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STATION DESIGN FOR DX

Part III — (a) Station Configuration and (b) Receiver Topics

BY PAUL D. ROCKWELL,* W3AFM

The equipment and layout at an amateur station are important factors in its overall performance. Hundreds of different configurations are giving good results. Table II summarizes the set-ups of a sampling of DX stations with outstanding contest achievements, based on returns from a questionnaire earlier this year.

Several items are worthy of note. Median antenna height is 74 feet and median boom length is 36 feet. Of the antennas, 96% are Yagis: 4% are quads. There is a preponderance of Eimac tubes and a preference for 4-1000s in the finals. The tabulation gives a good approximation of what sort of equipment complement it takes to be top dog in W/K-land.

Not shown, but evident on the questionnaire responses, is that less than 10% of the DXCC stations have electronic break-in at present. Only 20% use preamplifiers, and all of these 20% have antennas below the median height.

The configuration at W3AFM, plus a few planned improvements not yet in place, is shown in Fig. 8. Note particularly (a) the use of a second receiver for spotting, and (b) the T/R bypass. The set-up for multiple-band or multiple-operator application needs more than shown here, if it is to do the best possible job. Most of the big, contest-successful stations use separate finals and separate antennas for each band. If they use multiple operators, they provide two or more operating positions. In areas where DX-tip nets exist, such as the LIDXA 2-meter link, an appropriate standby receiver is a must.

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Receiver Preamplification, Preselectivity and Matching

There is a line of reasoning which says that on DX bands, like 20 meters, any good modern receiver has sufficient noise figure to operate effectively without pregain. With respect to sideband operation, this may be true. However, it has repeatedly been observed not to be true, even with receivers of very good repute, on c.w. Apparently the use of sharp-selectivity i.f. filters, accompanied by the use of a nearby notching filter for further narrowing of receiver noise band-

