

Control Circuit for a Thermal Printing Machine

This invention relates to a control circuit for a thermal printing machine, with a thermal print head having a series of electrically drivable heating elements, with a microprocessor transferring data to be printed into a register associated with the thermal print head and driving driver circuits connected to the heating elements, the register receiving the data in serial form.

In known thermal printing machines, thermal print heads are used which include a series of electrically selectively drivable heating elements. Between the heating elements and a platen roll, the recording medium to be printed upon and - if the latter is not thermally active - the effective part of a thermally activatable ribbon are arranged so that a current flowing through the heating elements results in dyeing (as a rule, blackening) of the recording medium. In the prior art as known, for example, from DE 36 13 946 A1 or EP 501 707 A2, the data to be printed is forwarded to the thermal print heads via a serial data line. Thus, data is transmitted via one line only from a microprocessor arranged on the mother board to the print head, paralleled there by means of a (shift) register - one register corresponding to one print line - and used for driving the driver circuits of the heating elements.

In such an arrangement, the high expenditure of time involved in transmitting data serially is to be regarded as a disadvantage: Considering that thermal print heads built to today's design comprise mostly more than 1,000 heating elements and just as many register elements, the time lag caused by changing the data to a serial form by

means of the microprocessor and transmitting it sequentially is rather significant. The microprocessor being not available for other tasks during this time (such as arithmetic operations or the control of the platen roll), it has to execute these tasks afterwards, as a result of which the maximum printing speed is substantially reduced.

Further, in printers the stepping motor driving the platen roll is controlled - as known, for example, from JP 60-83864 A - in such a way that a control circuit supplies pulses to a stepping motor, their number corresponding to the respective feed of the recording medium. Because for reasons of cost and for avoiding synchronization problems the same microprocessor controls as a rule both the data transmission to the print head and the stepping motor of the platen roll, software routines are conventionally used resulting in the issuance of corresponding pulses to the stepping motor, while yet blocking the microprocessor for other tasks during the feeding cycle of the recording medium.

Such a software-based control of the stepping motor results equally in the disadvantage of a considerably reduced printing speed.

It is accordingly an object of the present invention to improve the known control circuits in such a way that the efficiency of the microprocessor is enhanced and the realizable printing speed is increased.

In the following, two alternative or jointly realizable proposals for accomplishing this object will be described, one referring to the data transmission to the

thermal print head, the other to the control of the stepping motor of the platen roll.

According to the present invention, this object is accomplished by a buffer storage connected to the microprocessor via a parallel data line, as well as by a separate load state monitoring circuit connected to the buffer storage and causing data to be transferred from the buffer storage into the register when the data written into the buffer storage from the microprocessor has reached a defined quantity.

The gist of the invention is to relieve the microprocessor by means of an external storage and a load state monitoring circuit. Data is read out of the microprocessor into the buffer storage in parallel at high speed and subsequently transferred into the register of the thermal print head sequentially in a conventional fashion, with the sequential transmission of the data to the register being controlled by the separate load state monitoring circuit, rather than by the microprocessor. The load state monitoring circuit monitors the level, that is, the portion of the storage containing the data to be printed, activating the transfer into the register of the print head as soon as a predetermined value is exceeded. As a rule, the capacity of the buffer storage corresponds to that of the register of the thermal print head. A decisive aspect herein is that the microprocessor, following transmission of the data to the buffer storage, is available for other tasks - such as the control of the printer mechanism or the calculation of data to be printed out (bit map), being no longer responsible for bringing the data in sequential order or controlling the transmission.

Irrespective of the fact that physical conditions require that the transmission speed of the data to the register be maintained at a constant level, the invention enables a substantial acceleration of the printing process to be achieved because of the relief the load state monitoring circuit provides to the microprocessor.

Although it would be conceivable to start the transfer of data into the register not until after write-in of a data volume necessary for driving the whole line of heating elements into the storage is completed (that is, equating that portion of the data transferred into the buffer storage at which the load state monitoring circuit starts transferring into the register, with a print line), it is recommended to start read-out from the buffer storage already after a smaller data volume (30%, for example) is written into it, rather than waiting until the data of the whole line is written. On the one hand, for reasons of economy a control of this type makes it possible to select the capacity of the buffer storage lower than that of the register of the thermal print head and to transmit the data of a print line successively in subsets from the microprocessor to the register via the buffer storage, on the other hand, however - and this is the preferred procedure - it enables data to be written into the register concurrently with the transmission of data from the microprocessor to the buffer storage. The advantageous result consists in time savings realized by the simultaneous data transmission operations allowing a higher printing speed.

