POWER SUPPLIES FOR THE LNLS MAGNETS

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Abstract

In this paper we discuss different types of power supplies that have been developed for the Linac and VUV storage ring of LNLS.[1]

1. Introduction

Different kinds of magnets are required for the construction of the LNLS accelerators:

- Focussing lenses, confining solenoids and steering coils for the accelerating structure of the Linac.
- Focussing coils for the klystrons.
- Spectrometer.
- Bending magnets and quadrupoles for transport lines.
- Bending magnets quadrupoles and sextupoles for the booster and storage ring.

In each case the power supply is designed to optimize performance and cost based on a rational use of available electronic devices.

We discuss in this paper three different kinds of power supplies that have been developed at LNLS.

1) Low voltage, low current: up to 100 V, 50 A. These power supplies are used for the Linac magnets: focussing lenses, solenoids and transport line.

2) Low voltage, medium current: up to 50 V, 150 A. These include power supplies for klystron focussing coils.

3) Medium voltage, medium current: up to 300 V, 150 A to be used in the spectrometer, and bending magnets for the booster.

In the following we discuss some general aspects of the structure and performance for each of these and describe the main results obtained.

2. Low voltage, low current power supplies

In this case the power supply is a current source with a MOSFET transistor chopper according to the schematic diagram of Fig. 1.

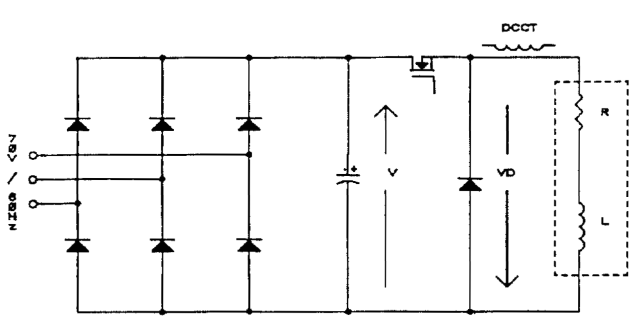

Figure 1 - Schematic diagram of low voltage, low current power supply.

Control is based on the current limit modulation (CLM) method. Current is measured on a shunt or DCCT and compared with the reference. The amplified difference is fed into an hysteresis comparator which drives the MOSFET transistor as shown in Fig 2. This results in a load dependent chopping frequency f.

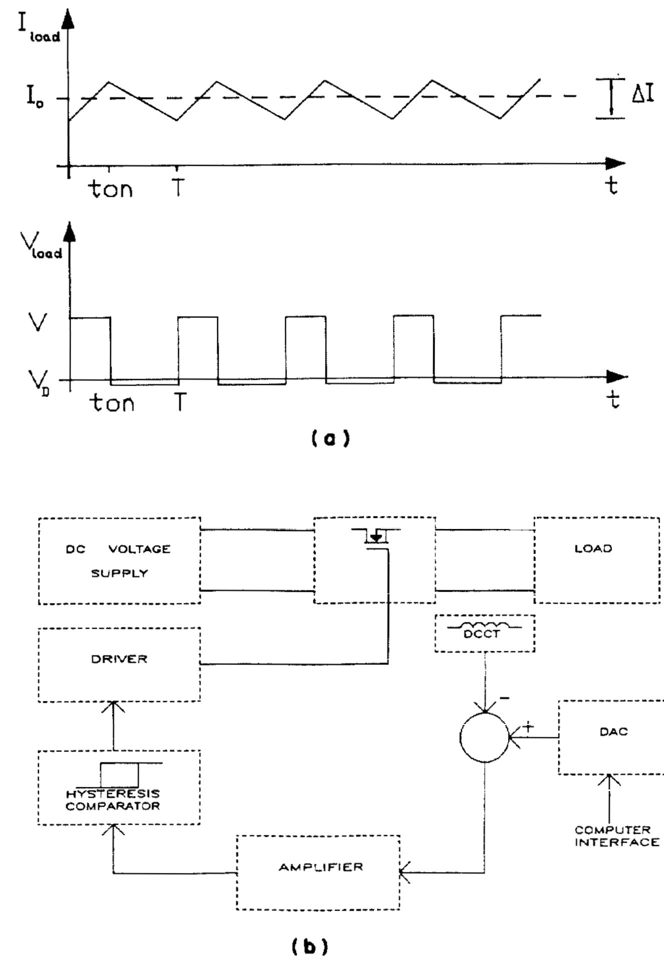

Figure 2 - (a) Waveforms of CLM control method.
(b) Block diagram of CLM control method.

If ΔI is the maximum current variation and I the mean current, we have for the frequency f the expression.

$$f = \frac{R I_o + V_D}{L \Delta I} \left[1 - \frac{R I_o + V_D}{V + V_D} \right]$$

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This type of control requires special care with shielding and grounding of different signals. The periodical interruption of current in the transistor and freewheel diode generates considerable electromagnetic interference which should be dealt with by special arrangement of components and wiring. In order to reduce this interference we use a coaxial box mounting of the critical components. The rectifier, chopping transistors and freewheel diode are mounted inside a metallic tunnel with current flowing out of the tunnel through wiring and returning via the tunnel walls. This same tunnel is used for air cooling of the components.

With proper mounting and use of precision components this type of power supply, produces a stable current source with currents up to 50 A (25 V) and low ripple (10^{-4}) operating typically at frequencies of 10 kHz.

