

IBM

Customer Engineering
Manual of Instruction

7090

Power Supply

Control and Distribution

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FOREWORD

This manual has been prepared for teaching purposes and as an aid for learning the IBM 7090 Converter Power Supplies. All material is related to production at a given engineering change level; use of this manual as a reference is subject to changes in the system.

Text and illustrations explain the theory and logic of the modular power supplies, the power control unit, the power converter unit, and tape unit power supplies.

MAJOR REVISION (February 1961)

This edition, Form 223-6904, obsoletes Form 223-6839. Significant changes have been made throughout the manual, and this new edition should be reviewed in its entirety.

POWER SUPPLY CONTROL AND DISTRIBUTION

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1.0.00 INTRODUCTION

THE POWER SUPPLY used with transistorized circuits in standard modular systems (SMS) has four major parts:

1. The IBM 7608, a power converter or motor-generator set which converts incoming 60-cycle, three-phase (3ϕ), 208 v power to regulated 400-cycle, 3ϕ , 208v power.
2. Power supplies in each modular frame which supply voltage to all circuits in that frame.
3. The IBM 7618, a power control unit (PCU) which contains system power control circuits, motor-generator (M-G) regulator and marginal check Variacs*.
4. Marginal check (M/C) controls located in the main console.

The output voltage of the motor-generator set, a commercially available unit, is regulated, eliminating the need for voltage regulation in most of the modular power supplies. Using 400-cycle AC to rectifiers means fewer filter capacitors are required in the modular power supplies, as well as smaller transformers.

Figure 1.0-1 shows the logic of the power system. Two power supplies are located in each modular frame; one supply (power supply A) is for gates A and B; the other (power supply C) is for gates C and D. The power supplies are three-phase, full-wave rectifiers using the 400-cycle output of the generator. All rectifiers are silicon diodes which have large current carrying capacities. The power supplies are physically located at the rear of each slide in the modular frame.

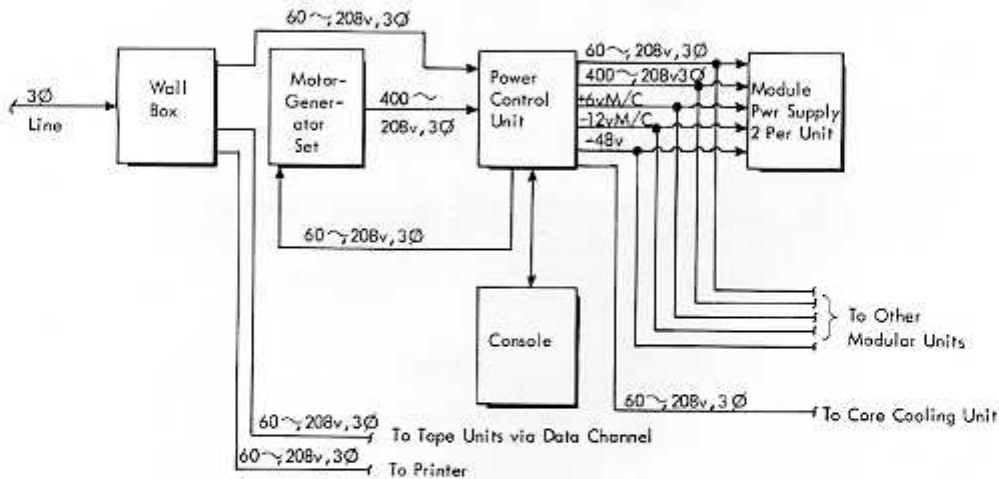


FIGURE 1.0-1. 7090 POWER SUPPLY SYSTEM

* Trademark of General Radio Company

Marginal checking may be performed on part of the +6v supply, part of the -12v supply, and core storage driver collector voltages. Marginal check controls for all units are mounted on the console unit.

Each modular power supply has its own open-fuse detection circuit. In 7090 systems, a blown fuse drops power to only its own frame. Interlock circuits drop power to the second half of the unit when a fuse blows.

