ABOUT POWER SUPPLIES
BETTER DYNAMIC CHARACTERISTICS
MEAN BETTER OUTPUT ON CW, AM AND SSB

Here, for the first time, is a revealing discussion of how transient oscillations in the conventional power supply filter spoil the performance of an otherwise good rig—and what can be done to correct the difficulty.

The next issue of G-E HAM NEWS will contain design and construction specifications for 750-volt and 1500-volt supplies employing the principles discussed here.
What is dynamic regulation in a power supply? Because the literature in this field is exceedingly sparse, perhaps a good way to start is to take two common definitions and directly relate them to the subject at hand, thus:

- "VOLTAMETERS MISLEADING"

  Consider the final stage of a CW transmitter. At key-up the load is zero, or, at most, a rather small one. When the key is closed, the maximum load current is drawn. Now does the power supply follow the same curve that was plotted under static or slowly varying loads? An ordinary voltmeter might lead one to think so.

  But look at Figure 2! This is a photograph of a cathode-ray oscilloscope which shows how the voltage varies with time in the ordinary power supply when the load is suddenly applied as in keying a CW rig. The solid upper line shows the no-load output of the supply, 420 volts; the lower solid line represents zero-volt output. The upper wave line is a 5-cycle timing wave which permits reading the actual load voltage (repre- sented by the difference between the accelerating line) at any fraction of a second from the instant the load was applied. The spot on the oscilloscope trace in Figure 2, which shows the actual load current on the screen, is 0.01 second after the key was closed to a 250-milliampere load. (The steady current rating on the test supply is 250 milliamperes.)

  Note how the load voltage dips suddenly to less than a third of the no-load voltage line, then starts to rise and slowly overshoots the line and oscillates about it until it finally settles down to the average loaded voltage of 700 volts—which is the same as the static loaded output voltage shown in the curve of Figure 1 for a 250-milliampere load.

  Incidentally, the ripple under load is visible on the right-hand portion of the load voltage curve of Figure 2, but is fairly small compared with the extraordinary excursion of the voltage in the period immediately following the application of the load.

  A dc voltmeter that was connected across the line at the same time merely dropped from 420 to 700 volts and gave no indication of the actual torque immediately after keying.

  **EFFECT ON CW OPERATION**

  Is this anything to worry about? Well, the final stage in a CW transmitter is generally Class C, and the transient oscillation shown across the power supply can influence each character with that same wave form quite independently of any keying filter that may be provided for drift reduction. This, then, is the signal envelope—somewhat poorer than ideal.

  How long is a dot or a dash in seconds? That depends on the operator for the most part, of course. This is a matter of the operator's judgment of the correct timing of the voltage in the points of Figure 2. The voltage does not settle down to a steady ripple until more than a tenth of a second has elapsed. And as someone who has played with timing in radio or television may know, the possibility of this wave from what is normally thought of as "instantaneous"-

  -Voltage in the load is restored to its steady state—of course, the power supply voltage behaves as photographed in Figure 3—and, with oscillation fre-quently settling down to the no-load line. Of course, it depends on "on" and "off" effect, but the filter circuitry and all other stranded equipment are subjected once
Above data taken with this 750 V/250 ma d-c supply (see text):
again to this voltage turnstile. This may explain why every once in a while a ham's whole rig is blown to kingdom come when he shuts it off.

The oscilloscope shown only to single keying actions. Fast keying conditions intensely the transient shown in Figures 2 and 3.

**EFFECT ON PHONE OPERATION**

So much for CW loads on the common emission variety power supply. Now before the phone men start hugging up their wires at their brain-bounding hotels with "hand-modulated" rigs, let's take a close look at Class AB, AB, and B modulators operated with conventional power supplies.

It is characteristic of these modula of operation to draw average plate current which is a function of the modulating signal. Thus, the modulator load is similar to the on-off type of load experienced in a keyed CW transmitter, and the power supply transients so induced can be a real hazard to good quality. Because of the relatively sluggish action of a d-c plate current instrument (which tends to indicate current flow averaged over about half second or so) for actual cyclic or syllabic transient load presented to the power supply is much greater than one would be led to believe by just reading the plate meter.

What happens when the power supply behaves as it properly should? Assume theistor distortion and loss of required peak power because most of the supply's volt seconds is not there for the part of the time it is needed by the modulator, and so the modulator tubes cannot drive the peaks of plate current that the grid drive on the modulator stage says should be driven.

And remember, distortion tests made with steady tones will not show this "dynamic" distortion because the drain on a power supply induced by a steady tone is constant when averaged over one-half of the period of the tone base wave—relatively short compared to a filter transient which lasts more than a tenth of a second.

