

The present invention relates to the control of electric motors.

5 In some applications it is desirable to cause the motor to operate sometimes as a stepping motor sometimes as a constant speed regulated motor.

Generally, this problem being difficult to resolve, two motors have been used for this type of application, one being controlled in the stepping mode, the other at a constant speed, those motors being alternatively engaged.

10 During the last few years, motors which lend themselves to operate either in the stepping mode or in the normal mode have been developed. To exemplify such a motor, one can mention the disk-shaped magnet and the integrated angle encoder motors such as the one marketed
15 by company Portescap (France), referenced PP520.

EP-A-189,732 discloses a driving device for a motor operable either in a stepping mode or in a self switched mode.

20 Those motors effectively lend themselves to operate in either mode, but in the known application circuits, distinct circuits are used for each of the two control functions.

The object of the present invention is the alternate control of a motor such as of the disk-shaped magnet and integrated angle encoder type, in the stepping or continuous running mode, the operating speed in the continuous running mode being regulated, by using a single electronic circuit for the control of those two modes.

Specifically, the present invention aims at providing such a control circuit which is particularly simple and uses a minimum number of integrated circuits, those integrated circuits being shared for both functions.

To achieve those objects, the present invention provides for a stepping or the circuit controlling the self-switching mode, with a speed regulation, of a motor of the disk-shaped magnet and angle encoder type, devised to be fed by a two-phase control signal. The stepping mode control is ensured by a set of two integrated circuits, the first integrated circuit receiving the stepping clock signals and supplying the two-phase control signal to the second integrated circuit being a driver, the first integrated circuit also comprising means for applying intermittent enabling signals to the second integrated circuit when it receives on a so-called security input a signal indicating that the current in one at least of the phases is higher than a determined threshold. The control in the self-switching mode is supplied by a programmable logic array from the outputs of the angle encoders. The same second integrated circuit is used for amplifying control signals in the self-switching mode and the same first integrated circuit is used for speed regulation in the self-switching mode, this first integrated circuit then receiving at its security input the signal resulting from

the frequency/voltage conversion of the output of one of the angle encoders.

5 This invention also provides the application of the above-mentioned control circuit to the control of a motor used in a system for magnetic reading and printing of tickets.

10 The foregoing and other objects, features and advantages of the invention will be apparent from the following detailed description of a preferred embodiment as illustrated in the accompanying drawings wherein:

Fig. 1 shows a stepping motor control device;

Fig. 2 shows a dual stepping or continuously regulated control, according to the invention;

15 Fig. 3 shows wave-shapes illustrating the operation of the circuit of Fig. 2; and

Fig. 4 shows an exemplary application of a dual controlled motor according to the invention.

20 Fig. 1 shows a motor M fed by a stepping control circuit. This motor receives signals onto two windings, namely a phase signal 1 between output conductors P11 and P12 and a phase signal 2 between output conductors P21 and P22. Conventionally, this control is carried out by means of two integrated circuits available on the market, namely a first control integrated circuit CI1 such as
25 circuit L297 manufactured by SGS corporation and a second driver integrated circuit CI2 such as circuit L298 also manufactured by SGS.

30 The control circuit CI1 receives an ON/OFF command signal M/A, a rotation-direction control signal ROT, a clock signal CL supplying the stepping control pulses, and a signal OSC from an oscillator operating at a high frequency with respect to the motor frequency. This cir-

cuit CI1 supplies for the control of phase 1 a signal on lines C11 and C12 and for the control of phase 2 a signal on lines C21 and C22.