The PCU is a separate frame containing circuits which control power to all modular units. Power sequence contactors, power-on and marginal check Variacs, blower relays and their overload circuit breakers (CB), and system power control keys are the major circuits in the PCU.

Power is brought up in the system by closing a power-on key, which starts the motor-generator. A power-on Variac, through contactors for the modular frames, brings all voltages, except core storage power transistor collector voltage, up slowly. A second Variac cycle brings up collector voltage to the core storage power transistors through a special power supply in the core storage module.

Power for the tape drives is from the wall outlets through the channel module, where the power is interlocked with a data channel power-on relay.

A 55 volt supply and a 48 volt supply located in the printer furnish necessary DC voltages to the card machines.

2.0.00 MODULAR POWER SUPPLIES

2.1.00 STANDARD MODULAR POWER SUPPLY UNIT

Each SMS unit contains two independent standard power supply units. Supply voltage for the units is 400 cycle, 3-phase, 208v power from the power converter unit. Each standard power supply unit controls two of the SMS unit's four gates: one power supply unit supplies gates A and B; the second unit supplies gates C and D.

7090 Standard Modular Power Supply

A typical standard modular supply is shown in Figure 2.1-1.

Figure 2.1-2 shows the logic of a standard power supply unit. A single transformer feeds all rectifiers in the unit. Each unit (Figure 2.1-3) develops nine separate voltages. Marginal check voltages M/C-1 and M/C-2 are voltages that may be varied to marginal-check the unit. M/C-1 voltages vary the voltage in gate A; M/C-2 voltages vary the voltage in gate B. (The power supply that feeds gates C and D uses M/C-1 for gate C and M/C-2 for gate D.)