Another possibility that suggests itself is to control the microprocessor in such a way that it will stop

feeding data to the buffer storage after data of one print line is transmitted, attending instead to the other above-mentioned tasks - such as the control of the printing mechanism or the calculation of the subsequent print line - and that, after at least part (or all) of the data is transmitted from the buffer storage to the register, it will start writing the data corresponding to the next print line into the buffer storage. There is accordingly the possibility of completely decoupling the register from the microprocessor and concurrently reading out the data of one print line from the buffer storage, while at the same time transmitting the subsequent line to the buffer storage as soon as free capacity becomes available therein.

As buffer a storage known under the designation first-in-first-out storage is, primarily considered for use because it enables the data to be transmitted in the appropriate sequence, the first data stored being the first data transferred into the register. Via a data bus, a parallel-to-serial converter is connected to the buffer storage in such a manner that one data word each of the same (first) storage area can be read out. The microprocessor writes the data of the first data word to be output (comprising, for example, 16 bits) into this storage area. At the same time, an (initially reset) counting pointer is incremented by a pulse present at the write output of the microprocessor. By means of the counting pointer, the subsequent data words are written into the subsequent storage areas, the counting pointer being incremented by one after each write-in operation of a data word (of 16 bits, for example). Thus, the buffer storage is loaded in successive sequence. The load state monitoring circuit recognizes the storage load by means

of the counting pointer, activating the transmission of data to the parallel-to-serial converter when a defined quantity is reached. The data of the first storage area is read out. In addition, after a data word is read out, the counting pointer is decremented, and the data of the subsequent storage areas is copied word by word into the preceding storage area. The buffer storage is thus dynamically managed in the manner of a queue (first-in-first-out). Of course, it is also possible to enter the data from the microprocessor invariably into the same storage area, shift it successively forward and determine the address of the respective storage area that has been read out by means of the counting pointer.

Modern thermal print heads as described, for example, in EP 501 707 A2 have an input for a print release signal suitable for activating the heating elements. As the latter have a much reduced service life when in continuous use, it proves necessary to chop the print release signal, that is, to compose it of individual pulses. In the concrete, a print release signal comprising an initial continuous pulse with rectangular pulses following, is advantageous and thus customary. The duration of pulses and pulse spaces defines the heating energy and thus the temperature of the heating elements. In order to relieve the microprocessor of the need to generate the print release signals, which task is performed by software routines in the art requiring a corresponding expenditure of time, it is proposed herein to provide the respective output of the microprocessor and/or the load state monitoring circuit with a circuit generating the desired pulses. Thus, all the microprocessor is required to do is supply a pulse for activation of the circuit, so it is immediately available again for

other tasks while the circuit is busy generating the print release signal. As a rule, the microprocessor will transmit to the circuit data indicative of the duration of the pulses and pulse spaces before the output of a print page. On the one hand, a sufficiently frequent adaptation to the current print parameters is thereby possible, on the other hand, the time required for updating is kept within limits. The print release signal can be activated by the microprocessor and/or the load state monitoring circuit. It is to be noted that, apart from considering the print release signal, the print head generally considers also the previous print data and the data of the adjacent heating elements (referred to as the dot history) in the calculation of the energy to be supplied to the heating elements.

Moreover, it is suggested to provide the thermal print head with a temperature sensor and to connect the latter to an input of the microprocessor, the microprocessor being then in a position to use the temperature of the print head to control the circuit for generating the print release signal by varying the duration of the pulses and/or pulse spaces in such a way that the maximum permissible temperature of the print head is not exceeded, while on the other hand optimum print results are obtained.

As an addition or alternative to the above, the print release signal may be varied by the microprocessor in such a way as to accomplish an optimum adaptation of the temperature of the heating elements to the printing speed and/or the type of paper to be printed upon.

As an alternative to the teaching of claim 1, in a control circuit for a printing machine with a print head adapted to be moved into contact with a platen roll driven by a stepping motor, with a microprocessor including an output connected to the stepping motor, the problem underlying the present invention can be solved by inserting a pulse generator and a stepping motor driver are connected between the output of the microprocessor and the stepping motor.

Rather than generating the control pulses of the stepping motor by suitably programming the microprocessor as is customary in the prior art, the basic idea is to have these pulses produced by hardware using a separate pulse generator. Its output signals are amplified in a stepping motor driver and finally delivered to the stepping motor.

It is thus possible to relieve the microprocessor of the task of controlling the stepping motor, all it is required to do being the activation of the pulse generator to perform a paper feed. After this, the microprocessor is available for other tasks, which enables the printing speed to be increased because microprocessor-related idle times are avoided.

