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• *Beginner and Novice*

The Art of Dipping

Twenty Ways to Use Your Dipper

BY BENJAMIN CLARK,* WB4OBZ

THE GRID-DIP oscillator has long been a standard piece of test equipment in the ham shack. All recent editions of the *Handbook* have carried a circuit or two and discussed its uses. Several articles each year in *QST* treat the dipper, giving new designs or new ways of using this useful instrument. This article is an attempt to summarize uses of the dipper, in the hope that it may serve as a single reference.

To obtain the fullest use of the dipper three accessories are needed, a "standard" capacitor, a "standard" inductor and a calibrated all-band receiver. A capacitor of 100 pF and an inductor of 5 μH are recommended in the measurement section of the *Handbook*, and these values handle most any need.

* Mepkin Abbey, Route 3, Box 357, Moncks Corner, SC 29461.

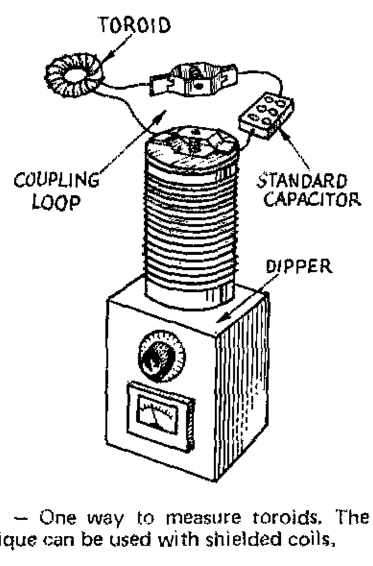


Fig. 1 — One way to measure toroids. The same technique can be used with shielded coils.

Resonant Frequency

The original use of the dipper was to measure the resonant frequency of a tuned circuit, and this use has been sufficiently covered that it merely needs to be mentioned here. One couples the dipper to the circuit to be measured, tunes the dipper until the meter dips, indicating resonance. The only precautions to be observed are to use the loosest coupling that will give a good dip, and to be sure that the dipper is indicating at the resonant frequency of the circuit to be measured and not at the resonant frequency of a circuit within the dipper itself. It's a good idea with any dipper, commercial or homemade, to check all ranges with the unit not coupled to anything and make note of any dips which occur. These are internal resonances within the dipper itself and knowing where they are can save much time and frustration when the unit is in actual use. One expects commercially built dippers to be free of such resonances, but a homemade unit may not be.

The calibration of the ordinary dipper is only approximate, close enough for most practical purposes, but not for all. Furthermore hand capacitance and the effect of the circuit to which the dipper is coupled will detune the oscillator somewhat. When greater accuracy is needed, one can make use of a frequency counter, or if this is not available, a calibrated frequency meter or receiver.

All dippers can be used as absorption frequency meters, for an absorption frequency meter is nothing more than a calibrated tuned circuit with some sort of resonance indicator. In every dipper, the current that passes through the meter is rectified rf from the tuned circuit, whether rectified by the grid circuit of a vacuum tube, by the gate junction of a JFET, or by a separate rectifier connected across the tuned circuit. It will rectify equally well whether the rf is generated by the dipper oscillator or is picked up from outside. With tube-type dippers, the plate voltage must be removed without cutting the heater or filament supply, to allow the grid-cathode circuit to act as a diode rectifier. An adjustable plate voltage is even more helpful, as this will permit the oscillator circuit to act as a Q multiplier when the voltage is adjusted to just below the point of oscillation, giving a sharper and more sensitive peak when the tuned circuit picks up rf to which it is resonant.

Inductance

With a capacitor standard it becomes easy to measure the inductance of a coil. Simply connect the coil in parallel with the capacitor and measure the resonant frequency. Then if you feel like doing some figuring, you can use the formula for finding resonant frequencies to determine the inductance, or you can do it the easy way by using an L/C/F calculator.[1]

The usual way of coupling to a coil inductively will not work as well when the coil to be tested is a toroid or is shielded, precisely because these types of coils are intended to have as little external field as possible. There are three ways that one can couple them to the dipper for measurement, however. If the dipper has the hot end of the coil connected to an external terminal, a small capacitor, say 5 pF, can be connected between that terminal and one side of the coil and capacitor standard combination, the other side being connected to the dipper chassis.