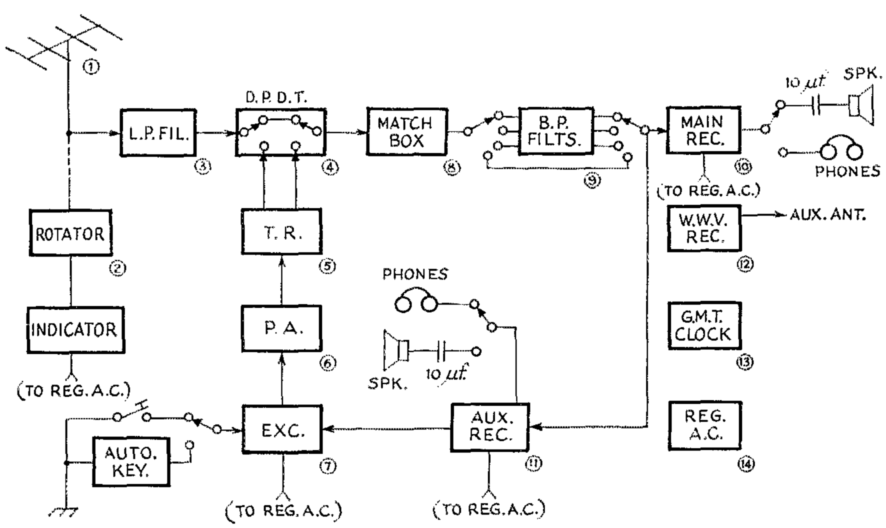

Fig. 8—1. Ant., Yagi. As long a boom and as high as possible (W3AFM: 203C up 45 feet); 2. Rotator: heavy duty, with brake; 3. Low-pass filter, kw. rating; 4. D.p.d.t. coaxial transfer switch, 110 v.a.c. (DK-2-60B); Coil paralleled with tx h.v. "on" control line; 5. Transmit/receive electronic switch (B & W 381); 6. Power amplifier, 1-kw. input, biased to cutoff. (Pair of 250THs); 7. Exciter, with provision for transceive operation with item 11 v.f.o. homemade; 8. Matchbox: Johnson 250-30-3; and preamplifier; 9. Bandpass filters, set of 3 covering 14,000–14,105 kc. not installed. Would make preamplifier necessary; 10. Main receiver. Calibration accuracy, ±0.5 kc. 14,000–04,100. Selectivity: 2 & 0.5 kc. (75A-4). 11. Auxiliary receiver tuned to the station in QSO with DX, for spotting. (75S-3B); 12. WWV receiver. On 5, 10 or 15 Mc. Most anything. W3AFM uses a BC-453 with homemade xtl converter; 13. Digital 24-hour GMT clock. (Tymeter Numechron); 14. A.c. line-voltage regulator.

TABLE II

Equipment Complements of High DXCC Stations (20 meter ants only)

	DXCC	*Ant. Ht. (ft.)*	*Foregnd. (ft.)*	*Boom (ft.)*	*P.A. Tubes*	*Exciter*	*Receiver*	*Dual Rec.*
W1JYH	341	60	—	17	4x811	32S1/310B	75S-1	—
W1BIH	340	50	level	20	2x813	BW LPA	NC-303	—
W1FH	342	80	—	18	2x4-400	32S1	75A4	75A2
W1GKK	342	65	—	24	2x813	Ranger	NC-303	—
W2BOK	331	40	level	40	5x572B	32S1	75S1	—
W2FZY	325	50	—	26	2x4-400	100V	2B	2B
W2JT	336	70	−50	36	4-1000	—	75A4	—
W2PCJ	329	78	level	20	2x4-400	SSB-100F	75A2A	No
W2SAW	330	65	—	16	4-1000	GSB-100	75A4	—
W3AFM	310	45	+30	24	2x250TH	Homemade	75A4	75S3B
W3ECR	—	80	−70	8	2x4-400	RV-3	R-4	RV-3
W3GAU	340	80	—	24	4x811	32S1	75A4	—
W3GHD	342	52	—	36	2x4-125	GSB-100	75S3	2B
W3KT	344	62	—	24	2x4-400	—	75A4	Yes
K3OKX	—	65	−300	36	4-1000	Homemade	75A4	75A4
K3UPG	338	70	—	36	2x5-500	32S3	75A4	—
W3WGH	329	54	−1100	18	4-1000	DX-100	75A4	—
W4DQH	339	100	level	54	4-1000	TR-4	TR-4	75A2
W4QCW	333	60	level	55	2x4-400	T-4X	R-4	75A2
W5KC	338	54	—	20	2x6580	T-4	R-4	—
W5UX	330	80	—	22	4CX250B	KWS-1	75A4	—
W5VA	280	100	−30	46	4CX1000	2x32S3s	75S3B	75S3B
W6CUQ	340	65	level	24	4-1000	GSB-100	75A4	—
K6EVR	332	76	level	46	4-1000	32S3	75S3	—
W6YY	338	80	level	48	4CX1000	32S3s	Racal-17	Dual LO
W8BRA	"All"	65	−20	20	2x304TL	100V	75S3	HRO
W8EWS	342	65	+30	36	4CX1000	32S3	75S3	51S-1
W8JIN	340	65	level	17	2x813	310B/GSB-100	75A4	—
W8MPW	332	60	—	26	2x3-400Z	32S3	75S3B	75A4
W8PQQ	336	60	−360	36	4-1000	HT-32	75A4	SP600
WØAIW	339	80	−200	30	4CX1000	310B	75A4	75S3
WØDU	339	55	−50	18	4-1000	32S3	75S3	—

width and reduction of interference, results in an insertion loss which is more than the receiver can handle. Also, the 20-meter background noise is a random quantity. For some percentage of time, however small, a noise figure as low as 2 db. may permit reception of signals not readable through an n.f. of 10 db. A 10-db. n.f. is typical for many receivers. In any event, a pregain of 20 db., with n.f. of 2 db. has proven advantageous on numerous occasions. Convenient means should be provided for switching the preamplification out during periods when its use aggravates cross-modulation problems to an extent offsetting its advantages.

