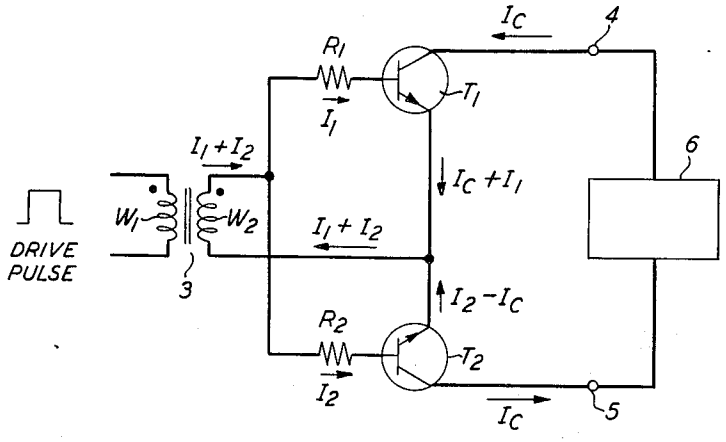
Feb. 15, 1966 W. B. GAUNT, JR 3,235,753

SERIAL DRIVEN TWO TRANSISTOR SWITCH CIRCUIT

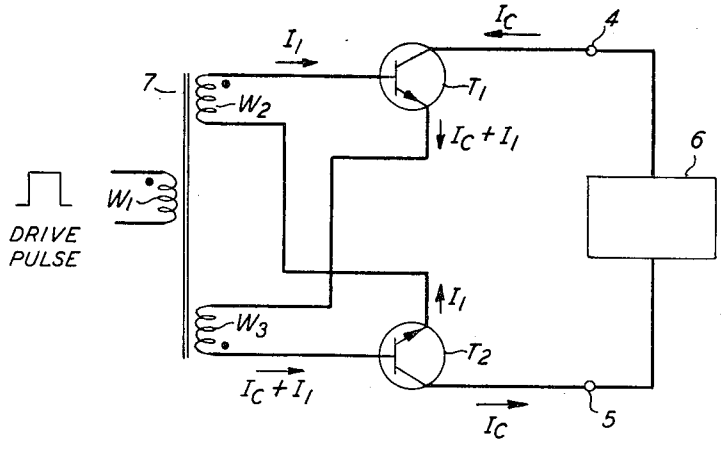
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FIG. 1



PRIOR ART TWO-TRANSISTOR SWITCH

FIG. 2



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SERIAL DRIVEN TWO TRANSISTOR SWITCH CIRCUIT

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This invention relates to switch circuits and more particularly to serial driven two-transistor switch circuits.

Switch circuits are incorporated in a wide variety of systems in present day technology. A common type of switch is one which normally blocks current flow, but allows current to flow through it when it is enabled by a drive pulse. A desirable characteristic of such a switch when it does permit current flow through it is that it have no voltage drop across it.

Prior art switches of this type often comprise two parallel driven transistors. Examples of such switches may be found in Patent 2,962,603, issued Nov. 29, 1960 to R. L. Bright. The transmission current may enter and leave the switch at the two collector electrodes. The two base-emitter junctions are connected in parallel, and are driven from the same source. In the absence of a drive pulse no current flows through the switch. When the switch is enabled, current flows through the switch and the voltage drop across the switch is negligible.

It has been found that a shortcoming of such prior art switches is that to insure equal peak current capabilities in the two directions, it is often necessary to provide individually adjusted equalizing resistors in series with the base terminals. Not only do these resistors require additional drive power, but if margin requirements are severe the individual adjustment of the resistors may require considerable time and effort. The base equalizing resistors are required to compensate for the differing characteristics of the two parallel connected transistors.

It is a general object of this invention to provide a two-transistor switch having approximately equal peak bilateral transmission current capabilities without requiring the use of base equalizing resistors to compensate for the different characteristics of the two transistors.

In a typical prior art two-transistor switch the enabling source is connected across both base-emitter junctions. Because the drive current of each transistor is derived from the same source, if either transistor requires an excessive base drive current there may be insufficient current left to drive the other. In other words, either of the transistors may "rob" base drive current from the other. The base equalizing resistors are often necessary to compensate for this effect.

In accordance with an aspect of my invention, however, the two base-emitter junctions are not connected in parallel across the enabling source. Instead, the two base-emitter junctions and the drive source are all connected in one series circuit. As a result, it is not possible for one transistor to rob the other of base drive current. Base equalizing resistors are thus not required in the serial driven switch of the invention as they are required in the prior art parallel driven switches.

It is a feature of this invention to connect the enabling source and the control electrodes of a two-transistor switch in series.

Further objects, features, and advantages of the invention will become apparent upon consideration of the following detailed description in conjunction with the drawing in which:

FIG. 1 is a schematic representation of a typical prior art parallel driven two-transistor switch; and

FIG. 2 is a schematic representation of an illustrative embodiment of the invention.

The problems overcome by the switch of my invention may be best appreciated by first considering a typical prior art switch. Referring to FIG. 1, the switch comprises two transistors T_1 and T_2. A load 6, which may comprise a signal source, etc. is connected across terminals 4 and 5 of the switch. When the switch is enabled, current flows in either direction between terminals 4 and 5, and the voltage drop across the switch is negligible. When the switch is disabled, current flow between terminals 4 and 5 is inhibited. The enabling pulse is applied to the primary winding W_1 of transformer 3.