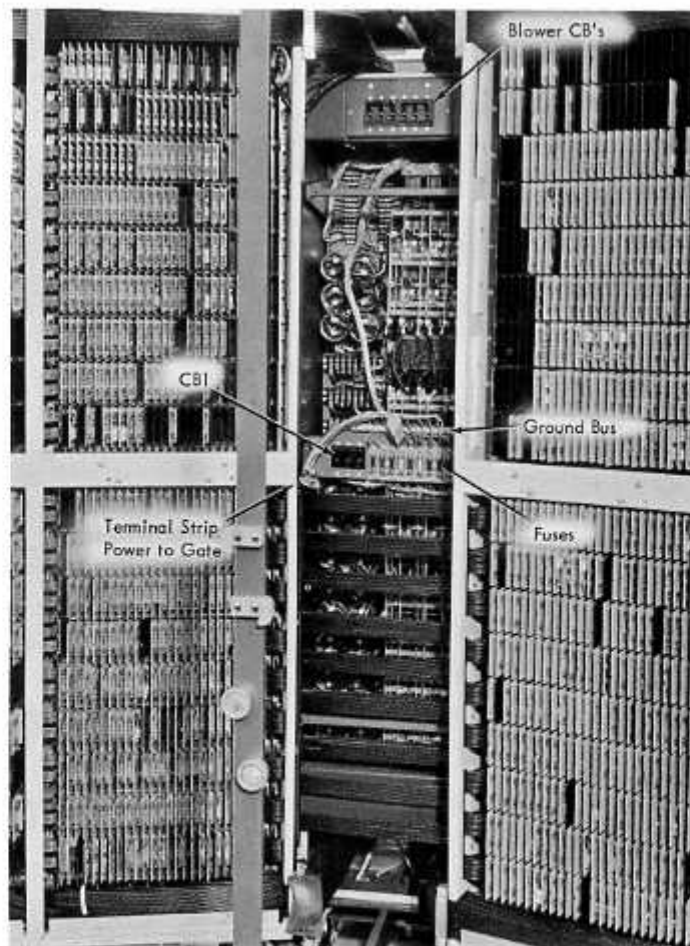


FIGURE 2.1-1. 7090 STANDARD MODULAR SUPPLY - INSTALLED IN 7607

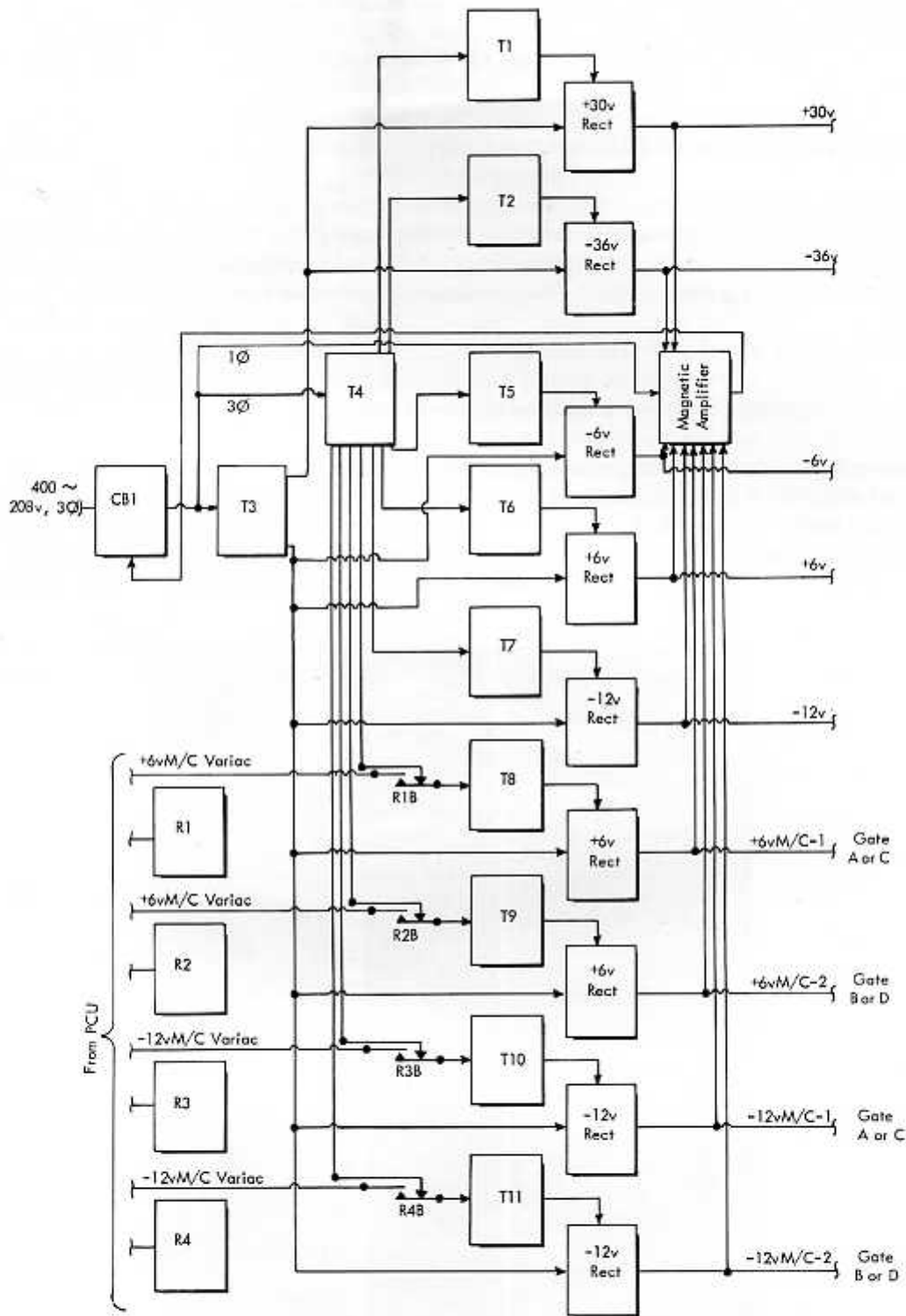


FIGURE 2.1-2. STANDARD POWER SUPPLY UNIT

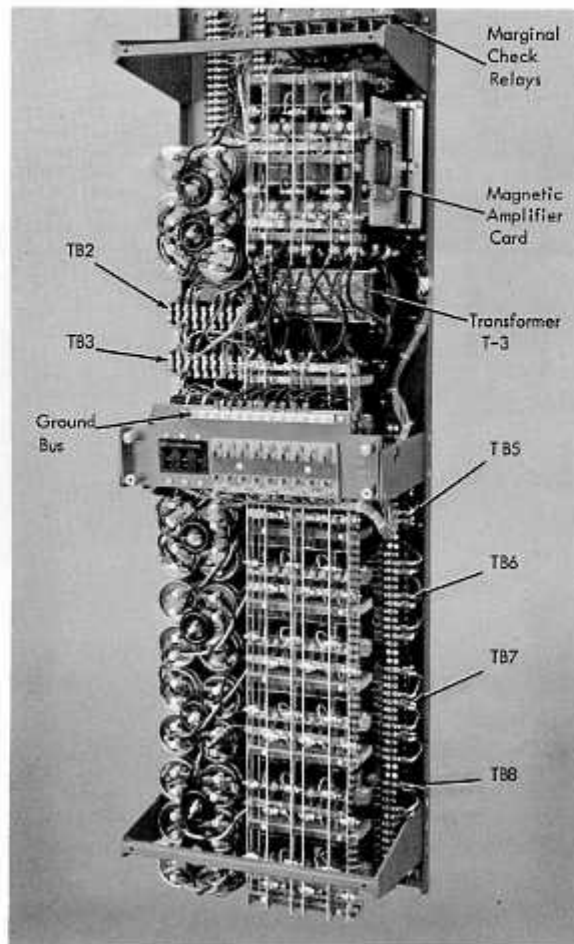


FIGURE 2.1-3. STANDARD MODULAR SUPPLY

Schematically, each of the nine separate voltage supplies are identical. Each supply feeds a magnetic amplifier, which opens the CB points (feeding the input of T3) if a fuse opens. Another point on the CB drops all DC power to the SMS unit in which the fuse opened.

2.1.01 Rectifier Voltage Supplies

A typical voltage supply is shown in simplified form in Figure 2.1-4A. When the positive-going pulse A is seen at the plate of rectifier C, electrons flow from point E through the load, half of the secondary winding of T5, rectifier C, the secondary of T3, and back to point E. When the plate of diode D goes positive, current again flows from point E through R_L , half of the secondary winding of T5, rectifier D, the secondary of T3, and back to point E. The result is a full-wave rectifier.

In the Figure 2.1-4A, any action of T5 is ignored. With T5 in the circuit, the output voltage V_L can be varied under control of the primary winding of T5.