**EFFECT ON SSB OPERATION**

Single-sideband transmitters employing Class AB, AB, or RF stages present the same type of load to their respective power supplies—and, as a result, also introduce considerable distortion in the radiated signal.

About the only types of emissions in common use which do not suffer "on the air" losses as a result of transient filter characteristics are SSBM and FSK. (No transients are excited in the filter because the load is steady.) Liers and modulators loaded with AM signals overcome this dynamic power supply regulation problem, but are not in the output of this mode of operation is so low that use of linear amplifiers in amateur AM transmitters is incidental. Retriggering, rectifying current (or Hening) modulation for AM is another case where dynamic power supply regulation is not of primary importance. Grid modulation systems—control, screen or suppressor grid bias, and the more recent B stage of operation, are also immune to power supply considerations of rating and ripple filtering.

What can be done to improve the dynamic regulation of the output power supply? Let us follow the steps that were taken in the shock of WJKUJ to attack the problem.

**THE SOLUTION**

It became apparent that merely improving the ripple attenuation by adding more filter sections affected the dynamic regulation very little. So the first step was to increase the capacity of the existing filter from 2 microfarads to 5 microfarads per capacitor. The result appears in Figure 4—which shows excellant ripple filtering but only slightly reduced voltage excursions as compared with the transient of Figure 3.

Next, the two 5 microfarad capacitors of the two-section filter were connected in parallel to make a single-section filter (with the two chokes left in series). As shown in Figure 5, the voltage excursions are not greatly changed in magnitude, but have a less complex pattern—comparable, in fact, to that of a simple damped oscillation. But here again, the oscillation is excited in the filter by the suddenly-applied load.

The next step in the test was to use 45 microfarads of capacity as the final element of the filter. The dynamic regulation performance responded nicely, as shown in Figure 6. Note the reduction of magnitude of voltage swing and lowering of the resonant frequency of the filter as compared with Figures 4 and 3.

**FINAL DESIGN**

This encouraged a final design in which 90 microfarads of capacity rendered the curve shown in Figure 7. Here the dynamic regulation is just slightly greater than the static regulation, which, incidentally, measures 9.4%—quite good for almost any amateur transmitter. The "break" characteristics of this final design are pictured in Figure 8. Use of more capacity would improve the dynamic characteristics of the power supply correspondingly because the resonant frequency of the filter would be lowered even further.

(For more detailed theory on the dynamic characteristic of plate power supplies see "Design's Corner," page 6.)

**USING FLUORESCENT TUBE AS TUNING INDICATOR**

A sure indicator of maximum RF in your antenna is a fluorescent tube placed in the antenna field. The tube will be rapped against the antenna at the voltage node. Here in tuning the final or the antenna coupling sections of a transmitter it is possible to sense up to 50 watts. It is particularly useful when you must locate a window of the instrument that is out of sight.

This is particularly convenient when your antenna is located in such a position that it is out of sight. This is not an entirely new development, but is effective.

(Ed. Note—No doubt the neighbors will be confused no end, however, if you suddenly turn on the light for 20 or 30 w—until they suddenly tumble to the fact that there may be some relationship between that blinking light up in the sky and the twelve lights that TV picture tubes take on at certain times.)
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Some time ago when checking out my SSB trans- 
mitter I ran into a dissatisfying situation. 

Checks with a steady audio tone showed the rig
was putting out all that could be asked for. But voice
peaks measured on the oscilloscope would not come
together and I knew something was not right, but it was not
to determine, and it finally turned out to be tablespoon
drops in the power supply due to anything
portion of each syllable as a result of filter
oscillations. In a more recent test I actually photographed these
value drops, as pictured in the following article.

The problem is one which doesn't effect damping of
filter resonance or reducing the coupling between
the load variations and the required system of filter
choke and capacitors--or both--without sacrificing
safety or static regulation, and without overloading
the rectifier tubes or any other power supply com-
ponent. All this must be done without increasing the
load of the final design appreciably over that of the
conventional power supply. It sounds a lot like "eating
your cake and having it too," since what we have seen in
the oscilloscope of Figures 2, 3, 4, and 5 are commonly
accepted except for rarely suspected performance.

THE SOLUTION

The practical solution of the filter resonance prob-
lem involves these basic steps:

1. Reducing the Q of the filter without increasing its series resistance, and
2. Increasing the energy storage in the last filter

The first step can be achieved by shorting capaci-
tors and chokes with resistors, but if this is done the
peak current handled by the rectifiers would go up,
the static regulation would be poor, and a great deal
of power would be wasted in the damping resistors--
that is, the efficiency of the power supply would be
low.