Particularly in urban areas the subject of preselectivity is often undertreated in station design. In the first place, the use of a low-pass filter between receiver input and antenna may result in a very useful suppression of monkey-chatter due to near-by television stations, or TV receiver local oscillator radiations. Such intermodulation products were sufficient seriously to degrade W3AFM's DX capability. The customary transmitter low-pass filter may of course serve both receive and transmit purposes. Insertion loss of a good low-pass filter is only a fraction of a db. at 20 meters. However, a KW Match-box can serve this and other functions, as described below.

Crystal filters at 14 Mc. can pass 30-kc. bandwidths with attenuations less than 6 db., and reject bandwidths exceeding 80 kc. by more than 80 db. Figure 9 shows results measured by C-F networks.[18] Manufacturers of such filters have not catered directly to the amateur market because of high engineering costs.

Helical resonators[19] invite application. Operating Qs of the order of 1000 can be obtained in moderate volumes. That is, in about four cubic feet, using this design technique, it is possible to construct a tunable preselector having, say 14-kc. nose bandwidth at 14 Mc.

Urban operating conditions, made less than pleasurable by receiver overload from nearby signals, can be greatly improved by attention to preselectivity. Even clean signals, in a radius

[18] Meyer, "Front-End Crystal Filters for Amateur Radio Use, *Interadio* (annual publication of the International Amateur Radio Club, Geneva) 1965, p. 60.

[19] McAlpine and Schildknecht, *Electronics*, Aug. 12, 1960, p. 140.

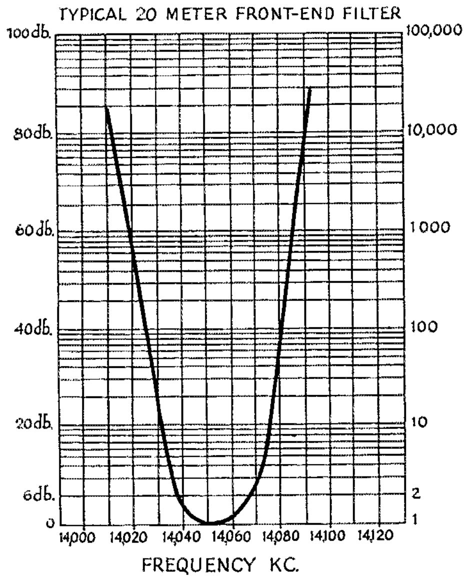

Fig. 9—The results measured by crystal front-end filter networks.

of a couple of miles, and offset more than 50 kc. in frequency, can hurt DX reception. Modern techniques can reduce the trouble-radius from a couple of miles to a couple of city blocks.

Receiver matching to the antenna has been known to yield as much as 6-db. improvement in signal-to-noise ratio. Even if the antenna is matched 1:1 at the feeder connection, there can be (and often is) a serious mismatch to down-coming energy at the receiver input-terminals. Energy reflected from this point to a matched antenna never comes back — it is re-radiated. This may account, in certain situations, for a part of the effectiveness of low-noise-figure pregain.[20] Some amateurs prefer to use a low-loss matching network at the receiver terminals, omitting preamplification.[21] This is effective if (a) the receiver happens to need it, and (b) the matching network is extremely low-loss. An enclosure no smaller than one cubic foot, and large, high Q coils should be used. Construction as for transmitting use[22] may do.

[20] For very-low-noise receivers, the input is customarily mismatched to optimize noise figure. See *Vacuum Tube Amplifiers*, Valley and Wallman, McGraw-Hill, 1948, or "Low-Noise Amplifier," Wallman *et al*, *PIRE*, 1948, p. 700. The arguments for control of input coupling are still valid.

