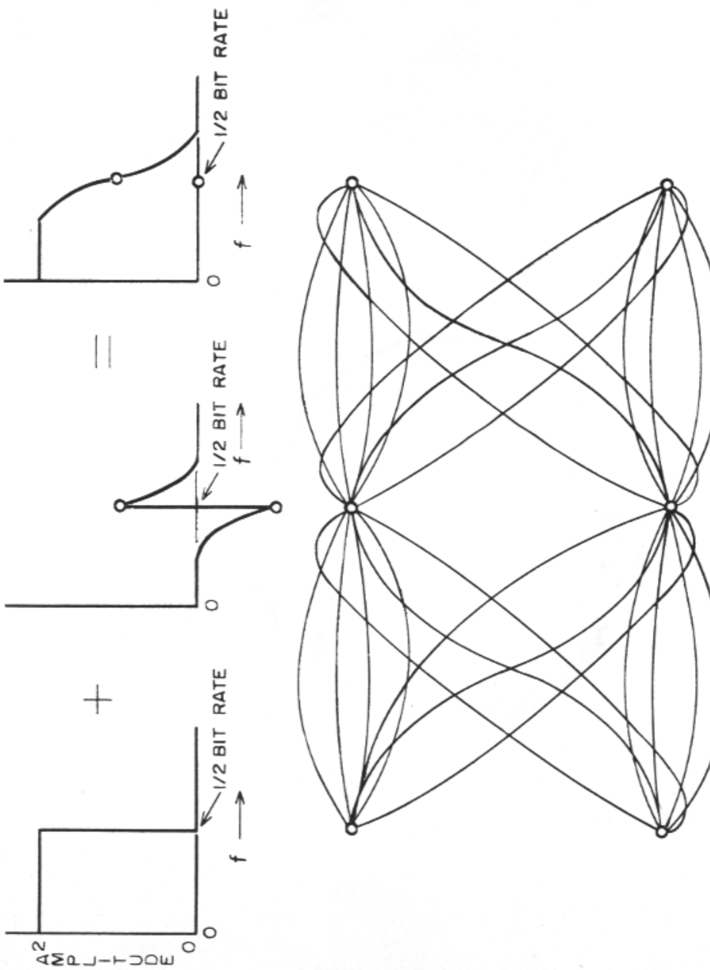
RTTY



ROLL-OFF CHARACTERISTIC THAT
PRESERVES VALUE AT MIDPOINT OF SIGNAL ELEMENT

FIGURE 2

FILTERS FOR RTTY

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NEWS OF AMATEUR RTTY

MAY, 1964
30 Cents
Vol. 12, No. 5

HORSE TRADES

This page of the Bulletin is for use of amateurs who have RTTY EQUIPMENT FOR SALE OR TRADE and those looking for equipment to buy or trade. It is a free service and may be the means of getting someone on the air.

FOR SALE: TT-63A regenerative repeater. Brand new government surplus. $39.95 FOB San Francisco. Telemethods International, 3075 East 123, Cleveland, Ohio 44120.

SWAP: Two Lico 5" scopes, one complete, one minus cabinet, both in operating condition, One RCP VTVM Model 662 operating, for one model 19 Teletype complete, W1IFB, 41 Sargent Street, Lawrence, Mass.

FOR SALE: Send for lis tof RTTY gears and parts. Good assortment available at this moment. 88 mhy and 44 mhy toroids available, 5 for $1.50 Postpaid. W6VPC, 1067 Mandana Blvd., Oakland, California, 94610.

FOR SALE: Electrocom with 850 cycle filters, and center frequency filter, $250.00 complete. K0DOM, 809 Carlos Drive, Lincoln 5, Nebr.

FOR SALE: Model 15 Teletype, make offer or trade, Bill Johnson, 3240 Palm Avenue, Lynwood, California.

FOR SALE: W2PAT terminal unit complete with polar relay and loop supply (no meters) $55.00 FOB, W8FET, R.R. 4 Buckhannon, West Va.

FOR SALE: Or Trade, model 19 complete with table for DRAKE 2 B or $175.00 cash. K4GIJ, R.R. No. 2, Winchester, Ky.

WANTED: Communication type face, baskets for model 15. Can use two, W6CEM, 570 El Bosque, Santa Barbara, Calif.

FOR SALE. Model 26 with table, in excellent condition and operating perfectly. Must be picked up, $75.00. Also; W2JAV terminal unit with meters on a 5¼" rack panel with loop supply. $50.00. K0GXL, 6701 Hickman Road, Des Moines, Iowa 50322.

FOR SALE: Model 15W/table, communications type, in good condition. $100. 00 Model 14 typing reperf (recv only) W/35 rolls 11/16" tape. $75.00 Model 14 TD W/torn tape and end of tape stop, new condition, $60.00 W.E. power supply 120 V @ 200 ma $15.00 or all of the above for $200.00 or trade for a model 28 KSR. MUST PICK UP. WA8ABF, 5836 Drake Avenue, Cleveland, Ohio 44127.

WANTED: Model 15 keyboard. K3ASI, 513 South Main Street, Cambridge Springs, Penna.

RTTY, INC.
372 Warren Way
Arcadia, California 91007
Return Postage Guaranteed

U.S. POSTAGE PASADENA APR 30 '64 CALIF. 16 P.B. METER 497313

AIR MAIL

FILTERS FOR RTTY

VICTOR D. POOR, K3NIO
430 Center Street, Frederick, Maryland

For most amateurs the following article will raise more questions than it will answer. The are of filter design is not easy to master. Perhaps future articles can deal with more specific problems than the general discussion below. In the meantime, those who want to pursue the subject further should obtain a copy of Reference 6 and start studying. — *Editor*

No other factor in the design of RTTY equipment bears as much on performance as the filters used to separate the received signal from its surrounding noise. At the same time, however, there is probably less understood by the average amateur about the design of filters than any other aspect of RTTY. One commonly hears many bold and conflicting statements made by amateurs such as: "Filters only need to be wide enough to permit the first harmonic of the teleprinter signal pass," or "Filters need to be wide enough to let the third (or fifth or umpteenth) harmonic pass," (both statements by themselves are false) or "You need a six-section band pass filter to dig into the noise," or "It really doesn't make any practical difference whether you use 60 cycle or 200 cycle filter for your tone channels," and so on.

The purpose of this short article is to try to deal with a complicated subject in a simple way and give the reader a really *objective* basis for determining what filter is required for a particular situation and a means of judging if this or that claim about a pet filter is correct.

This article is based almost entirely on an exhaustive paper[1] written in 1928 by Dr. H. Nyquist. Before someone cries that things have changed since 1928, let me say that what Dr. Nyquist published then, is still very much true and forms a sound basis for understanding present day telegraph transmission practice. So far as applicable to RTTY, the paper covered three important phases. (1) Bandwidth requirements for telegraph keying waveforms were established, (2) A criterion for perfect transmission was established and directions for describing filters to obtain perfect transmission were given and (3) application of the above to keyed carriers was discussed.

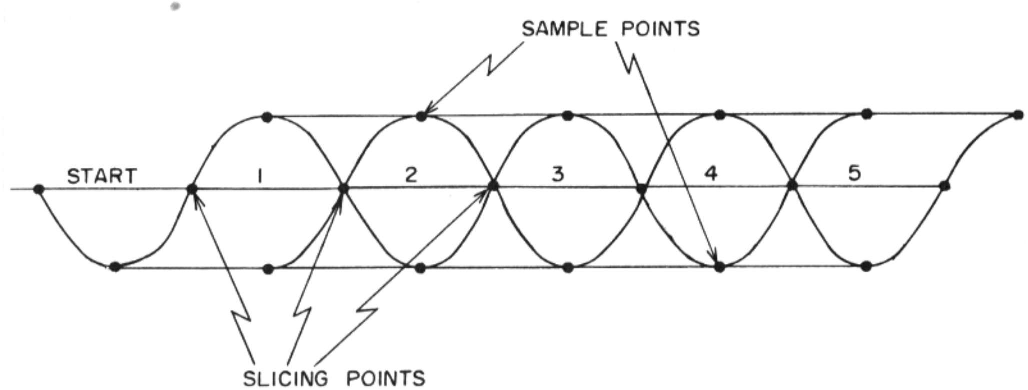
Some Fundamentals

An RTTY signal as transmitted by an amateur FSK transmitter consists (for all practical purposes) of a transmitted carrier frequency modulated by a rectangular waveform. The requirement of an RTTY receiver is to reconstruct an accurate replica of the transmitted signal. Nyquist showed that the frequency spectrum of the rectangular wave is very redundant and that all of the information is contained in the frequency band from zero to one-half the bit rate and is repeated in bands of this width all the way to infinity. Obviously no information is lost if less than infinite (!) bandwidth is used. In theory, bandwidth can be limited to a sharp cut-off at a frequency of one-half the bit rate but such a system (if you could actually build it) would require infinite delay for getting the signal through the system. The two limits for bandwidth therefore are ½ the bit rate and infinity. To arrive at an optimum value for your particular system, you find what cut-off frequency to use and, what is much more important, the *shape* of the attenuation or "roll-off" curve.

