Modification 2 (swap switch) will ensure adequate phase shifting range above 300 kHz:

- A double-pole / double-throw (DPDT) “swap switch” (Radio Shack 275-614, or equivalent) is added in available space near the upper right hand corner of front panel.
- Separate the middle pin (wiper arm) of each antenna gain pot from the circuit board: these are R20 (Auxiliary Antenna Gain) and R9 (Main Antenna Gain).
- Install a wire from the R20 middle pin to swap switch section #1 arm.
- Install a wire from the R9 middle pin to swap switch section #2 arm.
- Install a short wire from swap switch section #1 “normal” contact to swap switch section #2 “swapped” contact.
- Install a short wire from swap switch section #2 “normal” contact to swap switch section #1 “swapped” contact.
- Locate the Q5 and Q8 transistors. Each of these transistors has one side having two leads (these are the drain and source leads). The other side of each transistor has a single lead (the gate lead). Solder pads are located on plated-through holes immediately adjacent to the Q5 and Q8 gate leads. These pads will be wired to the swap switch in the next two steps.

- Install a short wire from swap switch section #1 “normal” contact to the plated-through hole solder pad that connects through the circuit trace to the Q8 gate lead. Alternately, instead of going to that point, you could wire to the circuit board pad that had previously been wired to the now-cut R20 arm pin.
- Install a short wire from swap switch section #2 “normal” contact to the plated-through hole solder pad that connects through the circuit trace to the Q5 gate lead. Alternately, instead of going to that point, you could wire to the circuit board pad that had previously been wired to the now-cut R9 arm pin.

Figure Error! No text of specified style in document.**-1 The MFJ-1026**

With the DPDT switch set to “normal”, the switch completes the previously wired paths: R20 arm to Q8 gate; R9 arm to Q5 gate. In its “swapped” position, the R20 arm gets connected to the Q5 gate and the R9 arm gets connected to the Q8 gate.

A couple of minutes spent studying the schematic and board layout should make it obvious how to install these modifications. An additional modification suggested by Al Merriman is to remove the existing two Antenna Gain knobs and the one Phase Control knob and substitute larger knobs, such as Radio Shack part number 274-416 (diameter = 1” = 2.54 cm).

So now you’ve got the modifications installed and it’s time to put the unit into use. If you’re using two relatively short antennas, these should be run out at a right angle to each other to prevent collateral nulling of both desired DX stations and “pests”. With two wires at a right angle, the best null / peak axis will be along the bisector (the line that divides the angle in half). Longer antennas (over 150 m / 500 ft.) can be run closer to parallel and still produce good nulls, especially if there is some separation (1/8 wavelength or so) between them or if they are of somewhat different lengths or if one is terminated and the other is not. E-mail correspondence with Tom Rauch (W8JI) brought up another interesting possibility. If two similar small active broadband antennas (e.g. MFJ-1024 whips) are separated by 1/16 to 1/4 wavelength, good nulling performance can be expected. The line drawn between the two antennas would describe the best peak / null axis of cardioid patterns to be produced. One-sixteenth wavelength at 500 kHz (or 1/4 wavelength at 2000 kHz) turns out to be 600/16 = 37.5 m = 123 ft. Using two broadband active whips (with coaxial feedlines of about 22 m each) has been tried here and the 2-whip array is broadband for easy parallel checking and "frequency agility". Tom Rauch also mentioned using broadband loops instead of broadband whips. They could be spaced 1/16 to 1/4 wavelength and oriented the same way, or they could be located closer to each other and pointed at a right angle to each other as in the old goniometers. Also, a co-located active whip / broadband loop could be used for loop- sense cardioid array (LSCA) operation (see IRCA reprints A5, A6, A7, A18 and A32 for early work on this subject). Later work (Dallas Lankford’s LIL-3) is described in IRCA reprint A-104.

The MFJ-1026 can be operated with a ham transceiver as it has built-in transmit / receive (T/R) switching on its main antenna input. I suspect that the reviews of the unit in amateur magazines such as QST and CQ will cover this aspect of operation.

