Selectivity Characteristics of the Hammarlund HiQ-30

While the actual selectivity of a receiver can be determined exactly in the laboratory, without regards to its sensitivity or amplifying ability, the average receiver owner judges the selectivity of a receiver by its apparent selectivity. The difference between the actual selectivity and apparent selectivity of a receiver is very important.

A comparison between two receivers, one of which has a sensitivity three times that of the other will serve to illustrate the difference. If both have the same actual selectivity and both are tuned to a station which is transmitting on 600 kilocycles, while a distant station is transmitting on 580 kilocycles, the distant station will be brought in by the more sensitive receiver and may cause interference. The insensitiveness of the less sensitive receiver will lead one to believe that it is more selective because it fails to bring in the distant station to the same degree as the more sensitive receiver, apparently resulting in less interference.

Because of the high gain or sensitivity attained in the HiQ-30 by the use of three stages of high gain radio frequency amplification, special precautions had to be taken to prevent any apparent lack of selectivity.

In the conventional receiver employing three stages of tuned radio frequency amplification and a tuned detector stage, there are four tuned circuits.

If we assume that the four circuits are substantially alike, are arranged in the usual cascade form, and are tuned to the same frequency, the selectivity of the various stages is cumulative.

If each stage has a selectivity factor of 10 for a five percent difference in frequency, the selectivity curves for the receiver in terms of the various stages will be substantially as shown in Fig. 1 when the receiver is tuned to a station of 1,000 kilocycles.

If the maximum response, at 1,000 kilocycles, is taken as 1, the voltage ratio or relative response at the various frequencies will be as shown in Fig. 1, where curve number 1 shows the effect of the first tuned stage in reducing the signal strength of all frequencies other than the 1,000 kilocycle frequency to which the stage is tuned, curve 2 shows the effect of both the first and second stage acting together, curve 3 shows the effect of the three first stages in reducing the response to undesired frequencies and curve 4 shows the effect of all four stages in tuning the receiver to the desired signal, to the exclusion of undesired frequencies.

Thus if two signals of equal intensity transmitted by two stations approximately the same distance from the receiving antenna are respectively 1,000 and 950 kilocycles, the 950 kilocycle frequency will be only 1/10th as strong as the 1,000 kilocycle frequency after passing through the first stage, 1/100th as strong after passing through the second stage, 1/1,000th as strong after passing through the third stage and only 1/10,000th as strong as the 1,000 kilocycle frequency after passing through the fourth stage. If the signal produced at the receiving antenna were ten times that of a desired station at resonance however, either because the undesired station is closer to the receiving station or is transmitting at greater power, the interfering signal of 950 kilocycles, would be equal in strength to the desired signal at 1,000 cycles after passing through the first stage and would be 1/1,000th as strong as the desired signal after passing through all four stages.

In the HiQ-30, a preselecting unit consisting of three tuned circuits designed to give band-pass characteristics are used between the antenna and the first radio frequency amplifier. The effect of this type of band-pass filter in giving greater selectivity and at the same time broadening the top of the curve to give better reproduction by preventing the elimination of the signal sideband frequencies is illustrated in Fig. 2. In this chart, A represents the response curve of the band-pass filter and first tuned stage of the HiQ-30 receiver while B represents the response curve of the first tuned stage of the standard tuned radio frequency receiver. It will be seen that at 950 kilocycles, the response for a 950 kilocycle signal is still 1/10th of the maximum or 1,000 kilocycle station on the standard R. F. stage while it is only 1/450th as much as the maximum after passing through the band-pass filter and first R. F. stage of the HiQ-30.

Curves A and B of Fig. 3 show clearly the relative overall selectivity of the HiQ-30 as compared with a corresponding four tuned circuit receiver. Curve A shows the broader top curve of the HiQ-30 at resonance which results in improved reproduction due to the inclusion of the sidebands of the desired signal as against the sharp cutoff at resonance of the standard tuned radio frequency receiver. The HiQ-30 response curve then narrows down while the curve of the standard tuned radio frequency receiver broadens out, showing the greater effectiveness of the HiQ-30 in eliminating interfering stations.