Since the Q of the choke is Xc / R where Xc is the
inductive reactance at a given frequency, and R is the
effective series resistance of the choke at the frequency
considered, and after the Q of the filter is equal to the
Q of the choke (C of the condenser has a relatively
high effective series resistance), Q can be lowered by
decreasing Xc or increasing R. If R is increased, the static
regulation will suffer as a consequence, so the approach
should be through decreased Xc. Since Xc = 2πfL / 2L
a low product of fL is desired. In the interest of efficiency
and static regulation, practical limits are placed on the
value of fL. In the case of the given choke, the factor f
is the only one left to be altered.

NEED LOWER FILTER Q

What determines D? The resonant frequency of the filter
is the quantity I'm in question. To a first approxima-
tion, f = 1 / (2π√L C), where C is the capacity of the filter
condition with which L resonates. Therefore, the Q
of the filter can be increased by increasing the shunt
help in attainment of the second basic step stated
above.

What would have happened if L had been increased by a
factor of 9, instead of increasing C by the same

factor? The resonant frequency would have been
lowered as much, but the series resistance probably
would increase by about 20% (I certainly would
if 9 times the number of identical chokes had
been used) and the static regulation would be some-
times that indicated by Figures 1, 2, 5, 6, and 7, or
8V0, a drop from 850 v, no load, to 121 volts at
200 mA load! The Q would be the same in the filter,
but the total performance would be so badly degraded
that such a supply would be useless except for salvaging
of parts.

In some cases, the best design would be one in which
both the chokes and the condensers were increased in
value until suitable dynamic performance was ob-
tained. In high-voltage supplies this begins to pay
dividends since the "critical" induction increases
with voltage for a given minimum or bleed current
value, and high-voltage capacitors begin to get ex-
pen sive. Static regulation depends on the DC resistance
of the choke (together with the equivalent series
resistance due to the plate transformers) but a given
equivalent resistance of the chokes and trans-
former yields less percentage voltage drop as the oper-
ating voltage is increased.

TWO POWER SUPPLY DESIGNS

We have designed two power supplies which promise
to provide excellent dynamic regulation, good static
regulation and good ripple filtering. Best of all, these
supplies are not expensive ones. The first supply has
a continuous rating of 750 volts 250 MA output for
moderate and low power applications, while the second
is rated at 1500 Volts 250 MA. One nice thing about it
is that the builders may override the principle we have
explained and proceed in order to build other supplies
that are not included in the two basic design
latter. Either power supply is ideally suited for CW
transmitters, Class B modulators, linear amplifiers
(such as the Linear List or the Power Peaket), or
any application where the voltage and average current
requirements are within the rating given. The final
sample of these two power supplies were not compl-
ited for the time this issue of G-E HAM NEWS
went to press, but construction details will be given in
the March/April issue.

NEXI

2. J. S. Wilcox. In some reactions only static regulation is
considered. Good Background material, though.
3. G-E HAM NEWS Volume 6, No. 4
4. E HAM NEWS Volume 7, No. 8

HOW TO GET G-E HAM NEWS

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for a total of 11 per year G-E will mail HAM
NEWS to you home. Write to G-E HAM NEWS, Tube
Department,eward Electric Co., Schenectady, N. Y. 1
This subscription plan is available only in the United States. Also available as the "Armine Canal Zone, 
Amateurs in Canada should address requests to
Tapes educational Supply Corporation, 685 4th 
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for additional 4550 word HAM NEWS may be obtained through International General Electric distributors.
Seems like one thing that plagues most humans is a perpetual list of unfinished projects. Perhaps it’s partly a general failing of the human race to bite off more than can be chewed. But as far as garms go, a lot of the trouble comes from what we might call “over-enthusiasm.” In the field of ham radio there are so many things to do, so many types of equipment that can be built.

But one of the fellows here dropped a comment a while ago which can help keep down the number of unfinished projects—by keeping down the list of projects. We had asked him if he would like to see an article published on a certain piece of equipment and he shot right back at us: “What would I use it for? I don’t keep anything in the shack I don’t use.”

That’s an admisible policy, we thought. We made a New Year’s resolution and that night cleaned house. And we found that we get along very nicely without the old junk.