The auxiliary channel input can be from the built-in whip antenna (that goes through an internal preamplifier) if the front panel Pre-Amp switch is set to ON. Otherwise, whatever antenna you’ve connected to the rear panel auxiliary antenna jack will be fed to the Auxiliary Antenna Gain pot. I have phased the whip against Main antenna inputs ranging from tuned loops to untuned random wires. The internal whip on a modified MFJ-1026 has reasonably good sensitivity, especially above 800 kHz. Even at 530 kHz, the internal whip was able to discern Turks & Caicos at threshold level (about S2 to S3) on groundwave from a receiving site in Harwich, MA on Cape Cod. This is on par with the sensitivity of the Quantum and Kiwa loops. For comparison, an outdoor sloper to the top of a 20 m pitch pine tree at the Harwich site gives a Drake R8A S-meter reading of about S6 on Turks & Caicos - 530 groundwave.

There are four potentiometers (pots) on the front panel of the MFJ-1026 and there are four switches (five when you consider the user-added Swap Switch). The potentiometers are T/R delay (R3), Auxiliary Antenna Gain (R20), Phase (R16), and Main Antenna Gain (R19). Switches (besides the Swap Switch) are Power On / Off (SW1), Pre-Amp On / Off (SW4), Freq. High / Low (SW2), and Phase Normal / Invert (SW3). The T/R Delay control is only of concern if you will be transmitting as well as receiving. The Power On / Off switch sends the Main antenna straight through to the receiver if set to OFF. The Freq. High / Low switch is usually set LOW for frequencies from 300 kHz to 7 MHz, either LOW or HIGH for 7 to 12 MHz, and HIGH for 12 to 30 MHz.

The instructions in the MFJ-1026 manual are clear and will get the first-time user into the nulling game without much trouble. This is an easy-to-use unit compared to the L-C-R and delay-line phasers that preceded it. I would summarize operation as follows:

- Set the (SW2) Frequency switch to LOW for medium-wave use. Set the Auxiliary Gain (R20) fully clockwise and the Main Gain (R9) fully counterclockwise (anticlockwise) and take note of the strength of the station to be nulled.
- Then set the Auxiliary Gain fully counterclockwise and the Main Gain fully clockwise and take note of the strength of the station to be nulled.
- If the reading was lower with Main Gain fully clockwise, temporarily set it counterclockwise and set Auxiliary Gain to get the reading that you had with maximum Main Gain. Then put Main Gain back to fully clockwise.

- On the other hand, if the S-meter reading had been lower with Auxiliary Gain fully clockwise (rather than with Main Gain that way), set Auxiliary Gain fully counterclockwise and set the Main Gain to get the reading you had with maximum Auxiliary Gain. Then put the Auxiliary Gain back to fully clockwise.
- Rotate the Phase control (R16) to look for a null. If the null isn't obvious, or if it tends to be at either end of the Phase control's range, try the opposite position of the Phase Normal / Invert switch (SW3) and rotate the Phase control again to search for a null.
- If a satisfactory null still hasn't been achieved, try the opposite position of the added Swap Switch and repeat the previous step.
- Once the correct combination of Phase control, Normal / Invert, and Swap Switch position has been arrived-at, make small interactive adjustments of the non-fully-clockwise Gain control and the Phase control until the deepest possible null has been acquired. Subdominant signals, if present, should be evident.

If the active circuits in the MFJ-1026 get overloaded by strong local stations, use moderate-Q tuned inputs such as loops or L-C tuned whips/wires - or, in cases of untuned wire inputs, just use less gain (as selected by the two 250-ohm Gain pots).

"Real life DXing" MFJ-1026 field tests were done on Saturday, 26 July 1997 (local) from the Robbins Road - Holmes Field beach-DXpedition site located off Route 3A in Plymouth, MA (approx. GC= 70.68 W / 41.98 N). I used the Drake R8A receiver, and both it and the MFJ-1026 were powered from the car battery. Two 90 ft. / 27 m wires lying on the ground were used. This less-than-ideal set-up had been used with delay-line and other phasing unit designs previously, so I had a feel for what to expect. The "main" antenna for the MFJ-1026 ran on a slight downslope along the side of Robbins Road straight towards the sea at a bearing of about 70 degrees. The "auxiliary" wire ran out at a right angle into an open field of grass at an approximate 160-degree bearing. I was on site at about 7 p.m. local / 2300 UTC. This is about an hour before sunset. I felt that one of the big challenges would be to null WPLM-1390, located less than 2 miles / 3 km from the site. Luckily, its very large signal did less overloading damage than WRKO-680 does back at home near the Shawsheen River marsh. Nulling WPLM a good 50 dB was easy! It wasn't too long before evidence of co-channel skip stations from ME, NY, and VT started bubbling in behind the nulled WPLM audio. Better yet was rather good audio from Netherlands on 1395 heard somewhat later!