For illustrative purposes, it is assumed that transmission current I_c flows into the switch at terminal 4, and out of the switch at terminal 5. The current into the base of transistor T_1 is I_1, and the current into the base of transistor T_2 is I_2; thus, the drive current supplied by secondary winding W_2 is the sum of the two base currents, I_1+I_2. The current flowing into and out of the various nodes of the switch circuit may then be determined by an application of the principle that the sum of all currents entering a node is zero. The resulting currents are as shown in FIG. 1.

Base equalizing resistors R_1 and R_2 are required to insure equal peak bilateral transmission current capabilities. These resistors are necessitated because of the different characteristics of the two transistors. Assume that the relative transistor characteristics are such that transistor T_1 takes most of the drive current, i.e., I_1 is greater than I_2. As I_c increases, the emitter current through transistor T_2 decreases toward 0. The emitter current of transistor T_2 would cease when I_c reached a value such that this portion of the current from the emitter of transistor T_1 entering the emitter of transistor T_2 equaled the drive current through transistor T_2 flowing from base to emitter. In such a case the base-emitter junction of transistor T_2 would cease conducting and the transmission current would be forced to flow from the collector of transistor T_1 to the base of transistor T_1, through resistors R_1 and R_2, and then through the base-collector junction of transistor T_2. As resistors R_1 and R_2 present an impedance to the transmission current, it would seem best that they be reduced in magnitude. Thus, it is seen that a desirable parallel driven switch would have no base resistors in order that maximum transmission current be allowed to flow in the direction shown in the event the characteristics of transistor T_1 require a larger base drive than those of transistor T_2. (Similarly, if transistor T_2 requires the larger base drive, and transmission current flow is oppositely poled, then, in the similar extreme situation where the emitter-base junction of transistor T_1 is forced to nonconduction, it is desirable that R_1 and R_2 be small.) On the other hand, now assume that the characteristics of transistor T_2 require the larger base drive current. The base drive current supplied to transistor T_1 may be insufficient to keep it saturated when the transmission current flows. The transmission current that does flow reduces the emitter-base drop of transistor T_2, which causes the latter transistor to take even more base drive current at the expense of transistor T_1.

To insure that transistor T_1 be supplied with a sufficient base drive current, a large value of resistor R_2 is desirable. The larger the value of resistor R_2, the larger is the peak transmission current which can flow in the direction shown if transistor T_2 requires the larger base drive current. (Similarly, if the transistor T_1 requires a larger base drive current than transistor T_2, for maximum transmission current flow in the direction opposite to that shown in FIG. 1, resistor R_1 should be large. In the limiting case where the two resistors approach infinity, it is seen that the two transistors are supplied with equal base drive currents.)

No matter which of the two transistors requires the larger base drive current, due to the different characteristics the peak transmission current capabilities in one of the two directions is reduced in magnitude. To overcome this difficulty, some base resistance is included in each transistor connection. A value of resistance is chosen for each base connection sufficient to allow the peak bilateral transmission currents required. These resistors are provided, however, at the expense of drive power, and if margin requirements are severe, their individual adjustment is required.

The switch of the invention, an illustrative embodiment of which is shown in FIG. 2, does not require the base resistances and does not present the concomitant disadvantages. A second secondary winding W_3 is provided. Each of the two secondary windings is connected between the emitter of one transistor and the base of the other. It is seen that the two secondary windings and the two base-emitter junctions form a series circuit. Assuming that a transmission current I_c flows in the direction shown and that a base current I_1 flows into the base of transistor T_1, the currents in the remainder of the switch circuit are easily determined, and are as shrown in FIG. 2. Although the base currents are still a function of the transmission current, they are no longer a function of the transistor characteristics. Neither transistor can "rob" the other of base drive current because the two base-emitter junctions are connected in series with one another. In the prior art switch, if one of the two transistors requires a large base drive, there may be insufficient drive current remaining for the other transistor. Such is not the case in the switch of FIG. 2, however, because of the series drive connection. It is thus no longer necessary to provide equalizing base resistors to compensate for the different transistor characteristics in order that equal peak bilateral transmission current capabilities be obtained.

Although the invention has been described with reference to a specific embodiment, it is to be understood that this embodiment is only illustrative of the application of the principles of the invention and that various modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A switch circuit comprising first and second transistors each having emitter, base and collector electrodes, a drive transformer having a primary winding and first and second secondary windings electrically isolated from each other, means connecting said first secondary winding between said base electrode of said first transistor and said emitter electrode of said second transistor, and means connecting said second secondary winding between said base electrode of said second transistor and said emitter electrode of said first transistor.

2. A switch circuit comprising first and second transistors each having first, second and third electrodes, a drive transformer having a primary winding and first and second secondary windings electrically isolated from each other, means connecting said first secondary winding between said first electrode of said first transistor and said second electrode of said second transistor, and means connecting said second secondary winding between said first electrode of said second transistor and said second electrode of said first transistor.

3. A switch circuit in accordance with claim 2 further including output means connected between said third electrode of said first transistor and said third electrode of said second transistor.

4. A switch circuit comprising first and second transistors each having emitter, base and collector electrodes, driving means having an input and two output circuits, and means for electrically connecting in series said two output circuits and the base-emitter junction of each of said first and second transistors.

5. A switch circuit comprising first and second switching devices, each of said switching devices having an output terminal and a drive circuit including first and second terminals, a drive transformer having a primary winding and first and second secondary windings electrically isolated from each other, means connecting said first secondary winding between said first terminal of said first switching device and said second terminal of said second switching device, and means connecting said second secondary winding between said first terminal of said second switching device and said second terminal of said first switching device.

6. A switching circuit comprising first and second switching devices each having an output terminal and a drive circuit, two enabling circuits, and means for electrically connecting in series said two enabling circuits and said drive circuits of said first and second switching devices.

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ARTHUR GAUSS, *Examiner.*