Another method for coupling to toroids and shielded coils makes use of the fact that the loop formed by the leads from the capacitor standard to the coil forms one turn of the coil, and can be coupled inductively to the dipper. The coupling is quite loose, but the high Q of the unloaded coil will usually make it adequate to get a good dip at resonance. See Fig. 1.

A third method for toroids is to wind links around the toroid coil and the dipper coil and connect them together as described in the April, 1973 issue of *QST* page 60, and shown in Fig. 2.

In the design of inductively coupled bandpass filters, one often needs to know the mutual inductance or coefficient of coupling of a pair of coils. The *Handbook* gives the following method: measure the inductance of one of the coils with the other first open, then shorted. The coefficient of coupling, (k) is found from the formula:

[1] LaPlaca, "Using the ARRL L/C/F Calculator," *QST*, December, 1973.

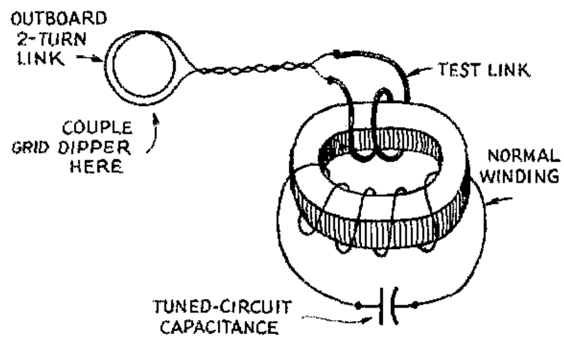


Fig. 2 — *Another method for testing toroids.*

$$k = \sqrt{1 - \frac{Ls}{Lo}}$$

where Ls is the inductance measured with the other coil shorted, Lo is the value measured when the short is removed. See Fig. 3 a and b. With known capacitors in use, measuring the frequency will enable you to determine the inductance.

Mutual inductance can be measured by finding the inductance of the two coils connected in series, noting the value, then reversing the connection to one of the coils and measuring the inductance again. Half the difference between the two measurements is the mutual inductance. Mutual inductance (M) and coefficient of coupling (k) are related by the formula:

$$k = \frac{M}{\sqrt{L1L2}}$$

For accurate measurement of mutual inductance or coefficient of coupling, something better than the dipper calibration may be needed, and may be obtained by using the frequency counter method described earlier. If one has a counter, or a receiver covering the required range, fine. But if your receiver is of the amateur-bands-only variety, your capacitor standard may not be able to tune the coil within your receiver's range. In that case, use any capacitor that will do

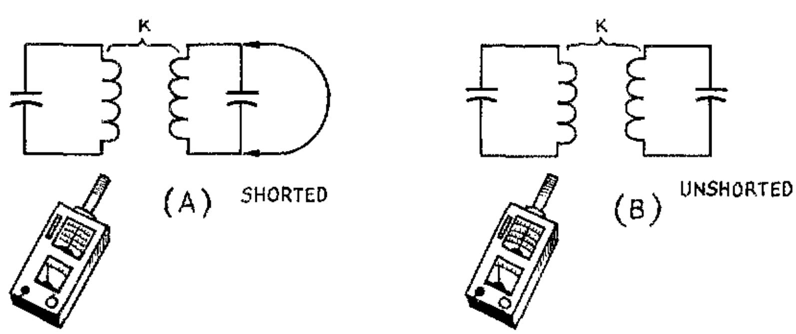


Fig. 3 — This shows how to determine the value of an unknown inductance as described in the text.

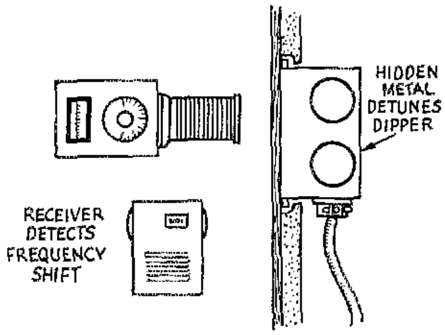


Fig. 4 — Locating hidden metals with a dipper.

so, and compute the coefficient of coupling as shown above, but using another formula that does not require that one determine the actual value of the inductance:

$$k = \sqrt{1 - \frac{fo^2}{fs}}$$

where *fo* and *fs* are the frequencies measured with the other coil open and shorted respectively.