To illustrate Nyquist's criteria of bandwidth shaping and its relation to pulse transmission, the so-called "eye picture"[2] is introduced to help explain the idea. The "eye picture" is a graphical representation of the output of the low pass filter (post detector filter) of an FSK tuning unit at the point that it is applied to the Schmidt trigger or whatever circuit is used to make the final mark/space decision. The name comes from the fact that as this waveform (see Figure 1) is displayed on an oscilliscope (in a near-optimum system) the area between the points where the waveform crosses the horizontal axis looks somewhat like an eye and this opening is of vital importance in determining performance.

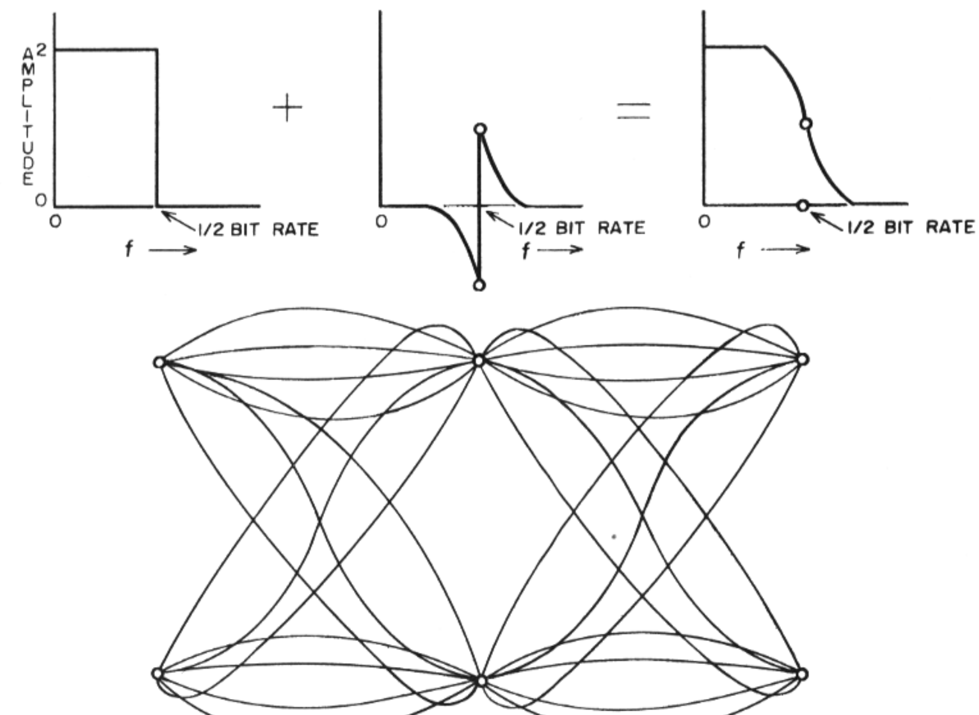
Figure 1 is the waveform (several overlapping teletype characters) which would occur in an ideal system in which Nyquist's requirements are met with a minimum bandwidth. There are two critical points in the waveform. One is the slicing level where the decision between mark and space is made (which determines synchronization or timing) and the other is the sample point where the teleprinter "samples" each bit to determine if it is mark or space. It is these two points that Nyquist considers in defining the criterion for perfect transmission.

In order to preserve the mid-bit value of the transmitted waveform (in a minimum bandwidth system) the frequency response *shape* (see Figure 2) of the system must be equal to a rectangular shape plus a shape with odd symmetry about a frequency equal to one-half the bit rate. There are an infinite number of shapes that meet this requirement, but a response with one of these shapes does



"EYE PATTERN" OF SEVERAL SUPERIMPOSED TELETYPE CHARACTERS AT THE OUTPUT OF A TUNING UNIT LOW PASS FILTER.

FIGURE 1



ROLL-OFF CHARACTERISTIC THAT PRESERVES VALUE AT MIDPOINT OF SIGNAL ELEMENT

FIGURE 2

not assure that crossover occurs at the right point in time.

In order to preserve the cross-over timing point (see Figure 3) a system response must have response shape which equals cosine $\frac{2\pi F}{2\,(\text{bit rate})}$ from zero to a frequency one-half the bit rate plus a shape with even symmetry about one-half the bit rate (wow!). Keep reading—this is just about the worst of it.) There are an infinite number of shapes that meet this requirement, but they do not assure us of accurate mid-bit values.

Now, inorder to have an ideal system, one has to meet both the above requirements in one response curve. Well, it so happens that there is one and only one curve (Figure 4) that meets this requirement. This is the so called "cosine roll-off" response.

Now what I have said is simply this: If you want to have a minimum bandwidth system, you must control its overall frequency response (from the point where you modulate the transmitter to the point where you slice the received signal) so that it approaches Nyquists's cosine roll-off response.

Ideal vs. Not So Ideal

"Pooh," you say, "Nobody's system is minimum bandwidth so what we say doesn't really apply to the 'practical' situation." In order to discuss the practical situation, we have to discuss particular systems rather than deal in general terms as before. In amateur RTTY practice, no significant filtering is done at the transmitter, and for good reason) so we can limit our response analysis to the receiving end only.

Before discussing a complete FSK tuning unit, let's discuss a simple tone detector illustrated in Figure 5.

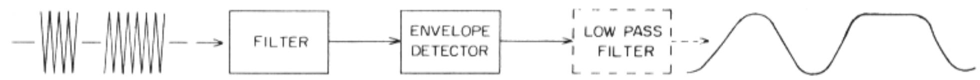
If you want to obtain the greatest signal to noise ratio, then you want the filter to be the narrowest possible for the keying rate. (This isn't strictly true, but is certainly close enough for good amateur practice). In this situation, the filter should be a band pass filter with a cosine roll-off on both upper and lower side of center frequency. In the case of RTTY where the bit rate is 45 per second, this would mean a total bandwidth of 90 cycles at *infinite* cutoff limits. (Note that the 3 db points which define bandwidth in the normal sense are 45 cycles apart). You can become more careless of bandpass response shape as you increase bandwidth. As you increase bandwidth, the filter has more time (relative to the bit rate) to recover from overshoot and ringing which comes with filters not meeting Nyquist's requirements. If you want to use wider bandwidth and still minimize overshoot and crossover error with your filter, then you simply meet the two requirements for some multiple of the bit rate.

If in the case of Figure 5 you should have a wider than minimum filter ahead of the detector, you can still get a minimum bandwidth system by using a low pass filter after the detector. So long as the signal at the detector is above the threshold of the detector (the largest signal present at the detector), then the system bandwidth is determined principally by the low pass filter. Now this isn't as good as having the entire filtering job done before the detector since the filter is least effective when you need it most, but it does help significantly. In other words, there is no excuse for not having a minimum bandwidth system just because you can't afford narrow band tone filters. When you use a low pass filter to obtain your system bandwidth, you obtain the Nyquist performance by having a "cosine roll-off" shape to your low pass filter with the infinte cut-off at 45 cycles.

Now in actual practice, you are not detecting one tone—but two. The most common practice is to feed the two tones into a limiter/discriminator and follow the discriminator with a low pass filter and a slicer. An alternate method which is becoming popular among amateurs is to filter and envelope-detect the two tones separately, then combine them after detection and slice the resulting signal by some variable threshold means.