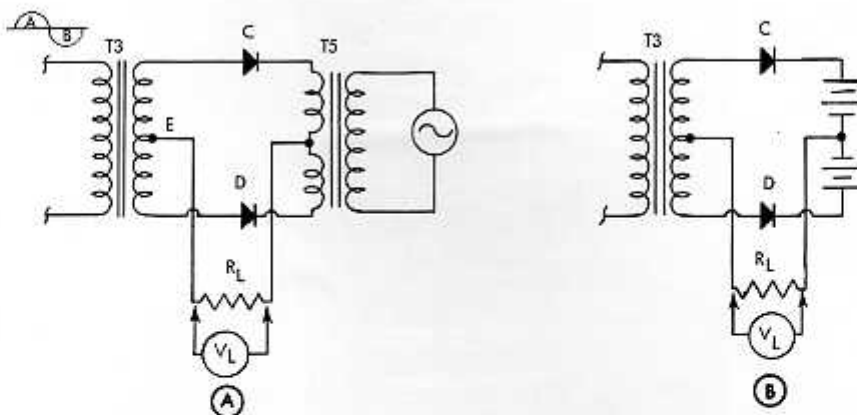


FIGURE 2.1-4. SIMPLIFIED VOLTAGE SUPPLY

If a voltage source is applied to the primary winding of T5, a voltage is developed across the secondary windings of T5. The polarity of this voltage either aids or opposes the output voltage of the rectifier. When a positive-going pulse appears at rectifier C (Figure 2.1-4B) conduction cannot begin until the voltage level of the pulse at the plate overcomes the bias of the battery in the cathode circuit. As a result, current flows for a shorter period of time during each cycle and, V_L decreases. The reverse is true if the voltage source is added with opposite polarity; the rectifier conducts at a lower plate voltage and V_L increases.

Several advantages are obtained from this type of circuit:

1. In actual 6v and 12v power supply circuits, the voltage on the primary of T3 is such that V_L should be 9v. By bucking or boosting 3v, it is then possible to obtain both 6 and 12v supplies with identical circuitry and parts.
2. By replacing the voltage source in the primary winding of T5 with a tapped output transformer, changing the tap settings adjusts voltage V_L for exact values to compensate for variations in component values and line loss.
3. Replacing the voltage source in the primary winding of T5 with a Variac allows the voltages to be varied either up or down for marginal checking.

2.1.02 Three-Phase Variac

A three-phase Variac (Figure 2.1-5A) is analogous to a three-phase potentiometer. The movable point taps off a voltage somewhere between the incoming line voltage and AC neutral. The line-to-line output voltage is shown in Figure 2.1-5B. With the movable point of the Variac at the bottom of the coil, or point A in Figure 2.1-5A or B, all output lines are effectively tied to the AC neutral line and no voltage exists between lines. As the movable point is moved up along the resistance coil to point B, a gradual increasing voltage develops between output lines. The voltage between points B-B is the voltage between output lines; the voltage A-B is the output line-to-AC neutral voltage. As the movable point is moved up the coil to point C, the output-to-line voltage increases until it is the same value as the input voltage.

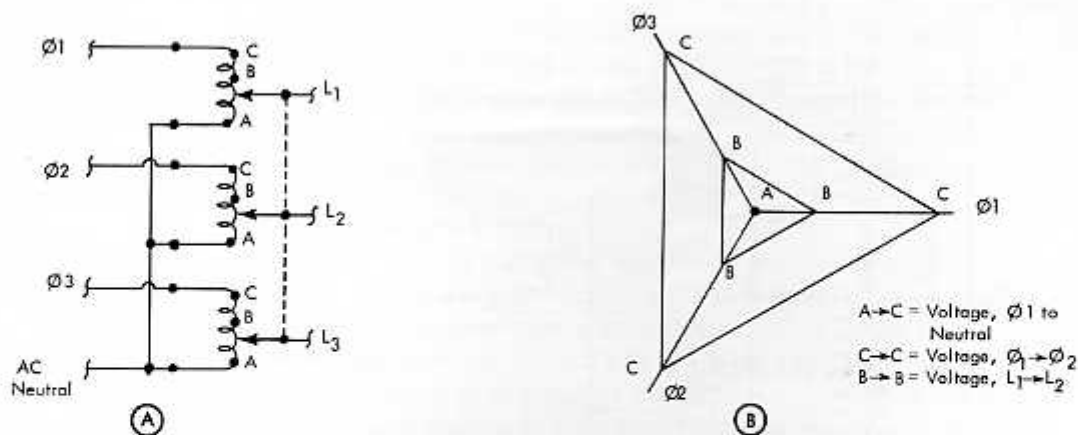


FIGURE 2.1-5. THREE-PHASE VARIAC

Variacs are used to bring circuit voltages up slowly and to vary individual supply voltages for marginal testing.