The stations that the MFJ-1026 had the most trouble nulling were those with high-angle skip, especially if some groundwave was blended in. The stations on the top end of the dial, such as WNRB-1510, were particularly troublesome in this regard. Null control settings required constant adjustment, especially in the period from an hour before sunset to an hour after. The best sustained null depth I could manage on stations such as WNRB, WDCD, and WQEW was about 15 dB (although momentarily-deeper nulls popped in and out). Shortwave DXers will probably experience similarly "jumpy" results above 2 MHz. Pure "groundwavers" such as WPLM, and longer-skip / lower frequency stations such as WLW-700, nulled more deeply and for greater time intervals between required control re-adjustments. These results are consistent with those found for any previous-used phasing scheme, whether delay-line, tuned L-C, or other.

As the evening progressed, the MFJ-1026 / phased wires set-up proved its value as numerous Trans-Atlantic stations were logged. Some of these came in fine on the 70-degree "Euro-wire" without the need for phasing, but, in a number of instances, phasing the two wires made the difference between a slop-plagued DX signal and crystal clarity. The two Croatia stations (1125 and 1134) come to mind. WBBR-1130 New York has a VERY strong signal at night here in eastern Massachusetts. Indeed, outside the immediate groundwave zones of locals, it's one of the five strongest stations night after night. When I was tuned to 1134, Croatia was running a good S9+20, but it was still trashed by WBBR slop at times - even on the "Euro-wire". With a few quick twists of the controls on the MFJ-1026, WBBR was reduced by better than 20 dB and Croatia-1134 roared in with absolutely beautiful audio. On peaks, it was stronger than what was left of WBBR. Not only did the phasing accomplish a nice clean-up on 1134, but also the much-weaker Croatian on 1125 was brought into the clear with just a bit of co-channel flak from Spain. Prior to phasing, it didn't have a ghost of a chance against the barrage of WBBR slop.

Earlier on 26 July, I had done a few daytime DX tests of the MFJ-1026 from Harwich, MA on Cape Cod. The first battery of tests involved feeding a Quantum Loop into the MFJ-1026 "main" input and using the 1026's built-in broadband active whip as the "auxiliary". With the loop at normal (i.e. high) Q, audio null depths only reached about 20 dB (versus better than 40 dB for carrier). This is consistent with previous nulling scenarios where a high-Q tuned source is phased against a broadband one. You get what sounds like a double-sideband suppressed carrier signal. If the desired DX is more than 20 dB below the dominant, you probably won't hear it even during stable midday conditions. Q-spoiling the Quantum Loop (15K resistor shunting the L-C tank) increases nullability of "pests" maybe to 30 dB, but the loop's usable sensitivity is compromised. At night, this is probably a non-issue (except in aurora), but during the day you need every bit of signal you can squeeze out of the small loop.

A second battery of tests at Harwich used two wires at a right angle, similar to the set-up employed at Plymouth. Daytime nulls were smooth; WGAN-560 was easily dumped to reveal WHYN, near-equal WPRO and CFCY on 630 could each be brought up alone, much the same on 740 with WJIB and WGSM, WJTO on 730 was nulled a good 30 dB to pull out WACE over CKAC, strong WCLZ-900 was phased under the co-channel CKDH/WMVU mix, WZNN-930 easily surrendered to CFBC, and so forth. Nulling with two wires was decidedly better than any loop-versus-whip or loop- versus-wire scheme.

Once the MFJ-1026 is modified, it makes a very competent phasing unit that will undoubtedly bring the technology into the hands of many DXers who have not previously experienced its value in bringing new stations out of "the mud".

(Editor's note: The above is an edited version of an extensive review that is available at http://www.hard-core-dx.com/nordicdx/antenna/special/mfj1026.html. Since this review was written, users have discovered the MFJ-1026 can generate mixing products that show up particularly on frequencies below the medium wave band (IRCA reprint A146). They are mainly noticeable when the Auxiliary Antenna amplifier is used. Very faint mixing products from SW broadcasters have also been noticed at 5 kHz frequency multiples within the MW band. These are due to limitations in the internal amplifiers, and may be reduced by attenuating incoming signals from the antennas)