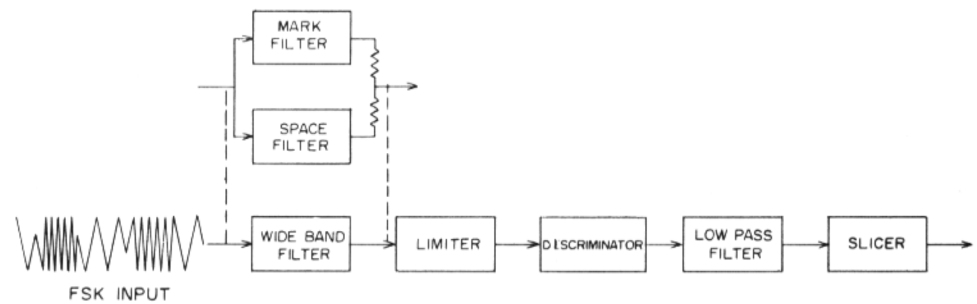
Let's treat the limiter first. A limiter in the system makes it an FM detector and subject to some strange behavior. In the limiter system, one of two kinds of filters are found ahead of the limiter. One is the wide band filter which is wide enough to include both mark and space tones. The limiter is captured by either the mark or space tone and the output of the discriminator is essentially a rectangular wave. Now so long as the limiter is captured by the transmitted signal, then the system bandwidth is determined by the low pass filter following the discriminator. When the signal is below limiter threshold, then the system bandwidth is essentially the pre-limiter filter bandwidth.

Now, you can narrow down the pre-limiter filter into a pair of narrow filters meeting the two Nyquist requirements and, so long as the incoming mark and space tones are of equal level, you have good Nyquist performance. Unfortunately, when mark and space are unequal, which is usually the case, then the limiter gives you trouble. To a first approximation, the limiter output frequency is the same as the frequency of the strongest input signal. Since the limiter is looking at the sum of the outputs of two narrow filters and one filter is decaying in output level when the other is rising, the point at which the limiter "switches" from one frequency to the other determines the mark to space transition. In minimum bandwidth filters, this decay or rise in a filter takes a whole bit time and if one tone has faded to say 10% of the other's value, then the timing error due to the relative levels into the limiter become prohibitive.



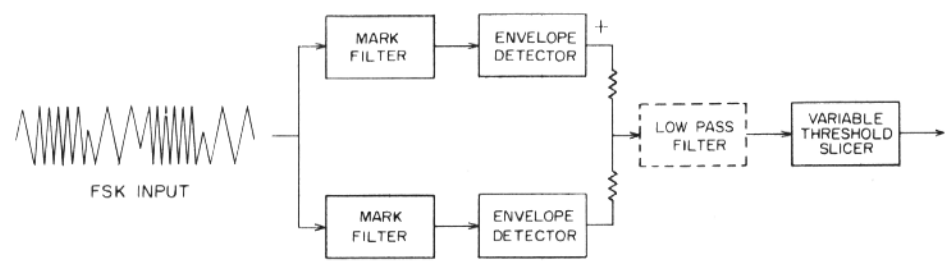
SINGLE TONE SYSTEM

FIGURE 5



LIMITER SYSTEM

FIGURE 6



TWO TONE SYSTEM

In other words, *you cannot obtain the narrowest possible pre-detection bandwidth for an HF wide shift FSK detector using a limiter.* In order to reach a reasonable compromise for pre-limiter filtering, your individual tone filters should meet the Nyquist requirements but at some multiple of the bit rate. My guess is that four times the Nyquist minimum would be a fair value since timing error would only approach 25% at worst case.

In any case, the system bandwidth can still be minimum when both mark and space are above threshold by providing a minimum bandwidth low pass filter after the discriminator.

Two-Tone Detectors

Now with two tone detectors you can achieve better performance than is possible with a limiter (NOTE: You can, but this doesn't mean you will, unless you follow the rules. For the fellow who wants it easy, the limiter is the thing to use).

With the two tone approach, both mark and space tone filter can be of minimum bandwidth and when followed by a good variable threshold detector, you can obtain optimum detection of FSK signals.

If you choose to use wider than minimum for your tone filters, then you need to obtain minimum bandwidth after detection. This produces a new problem in that for good operation of a variable threshold detector, all the filtering needs to be done ahead of the variable threshold part of the system. For the dual slideback detector circuit or the ratio corrector circuit, this presents a very difficult circuit design problem. The DTC circuit recently published in RTTY solves the problem by combining the outputs of the two envelope detectors and feeding a single ended low pass filter ahead of the variable threshold circuit. I'm sure a single ended version of the slideback/RCC detector scheme could also be worked out for those cases where wider than minimum tone filters are used.

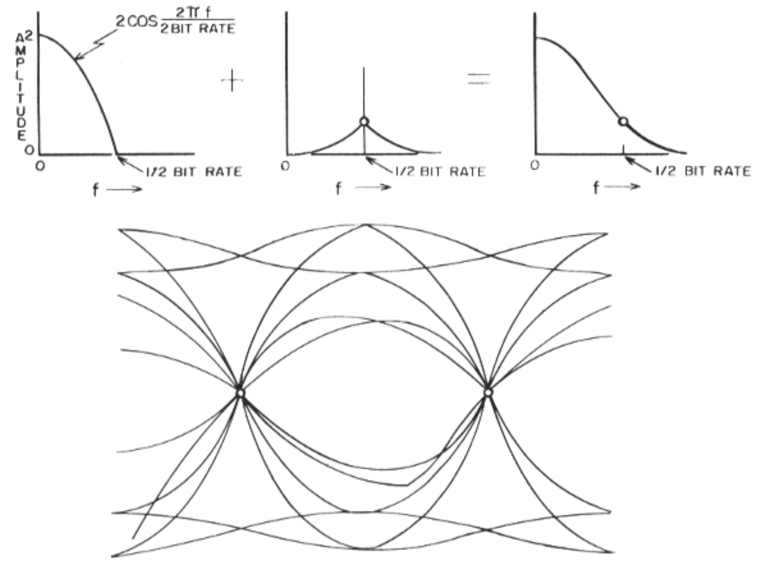
Why Narrow Bandwidth

To a first approximation, every time you cut bandwidth in half (as long as you don't go below Nyquist's minimum) you are doing the equivalent of doubling the sending station's transmitting power. If you can reduce bandwidth ten times, you increase the other fellows 1 kw. to 10 kw. (You can't do that well with a good beam.) Now some purist will observe that some of the transmitter's energy will fall outside a minimum bandwidth tone filter so you don't realize the full increase in performance. This is true. Maximum signal-to-noise -ratio in the case of RTTY does not come with minimum bandwidth. Maximum signal-to-noise ratio comes with what is called a "matched filter"[4]—that is, a filter whose frequency response curve matches the spectrum of the signal being detected. But what we are talking about when we say signal-to-noise is signal-to-random-noise and on amateur bands, that's not what you get. You get carrier-type noise, and to combat this you need absolute minimum bandwidth. Moreover, a "matched-filter" for RTTY is a very difficult thing to build especially if it is to be "matched" after the transmitter signal goes to the ionosphere and back.

Filter Design

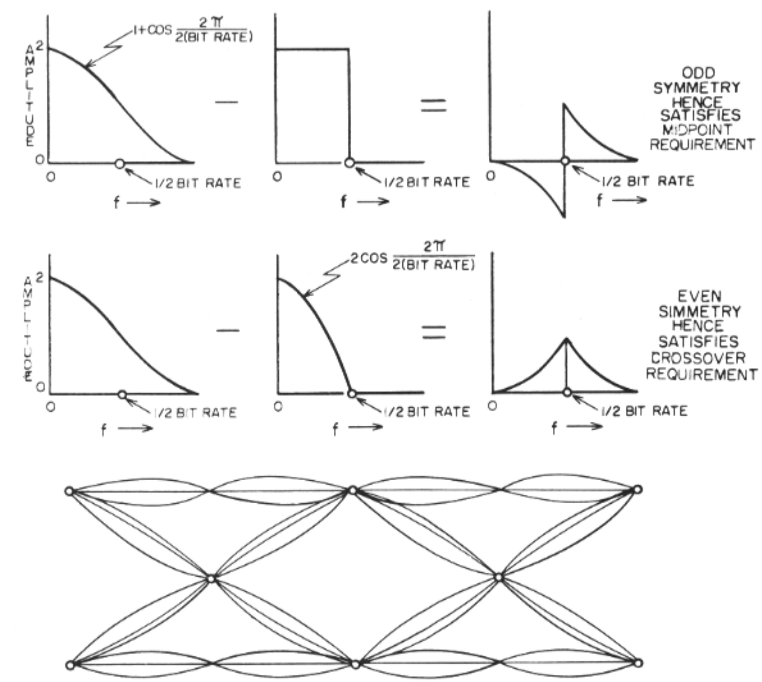
Now, we have all agreed (!) that to build good FSK demodulators we all have to pay heed to Nyquist and go by the rules. But how do you design a filter that meets the Nyquist requirement for minimum bandwidth? Yon can't. A Nyquist minimum bandwidth filter is not physically realizeable. There are some good approximations, though. The one most widely used in telegraph practice is the 3-pole Butterworth filter. A 3-pole Butterworth, using high Q inductors, can provide near minimum bandwidth band pass filters in the audio range and with even quite low Q inductors, provide minimum bandwidth low pass filters for post detector filters. Since the 3-pole Butterworth is a compromise filter, you don't get rock bottom minimum bandwidths, but you do come close. To get the closest match to the Nyquist requirements, you use a cutoff frequency of 0.6 the bit rate for the low pass case and bandwidth of 1.2 the bit rate for the bandpass case. This gives you a system bandwidth of about 27.3 cycles and compared to the Nyquist minimum of 22 cycles you find yourself pretty close to the limit. For most amateur FSK demodulators I have come across, this would be a striking improvement. The crossover error is too small to measure and the mid-bit error is about 2% with a 3-pole Butterworth. There is about 10% overshoot, but it occurs past mid-bit and does not significantly affect either crossover time or mid-bit value.