[21] From W6AM: "The hams hereabouts find a Johnson KW Matchbox placed conveniently next to the receiver for receiving-only improves s/n. The 275-watt Matchbox doesn't work as well. Four attempts at making smaller receiver-type Matchboxes failed to equal the Johnson. Apparently the large shielded box and large silver-plated coil do the job better than anything smaller. The receiver tap is moved from the 300-ohm position to the transmit 72-ohm position. This KWMatchbox has proved far more satisfactory than preamplifiers for a number of local DX hams."

[22] McCoy, "A Completely Flexible Transmatch for One Watt to 1000," *QST*, June 1964, p. 39; and "A Versatile Transmatch," *QST*, July 1965, p. 58.

A.f. Selectivity

In c.w. work there is no need to pass audio frequencies outside the band 300-800 c.p.s. As sharp a roll-off as practical is recommended. A simple expedient is to put an oil capacitor in series with the loudspeaker voice-coil. The loudspeaker at W3AFM seems to resonate around 800 c.p.s. with 10 mf. in series. For earphones, a pair of old ones with natural resonance (Weco CW 49003) are employed.[23] Five-inch trumpets aren't bad.

I.f. Selectivity

For routine c.w. operation, a 500-c.p.s. mechanical filter is ideal. For special situations, 2-kc. and 200-c.p.s. filters should be available. The 2-kc. filter is used for wobbly signals, and sometimes for net standby. The 200-c.p.s. crystal-lattice filter is for QRM situations and "digging in." The 200- and 500- c.p.s. filters are used, in the end, about half the time each. Use of the 2-kc. filter is almost negligible, and it could be done without.

On both the 75A4 and 75S3B receivers, it has been observed that readability of threshold c.w. signals is improved by use of the "Rejection Tuning" notch filter, accompanied, of course, by careful optimization of b.f.o. frequency. Careful adjustments of these two controls can bring in a signal otherwise unreadable. The notch-filter, in this sense, is not being used in its intended purpose of rejecting an interfering carrier. Rather, it shades the channel noise-response and improves both s/n ratio and signal readability. This is true both on 200- and 500-c.p.s. filters.

Filters of 100-c.p.s. bandwidth, 455-kc. center-frequency, are now available. The 8-crystal, ½-db, Tschebycheff (i.e., ½-db ripple) response filter has attractive characteristics but seems impractical at present because (a) it is not in production; so costs are high (b) few, if any, receivers have sufficient interstage shielding to take advantage of the skirt-selectivity of such filters, and (c) questions of nose shape and ultimately-useful narrowness are not yet clearly established. It is feasible to make 455-kc. crystal-lattice filters with 10-c.p.s. bandwidth and steep skirt-selectivity, for example—but the practical usefulness is very doubtful. Keying pulses are rounded, making them difficult to copy at bandwidths approaching F, where F is equivalent frequency of the shortest keying pulse. For manual telegraphy, $F\ (c.p.s.) = w.p.m.$ is a useful approximation. From this, 20 c.p.s. would be near the ultimate. Drift of distant-end and local oscillators, ease of tuning, and psycho-otological factors indicate this is too narrow for practical application.

W4KFC finds, with a 75A2 receiver, he gets best results with tandem use of a 500-cycle mechanical filter and a single-crystal filter-stage (No. 1 position on the 75A2).

For c.w. operation only, a recommended com-

[23] See also W6EUM, *73*, July 1962, p. 58.

bination is to build in a 500-cycle filter i.f. stage, then precede this with a stage having options for narrower selectivities. For example, insert a 500-c.p.s. mechanical filter between 1st and 2nd i.f. stages and a 200-c.p.s. filter between the mixer and 1st i.f. stage. Thus the limitations of interstage shielding are improved from, say, 50 db. to 100 db. with respect to skirt rejection.

