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PULSE SOURCE ARRANGEMENT

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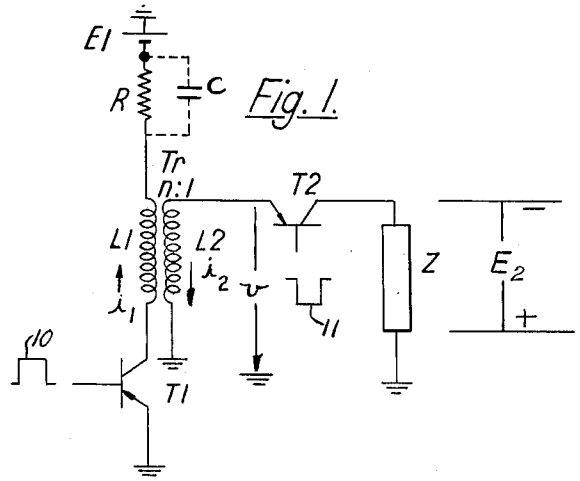


Fig. 1.

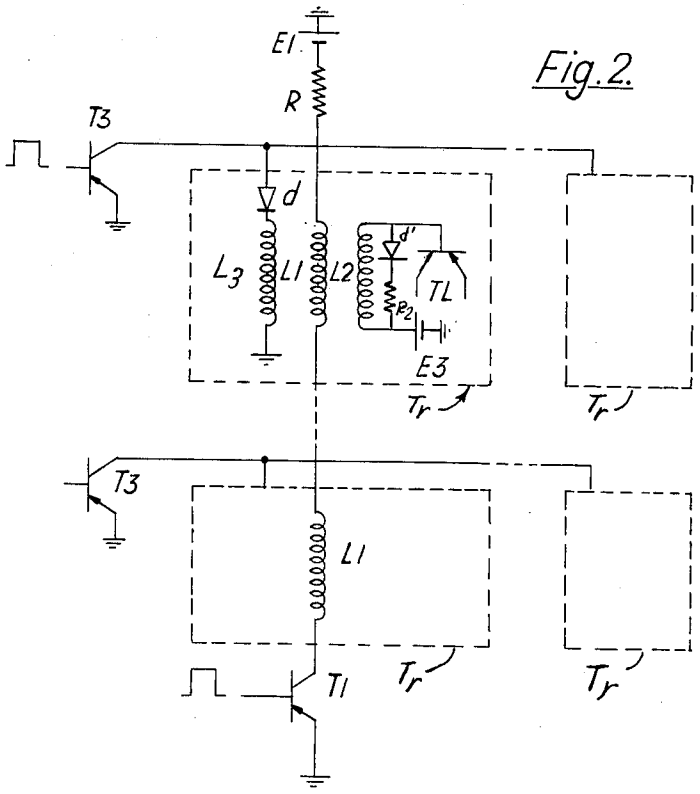


Fig. 2.

Inventor
J. BAUWENS

By Paul W. Hemminger
Attorney

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PULSE SOURCE ARRANGEMENT

Jan G. Bauwens, Antwerp, Belgium, assignor to International Standard Electric Corporation, New York, N.Y., a corporation of Delaware

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7 Claims. (Cl. 340—166)

This invention relates to a pulse source arrangement and more particularly to a transistorized pulse source comprising electromagnetic devices.

Such pulse sources are already known. For example, it is well known to provide pulse sources comprising a charging resistor, self induction coil, and switching means such as a transistor switch, all connected in series between a potential source and ground. The self induction coil is coupled to a load impedance. These known sources further include means for periodically switching the transistor between a conducting and a non-conducting state.

Difficulties have been encountered in the use of these prior art pulse sources; among other things, the load current is dependent on the load and accordingly current flowing in the load exponentially decreases or increases as a function of the load variations. Also, the prior art arrangements further have the disadvantage that the load current may not be made much larger than the charging current.

It is therefore an object of the present invention to provide a pulse source arrangement which is able to supply to a load a current which always decreases independent of the load.

