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SIGNAL DIVIDERS

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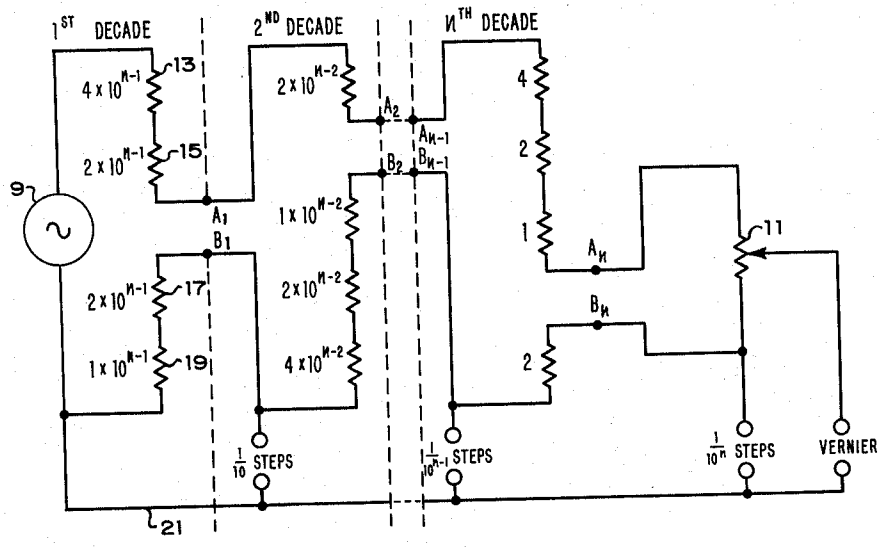

Figure 1

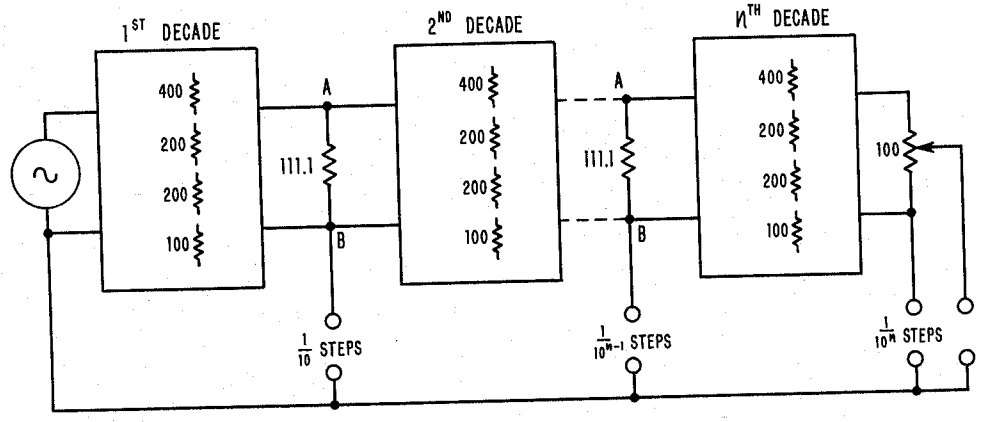

Figure 2

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SIGNAL DIVIDERS

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This invention relates to decade signal dividers which use only four resistors per stage to provide ten equal increments of signal division. Each of the divider stages shows constant input impedance and is connected in cascade with adjacent stages without the aid of isolation amplifiers.

The principal object of the present invention is to provide an improved decade signal divider which provides the high signal-division accuracy of a conventional Kelvin-Varley divider but which uses fewer components.

It is another object of the present invention to provide an improved decade signal divider.

These objects are accomplished in the present invention by using four resistors per decade stage which have normalized resistance values respectively of one, two, two and four relative to the value of the resistance connected to the output of the stage. The desired decade division per stage is achieved by properly arranging the four resistors and the resistor connected to the output of the stage in a series circuit and by obtaining the voltage drop across selected ones of the resistors in this circuit.

Other and incidental objects of the present invention will be apparent from a reading of this specification and an inspection of the accompanying drawing in which:

FIGURE 1 is a schematic diagram of the divider of the present invention; and

FIGURE 2 is another embodiment of the divider according to the present invention which uses similar resistance values in each of the decades.

Referring now to FIGURE 1 there is shown a plurality of decades each including four resistors **13**, **15**, **17**, **19** having normalized values of one, two, two and four relative to the value of a resistor connected to the output of the stage. A source **9** of signal to be divided is connected to the input of the first decade and another resistor having a normalized value of one is connected to the output of the last decade-divider stage. The actual values of the resistors in the decades increase by an order of magnitude starting from the last decade and continuing to the first. Thus, if the resistor **11** connected between terminals A and B at the output of the last decade has a normalized value of one then the normalized values of the resistors in the last decade have values as shown. By the term normalized values is meant the values of resistors relative to the value of a reference resistor, say resistor **11**. If this resistor has an actual resistance of 250 ohms then this resistor is said to have a normalized value of one and resistors having resistances of 250, 500 and 1000 ohms are said to have normalized values respectively of one, two and four. Successively more significant decades have normalized values which increase by an order of magnitude per decade. The resistor **11** at the output of a decade divider stage may have an adjustable tap as shown to provide a continuum of values over the range between the upper and lower limits of the $\frac{1}{10}$ signal division step appearing across its terminals. The input impedance looking into the terminals A and B of each of the decade dividers remains constant independent of the attenuation setting provided by a successive decade. By way of example, the arrangement of the resistors shown attenuates the signal from source **9** to .37 . . . 2 of its value where an output is taken from terminal B at the output of the *n*th or last decade with