2.1.03 Marginal Voltage Development

Marginal voltages are developed by varying the amount of buck or boost voltage in the rectifier circuit. A typical marginal voltage supply is shown in Figure 2.1-6. Notice that the primary winding of T5 can be energized from two sources under control of relay R1. Under normal operation, R1 is de-energized as shown and T5 primary voltages are supplied from the tapped outputs of T4 as shown in Figure 2.1-2. When R1 is energized, the primary of T5 is then under control of the Variac; the amount of buck or boost voltage in the rectifier circuit can now be varied to change the output voltage to marginal limits. The Variac is approximately in the center of its operating range with circuit voltages at normal values; this allows a full range of upper and lower voltage limits. Relays R1, R2, R3 and R4 are constructed so that the n/o points close before the n/c points open.

2.1.04 Magnetic Amplifiers

Magnetic amplifiers are variable impedance devices. The impedance offered by the amplifier is varied by an independent source of control power; amplification occurs because the power requirements of the control source may be many times less than the power being controlled. By varying the controllable impedance, output circuit current and voltage are controlled.

Magnetic amplifiers vary widely in size and shape, depending on their use, but all use a saturable core with one or more control windings. Magnetic amplifiers may be classified in two types: saturable reactor or self-saturating.

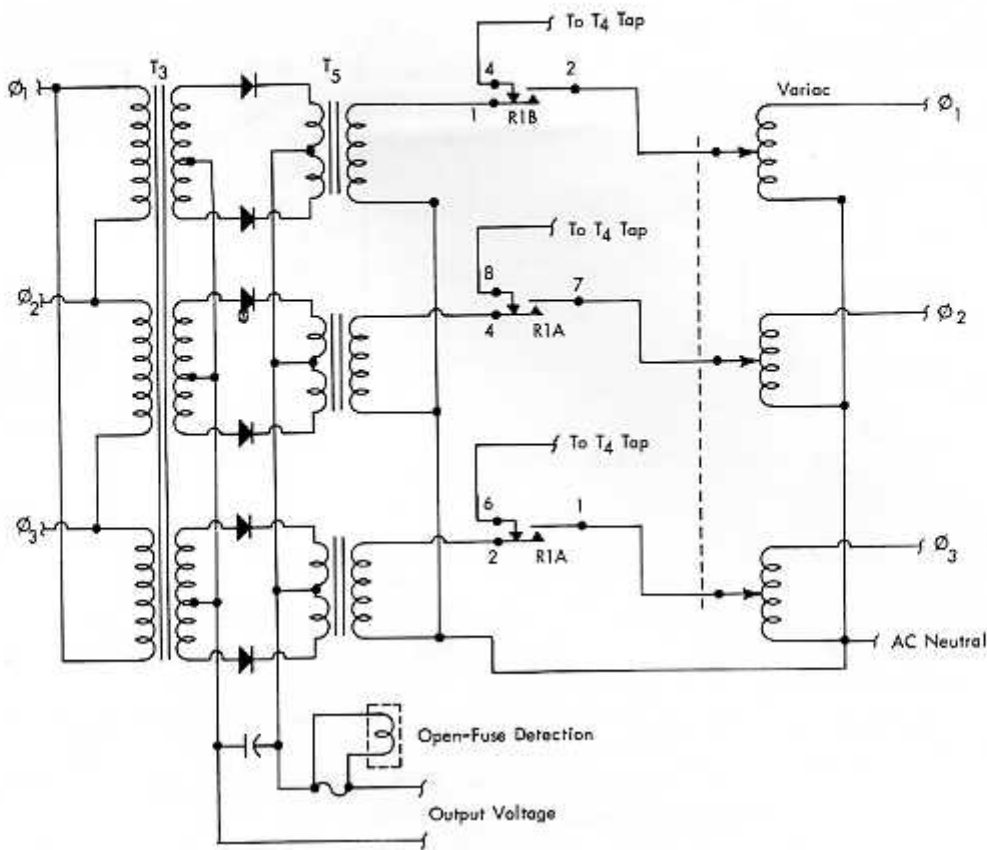


FIGURE 2.1-6. MARGINAL VOLTAGE DEVELOPMENT

2.1.05 Saturable Reactor

A saturable reactor (SR) is an inductor in which the impedance is controlled by varying the amount of flux in the core. Figure 2.1-7A uses an adjustable impedance (X_1) to represent a saturable reactor. By moving the adjustable tap A, the amount of impedance may be varied, controlling the voltage across R_L . Assume that R_L can be varied and that it is desired to have V_L remain constant. Reducing R_L tends to reduce V_L but, if X_1 is adjusted at the same time so that it has less impedance, more current flows through the circuit and V_L can be held constant.