Why a 3-pole Butterworth filter? Why can't some other filters be used? Well, using modern network theory, you can come closer to achieving a Nyquist minimum bandwidth system than the Butterworth, but when you consider how little more there is to gain, it doesn't seem worth the cost. To the amateur there are only three types of filters available to draw from: One is the well known constant-K filter (and its companion M-derived section) and design data appears in the Radio Amateur's Handbook for it. A single section of constant-K is identical to a 3-pole Butterworth provided you have infinite Q inductors. You don't have, so forget it. The other two are of course, the Butterworth and the Tchebycheff filters. There are still more filters to be sure[5], but "cook-book" design data is not available and can't really be considered by the amateur. If you use Constant-K, you need more sections to do as well as Butterworth with frequency response. If you use



ROLL-OFF CHARACTERISTIC THAT PRESERVES LENGTH OF SIGNAL ELEMENT

FIGURE 3



ROLL-OFF CHARACTERISTIC THAT PRESERVES BOTH MID-VALUE AND LENGTH

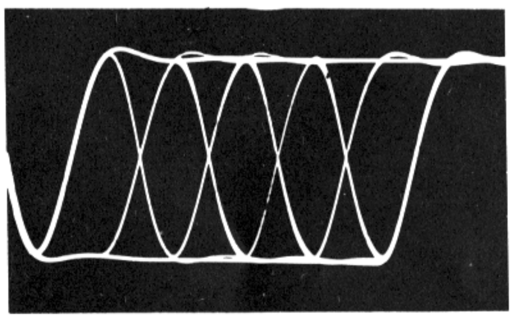
FIGURE 4

more sections you stray further from the required response due to unequal propogation delay through the filters at different frequencies within its bandpass. In all cases[3] the Tchebycheff filter is a much poorer match to Nyquist than the Butterworth. (The Tchebycheff is meant for an entirely different kind of application.) How about more sections to a Butterworth filter? More sections will give you steeper skirts, but the whole point of writing this is to show that it is the *shape* of the response that counts and the 3-pole comes closer to the proper shape than either fewer or more poles.

To cover the actual design of Butterworth filters would require another article as long as this one. Fortunately, you do not have to wait for another article. At least one text (Reference 6) has been recently published which reduces this type of filter design to a level that can be handled by the advanced amateur. This text will show you how to design Butterworth filters of both low pass type and band pass type. Giving actual examples of filter design here is not too fruitful, since each filter needs to be tailored to its associated circuitry and to the components available to the individual designer. Filter design is tricky. Be sure and take your time and understand the procedure before attempting construction.

REFERENCES

1. H. Nyquist, "Certain Topics in Telegraph Transmission Theory", AIEE Transactions Vol. 47, April, 1928.
2. S. Brand and C. W. Carter, "A 1650-Bit Per Second Data System for Use Over the Switched Telephone Network", AIEE Conference Paper, Winter General Meeting, 1960.
3. K. W. Henderson and W. H. Kautz, "Transient Response of Conventional Filters", IRE Transactions on Circuit Theory, Vol. CT-5, No. 4, Dec. 1958.
4. George L. Turin, "An Introduction to Matched Filters", IRE Transaction on Information Theory, Vol. IT-6, No. 3, June 1960.
5. Peless, Y. and Murakami, T., "Analysis and Synthesis of Transitional Butterworth Thompson Filters and Bandpass Amplifiers" RCA Review, Vol. 18, No. 1, March 1957.
6. Philip R. Geffe, "Simplified Modern Filter Design", John F. Rider Publisher, Inc., New York, 1963.



PHOTOGRAPH OF 3-POLE BUTTERWORTH FILTER OUTPUT IN RESPONSE TO SEVERAL TELETYPE CHARACTERS (SCOPE SYNCHRONIZED ON START PULSE).

FIGURE 8

BRAILLE AMATEUR RTTY

RAY E. MORRISON, W9GRW

A study of the codes indicates that the five unit teleprinter code used by the radio amateurs for RTTY can be translated to the six unit Grade 1 braille. This is letter for letter braille.

To ensure continuity of braille information regardless of poor signals or hits causing false carriage returns and line feeds, a standard "Banks" tape brailler was used for embossing by adding solenoids to operate the keys as required. This unit is shown on the cover.

Since the visually handicapped radio amateur can use the standard teleprinter keyboard for transmitting, translation is necessary only for receiving. As developed, this translator used the stunt box of a Type 28 printer for a read-out source and a diode matrix for the translation device. However, a receiving distributor and relays could be used instead.

The stunt box was equipped with contacts as shown in Figure 1. The figures contact is latched when operated and released by the letters function bar. Note the special sequence of space, Figures, Z. In the five level code the "quote" (upper case Z) character is the same as the unquote. In braille, it is different. Consequently, the space, figures, Z sequence is used to differentiate.

The diode matrix is shown also in Figure 1. Since the lower case and upper case translation is different, a letters-figures shift relay, under control of the stunt box figures contact above, determines the correct translation. See Figure 2.

Figure 2 shows the individual braille position relays and solenoids. Relays are used because the available diodes would not carry the heavy solenoid operation current. These relays are positioned next to the solenoids for short leads and are shock mounted to ensure reliable operation. Contact protection networks are connected across each solenoid to reduce relay contact arcing.

This setup translates the five level teleprinter code into Grade 1 braille except for the number (#) sign. This # sign should be disregarded in front of any braille character except the letters A through J where it denotes the following letter is the number 1 through Ø respectively.

This system was developed as a contribution of Amateur RTTY to the visually handicapped radio amateur and to get K4ZBC "on the air." It was undertaken as a SAVE project (Service Activities of Volunteer Engineers). Anyone interested is invited to write for more details.