respect to common conductor **21**. Resistors **13** and **15** of the first decade are serially connected with the input resistance of the second decade appearing between terminals A_1 and B_1. This group of serially connected resistors is, in turn, connected to the series resistors **17** and **19** of the first decade. It can be seen that the signal appearing between the terminal B_1 at the output of the first decade and the common conductor **21** is .3 of the value of the signal from source **9**. It can also be seen that one tenth of the signal from source **9** appears across input terminals A_1 and B_1 of the second decade. This portion of the signal from source **9** is further divided by the series combination of the four resistors in the second decade and the input resistance appearing between the terminals A_2 and B_2 of the next successive decade. The connection of the resistors as shown in the second decade thus attenuates to .7 the signal applied to its input terminals A_1 and B_1, which signal is one tenth of the signal from source **9**. The output signal from the second decade is thus .37 of the signal from source **9**. Each of the successive decades to the *n*th decade, as shown in FIGURE 1, divides the portion of signal from source **9** appearing at its input terminals A and B in a manner similar to that described above in connection with the first and second decades. The output signal which appears between terminal B_n at the output of the last decade and the common conductor **21** is thus .37 . . . 2 of the value of the signal from source **9**. Other combinations of the four resistors than those shown in each of the decades with the output taken between selected ones of the combined resistors yields ten equal steps of attenuation per decade. The switching logic to achieve this result is complex but is less expensive than the additional number of precision resistors heretofore required as in Kelvin-Varley dividers to provide the same accuracy in decade attenuators.

The embodiment of FIGURE 2 eliminates the need for impedance multiplication from stage to stage and provides additional economy of components by using similar value resistors in each of the decades. For resistors having normalized values as shown in each of the stages, the normalized value of the input resistance appearing between terminals A and B of a stage is 100 ohms, which input resistance is serially connected with the four resistors of a preceding stage to yield an input resistance in the preceding stage of 100 ohms. A decade divider connected in this manner thus comprises identical stages, each of which stages requires only five resistors to provide decade attenuation steps.

We claim:

1. Signal apparatus comprising:

impedance means having a normalized impedance value of one;

at least first and second sets of impedances, each set including not more than four impedances having normalized values related by integer multiples to the normalized impedance value of said impedance means;

first and second input terminals and first and second output terminals for each of said sets of impedances;

means serially connecting a selected number of the impedances in the second set between the first input and output terminals of the second set;

means serially connecting the remaining impedances in the second set between the second input and output terminals of the second set;

means connecting said impedance means between the first and second output terminals of said second set;

means serially connecting a selected number of the impedances in said first set between the first input and output terminals of the first set;

means serially connecting the remaining impedances in the first set between the second input and output terminals of first set;

means connecting the first and second input terminals of the second set to the corresponding first and second output terminals of the first set, the first and second input terminals of the first set being connected to receive an applied signal; and

means connected to one of the output terminals of the second set for providing an output signal with respect to the first input terminal of the first set.

2. Resistance apparatus comprising:

a pair of input terminals connected for receiving an applied signal, and a pair of output terminals;

resistive means connected to said pair of output terminals;

at least first and second sets of resistors, each set including first, second, third and fourth resistors having resistance values respectively in the ratios of one:two:two:four;

means serially connecting said resistive means and a selected number of said resistors in the second set to form a first group;

means serially connecting remaining ones of the first, second, third and fourth resistors of said second set to form a second group;

means including serially connected first and second groups and forming a first circuit;

means serially connecting the first circuit and a selected number of said resistors in the first set to form a third group;

means serially connecting remaining ones of the first, second, third and fourth resistors in the first set to form a fourth group;

means serially connecting the third and fourth groups between said input terminals; and

means connected to one of the pair of output terminals for producing an output with respect to one of said pair of input terminals.

3. Resistance apparatus having input terminals and comprising:

resistive means having a normalized resistance of one and having a pair of terminals;

at least first and sceond sets of resistors, each set including first, second, third and fourth resistors having resistance values respectively in the ratios of one:two:two:four;

means serially connecting said resistive means and a selected number of said resistors in the second set to form a first group;

means serially connecting remaining ones of the first, second, third and fourth resistors of said second set to form a second group;

means including serially connected first and second groups and forming a first circuit having a pair of terminals;

means serially connecting the first circuit and a selected number of said resistors in the first set to form a third group;

means serially connecting remaining ones of the first, second, third and fourth resistors in the first set to form a fourth group;

means serially connecting the third and fourth groups between said input terminals; and

means connected to one of said pair of terminals of said resistive means for producing an output from said apparatus with respect to one of said input terminals.

4. Signal divider apparatus having input terminals and comprising:

resistive means having a normalized resistance value of one and having a pair of terminals;

at least first and second sets of resistors, each set including first, second, third and fourth resistors having resistance values respectively in the ratios of one:two:two:four;

means serially connecting said resistive means and a selected number of said resistors in the second set to form a first group;

means serially connecting remaining ones of the first, second, third and fourth resistors of said second set to form a second group;

means including serially connected first and second groups and forming a first circuit having a pair of terminals;

means serially connecting the first circuit and a selected number of said resistors in the first set to form a third group;

means serially connecting remaining ones of the first, second, third and fourth resistors in the first set to form a fourth group;

means serially connecting the third and fourth groups between said input terminals;

a source of signal to be divided connected to the input terminals of said apparatus; and

means connected to one of said pair of terminals of said resistive means for deriving an output from said apparatus with respect to one of said input terminals.

References Cited by the Examiner

UNITED STATES PATENTS

3,030,569	4/1962	Chilton	323—75
3,064,182	11/1962	Chilton	323—79

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