It is another object of the present invention to provide a current source arrangement which is able to supply to a load a constant current independent of the load.

It is still another object of the present invention to provide a pulse source arrangement which enables current pulses having a higher amplitude than the output current to be fed to a load.

The pulse source arrangement according to the invention is characterized by the fact, that said self-induction coil constitutes the primary winding of a transformer, the secondary winding of which is coupled to a load via a unidirectional device. The primary winding is series connected between a charging resistor and a switching device. The series combination is, in turn, connected between a first and a second D.C. potential. When the said switching means is periodically operated and released, the induction coil is charged and discharged respectively. Thus, magnetic energy is periodically stored in said primary winding and periodically transferred to said secondary winding to produce output pulses therein that are independent of the load.

The above mentioned and other objects and features of the invention will become more apparent and the invention itself will be best understood by referring to the following description of embodiments taken in conjunction with the accompanying drawings wherein:

FIG. 1 represents a pulse source arrangement according to the invention;

FIG. 2 shows a two-coordinate selection matrix wherein the pulse source arrangement according to the invention is used.

Principally referring to FIG. 1, a charging resistor R, the primary winding L_1 of a transformer T_r and a transistor switch T_1 are connected in series between the terminals of a D.C. voltage source E_1, the positive terminal of which is grounded. The emitter and the collector of the transistor T_1 are respectively connected to the above ground and to the lower end of the above primary winding L_1, whereas the base of transistor T_1 is controlled by a control device indicated by the positive input pulse **10**. The secondary winding L_2 of the above transformer T_r is connected to a load impedance Z via a unidirectional transistor switch T_2, the base electrode of which is also controlled by the above control device as indicated by negative pulse **11**, which alternately and periodically renders conductive and blocks the transistors T_1 and T_2 respectively during a charging interval T_c. These conductive and blocked conditions are reversed during a so called pulse interval T_p.

The ratio of the number of turns of the primary winding to the number of turns of the secondary winding is indicated by the reference letter "*m*."

During the charging interval T_c magnetic energy is stored in the primary winding L_1 of the transformers T_r and the charging current i_1 in this primary winding exponentially varies towards the final value

$$\frac{E_1}{R}$$

At the end of the charging interval T_c and hence at the start of a pulse interval T_p, the charging current i_1 has reached the value I_{10} so that the magnetic energy stored in the core of the transformer T_r is equal to

$$\frac{L_1 I_{10}^2}{2}$$

This energy will induce a voltage across the windings of the transformer in order to force a transient current to flow of such an amplitude that there is no instantaneous change of the ampere turns applied to the core. When the transistor T_2 is conductive an induced voltage will be applied to the load so as to cause a current

$$I_1 = nI_{10}$$

to flow therein and a back voltage will appear at the primary side of the transformer. This back voltage swings the collector of the transistor T_1 down to a voltage which is larger than E_1 with a maximum of E_2. This voltage E_2 must fall within the voltage rating of the transistor T_1.

The induced current i_2 flowing in the secondary winding of the transformer T_r is a transient current which cannot maintain indefinitely. Indeed, it is equal to

$$i_2 = I_{1e}^{-\frac{t}{t_2}}$$

wherein t_2 is the time constant of the load circuit.

When the transistor T_1 is again rendered conductive at the end of the interval T_p, and hence at the beginning of a new charging interval T_c, the magnetic energy stored in the core of the transformer has only partially been dissipated. The remaining energy represented by the residual ampere-turns linking with the transformer core at this moment constitutes an initial condition of the primary circuit. Calling I_2 the value of the secondary current i_2 at this moment, one may write for the primary current

$$i_1 = \frac{I_2}{n} + \left(\frac{E_1}{R} - \frac{I_2}{n}\right)\left(1 - e^{-\frac{t}{t_1}}\right)$$

wherein t_1 is the time constant of the charging circuit.