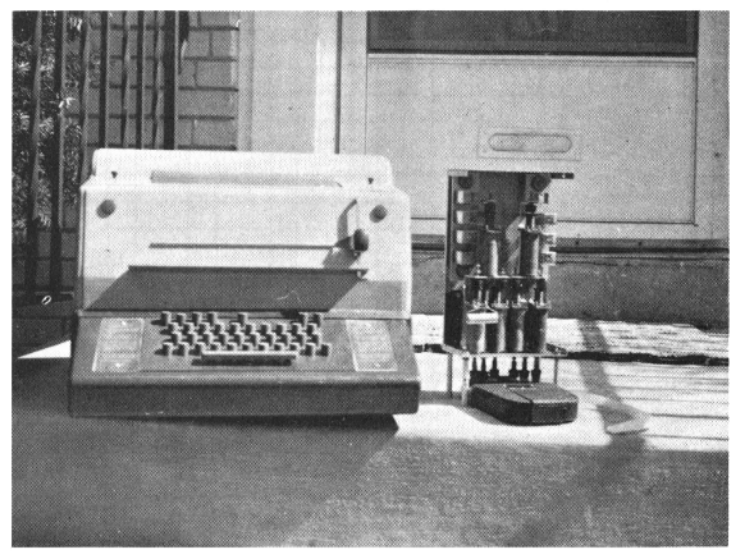


FIG-1

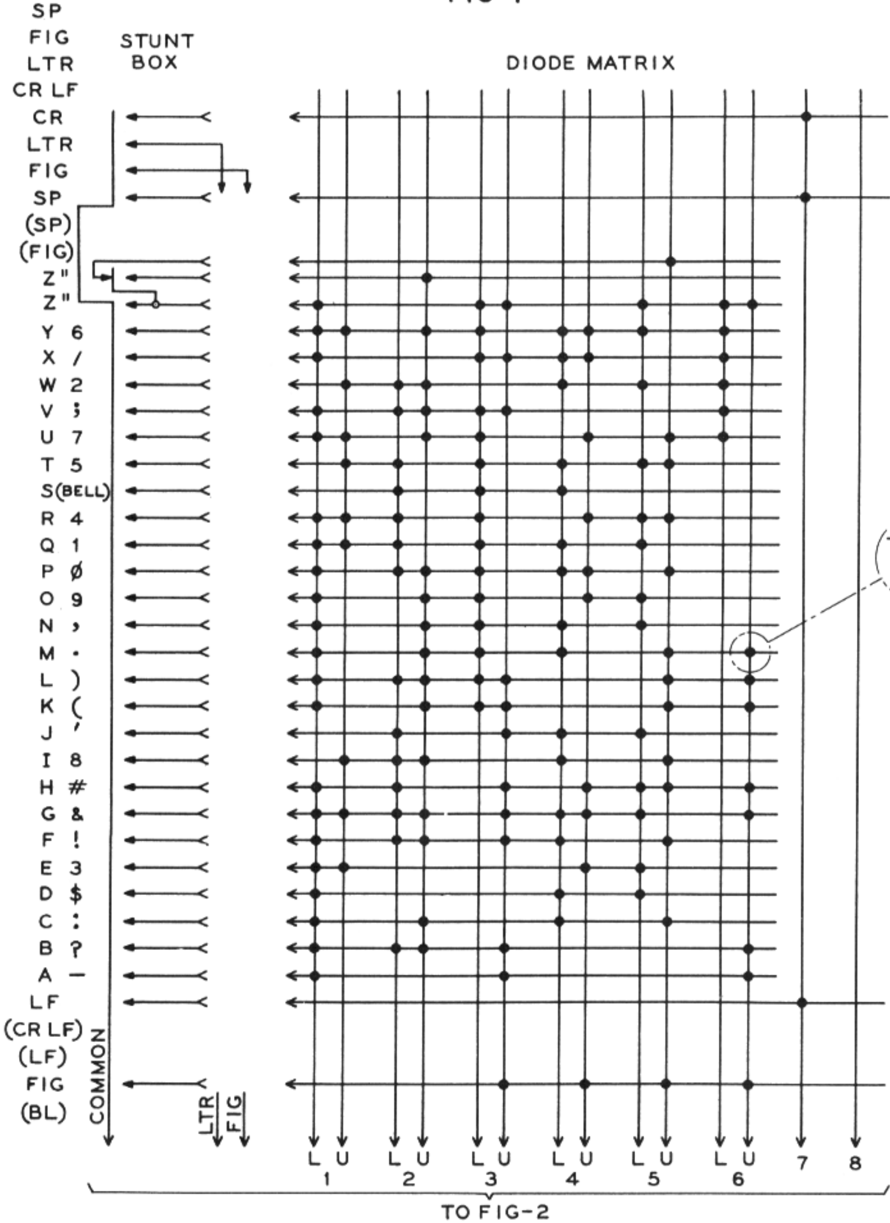
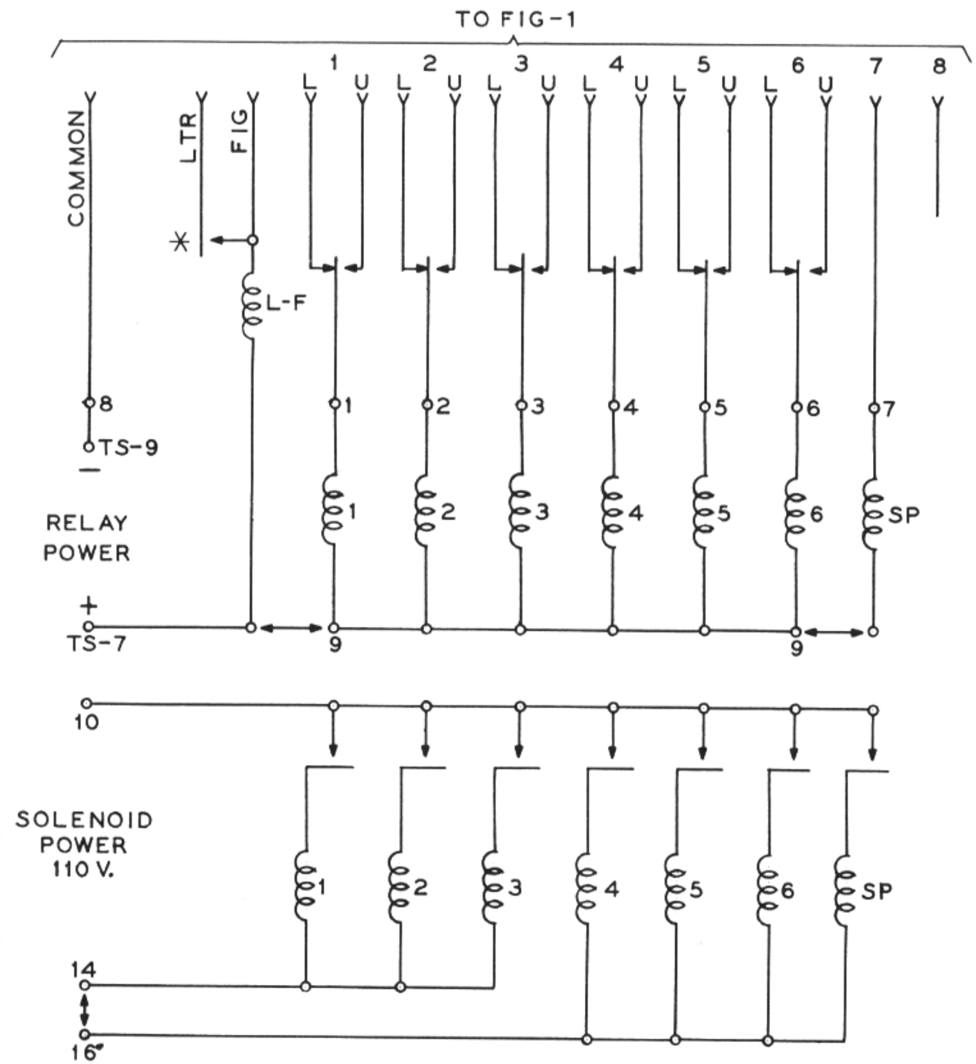


FIG-2



*REQUIRED IF 28 STUNT BOX NOT USED

COMMENTS ON DTC CIRCUIT

VICTOR POOR, K3NIO

I have received so many questions about the DTC circuit since the article was published, I thought I would write you a note covering the more significant ones. Let me say, to start with, that those who are really seriously interested in the DTC circuit should obtain a copy of the patent. My article was just a short introduction to the idea and was not intended to be a detailed study. The patent itself provides a very complete discussion of the technique and also gives several other circuits for doing the same trick. The reasons the particular form of the DTC was given in the article was that it was the easiest to adapt to the TU-D and (at least for me) the easiest to explain.

Does the DTC offer any improvement (or disadvantage) over the slideback detector tape sent signals?. As far as I can tell the two detectors are the same. Playing the same tape recorded signals through otherwise identical tuning units produces very close to the same rate both with slow and fast fading and with or without impulse noise present.

How about keyboard sending? Well, here is where the picture changes. First of all, consider impulse noise. If you are resting in a steady mark and a static burst comes along, even if you have carefully balanced channel filters an error is going to be produced by the slideback detector. Even though your filters are balanced the detector is very unbalanced during steady mark and will provide a mark to space transition with a high degree of probability. The DTC however is resting in a balanced state and does not have a built in preference for going to space during a steady mark. On a noisy night this can make a startling difference. Secondly, consider fading. If you have a sudden fade while in steady mark the slideback detector will produce an error. The DTC will not (except to the extent that only noise is left in the detector) produce an error and this is true regardless of whether the "time-constant" is 100 milliseconds or 350 milliseconds (the actual "time-constant" of the DTC shown in the article is somewhere between 150 and 200 milliseconds and is determined principally by C1 and R5 and C2 and R6). Now it is true that you can progressively shorten the time constant of the slideback detector and get better and better results with keyboard sending. At the same time, however, you are losing the feature you started out to obtain, that of fade compensation.

Can the DTC be used to copy mark only or space only signals? Yes, but not in the form shown in the article. Get a copy of the patent and read up on it.