Capacitance

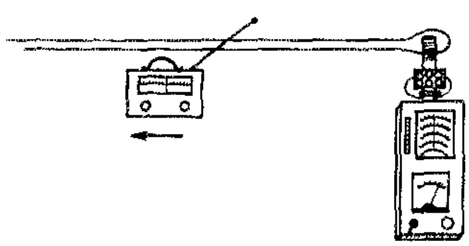
Capacitance is measured just like inductance except, of course, that you connect the inductance standard in parallel with the capacitor to be measured.

Transmission Lines

In constructing antennas, a quarter-wave section of line at the operating frequency is often needed. If one-fourth the wavelength in free space were required, the length could simply be computed by formula. But the electrical length of a line is always greater than the measured length; therefore the velocity factor of the coax should be taken into account. This will assure your getting the proper line length to within a few inches. To get a quarter-wave line, attach a loop to one end, leave the other end open, and dip. Trim until the dip is at the desired frequency. When the dip is where you want it, you have your quarter-wave line (or any odd multiple of a quarter wave, for that matter).

For a half-wave line, do the same as described above, except that the far end should be shorted, and a small coupling loop for the dipper should be used at the near end of the line. If the line is of reasonably good quality, the dip should be quite sharp in both cases.

Fig. 5 — A method for tracing hidden pipes or wiring using a bc receiver and a dipper.



To measure the velocity factor of a line, simply reverse the procedure: find the frequency at which the length of line is resonant (far end open), measure the length, and use the formula:

$$V = \frac{fl}{246}$$

where *f* is the resonant frequency, *l* is the length in feet, and *V* is the velocity factor. For long lines, greater than a quarter wavelength at the lowest frequency reached by the dipper (rarely the case in an amateur installation), a line terminated in an open circuit will be resonant at any odd multiple of a quarter wavelength. In this case, however, it may be necessary to check at several frequencies to be sure that one has the correct number of quarter wavelengths.

Miscellaneous

Simply because it is an oscillator with a wide tuning range, the dipper can serve as a signal generator, both for approximate alignment of receivers and for supplying rf for antenna measurements.

A dipper can also act as a neutralization indicator. When the dipper is coupled to the plate tank of a transmitter stage, tuning the grid tank through resonance will cause a dip if the stage is not neutralized. This method has the advantage of not requiring that the transmitter be turned on to make the check. A dipper can also be used in the absorption-frequency-meter mode to detect rf in the plate circuit when the grid is driven.

A troublesome problem in transmitters, both tube and solid state, is that of parasitic oscillations. The dipper can often be most helpful in determining the frequency of the parasitics and in identifying the resonances responsible.

In the oscillating mode of the dipper, particularly if regeneration is adjustable, a dipper can serve as a field-strength indicator. A short antenna, about 20 inches of stiff wire connected to the hot end of the dipper coil will serve to pick up the signal.

A dipper, when its signal is picked up on a communications receiver, can be used to locate metal. As the coil is brought close to the metal, the dipper oscillator will be detuned, and the change in pitch of the beat note in the receiver will enable one to locate the metal easily. See Fig. 4.

Hidden wiring or metal piping can also be traced by inducing an rf current in the metal, and following it while monitoring the dipper's signal in a bc receiver. (see Fig. 5.) In this case, however, use the weakest signal that will give adequate response, both to secure more accurate locations and to cut down on the interference possibilities to broadcast reception in your neighborhood. Whenever a small bc receiver is used for tests like these, it is best to try the techniques first on a piece of wire you can see and become familiar with the method and the behavior of the equipment, as otherwise one can be misled by the avc action of the receiver.

(Continued on page 33)

Testing and Operation

The amplifier is unconditionally stable, with no parasitics. To verify this, a zero bias check for stability was made. This involved shorting out the Zener diode in the cathode return lead, reducing bias to essentially zero volts. Plate voltage was applied, allowing the tube to dissipate about 885 watts. The input and output circuits were then tuned through their ranges with no loads attached. There was no sign of output on the relative output meter and no change in the plate and grid currents. As with most cathode-driven amplifiers, there is a slight interaction between grid and plate currents during normal tune-up under rf-applied conditions. This should not be misconstrued as amplifier *instability*.