Hence one may write for the above value

$$I_{10} = \frac{I_1}{n}$$

at the end of the charging interval T_c.

$$\frac{I_1}{n} = \frac{I_2}{n} + \left(\frac{E_1}{R} - \frac{I_2}{n}\right)\left(1 - e^{-\frac{T_c}{t_1}}\right)$$

The transformer T_r can be calculated if the output requirements are known. Suppose we need a certain voltage time product

$$\int_0^{T_p} v\,dt$$

where v is the voltage across L_2, during the pulse interval T_p. As stated above, the above output current i_2 varies from I_1 to I_2 during this pulse interval T_p so that one may write

$$\int_0^{T_p} v\,dt = L_2(I_1 - I_2)$$

wherein L_2 is the constant inductance of the secondary winding of the transformer T_r and of the load. Hence

$$L_2 = \frac{\int_0^{T_p} v\,dt}{I_1 - I_2} \qquad (2)$$

The maximum voltage to be realized across the load is called V_{max} and the maximum allowed voltage on the transistor T_1 is called E_2, as already mentioned above. Hence one may write

$$E_2 - E_1 = nV_{max} \text{ or } n = \frac{E_2 - E_1}{V_{max}}$$

Eliminating I_2 between the Formulae 1 and 2 gives

$$I_1 = \frac{nE_1}{R} - \frac{\int_0^{T_p} v\,dt}{L_2\left(e^{\frac{T_c}{t_1}} - 1\right)} \qquad (3)$$

In order to have a current source, I_1 that is independent of the load, the second term must be negligible with regard to the first, i.e.

$$\frac{nE_1}{R}$$

In other words, the relative current drop in the secondary winding

$$\frac{I_1 - I_2}{I_1}$$

must be much smaller than

$$e^{\frac{T_c}{t_1}} - 1$$

Since the latter term can never be negative it is clear that the end value I_2 of the output circuit will always be smaller than its initial value I_1. Such a current source is especially desirable in the case of magnetic core switching since quasi-rectangular pulses are then needed.

If the load is however, formed by a transistor which must be rendered conductive at the start of an impulse T_p it is not necessary that the driving pulses are rectangular since only the initial current should be sufficient to force this transistor quickly in the conducting state. In this case it is also not necessary to provide a unidirectional device such as the transistor T_2 in FIGURE 1, as the load transistor itself constitutes the unidirectional device.

From the above Formula 3 it follows that in order to realize a linear current drop in the load transistor it is sufficient that the charging time interval T_c be much smaller than the time constant t_1 of the charging circuit.

With regard to a load transistor it should be remarked that this transistor can be cut-off very quickly at the end of the pulse T_p by the addition of a capacitor across the charging resistor R. Indeed, as this capacity is discharged through the resistance R during the pulse T_p, the resistance R does not play a role at the first moment the transistor T_1 is again rendered conductive. Due to this a reverse voltage is developed in the secondary winding which reaches the value

$$\frac{E_1}{n}$$

instantaneously, so that the load transistor is cut-off very quickly.

Principally referring to FIG. 2, the above described pulse source is used for controlling the speech gates in an electronic telephone exchange. Each of these speech gates is constituted by a PNP transistor T_L and all these transistors are arranged in two-coordinate matrices having each e.g. a capacity of 10×10 for a group of 100 subscribers.

Each transistor T_L is connected to one end of the secondary winding L_2 of the associated transformer T_r which may be called a cross-point transformer and the other end of this secondary winding is connected to the positive terminal of a D.C. potential source E_3, the negative terminal of which is grounded.

The different primary windings L_1 of all the cross-point transformers T_r of a column are connected in series with the charging resistor R and the column transistor switch formed by PNP transistor T_1 (first switching means), between ground and the negative terminal of the D.C. source E_1. Each cross-point transformer further includes a tertiary winding L_3 and all the tertiary windings of a row are connected, via an individual diode rectifier d, to the collector of a common row PNP transistor switch T_3 (second switching means) the emitter of which is grounded. The other ends of the different tertiary windings are also grounded.

The driving of this matrix is as follows. Suppose that the load transistor T_L on the cross-point of the first column and the first row must be rendered conductive.

