

A new type electromagnet controller for isotope ratio mass-spectrometer (IRMS)

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The fundamental advantage of an electromagnet in comparison to a permanent magnet is that the magnetic field can be continuously controlled, including its switch off and reversal of its polarity, by varying of the coil current. The reversal of the magnetic polarity is important when both positive and negative ions spectra have to be investigated as it is the case of positive and negative TIMS. The scanning of mass spectra by varying the magnetic field leads to lower isotope fractionation in the ion source than by varying the high voltage (ion acceleration electric field). This is because that in the last mode low mass ions are extracted more efficiently by a higher voltage than high mass ions.

However use of the electromagnets requires a rather high power supply because the coils are fed continuously from a dc controller. Moreover, such controllers have a limited range of the current regulation. These drawbacks result from the use of transistors at which a voltage excess has to be reduced. In order to extend the range of current regulation, a common dc controller frequently has a switch for a rough matching of the voltage in the power supply, but even with such a switch it is hard to reduce the coil current close to zero and to record a spectrum over a large range.

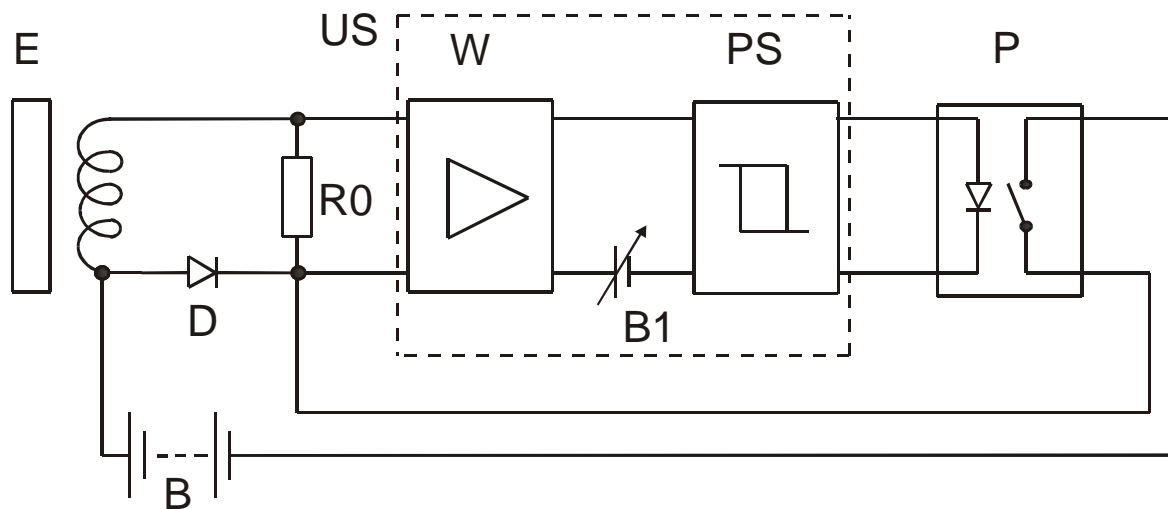


Fig. 1. Block diagram of the switching controller of an electromagnet.

We report here on a novel controller for electromagnets, which is free of drawbacks mentioned above. The power consumed by the switching controller is low, because it is predominantly used for a slight periodic supply of the coil current which is induced just after the controller was switched on. Inasmuch as a typical electromagnet coil has a low coefficient of dissipation energy due to high inductance and low resistance, the power needed for the periodic supply of the coil current is small. A precise adjustment of the coil current is can be made in a continuous manner by setting of the width of the current pulses. That width can be adjusted by means of precise potentiometer (voltage divider) or by a computer controlled reference voltage.

The only drawback – typical for all switching controllers – is a little modulation of the coil current around a very well kept average value (Soclof, 1985). The output ripple factor may be reduced, however, to such a low level that it may be considered as negligible.

A simplified circuit diagram of our switching controller (Halas, Nowak, 2004) is shown in Fig. 1. At the beginning the switch P is ON an the electromagnet coil is fed from a dc source B, the diode D does not conduct. When the coil current is sufficient to produce the desired strength of the magnetic field, the switch P is set OFF, thereafter diode D starts to conduct. In this way the coil current is continued until it drops (due to energy dissipation by all the resistances in the loop comprising the coil, diode D and reference resistor R0) to a designed level. The voltage drop on R0 is amplified and compared with a regulated refer-

ence voltage from the source B1. The block PS stands for the Schmitt trigger (a comparator with a hysteresis). It alters the switch P from ON to OFF when the coil current attains desired level, and *vice versa* – from OFF to ON, when the current drops to the value determined by the hysteresis of the Schmitt trigger (Soclof, 1985).

The described switching controller we successfully use in magnetically scanned mass spectrometer for isotope analysis.

References

- Soclof, S., 1985. Applications of analog integrated circuits. Prentice-Hall, New Jersey
(Polish translation: WKŁ Warszawa 1991).
- Hałas, S., Nowak, J., 2004. Patent description, P 365 718 of 1st March 2004 (in Polish).