Doesn't the fact that you can get an error from the DTC circuit after a steady mark, if the space signal happens to be faded at the instant you key, produce a higher error rate than the slideback detector (at least under some signal conditions)? No. Assuming that the probability of fade is the same on both the mark and space channels, your exposure to error on a steady mark with the slideback detector is proportional to the length of time between characters. On the other hand with the DTC your exposure to error due to fading occurs only for the duration of the character which you key after the steady mark. This means that the DTC offers the greatest advantage on the slowest keying. However, even at 30 words per minute (where the exposure to error on the slideback detector due to time between characters) the DTC still has the upper hand, since, with its longer time constant, it still has some memory of the last space level. A simple graph can be drawn illustrating the relative error rates of the two detectors as a function of sending speed, with one line representing the slideback detector and one line representing the DTC. The lines merge as keying approaches full speed and gradually separates as keying slows but the DTC always has an equal or lower error rate. It doesn't take a full sun spot cycle to draw the graph.

Shouldn't the time constant be shorter to combat fast fading? Well, one can't be dogmatic about a thing like that, but 150 to 200 milliseconds seems to be about optimum for that particular form of the DTC. I have run a good manfltape recorded signals through the DTC using both slow and fast fading signals and find that anywhere from 110 to 300 milliseconds produces about the same error rate. I think probably that even fast fading signals still have a slow fading component and if one doesn't get you the other will.

A couple of notes about building the circuit — there is a diode shown reversed in Figure 2, but the suggested circuit for converting the TU-D to DTC operation is correct. Be sure, P#3, you construct the thing, that you are getting good dynamic range. If you can't get ksing out of your TU with a 100 to 1 variation in input level (without limiting), you just don't have the job done. This is important.

You won't get DTC action with the input signal 100 times reduced but if you get any output to your printer with that kind of signal reduction you can feel fairly certain that you are getting good DTC action at the more normal signal levels.

N.Y.C. RTTY MEETING

On Monday, March 23, during the IEEE Convention in New York City, thirty-seven of the more ardent RTTY's gathered for a turkey dinner at a midtown New York restaurant. Most of the attendees were easterners, but the group did include WØEPY, K8ERV, K6RTD, and W6ZH.

Greetings from ARRL were brought by Ed Handy, W1BDI, and Herb Hoover, W6ZH.

A time for informal rag chews was followed by the dinner which was succeeded by the program which consisted of a series of technical discussions. Victor Poor, K3NIO, spoke on optimum bandwidths for RTTY terminal units; Al Hughes, W1FGL, discussed some of his recent findings on terminal unit design with particular emphasis on two-tone units; L. H. Montgomery, WA4END, spoke on experiments taking place at Broadcasting Station WSM (he is Chief Engineer) in Nashville, Tennessee. In these experiments they are using a 20-cycle FSK on the broadcast carrier to simultaneously transmit RTTY and the regular station material. The principal speaker of the evening was Stu Meyer, W2GHK, President of Hammerlund, who told us of the technical programs being made at Hammerlund in receiver techniques. Following the speakers, there was a period of floor discussion and questions leading up to adjournment.

W2PEE

ATTENDANCE AT THE 1964 RTTY DINNER

Name	Call
Albertson, Fred W.	W3FMC
Auld, William	W2DXD
Bernat, Norman S.	K2GYX
Block, Gerry	WA2YJD
Boivin, Paul B. Jr.	K2SKK
Catona, Phil	W2JAV
Davis, Robert M.	K2KAQ
Davis, Winfield E.	W2LBX
Field, Donald G.	W2UAE
Grumbacher, Walter J.	W2FWZ
Handy, F. E.	W1BDI
Hoover, Herbert Jr.	W6ZH
Hopper, Kenneth D.	K2VAM
Howard, Tom	W1AFN
Hughes, A. Morris	W1FGL
Hurlbut, Lucius A.	K1YZG
Jodice, James A.	W1ZQM
Kaufman, Edward	K2OXO
Key, Francis S. Jr.	WB2KKK
Kretzman, Byron H.	W2JTP
Lamb, J. Tom	K8ERV
Mastropole, Alfred J.	WB2AFH
Maynard, George F.	K6RTD
Mendelsohn, Alex	WA2IKT
Mendelson, Bob	W2OKO
Mildner, Otto H.	WA2DMY
Montgomery, L. H.	WA4END
Polin, Jerry	K3KVS
Poor, Victor D.	K3NIO
Scher, Donald	W2KDW
Scibilia, Salvatore J.	WA2LKF
Straub, Robert J.	W2PBG
Skinner, Thomas	K2YGL
Waddle, Lamar E.	W0EPY
Whiting, R. Alfred	K3BRS
Wyatt, W. Kirk	K3SNQ
Swanson, Elston H.	W2PEE

WA9IBB5 Reviews . . .

BAND PASS FILTERS WITH LINEAR PHASE

by Robert M. Lerner of MIT's Lincoln Laboratory
Proc. I.E.E.E.; March 1964; pp. 249-268.

JIM HAYNES
966 Chestnut, Deerfield, Ill. 60015

The ideal filter would have zero attenuation in the pass band, infinite attenuation everywhere else, and uniform delay for all frequencies within the pass band. Such a filter cannot be built; these characteristics are impossible even in theory. Filter designers therefore must approximate these characteristics as best they can. For many years the main use of filters was in speech transmission; an exhaustive literature details the filter design procedures which evolved during this period. As the human ear is not in the least sensitive to phase distortion very little attention has been given to the phase properties of filters. It turns out that the best filter equations from the amplitude response standpoint produce pretty lousy phase performance, tending to delay frequencies at the extremes of the pass band much more so than those near the center. This state of affairs is not very happy when we wish to transmit such things as pulsed tone telegraph signals. The signals come out of the filters with poor rise and fall times, overshoots, ringing, and a number of other defects. Consequently for pulsed tone transmission it has been found necessary to tack phase equalizers on to the ends of the conventional filters to improve the phase properties of the composite filters. A phase equalizer is a circuit which produces the same attenuation at all frequencies, but which delays some more than others. As you might expect, a phase-equalized bandpass filter can get to be a rather complicated black box.

It is possible to design filters having rather nice phase properties over a specified band of frequencies using conventional design equations. We are disappointed to find, however, that such filters have quite bell-shaped amplitude responses which are not at all well suited to the degree of selectivity we wish to achieve. Thus it has seemed that we cannot have good amplitude and phase characteristics and reasonable simplicity all in the same filter.

Mr. Lerner has taken a fresh approach to filter design with results which appear to be startlingly successful. He proposes a filter circuit having the following agreeable properties:

(1) Amplitude and delay are quite flat over the passband.

(2) All the inductors are the same size, except for two which have twice the inductance of the others.

(3) The filter is relatively tolerant of non-ideal component parts.

(4) Additional out-of-band attenuation can be obtained by adding simple networks. Their presence does not upset the design of the main filter section.

(5) The filter is relatively tolerant of incorrect sources and load impedances, and of incorrect component values.

(6) The design procedure is applicable to crystal filters as well as to LC circuits.

The basic filter circuit is illustrated in Fig. 1, while the impedances Z_a and Z_b are detailed in Fig. 2. The circuit of Fig. 1 is the familiar half-lattice which so often appears in amateur crystal filters. The two lattice elements are seen to be networks of simple series resonant circuits in parallel. f_0 is the lower cutoff frequency at which the response of the filter is 6db down. f_1 on the opposite lattice arm is higher than f_0 by the parameter Δf. f_2 is spaced from f_1 by $2\Delta f$. f_3 is spaced above f_2 by an equal amount, and so on up to the last resonator f_{n+1} which is higher than f_n by Δf. The two out-of-band resonators f_0 and f_{n+1} are termed *corrector resonators.* Fig. 3 perhaps illustrates the situation a little more clearly. Calculation of the various component values is relatively simple since the frequencies of the resonant circuits are explicitly specified. The one fly in the ointment seems to be the source and load impedance R/2, which is specified as $4/\pi$ times the calculated impedance of L at a frequency of $2\Delta f$ cps. For the usual inductors this results in a rather low value of R.

Perhaps one way out of this problem is to use an ordinary plate to voice coil (multi-tapped) transformer for the input transformer and a similar transformer (tap not needed) at the other end, although the characteristics of the ordinary transformers may be too poor in the application. Mr. Lerner promises a future paper which deals specically with design of practical filters, whereas the present paper is primarily theoretical in tone.

The one remaining design problem is to determine how many resonators are needed to make a good filter. No doubt this information is to be found with one of the many equations in the later sections of the paper.