Multi-color printing can be realized with particular ease if the microprocessor controls at least one further thermal print head in addition to driving, via at least one further pulse generator and at least one further stepping motor driver and stepping motor, one further platen roll each against which a respective one of the thermal print heads rests. Because the diameters of platen rolls mostly differ slightly, it is necessary to

drive them at different rotational frequencies. While problems are anticipated in a conventional software-based control when the pulses of two stepping motors, while being required to coincide, differ in time due to sequential programming, a control of this type can be implemented without any problems because each stepping motor is driven by a pulse generator of its own.

Embodiments of this invention will be described in more detail in the following with reference to the accompanying drawings. They show in schematic view in

- FIG. 1: a control circuit for a thermal print head;
- FIG. 2: a drive of the platen rolls advantageous for multi-color printing;
- FIG. 3: a circuit for the generation of the print release signal;
- FIG. 4: a pulse diagram of the above circuit; and
- FIG. 5: a load state monitoring circuit.

The control circuit for a thermal print head (1) illustrated in FIG. 1 includes a microprocessor (2) to which a control keyboard (3) is connected as a data input facility. The microprocessor (2) is connected to a data input interface (4), a read/write control circuit (5), a first pulse generator (6), a circuit (7) for generating a print release signal, and a temperature sensor (8) for sensing the temperature of the thermal print head (1).

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The microprocessor (2) further drives a second pulse generator (9) connected, via a stepping motor driver (10), to a stepping motor (11) for driving the platen roll (12).

Indicated in rough outline in the thermal print head (1) is a register (13) having as many storage cells as the thermal print head (1) has heating elements (14). The present embodiment may provide a thermal print head (1) having 1,280 heating elements (14) and register elements (13), for example.

The core of the control circuit is formed by a buffer storage (15) comprising, for example, 80 storage elements each of 16 bits. The data to be printed is read into the register (13) of the thermal print head via a parallel-to-serial converter (16) connected to the buffer storage (15). The clock pulses of the pulse generator (6) are directly fed to the thermal print head (1). Moreover, the storage contents of the buffer storage (15) are monitored by a load state monitoring circuit (17).

When, under the control of the keyboard (3), the microprocessor (2) is caused to read data into the buffer storage (15) via the data input interface (4), the load state monitoring circuit (17) will check how much storage space is occupied in the buffer storage (15). If a designated portion of, for example 30%, is already occupied, the load state monitoring circuit (17) will cause the read/write control circuit (5) to read data into the parallel-to-serial converter (16) and to write it into the register (13), clocked by the first pulse generator (6). Parallel to this operation, data will continue to be

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read into the buffer storage (15) under the control of the read/write control circuit (5).

When the register (13) of the thermal print head (1) is full, the microprocessor (2) will cause the circuit (7) to send a print release signal to the thermal print head (1), causing printing of the stored data onto a recording medium (18). Parallel thereto, the microprocessor (2) will start the second pulse generator (9) which then activates automatically, via the stepping motor driver (10), the stepping motor (11) which drives the platen roll (12) for feeding the recording medium (18).

FIG. 2 indicates in schematic outline a multi-color thermal printer comprising, in addition to the microprocessor (2), the second pulse generator (9), the stepping motor driver (10), the stepping motor (11), the platen roll (12) and the thermal print head (1), a further pulse generator (19), a further stepping motor driver (20), a further stepping motor (21), a further platen roll (22) and a further thermal print head (23). In the present embodiment, the temperature-sensitive recording medium (18) responds to temperature variations with different colors. Thus, multi-color printing can be accomplished by heating the heating elements (14) of the two thermal print heads (1, 23) to different temperatures, printing upon the recording medium (18) being then performed in successive sequence. The advantage of an arrangement of this type is that the two platen rolls (12, 22) are driven independently of each other, after the pulse generators (9, 19) have been started by the microprocessor (2). Thus, manufacturing tolerances of the platen rolls (12,

22) can be compensated for without the recording medium (18) tearing or forming loops.

FIG. 3 shows the circuit (7) for generating the print release signal. It is controlled by the microprocessor (2) and comprised of a first (24), a second (25) and a third (26) rectangular pulse generator. The output of the first rectangular pulse generator (24) is connected to the non-inverting inputs of a first (27) and a second (28) AND-element, while the output of the second rectangular pulse generator (25) is connected to the non-inverting input of the first AND-element (27) and the second AND-element (28). The outputs of the first AND-element (27) and of the third rectangular pulse generator (26) are connected to the inputs of an OR-element (29) delivering the print release signal via its output.