In addition, the integrated circuit CI2 of the above-mentioned type comprises outputs I1 and I2 representing the currents in phase 1 and phase 2. Those outputs are applied to a current/voltage converter 10 and the integrated circuit CI1 comprises corresponding inputs V1 and V2 permitting to compare the voltages V1 and V2 resulting from the voltage transformation of currents I1 and I2 with a reference voltage VREF. On the drawing of Fig. 1, voltages V1 and V2 have been added in an adder 11 and the input terminals V1 and V2 of circuit CI1 are interconnected. The integrated circuit CI1 compares the sum of voltages V1 and V2 with a reference voltage VREF and, if this sum is higher than the reference voltage VREF, circuit CI1 supplies to circuit CI2 a signal OSC1 resulting from the control by signal OSC to allow the output signals to flow only when the oscillator signal is high, thus chopping those signals and reducing the electric power available for the motor. Thus, the comparison of $V1 + V2$ with VREF constitutes a protection against overvoltages in case currents I1 and I2 exceed a predetermined value. However, it will be noted that in normal operation, when the circuit operates without trouble, values V1 and V2 are close to zero and the security loop does not supply any signal.

Fig. 2 shows an embodiment of the dual control circuit according to the invention. Motor M, integrated circuits CI1 and CI2 and the security loop comprising components 10 and 11 are shown again. Motor M is a disk-shaped magnet motor provided with integrated angle encoders sup-

plying signals S1 and S2 which are square pulses corresponding to the rotating speed of the motor (a given number of square pulses per rotation). Conventionally, such a motor is controlled by supplying from signal S1 and S2, through a PLA combinational circuit, signals C11-C12 and C21-C22 designed, after amplification by an amplifier that can be the above-mentioned circuit CI2, to supply signals P11-P12 and P21-P22 for controlling the two phases of the motor. Conventionally, the PLA circuit receives the direction command signal ROT to determine the way signals C11-C12 and C21-C22 will be derived from signals S1 and S2 for providing the appropriate rotation direction to the motor.

The present invention provides regulating the speed of motor M by using the integrated circuit CI1. Thus, one of the signals S1 or S2 of the motor encoders is sent to a frequency/voltage converter circuit 20 which applies its output to adder 11 near the above-mentioned interconnected inputs V1 and V2. Thus, when the motor speed increases above or decreases under a reference value, the sum $V1 + V2$ becomes higher or lower than the reference voltage and the output signal OSC1 acts upon integrated circuit CI2 in order to regulate the speed. Circuit 20 receives a setting signal R and a selection signal SEL to be activated only if it is desired to obtain the continuous running (or self-switching) mode. Similarly, the PLA circuit is controlled by signal SEL for, in the self-switching mode, supplying the appropriate signals to integrated circuit CI2 from signals S1 and S2 and, in the stepping mode, directly transmitting the outputs of integrated circuit CI1.

Fig. 3 shows the wave-shapes appearing on various points of the circuit shown in Fig. 2 to explain the operation of this circuit. It is assumed in this figure that motor M is in a regulated self-switching operation mode.

Signals S1 and S2 of the sensors incorporated in motor M, for example Hall sensors, have the shape of square pulses with a 0.5 duty cycle, those square pulses being shifted one with respect to the other by $\pm \pi/2$ according to the rotation direction. In the given example, signal S2 is lagging by $\pi/2$ with respect to S1.

Output signal $V1 + V2$ of the frequency/voltage (F/V) converter 20, derived from signal S1 in the given example, is a saw-tooth signal, the rising edge of signal S1 corresponds to the start of signal $V1 + V2$. One has shown the operation at the regulated state, that is, voltage VREF corresponds to an intermediate value between the minimum and maximum values of signal $V1 + V2$. Besides, it will be noted that the amplitude of this signal $V1 + V2$ is adjusted by an input R to converter 20.

The regulation signal OSC1 from integrated circuit CI1 is a high level signal when $V1 + V2$ is lower than VREF and a signal having a frequency corresponding to the signal from oscillator OSC when $V1 + V2$ is higher than VREF.

By way of example, signals CI1 and CI2 controlling phase 1 and C21 and C22 controlling phase 2 at the output of the PLA circuit are shown. They are signals with opposite phases on the two conductors of a same phase and shifted by $\pi/2$ from one phase to the other.