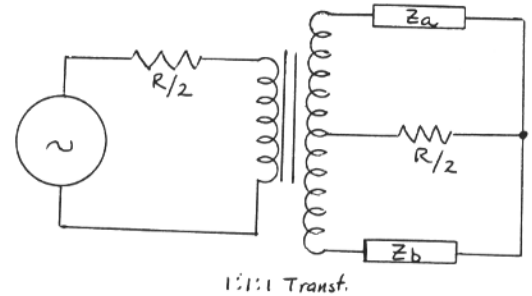


Fig. 1

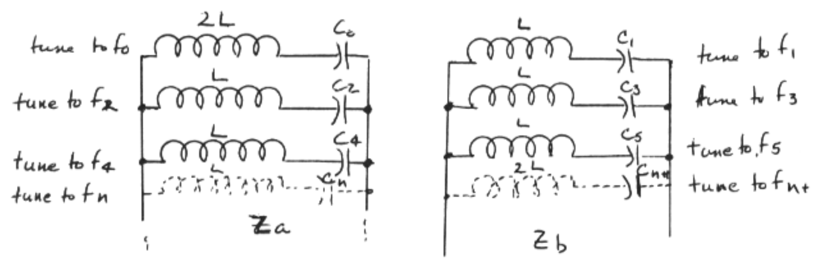


Fig. 2

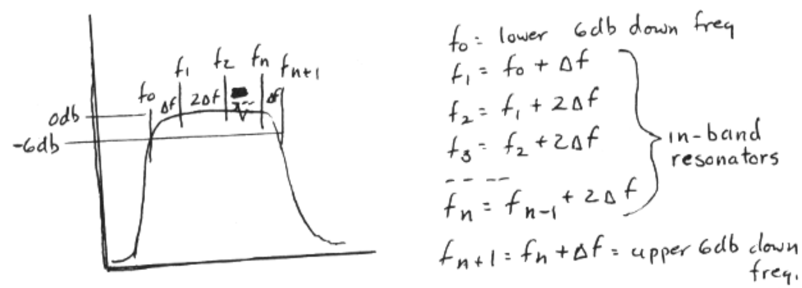


Fig. 3

JH 22 Mar 64

ANCHORAGE TRAFFIC

W6AEE DE WØAJL

I honestly think that in time of emergency and real need for fast communications that two stations working into the area where the emergency exists could shove in more traffic on RTTY than any way I know of — if these two stations work about 5 kc or whatever it takes so they don't QRM each other. All other stations could be giving their traffic to the one not sending traffic to the area in distress while the one that just finished with his traffic could gather up more and be ready to take over as soon as it was his turn again. Then on traffic coming back it could be reversed and one station copying everything and then going to the other frequency to find takers while the station working with him takes over and takes TFC coming in—then on the frequency where it is being resent, anyone celling in and saying they copied direct could be considered as having QSL as far as that message was concerned and it wouldn't have to be sent again, but assuming conditions do not permit others to copy then it could be resent, ect. KL7ERD who is employed by Alaska Communications Company—they were without power over two days—used the time he was off work to handle scads of traffic. He couldn't phone because on Saturday there were only 116 phones in operation and less lines — so what was left was strictly for official business. All of them were broadcast over the main station, KFQD, and they asked everyone to tell anyone not listening, etc., that there was a message for them, etc. It worked out real slick until Monday about two o'clock when KL7ERD had to go to work because the Alaska Communications System got their power back. We then went through KL7DRT in Kethickan, Alaska who was giving the traffic to all pilots leaving every few hours for Anchorage. The pilots would leave the messages at the Civil Defense Headquarters. KFQD was telling people to contact Civil Defense Headquarters for messages that couldn't be delivered fast, etc.

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April 2, 1964

Dear Merrill:

I have received many letters of which the attached is typical. Also many more phone calls expressing their thanks and gratitude. Thought perhaps you would like to know that the public does appreciate help in emergencies and pass the information along to the other fellows who might be doubtful.

Best way I know on RTTY is the way KØAEK and I did it. While one of us was sending to KL7ERD on 14090 kc., the other took tfc from anybody at 14100. Then when the one of us sending to KL7ERD ran out of tfc for Bob (KL7ERD) we would trade off with each other and kept KL7ERD printing messages steady. That way the most got through and not too much wasted time from QRM and wrecked copy.

KØAEK and I kept swapping from 14090 to 14100. 14090 to send to KL7ERD, 14100 to take tfc from anybody. Worked out pretty good. Some didn't get the idea and butted in on 14090, but most of them got the idea right off. (KL7ERD stayed at 14090.)

73, Walt

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726 E. Franklin Street
Appleton, Wisconsin
March 31, 1964

Mr. Walter E. Nettles
201 S. Eudora Street
Denver, Colorado

Dear Mr. Nettles:

Mrs. Klingbile and I wish to again express our great appreciation for the help you gave us in enabling us to learn the situation of our daughter Judy at Anchorage, Alaska.

I am sure that the ham radio operators have helped many families during this turmoil in Alaska and I have only the highest praises for such operators as you and others who have rendered such help.

Very sincerely yours,
HENRY H. KLINGBILE

CORRECTION TO PAGE 13 APRIL, 1964 RTTY

"Pin numbers should be 1, 3, 4, 5, 6, and 7."—Alfred Kiep, Jr., Box 41, Etna, Calif.

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CORRECTION TO PAGE 4 JANUARY, 1964 RTTY

"The .05 mfd capacitors shown in the low-pass filter should be .005 mfd."—K3NIO.

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REMEMBER!
ARMED FORCES DAY
16th MAY 1964
See April RTTY or May QST for details

BAND PASS FILTERS . . .

I have asked friend Irv, K8DKC, who is reputedly somewhat of a mathematical whiz, to look into this matter. No doubt he will enlist the aid of Jon, W8BZB/MM, sa soon as he can get a Model 28 typebox with integral signs in it; so we shall soon have a definitive answer. In any event Mr. Lerner states that, not counting the two corrector resonators, the linear phase filter is about as good amplitude-wise as a more conventional filter of equal complexity.

Since the impedance R is governed by Δf rather than by the operating frequency of the filter there isn't much we can do to raise R without disturbing the filter bandwidth. One possible solution is to execute the design as a crystal filter, since crystals have quite high apparent inductance combined with high Q/. Mr. Lerner makes the point in this connection that it is much more important to have the frequencies of the various resonators correct than to have a precise value of L.

Thus one might start with a batch of surplus crystals and a frequency measuring set-up (being cautious that the latter uses the series resonance of the crystals) and by careful grinding construct a set of filters operating at 455 kc or so. Even so a lot of care will have to be exercised since the frequency differences of the various crystals are such small fractions of the operating frequency (perhaps 20 parts per million). The fact remains that working filters can be built, for Mr. Lerner illustrates the results obtained with two; one an LC circuit with 9 in-band resonators and one a crystal circuit with 23 resonators. The response curves look nice indeed.

TO BUD SCHULTZ, W6CG

Dear Bud:

This is one of the first hours of peace I got after getting informed of the official results of last RTTY Sweepstakes and so will not miss the opportunity to drop you a few lines to explain why I did forward to you the type-writer-award offered from Olivetti to the Sweepstakes-Top Scorer.

As you know it was myself who asked Olivetti to offer such an award to the winner and myself only offered to take over charges for duty-free delivery to winner. Now being myself the fortunate, but in this aspect, embarrassed winner, I was not at all happy to take such award which was, in some ways, promoted by myself. So I thought it might be approved by all contest-participants and committee-members, if I would offer the award to the RTTY Society of California, sponsorer of the Sweepstakes and particularly to the man who had certainly the most work and troubles in preparing, participating and finally checking and tabulating — practically alone as I read — all the Log Results.

Bud, take this little offer not as given from the I1RIF alone, but from all RTTY'ers to whom you devote so much enthusiasm, sympathy and time of your life.

In this occasion, I would like to add all my very best wishes to the RTTY Society, to the managing staff and to all members around the world.

Yours sincerely,
Bruno, I1RIF

ED. NOTE: *A big thanks to Olivetti and I1RIF.*

MARY SCHULTZ, K6OWQ

DX-RTTY

EDWARD CLAMMER, K3GIF
5940 Avon Drive, Bethesda, Maryland

There are two new countries reported this month: OY7ML, Martin, Faroes Islands worked Chris, G3NAE, Martin is running about 100 watts to a dipole and has not been too strong in the States of late. Herbert, DL1VR, spent most of one afternoon trying to get Martin's copy straightened out – apparently the garble was caused by the incorrect speed of his tape printer machine. All is well now and Martin is expected to be a regular QSO for Stateside stations.