Receiver Dynamic Range

The exploitation of i.f. and a.f. selectivity advantages (as opposed to pre-receiver r.f. selectivity) is seriously inhibited by dynamic-range limitations in all present-day receiver designs. There is no use building in 100-db. rejection to outband signals, if, as is often the case, a few of them can get together and drop cross-products only 40 db. down squarely in the passband. Present-day station-design provisions are (a) pre-selectivity (b) pregain gain-control, usually by simply switching the preamplifier in/out, and (c) use of 7360 or equivalent mixers. Naturally, one uses as little r.f. gain as possible during interference conditions, and the receiver must have a separete r.f. gain control for this adjustment.

The 75A4 Receiver

Some DXers of proven good judgment hold that the 75A4, suitably modified, is the best receiver ever made. The simplest modifications are:

(1) Remove i.f. shunt resistors R46 and R29
(2) Remove a.f. feedback resistors R71 and R109. Substitute 820K for R109.

More complicated steps are:

(3) Install 7360 mixers per *QST*, July, 1964, p. 18.
(4) Install 6GM6 or 6EH7 stage with appropriate cathode and a.g.c. arrangements.

Reported results are: 12-db. improvement in sensitivity, better dynamic range (less nearby-signal overload problem), and less hum.

Some experienced 75A4 modifiers (W2JT, K3OKX and W2VCZ) prefer a 12AT7 first mixer (presumably per *73* Magazine. Oct. 1961, p. 32) and 6EA8 second mixer (presumably per *CQ*, June, 1960, p. 81, which is for the earlier 6U8A). The 7360 modification is complicated.

Serial numbers of 4200 and over are prized by 75A4 connoisseurs. These are the latest production version, and include the very-worthwhile vernier tuning knob. They may be recognized instantly by the lettering, upper right-hand corner of the front panel, NOISE LIMITER and AM CW-SSB all being on the same horizontal line.

A difficulty that occasionally occurs with aging 75A4s is p.t.o. instability. It is characterized by a lurch of one to five kc. This is especially noticeable because, when good, the receivers are paragons of frequency stability. Some steps to correct PTOs:

(1) New 6BA6s, V-14 & V-15; 0A2, V-18; and 5Y3, V-17.
(2) Replace C205, 51 pf. This can be done without removing p.t.o.
(3) Loosen p.t.o. mounting screws. Manually wiggle to relieve stresses. Retighten softly.
(4) Lubricate p.t.o. front bearing.
(5) Wring out 8 holes, 1 inch diameter, on the bottom cover plate under p.t.o. to ventilate. Replace 5Y3 with silicon plug-in.
(6) Replace the padder, and (especially) the temperature compensators.

If it reaches the point of Step (6), it's worth their fee (currently $46.00) to send the 70E24 back to Collins Cedar Rapids for turn-around. They have a temperature-cycling and calibration jig.

(Part IV of this series will appear in an early issue.)

Strays

WWV TO QSL "FIRST-DAY" RECEPTION

Want a gold-bordered QSL card showing the new WWV at Fort Collins, Colorado? Then be on deck when the changeover from the old station to the new takes place at 0000 GMT on December 1, 1966. Send your own QSL card to David H. Andrews, Chief, Frequency-Time Broadcast Services Section, Radio Standards Physics Division, National Bureau of Standards, Boulder, Colorado 80302, reporting the time of reception and quoting the new WWV voice announcement. To qualify for the WWV "First Day" card you must quote the announcement correctly and your card must be postmarked before midnight December 2, 1966, local time. WWV's QSL will have stamped on it the date and time of your reception of the signals. The three amateurs showing earliest reception time will receive, in addition, a framed 11 by 14-inch color photograph of the scene appearing on the QSL card.

Feedback

In the article, "The Simple Super-9," by W4GEB on page 22 of August 1966 *QST*, 13th line from the bottom of the first column, the term R_1 should read L_1.

Hotshot c.w. operators won't need to be told that we goofed in our space lengths in the tabulation on page 12 of the October issue. According to page 17 of *Learning the Radiotelegraph Code*, the additional space between letters is *two* code elements and the additional space between words is *six* code elements.