Signal OSC1 arriving on integrated circuit CI2 determines that output signals P11, P12, P21 and P22 corre-

spond to the passage of those signals C11-C22 through AND gates, the other input of which corresponds to signal OSC1. Thus, the signals P11-P22 are obtained, as shown. Consequently, if the amplitude of $V1 + V2$ increases, the
5 chopping of signals P11-P22 increases and, conversely, it decreases if signal $V1 + V2$ decreases. It is thus ascertained that motor M runs at a constant speed.

It will be understood that a characteristic of the invention is to use the integrated circuit CI1 and the
10 security function that is usually associated with integrated circuits CI1 and CI2 for ensuring the speed regulation of the motor in the self-switching mode. Moreover, as shown in Fig. 2, even in the regulation mode, it is possible to continue using the security function ensured
15 by the current/voltage converter 10 for reducing the power supplied to the motor in case of emergency, that is, in case of overvoltage on a phase.

A motor control according to the present invention is especially usable in a ticket validation device. It is
20 for example a fixed or hand-carried device, for example in a bus, designed to check magnetic track tickets.

A schematic exemplary device is illustrated in Fig.
4.

The user puts his ticket into a wicket GE. The ticket
25 is taken along by a transport web 1 rotating around rolls 2 and 3 and is driven by the above-mentioned motor M.

The ticket is detected by an input sensor CE and swallowed into the validation device. A slot shutter OF
30 is then operated by an electromagnet preventing any other admission while the ticket is being processed inside the device. The ticket is then driven in front of a magnetic head TM for the reading of digital coded information on

the magnetic track. The processing of this information is carried out (validation checking, decrease of the residual value, etc.) then the travel of the transport web is reversed to drive the ticket again under the magnetic head TM in order to code new data. Synchronization is ensured by an encoding sensor CC. The travel is then once more reversed in order to read again the information that has just been encoded (code checking). Once those operations are completed, the ticket is driven to a printing system TI, for example an impact printing system.

In all the above travels, especially for magnetic reading, the motor had to run at a constant speed in either direction. Then, it has to be stopped and be driven step-by-step in order to permit the transversal printing of a series of lines, dots or characters.

Lastly, the ticket is driven to an output wicket GS where it can be withdrawn by the user. The output sensor CS permits to check the withdrawal of the ticket. The input slot shutter is then released and the device is ready to process a new ticket.

It can be seen that in such a system wherein a combination of continuous travels at a constant speed and in the stepping mode is needed, the control system according to the invention is particularly well adapted.

Of course, the invention is liable of numerous variations and modifications within the scope of the claims. Especially, specific motors and integrated circuits have been exemplified hereinabove. Any other motor and integrated circuit exhibiting equivalent functions are usable.

CLAIMS

1. A circuit for controlling a motor in a stepping mode or a self-switching with speed regulation mode, said motor (M) being of the disk-shaped magnet and angle encoder type, designed to be fed by two phases (P11-P12, P21-P22) of a control signal, wherein the stepping mode control is ensured by a set of two integrated circuits, the first integrated circuit (CI1) receiving stepping clock signals and supplying the two phases of the control signal to a second driver integrated circuit (CI2), the first integrated circuit also comprising means for applying intermittent enabling signals to the second integrated circuit when it receives on a so-called security input (V1, V2) a signal indicating that the current in one at least of the phases is higher than a determined threshold (VREF), and wherein the control in the self-switching mode is supplied by a programmable logic array (PLA) from the outputs (S1, S2) of the angle encoders,

characterized in that the same second integrated circuit (CI2) is used for amplifying the control signals in the self-switching mode and wherein the same first integrated circuit (CI1) is used for regulating the speed in the self-switching mode, said first integrated circuit then receiving on said security input the signal resulting from the frequency/voltage conversion of the output of one of the angle encoders.

2. Application of the circuit according to claim 1 to the control of a motor used in a magnetic reading and printing system for tickets.