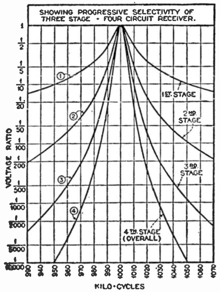

Fig. 1

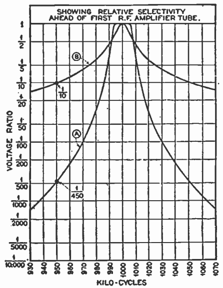

Fig. 2

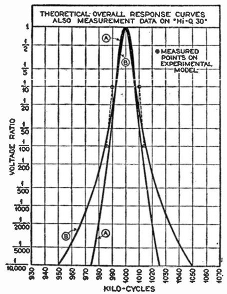

Fig. 3

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METER MULTIPLIERS: A Convenient Method of Increasing the Range of Milliameters and Voltmeters

Part 1

By the Engineering Department, Aerovox Wireless Corp.

SO many requests have been received by the Aerovox Research Worker for data on the use of series and shunt resistors for increasing the range of voltmeters and ammeters, that an article on the subject was prepared for this issue.

A knowledge of the internal construction of the average meter will prove helpful in understanding the simple principles involved in making the necessary calculations to determine the values of multipliers required to increase the range of different meters.

The movement most generally used in D.C. voltmeters and ammeters is the D'Arsonval movement shown in its simplest form in Fig. 1.

In this type of instrument, a delicate coil wound with very fine wire is suspended in the field of a strong permanent magnet. The coil is mounted with an axis through the plane of the coil. The indicating pointer or needle is at right angles to the axis or pivot. The end of the needle indicates on the scale, the deflection of the coil in the magnetic field. The needle is held at the zero or normal value of the scale by a fine hair spring similar to the type used in watches.

When the terminals of the moving coil are connected in a circuit so that current flows through the coil, the current flowing through the coil produces a magnetic field around the coil and the coil becomes an electromagnet with a north and south pole as indicated.

Due to the attraction of unlike poles and repulsion of like poles of two magnets, the coil and the indicating pointer attached to it will move in a clockwise direction to an extent depending on the strengths of the fields of the electromagnet and the permanent magnet. The relative strength of the field produced in the electromagnet depends on the current flowing through it so that the movement of the coil is a measure of the strength of the magnetic field and the current which produces it.

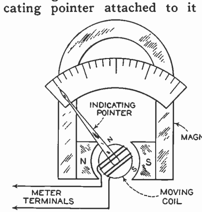

Fig. 1

By properly designing the constants of the permanent magnet and the electromagnet, a full scale deflection on the scale can be produced by different values of current flowing through the meter.

It is also possible, by the use of multipliers, or shunt resistors connected across the terminals of the coil, to limit the current through the coil in any given proportion so that the current measured is a given fraction of the total current flowing in the circuit.

It is a well known fact that when two resistors are connected in parallel as shown in Fig 2, the current in the circuit divides between them in inverse proportion to their resistances.

Thus if two resistances, R1 and R2 having resistances of 100 ohms and 1,000 ohms respectively are connected across a source of D.C. voltage of a value such that the total current in the circuit is 11 milliamperes, the total current of 11 milliamperes will divide between the two resistors, the lower resistance value R1 which has a resistance of 100 ohms taking ten times as much current as the higher resistance R2 which has a resistance of 1,000 ohms. A current of 10 milliamperes will therefore flow through R1 while a current of 1 milliampere will flow in R2.

This principle of the ratio of current existing between two resistances which are connected in

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parallel is used to increase the range of current measuring instruments such as milliammeters and ammeters.

Most meter manufacturers give in their descriptions of their ammeters and milliammeters, the current measuring range of the instrument, the scale divisions or total marked divisions on the scale and the internal resistance of the instrument.

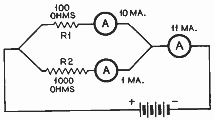

Fig. 2

These characteristics of the Pattern 88 direct current meters made by the Jewell Electrical Instrument Co. of Chicago, Ill. and the Model 301 direct current meters made by the Weston Electrical Instrument Corporation of Newark, N. J. are given in Fig. 3. These two types are the most popular in the field and may be obtained from most radio dealers or supply houses.