3. Low voltage, medium current supplies

For the focussing coils of the klystron power supplies up to 150 A and 25 V are used, with ripple values of 10^{-3} and 0,1% stability.

In this case the simplest and most economical solution, due to the low time constant of the load, is series regulation using bipolar power transistors in parallel connection as shown in Fig. 3.

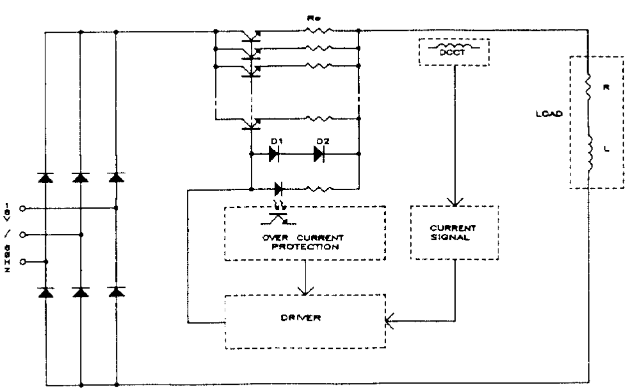

Figure 3 - Diagram of current regulator for low voltage, medium current.

The power block is made out of 30 transistor balanced with small emitter resistors Rs and driven by a MOSFET transistor. The same resistors Rs are used to protect individual transistors against over current, in case one transistor blows up, by activating the base to emitter path way via the diodes D1-D2, thus keeping base current limited (see Fig. 3).

4. Medium current, medium voltage power supplies

For the UV storage ring bending magnets, medium power supplies rated at 300 V, 150A are used.

The design of the power source is based on a combination of a SCR converter with a chopper regulator as shown in Fig. 4.

The SCR converter is fed directly from the mains and provides a 1% regulated and filtered voltage. In series with this is a separate low voltage power supply with a fast transistor chopper. Current is monitored in the load loop by means of a DCCT. This signal is compared with the current reference and the error is used to drive the MOSFET transistors with a current limit modulation control system, similar to the one described in section 2.

Thus the transistor switches full current at low voltage, which makes it possible to use similar electronic components as for the power supply described in section 2.

In this way the largest part of power delivered to the load is furnished by a standard SCR voltage regulator, while the transistor supply trims the current to required ripple and stability, handling a small fraction of the load power. Another important consequence of the combination of the two power supplies is that the transistor switching frequency is reduced due to the fact that the driving voltage used to trim the current to its regulated value is only a fraction of the total voltage. This is clearly shown by the expression for the switching frequency:

$$f = \frac{R\,I_o - V_o}{L\,\Delta I}\left[1 - \frac{R\,I_o - V_o}{V}\right]$$

In practice the system is constructed by assembling together two separate pieces: a switching transistor power supply of the type described before, upgraded in current to the required value, and a SCR converter with the needed voltage.

The result is a modular power supply with good ripple and current stability ($\sim 10^{-4}$) and a better than 50 : 1 dynamic range.

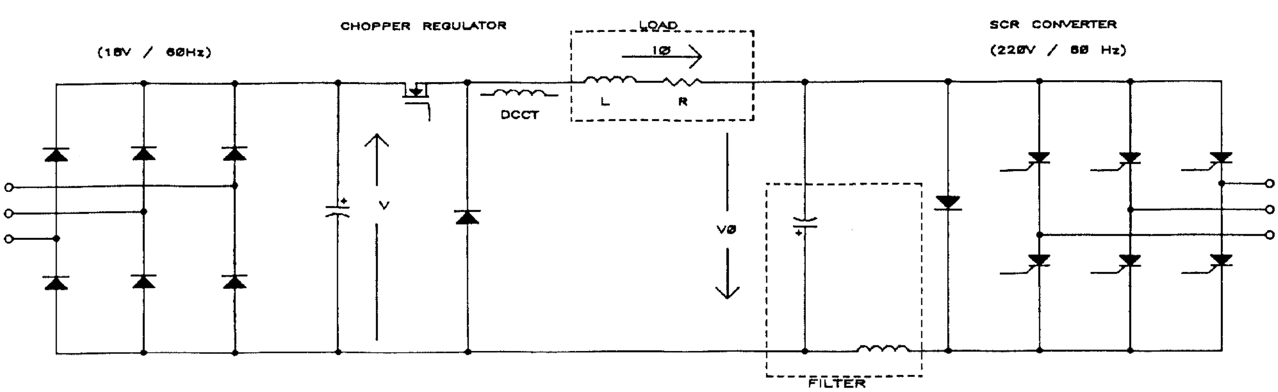

Figure 4 - Schematic diagram for medium voltage, medium current power supply.

5. Conclusion

Different types of power supplies for the Linac and VUV ring of the LNLS have been developed and tested.

According to each specific case different converters were used based on required performance and economic considerations.

Fo. the low current and low voltage a switching transistor regulator renders a stable and compact power supply.

Still for low voltage and medium current a transistor series regulator is used.

For medium current and voltage a modular combination of a SCR converter and switching regulator provides a satisfactory solution with a distribution of power handling adequate to the characteristics of each electronic device: major part of power controlled by the SCR with low regulation and a small fraction by the transistor with high regulation.

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1. C.E.T. Gonçalves da Silva, A.R. Rodrigues and D. Wisnivesky, these Proceedings.