Normally the column and row transistors T_1 and T_3 are conductive, so that magnetic energy is stored in all the primary windings of all the transformers belonging to the first column, whereas the tertiary windings of all the transformers included in the first row are short-circuited.

At the moment the transistor T_L must be rendered conductive, both first and second switching means transistors T_1 and T_3 are blocked during a time interval T_p thus liberating the magnetic energy stored in the primary windings of the column considered.

The transfer of energy from these primary windings towards the associated secondary windings will however only be possible for the cross-point transformer T_r since all the other tertiary windings of the cross-point transformers of the column considered are short-circuited.

The high back current needed to switch off the transistor T_L quickly is now delivered mainly by the row-transistor T_3 short-circuiting again the tertiary winding of the transformer T_r at the end of the time interval T_p. Indeed, at that moment the base of the transistor T_L sees a very low impedance and is practically short-circuited to the positive bias E_3.

From the above it follows that the described pulse source arrangement is particularly adapted for the control of electronic gates and especially for the control of the speech gates in a full electronic telephone exchange. Indeed during the above pulse intervals T_p current is delivered to the base of the transistors, constituting said speech gates, from a high impedance source whereas the impedance in the base circuit of these transistors is very low during the charging intervals due to the above tertiary windings being short-circuited.

In order to prevent a high reverse voltage to appear at the secondary winding of the transformer at the end of the pulse interval T_p, this secondary winding may be shunted by a diode in series with a resistance. This diode should be arranged in such a manner that it becomes conductive at the end of the above interval T_p.

While the principles of the invention have been de-

scribed above in connection with specific apparatus, it is to be clearly understood that this description is made only by way of example and not as a limitation on the scope of the invention.

I claim:

1. A pulse source circuit comprising a D.C. battery potential source and ground, transformer means; a series circuit comprising resistor means, a first winding of said transformer means and normally conducting switching means, connected between said battery and ground; load impedance coupled to a secondary winding of said transformer, unidirectional means in series between said secondary winding and said load impedance means, means for periodically operating said switching means, whereby said switching means is periodically blocked to periodically transfer magnetic energy stored in said first winding to said secondary winding for producing output pulses across said secondary winding, and means for operating said unidirectional means to conduct said output pulses through said unidirectional means to said load impedance.

2. The pulse source circuit of claim 1 wherein said unidirectional device is a transistor gate.

3. The pulse source circuit of claim 2 wherein said operating means provide a pulse having a length much smaller than the time constant of the series circuit.

4. The pulse source circuit of claim 2 wherein the said first winding is also coupled to a tertiary winding and said tertiary winding is branched in a closed circuit with a second switching means and is connected in series with a second unidirectional device.

5. The pulse source circuit of claim 1 having said secondary winding shunted by another series circuit comprising a third unidirectional device and a second resistor, said third unidirectional device being poled to be conductive at the end of said operating pulse.

6. The pulse source circuit of claim 1 wherein the relative current drop in said secondary winding during said transfer period is much smaller than the ratio of operating pulse length over the quantity e raised to the power of the time constant of said series circuit minus one, whereby the current supplied by said pulse source circuit is independent of said load and said output pulses are substantially rectangular.

7. A plurality of pulse source circuits as claimed in claim 6 for selectively producing pulses across loads, characterized in this, that said circuits include a number of three-winding crosspoint transformers which are arranged in a two-coordinate matrix comprising rows and columns, means for arranging the primary windings of the transformers in the same column of said matrix connected in series and associated to one of said pulse sources through said switching means, means for arranging each of the tertiary windings of the transformers are arranged in a same row of said matrix coupled to said second switching means, means for connecting the tertiary winding of said transformers in series with said loads, one of said second switching means being provided in common for the transformers of each of said rows, via another individual unidirectional device, and means for selectively simultaneously blocking the said first and second switching means associated with a desired one of said loads.

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NEIL C. READ, *Primary Examiner.*

IRVING L. SRAGOW, *Examiner.*