One of the nicest things about ham radio is the readiness of the fraternity to jump in and help whenever and whenever help is needed. And we don’t mean just (physical emergencies—men spiritual emergencies, too. As an example, the editor was telling us the other day how each member of the North West N. J. Radio Association (WDAV) sent a QSL card to a local lad who was afflicted with cerebral palsy. The interest that these stranger strangers showed in his life peaked the boy up, and his folks got him a communications receiver. Then the ham began to mention the lad’s name frequently in their local rag chew. He became an SWL, a silent member of the local network—and still hopes some day to be able to get his ticket. Incidentally, he’s still collecting QSL cards and if anyone wants to send him one, he’d sure appreciate it. Here’s the QTH: Richard Sterl, 422 West Avenue, River Edge, New Jersey.

A handy tip for both moibles and fixed stations to keep in mind comes via “Zero Beat,” bulletin of the Providence (R. I.) Radio Association: If called upon to report an accident along an unfamiliar stretch of highway, the location can be pinpointed by reporting the number on the nearest utility pole. . . . “Zero Beat” also expresses amusement at the things you hear on 2 meters. One Lubbocker, who was on towel at 1300 UTC, sends this note: “On the fly, six-7 shack, one cup water, and a pitch of salt for good luck. Boil until cranberries pop, pour into pie shell, cover with layer of whipped cream. Then reheat for another hour. “Zero Beat” now G.E. HAM NEWS assumes any responsibility for the taste of the dish. ‘Sparks,’ the bulletin of the Tri-State AEA at Evansville, Indiana, reports a 3-kw generator has been donated to the club by a local electric company.

“The Ham Hum,” bulletin of the Ark-la-Tex-Bay RC of Omaha (W6QKI), pages on this side shams up the front of the receiver and transmitter with a length of 2, 3/4-doped and painted to match the equipment. They say it makes the dial and meters more readable and gives the equipment a novel appearance. . . . The mobile section of the Michigan ARC (W8MBX) has been engaging in a community service which may be of interest to others—parade duty. They patrol local parades, sitting in keeping the people off speed and providing LID hook-ups where emergencies or other unforeseen problems arise, according to the club bulletin, “Marc Sparks.”

W8FY passes on a mobile moible reduction idea which he apparently got from WIDAS: Provide both the auto RC set and the converter with a hot lead direct from the battery—a lead with a well-grounded shield. They say this produces a good thick layer of mobile noise. A TV serviceman in California recalls a case where he found a set that had not been turned on for some time and noticed an intermittent failure. He used an infrared heat lamp to bring a burned chassis up to its normal in the cabinet operating temperature. This stunt is reported in the current issue of “Traffic Talk,” our Take Depart- ment publication for TV servicemen—available to them through authorized G-E tube distributors.

It’s reported W5WBF is maintaining a constant day-time watch on 3863 for any “QD Omaha” in antici- pation of communications emergencies in these months of snow, sleet, and ice. . . . The Detroit Amateur Radio Association (W5ZAP) has been hashing over the problems involved in delivering traffic from boys overseas asking their folks to send some money. When the citizen who doesn’t know such, if anything, about ham radio, gets a message that his or her boy wants money—well, it often leads to misunderstandings and suspicion. Some hangs now refuse to handle such traffic; others feel that all traffic must be handled. In any event, delivering such a message by phone is a ticklish problem. Those called upon to telephone such messages are cautioned not to become overly skilled in the art of the inevitable questioning of the address. The boys who have had trouble say it’s a lot worse than handling a Tquiv complaint.

Eighthaven January 7
HOW TO PHOTOGRAPH VOLTAGE DROPS

The oscillograms shown on page 3 of this issue of G-E HAM NEWS were taken with a 5-inch cathode-ray oscilloscope fitted with an oscillograph camera. In this photograph Don Norgard, WIZJ, is shown just before he opens the shutter of the camera and applies the load to a power supply he is testing for dynamic regulation.

The power supply output voltage is fed to the vertical deflection plates of the oscilloscope through a grid resistor in the grid circuit of one of the tubes in the grid stage. The grid resistor is then shorted to ground by a switch that is controlled by a contactor. The contactor is then closed by a relay which is held by a spring and is closed by the grid resistor, thus causing the relay to close and short the grid resistor to ground. This type of load simulates the load applied to a power supply feeding a keyed stage in a transmitter.

On one occasion the transient voltage developed in the power supply was so high that the multiplier resistor of a voltmeter reading the output voltage of the supply under test arced across and burned out the meter. That time the voltmeter did give some indication of the turnoff in the power supply following a suddenly applied load.

Don has been a regular contributor to G-E HAM NEWS and has been responsible for the design of the Harmoniker, or Log Linear, the Signal Sizer, the SSB Jr., and other pieces of ham gear described in G-E HAM NEWS.

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