From Rene, DL3IR, comes the story of his first QSO with EP2RW, Roy, in Teheran, Iran. Rene worked him at 10:00 GMT on March 16 and said that Roy came boiling in with a fine signal. Roy is running a full gallon with a cubical quad. His gear appears to be our military type and he is thought to be an American. Here is Asia again–the less difficult way!!

FG7XT, Jean, of Guadeloupe is planning a RTTY DXpedition for the last weekend in April. He expects to be operating as FS7XT from St. Martin with a new Collins KWM2 on his boat tied up in the harbor there.

Jean is planning to attend the VE2 Convention in Montreal in August and will stop off in several cities on his way to Dallas to call on his QSL manager there.

I1RIF, Bruno, plans on a trip to the States (NYC) in late April. He had planned to follow this with a vacation in the Bahamas but this portion of his trip has been deferred. Bruno's signal in the Eastern part of the States continues to amaze the RTTY Dxers. Recently he was heard working W8UJB on twenty meters at 6:30 P.M. E.S.T. Narrow shift too!!

YV1LK, Jose, made his initial RTTY contact with K3GIF. Jose runs about 175 watts from Punto Fijo – His mentor is Jack, W6CQK, who lives near Jose.

AFRICA SPEAKS!!

A seemingly large number of stateside RTTYers need only Africa for their RTTY W.A.C.

The latest report from the only active RTTY station in South Africa, ZS1FD, in Cape Town is that conditions are not good at this time and Henry hasn't been hearing many signals from West of the Mississippi (excepting for Walt, WØAJL).

Those stations who need Africa, therefore, should concentrate their efforts on working Don, 5A5TR, in Tripoli, Libya. Don is on twenty meters almost every day with a high class RTTY signal. Don's friend and neighbor, Carl will be on shortly with a 5A3 call from the same area.

GM8FM, Shank, is back on RTTY from Scotland. He appears to be the most active station from GM-land at this time.

HZIAB, Saudi Arabia, can be heard once in a while at about 2200 GMT on twenty meters. This station appears to be more active on SSB and C.W. so perhaps the best way to catch this Asian station is to meet them on fone or key and ask them to switch to RTTY. They usually will.

F8KI, Jean, and F8KR, Roger, are very active from the Paris area – both with good strong signals.

SM6CSC, Ingemar, so far the only Sm station heard on RTTY wirks Dick, W7LPM, regularly. Ingemar runs about 500 watts to a good beam and his signals should be workable anywhere in the States. Look for him on Monday, Wednesday and Friday from 1600 GMT on 14,100 Kcs.

Bill, DI4IA, is back home in Ohio after completing his military service. He hopes to operate RTTY from KV4 land for a while. This will be a new one to watch for.

MUNICH RTTY

One of the most remarkable examples of how RTTY interest can grow, can be seen in Munich. Several years ago, Herbert, DL1VR, came on the air as the first signal from the Munich area. Through Herbert's efforts, Rene, DI3IR, became interested to go on RTTY. Then followed: Dieter, DJ2ZJ, Guenther, DJ4BF and Doc, DL1LK. All of them have fine, strong, clean signals and are a credit to Munich and the efforts of Herbert who has so successfully spread the RTTY lore in his area.

Bill, ex-DL4IA, reports receiving a RTTY QSL from a Russian receiving station after his return to the States. This would indicate that there are machines available there.

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The RTTY DX fraternity was shocked at the sad news concerning the passing of Mary Schultz, K6OWQ, wife of Bud Schultz, W6CQ, director of this column. It was Mary who bore the brunt of the burden of checking and grading our logs in the RTTY DX Contests. The sorrow of her sudden passing will be with us for a long, long time.

HORSE TRADES

FOR SALE: Model 26 Teletype, includes table and W9UE automatic line feed and carriage return. Working condition. $50.00 Model 15, 50 cycle synchronous motor. Part #5 SH 25 AB 14, $10.00. FOB James A. Mose, P.O. Box 131 Sharpsburg, Maryland.

FREE: AN/FGC-1 to anyone who will come with a trailer and two strong men to help load the thing. W9WKC, 856 East Washington Street, Hoopeston, Illinois.

WANTED: Kleinschmidt TT-4A page printers, and TT-76A tape units. W9UE 6140 North Harding Avenue, Chicago 45, Illinois.

FOR SALE: Toroids, uncased 88 mhy 60c each, or five for $2.50. WA6VVR, P.O. Box 34, Dixion, California 95616.

WANTED: Manual (instruction) for B&W TT56/MGC Perforator-transmitter, and Kleinschmidt TT-4A/TG Teletypewriter, VE3FKR, 56 Joseph Street, North Bay, Ontario, Canada.

FOR SALE OR SWAP: Model 26 "A" Board. Model MXD (1E) 3 TD's 60 speed. Hallicrafters SX28A. BC 312/N Converted to AC. All above in good condition. Will swap for Elmac AF68A & PS. K3GYS, 1610 South Iseminger Street, Philadelphia, Pa. 19148.

FOR SALE: Model 14, 15 and 19s. Send stamped envelope for information. ILLIANA RadioTeletype Society, Leslie Johnson, WA9HDG. 1 Orchard Hill Farm, Tinley Park, Illinois 60477.

TRADE: HQ-180 mint condition for best model 28 offered, or sell for $275.00 cash. Also want two glass windows for model 14 reperf covers. Also sell or trade Collins 32-V3, excellent condition. Need 100V or 200V. W4AIS, 7 Artillery Road, Taylor, South Carolina.

FOR SALE: Complete AN/FRR-3 and AN/FGC-1X in new condition, $125.00 picked up. W6AFX. . .

Subscription Rate $3.00 Per Year
RTTY is the Official Publication of the
RTTY Society of Southern California
and is published for the benefit of all RTTY Amateurs and Experimenters

For "RTTY" Information:
W6DEO W6CG W6TPJ W6AEE

FOR SALE: Model 15 printer with table. Communication type and sync motor. In excellent condition $90.00. Waiver required. W6UGA, 2370 Knob Hill, Riverside, California. Also wanted: Strip chart recorder, self balancing potentiometer type similar to Minneapolis - Honeywell/Brown. State model, condition and price. W6UGA.

FOR SALE: Excellent condition, R-390A/URR with book at $750.00 KWS-1 with RTTY and book $700.00. Model 14 typing reperf at $100.00. CV 116a? URR IF converter, dual channel for diversity, with auto freq control, a real beauty with book at $250.00. Want SX 73 and R-278B/GR. W1LVW, 99 Water Street, Millinocket, Maine.

FOR SALE: Teletype keyboard new, for model 15 printer, $10.00 ea. Teletype sync motor, like new 110 V 60 cy 1 ph, 1/40 hp, 1800 rpm, AC complete with fan, base and plate, $10.00 ea. Send for free catalog. Atlantic Surplus Sales, 181 Sackett Street, Brooklyn, N.Y. 11231.

WANTED: 50 cycle sync motors, 220 or 110 volts, gears #84018, 84019, 84064, 84065. Model 26 with DC motor, 21A tape printer, model 1A tape head w/base, model TT-4 printer with governed motor and 60/66 wpm gears. FSK converter, Model 20 Teletypesetter manuals. John L. Porep, Lenkurt Electric, US Naval Radio Station, Navy 524, c/o FPO, New York, N.Y. 09564.

FOR SALE: AN/FGC-1 Radioteletype converters $75.00 each or two for $100.00. Heavy duty (25 Amps) Teletype power supply, PEC-260 $75.00. Standard 19" relay racks $60.00 value for $22.50. Send for free list. Gulf Electric Sales, Inc. 7031 Burkett, Houston, Texas 77021.

FOR SALE: Model 14 Trans-Distributor, in excellent condition cannot be told from brand new. Sync motor, 60 speed gearing, has tight tape and tape stops. $70.00 W9YVP, 11001 South Pulaski, Chicago, Illinois 60655

FOR SALE: Alltronics-Howard Model K Telewriter converter, mint condition, six months old, $140.00. Will crate and ship prepaid to Continental USA. W1VXV, 85 Middle Road, Falmouth, Maine.

FOR SALE: Complete model 19 with table $72.50. Complete model 15 with table $52.50. Model 15 less table and keyboard $39.50. All 60 wpm 60 cps sync motor and weather type. Pair 833A's new $5.50. H. Brown, 1718 Toklat, Anchorage, Alaska 99504.

Dear RTTY'ers:

It is very difficult for me to express my deep appreciation for the many thoughtful expressions of sympathy and concern received from so many of you during my recent tragedy. It is gratifying to be part of a hobby where one can find so many friends ready to help out at a time like this. All I can say is "thanks."

Sincerely,
Bud Schultz, W6CG