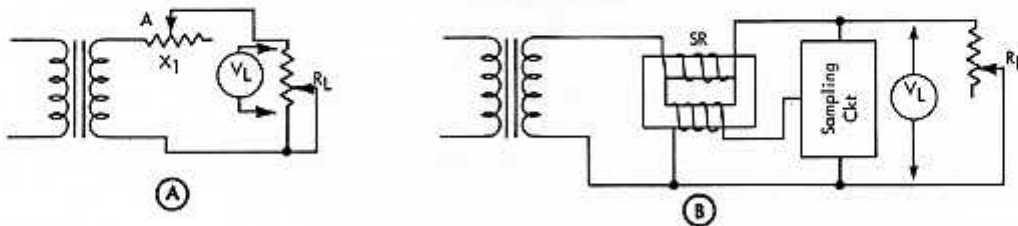


FIGURE 2.1-7. SATURABLE REACTOR ANALOGY

In Figure 2.1-7B, a saturable reactor replaces impedance X_L . The impedance of a saturable reactor is controlled by varying the magnetic flux in the core of the inductance coil. Because the impedance of an inductance coil is a function of the change in magnetic flux, the greater the change in flux, the greater the impedance. If the core of the SR is saturated (can hold no more flux) there can be no change in flux and the impedance is only the DC resistance of the coil. The farther away from saturation, the greater the impedance.

Assume that R_L (Figure 2.1-7B) is variable, but that it is desired to keep the voltage across R_L constant. A sampling circuit is used to measure the voltage across R_L . The output of the sampling circuit feeds a second (control) winding on the SR. This control winding determines how far the core is from its saturation point. Flux from the control winding can oppose or aid that of the inductance coil. Whether the flux from the control winding aids or opposes the flux from the inductance winding is determined by circuit design.

If R_L (Figure 2.1-7B) is increased, the sampling circuit detects the increase in voltage across R_L and causes the impedance of the SR to increase. The change in impedance of the SR allows less current to flow in the circuit and the voltage across R_L returns to its controlled value.

The operation of the SR can be explained in greater detail by use of a hysteresis loop. (Figure 2.1-8A shows two windings on a laminated saturable core; for the first portion of the discussion, disregard any action of the control winding.)

An alternating current A (Figure 2.1-8C) is applied to the circuit. As the current progresses from point a, b, c, d, to a', the core material (Figure 2.1-8B) has completed one progression around its hysteresis loop (points a, b, c, d, and back to a). The hysteresis loop shown is an ideal loop. An ideal loop is used because many factors (predominantly heat and frequency) can alter its shape.