Tolerances of the Zener diode used in the cathode return line will result in values of bias voltage and idling plate currents other than those listed in Table I. The 1N3311, a 20-percent tolerance unit, is rated at 12 volts nominal but actually operates at 10 volts in this amplifier (within the 20-percent tolerance).

All testing and actual operation of this amplifier was conducted with a Raytrack high-voltage power supply used in conjunction with the authors 6-meter amplifier. The power supply control and output cable harness was moved from one amplifier to the other, depending on the desired frequency of operation.

Drive requirements were measured for plate power-input levels of 1000 and 1600 watts with a Bird model 43 Thru Line Wattmeter and a plug of known accuracy. Output power was measured simultaneously with drive requirements at the 1000 and 1600 watt plate power input levels. A second Bird model 43 with a 1000-watt plug was used to measure amplifier output into a Bird 1000-watt Termaline load. A 2500-watt plug would be necessary to determine output power at the 2-kW input level, so I stopped at the 1000-watt output point and worked backwards to calculate apparent stage gain and efficiency.

Efficiency measurements also were made employing the "tube air-stream heat-differential" method. Several runs were made at 885 watts static dc and normal rf input. Apparent efficiencies of 62 to 67 percent were noted. These values were about 5-percent higher than the actual power output values given in Table I. Both efficiency measurement schemes serve to confirm that the amplifier is operating at the upper limit of the theoretical 50-60-percent efficiency range for typical Class AB2 amplifiers.

To commence routine operation, the variable capacitor in the input circuit should be set at the point where lowest input VSWR was obtained during the "cold tube" initial tube-up. The ability of the plate tank to resonate at 144-145 MHz with the top cover in place should be verified with a grid-dip meter, via a one-turn link attached to the rf output connector. Top and bottom covers are then secured. **As with all cathode driven amplifiers, excitation should never be applied when the tube heater is activated and plate voltage is removed.**

Table I

Performance Data

Power input, watts	1000	1600
Plate voltage	2600	2450
Plate current (single tone)	385 mA	660 mA
Plate current (idling)	50 mA	50 mA
Grid bias	-10 V	-10 V
Grid current (single tone)	35 mA	54 mA
Drive power, watts	18	41
Efficiency (apparent)	59.5 %	61.8 %
Power gain (apparent)	15.2 dB	13.9 dB
Power output, watts	595	1000

Next, turn on the tube heater and blower simultaneously, allowing 90 seconds for warm-up. Plate potential between 2400-3000 volts then may be applied and its presence verified on the multimeter. The power supply should be able to deliver 800 mA or so. With the VOX relay actuated, resting current should be indicated on the cathode meter. A small amount of drive is applied and the plate tank circuit tuned for an indication of maximum relative power output. The cathode circuit can now be resonated, tuning for minimum reflected power on the reflectometer, and not for maximum drive power transfer. Tuning and loading of the plate-tank circuit follows the standard sequence for any cathode driven amplifier. Resonance is accompanied by a moderate dip in plate/cathode current, a rise in grid current and a considerable increase in relative power output. Plate-current dip is not absolutely coincident with maximum power output but it is very close. Tuning and output-loading adjustments should be for maximum efficiency and output as indicated on the output meter. Final adjustment for lowest VSWR at amplifier input should be done when the desired plate input-power level has been reached.

Acknowledgements

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5) Cool Amp Silver Plating Powder, part No. 1233-500, available from The Cool Amp Co., 8603 S. W. 17th Ave., Portland, OR 97219.

6) Tube socket grid clips, part No. 149-842, and Teflon chimney, part No. SK-2216, available from Eimac Division of Varian, 301 Industrial Way, San Carlos, CA 94070.

7) *The Radio Amateur's VHF Manual*, 2nd Edition, p. 288. (This Edition was erroneously labeled as the 11th at the time of printing.)

The Art of Dipping

(Continued from page 18)

These twenty reasons are not all the possibilities, but seem to be among the most important, and illustrate why a dipper is a handy thing to have around the ham workshop. QST