While the values of resistance are approximate and may vary slightly they are accurate enough for the average use to which they will be put by most experimenters. Where extreme accuracy is necessary, it is taken for granted that accurately calibrated instruments will be employed.

For general all-around use it will be found that the milliammeter with a range of zero to 1 milliampere will be found most useful. In the Weston type of meter having 20 scale divisions, this means that when used alone, readings may be obtained in steps of 1/20th of a milliampere or 50 microamperes. In the Jewell instrument of this range which is divided into 50 scale divisions, readings may be obtained in steps of 1/50th of a milliampere or 20 microamperes. Intermediate values between division lines can of course be estimated.

The 0 to 1 milliammeter can be used to measure directly, all currents within its range. It is easily possible, however, to increase its range by any desired multiple by connecting a shunt resistance across the terminals of the milliammeter as shown in Fig 4, so that the milliammeter measures only a fraction of the current flowing through the combination resistance formed by the parallel connection of the meter resistance and the external shunt.

To determine the shunt resistance required to multiply the range of any ammeter, milliammeter or microammeter by any desired multiple, all that is necessary is to divide the resistance of the meter by a number one less than the multiple by which the meter range is to be multiplied.

A simple example will show this clearly.

If we have a 0 to 10 Model 301 Weston milliammeter which Fig. 3 shows to have a resistance of 8.5 ohms and we wish to convert it into a milliammeter having a range of from 0 to 50 milliamperes, the multiple by which the scale readings of the 0 to 10 milliammeter must be multiplied is 5 (10 times 5 equals 50).

One less than 5 is 4 so that the resistance of the milliammeter must be divided by 4 to get the desired range. The value of shunt resistance required is therefore 8.5 divided by 4 or 2.125 ohms. Each value of the milliammeter must then be multiplied by the multiple 5 when taking readings with the shunt in use.

If a fair degree of accuracy is required, it is important that the values of these shunt resistors be accurate.

The difficulty in making direct practical use of this simple method of increasing the range of current measuring instruments lies in the fact that accurate resistances in these small values are difficult to obtain.

If a shunt resistor which is slightly less than the exact required value is obtainable however, it is possible to make a calibration curve to show the new values of the meter scale divisions with the shunt in use.

This calibration can be obtained either by calculation, if the exact value of the shunt resistance is known or can be measured, or by comparison of the milliammeter with a standard milliammeter.

If we take the example given above for increasing the range of a 0 to 10 ma. milliammeter to 0 to 50 ma., we will note that the multiple is five, since 10 must be multiplied by 5 to give the maximum new reading for full scale deflection. The value of resistance required for the shunt was calculated as 2.125 ohms (¼ of the resistance of the milliammeter). This means that the current divides in the two branches, consisting of the resistance of the meter, 8.5 ohms, and the shunt resistance of 2.125 ohms, 4 parts going through the shunt resistance and 1 part going through the milliammeter. The total parts flowing through the combination or 4 plus 1 equals 5 is the multiple by means of which the readings on the milliammeter must be multiplied to get the values when the shunt is used.

Table of Meter Characteristics

	WESTON		JEWEL	
RANGE MICRO-AMP.	RESISTANCE OHMS	SCALE DIV.	RESISTANCE OHMS	SCALE DIV.
200	55	40	140	40
300			140	60
500	56.5	25	140	50
MA.				
1.	27	20	30	50
1.5	18	30	30	75
2.	18	20	25	40
3.			20	60
5.	12	50	12	50
10.	8.5	20	7	50
15.	3.2	30	5	75
20.	1.5	20		
25.	1.2	25	3	50
50.	2.0	25	1.5	50
100.	1.0	20	.75	50
150.	.66	30	.5	75
200.	.5	20	.37	40
300.	.33	30	.25	60
500.	.2	25	.15	50
800.	.12	40		

Fig. 3

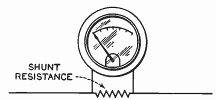

Fig. 4

Now if the shunt resistance used is exactly 2 ohms, instead of the required 2.125 ohms, the resistance of the shunt is 1/4.25ths of the resistance of the milliammeter so that for every milliampere that flows through the milliammeter, 4.25 milliamperes will flow through the shunt. For every milliampere indicated on the milliammeter there is 5.25 milliamperes flowing in the combination circuit consisting of the milliammeter and the shunt.