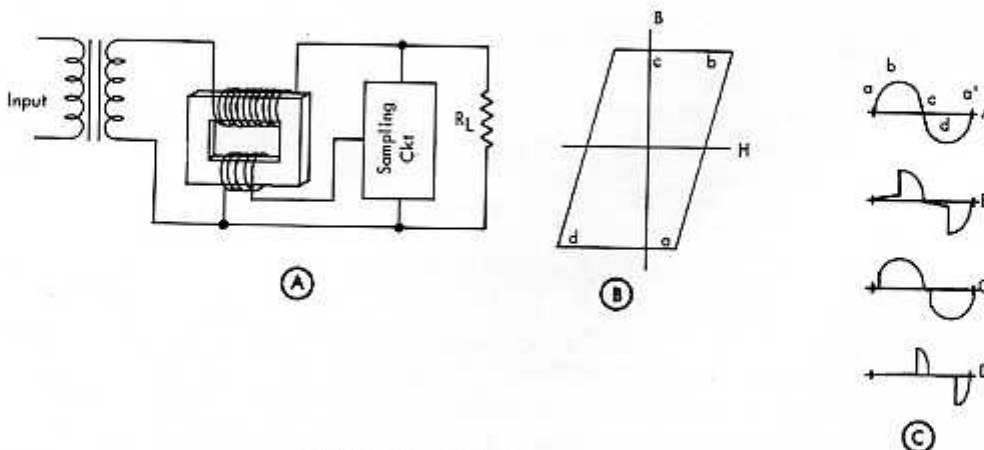


FIGURE 2.1-8. SATURABLE REACTOR CHARACTERISTICS

The output current wave form is shown at B in Figure 2.1-8C. During the first half cycle, the core follows the path ab on the hysteresis loop (Figure 2.1-8B). The changing flux in the core causes a high impedance in the inductance coil and little current flows. When the saturation point of the hysteresis loop is reached, there can be no additional change in flux. With no changing flux, the impedance of the inductance coil drops sharply; conversely, the output current rises sharply and follows the input current. As the input current goes from point b to c (Figure 2.1-8C), the operating point on the hysteresis curve goes from point b to c (Figure 2.1-8B). The movement from point b to c on the hysteresis curve involves such a small change in flux that the induced voltage is negligible and output current follows input.

The control winding controls the point along the input wave form at which the core goes into saturation. By driving current through the control winding, the amount of impedance in series with R_L is effectively changed. Waveform C (Figure 2.1-8C) shows the output current that would result from adding to the core current which allowed the core to saturate with only a small amount of input current. Current in the opposite direction through the control winding could cause output D (Figure 2.1-8C).

Driving current through the control winding in two directions as is required to obtain the output currents C and D (Figure 2.1-8C), can require complicated circuitry. To simplify circuitry it is desirable to be able to control output voltage by driving current through the control winding in only one direction. A third winding, called a bias winding, allows the desired simplification.

Figure 2.1-9 is a circuit using a bias winding. Current through the bias winding normally is in a direction such that the flux produced by it opposes the flux of the SR inductance coil. The theory of operation of the circuit with a bias winding is the same as for the other circuits previously described. The bias winding sets the static condition of the circuit which, in terms of V_L (Figure 2.1-9A), would produce a very low voltage. The control winding then carries current of sufficient value to control V_L . Figure 2.1-9B is a graphic view of the circuit operation. If the SR core is saturated, current is at its greatest value (point C). With no control winding current, the output current (I_{RL}) is at its lowest value (point A). The normal operating point would be point B, which allows the greatest amount of control.

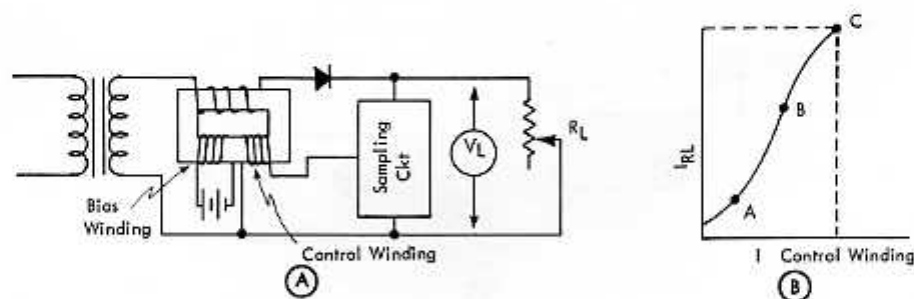


FIGURE 2.1-9. SATURABLE REACTOR WITH BIAS AND CONTROL WINDINGS