This means that every reading on the milliammeter must be multiplied by the multiple 5.25 to get the actual current flowing in the circuit.

A simpler method of arriving at the multiple is to use a modification of the formula already referred to for finding the shunt resistance when the meter resistance and the multiple required to increase the range are known.

If the shunt resistance required equals the resistance of the meter divided by one less than the multiple or:

$$Sr = \frac{Mr}{(M-1)}$$

where Sr is the shunt resistance required, Mr is the meter resistance and M is the multiple, then by transposing,

$$(M-1) = \frac{Mr}{Sr}$$

or

$$M = \frac{Mr}{Sr} + 1$$

If the meter resistance is 8.5 ohms and the shunt resistance is 2 ohms as in the above example, solving the above equation gives 8.5 divided by 2. ohms equals 4.25 and plus 1 equals 5.25, the desired multiple.

Multiplying the milliammeter reading by this multiple is a simple proposition but is not necessary. A calibration chart such as is shown in Fig. 5 can be made simply by laying out the scale divisions of the present milliammeter along the horizontal scale and laying off an equal number of divisions along the vertical scale to indicate the corresponding current readings when a shunt resistance is used.

All that is necessary then is to calculate one value of the vertical scale value corresponding to any given reading on the milliammeter and draw a straight line passing through that point and the origin of the two scales (zero on both scales).

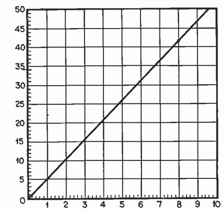

Fig. 5

Using the 2 ohm shunt resistance for instance the multiple by which the scale reading must be multiplied is 5.25. A reading of 8 milliamperes for instance would therefore indicate a current of 8 times 5.25 or 42 milliamperes flowing through the combination circuit of meter and shunt resistance. This point can be located where the projection of the 8 milliampere point of the meter scale crosses the projection of the 42 milliampere point on the vertical scale. A straight line passing through this point and the zero of both scales will give the corresponding values of both scales when the 2 ohm shunt is used with this particular meter. The same principle can be used to increase the range of any other meter, by first finding the exact value of resistance required with the meter and then using any slightly lower available resistance as the shunt and laying out a calibration chart as described.

Where the exact value of the shunt resistance can not be determined, its approximate value only being known, the comparison method may be used.

This consists simply in connecting the shunt resistance across the meter terminals and connecting the meter to be calibrated in series with a standard meter which is capable of covering the desired range, as shown in Fig. 6.

In this diagram, the 0 to 10 milliammeter is the one whose range it is desired to increase to 0 to 50 milliamperes by connecting the shunt resistance R across it. The 0 to 50 milliammeter is a standard against which to check the other. The voltage of the battery and the resistance R1 should be selected so as to produce a current flow of 25 to 50 milliamperes in the circuit.

Since the same current flows through both meters, any reading on the 0 to 10 milliammeter corresponds to the readings on the 0 to 50 milliammeter. Thus if the reading on the 0 to 50 milliammeter, for a given battery voltage and resistance R1 is 40 milliamperes, the reading on the 0 to 10 milliammeter corresponds to 40 milliamperes of current flow. If under these conditions the reading on the 0 to 10 milliammeter is 7.2 milliamperes, the multiple by which

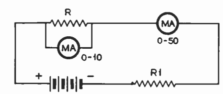

Fig. 6

the readings of the converted 0 to 10 milliammeter must be multiplied to obtain the actual current flow is 40 divided by 7.2 or 5.5.

By locating the intersection of the lines from the 7.2 ma. point of the 0 to 10 milliampere scale with the 40 milliampere point on the 0 to 50 milliampere scale and connecting this point to the zero of both scales, a calibration will be obtained which shows the corresponding readings when the shunt is used across the milliammeter.

Since this article will be continued in the next issue of the Research Worker, it is suggestd that this issue be kept for reference.