The pulse diagram indicated schematically in FIG. 4 illustrates the function of the circuit (7). First, the microprocessor (2) delivers a start signal (a) to the first (24) and to the second (25) rectangular pulse generator, the signal causing the first rectangular pulse generator (24) to deliver a pulse (b) and causing the second rectangular pulse generator (25) to generate a pulse (c). Both pulses (b) and (c) are applied to the first AND-element (27), pulse (c) thus being present at its output. Further, both pulses (b and c) are fed to the second AND-element (28) generating the signal (b AND NOT c) and delivering it to the third rectangular pulse generator (26). As the third rectangular pulse generator (26) is driven by this signal (b AND NOT c), it will generate the signal (d) which, in combination with the signal (c), will produce the print release signal (e) following an OR-operation in the OR-element (29).

Via line (30), the microprocessor is driven by the temperature sensor (8) located in the thermal print head. This causes the microprocessor (2) to vary the duration of pulse (c) in the second rectangular pulse generator (25) and the pulse duty factor of the third signal (d) generated by the rectangular pulse generator in such a way that the temperature of the thermal print head (1) assumes an optimum, non-critical value.

Finally, FIG. 5 shows the internal structure of a load state monitoring circuit (17) and its connection to the remaining control circuit. In this Figure, the data bus (D) of the microprocessor (2) is directly connected to the buffer storage (15). The microprocessor write output (WR) which is in the "1" condition during the output of data only is connected to both the buffer storage (15) and a counting pointer (31) of the load state monitoring circuit (17). During each write operation from the microprocessor (2) into the buffer storage (15), the output (A) of the counting pointer (31) is increased by one (incremented), its respective input being therefore identified by INC in the Figure. At the beginning, with the storages reset, the data words of the microprocessor (2) are entered into the lower storage area of the buffer storage (15) when viewing the Figure. As soon as the output (A) of the counting pointer (31) is incremented, the subsequent data is entered into the address of the buffer storage (15) corresponding to its output (A) and following the lowermost storage cell, the buffer storage being thus successively loaded from the bottom to the top.

The transfer of data from the buffer storage (15) into the parallel-to-serial converter (16) and into the register (13) of the thermal print head (1) is performed under hardware control (32). As soon as the output (A) of the counting pointer (31) reaches a predetermined number (corresponding to the defined quantity of data at which the read-out operation into the print head (1) is required to start), a pulse will be present at the output (cpy) of the hardware control circuit (32), this pulse representing a copy demand to the effect that, for one thing, the data word (D') of the lowermost storage cell of the buffer storage (15) is transmitted to the parallel-to-serial converter (16) and onwards, in serial form (D"), to the register (13), while for another thing the data words of all other storage cells of the buffer storage (15) are shifted down by one storage cell each - the output (cpy) being therefore connected to the buffer storage (15) and to the parallel-to-serial converter (16). The contents of the buffer storage (15) are thus successively read out into the register (13). As each data word is being read out, a pulse is at the same time applied to the input (DEC) of the counting pointer (31) which subtracts the quantity 1 from its output (A) (decrementing). If a write operation is then executed by the microprocessor (2), the next lower storage cell will thus be loaded with data - one storage cell having become available. The hardware control circuit (32) further activates a timer (33) at the output (clk) of which rectangular signals are present when reading out data, these signals serving as clock pulses for the parallel-to-serial converter (16) and the register (13).

It is necessary to synchronize the hardware control circuit (32) in order to avoid that an incrementing and a

decrementing signal are present at the counting pointer (31) at the same time - if the microprocessor (2) and the buffer storage (15) issue data concurrently - causing data to be entered into an incorrect address of the buffer storage (15). Synchronization may be accomplished in such a way that the hardware control circuit (32) suppresses the decrementing command (DEC) as long as the write output (WR) of the microprocessor (2) is in the "1" condition. Upon completion of the write operation of the microprocessor (2), the decrementing command (DEC) (and the copying operation in which the data words of all storage cells of the buffer storage (15) are shifted down by one storage cell each) is made up so that the output (A) of the pointing counter (31) is updated prior to the next write operation. The two operations being related to different addresses, it is thus possible to read data into the buffer storage (15) while at the same time reading it out.

As a result, a control circuit for a printing machine is obtained which is characterized by high efficiency and printing speed.



P A T E N T C L A I M S

1. A control circuit for a thermal printing machine, with a thermal print head (1) having a series of electrically drivable heating elements (14), with a microprocessor (2) transferring data to be printed into a register (13) which is associated with the thermal print head (1) and drives driver circuits connected to the heating elements (14), said register (13) receiving the data in serial form, **characterized by** a buffer storage (15) connected to the microprocessor (2) via a parallel data line, as well as by a separate load state monitoring circuit (17) connected to the buffer storage (15) and causing data to be transferred from the buffer storage (15) into the register (13) when the data written into the buffer storage (15) from the microprocessor (2) has reached a defined quantity.

2. A control circuit according to claim 1, **characterized in that** the defined quantity of data necessary for causing the transmission of data from the buffer storage (15) into the register (13) is lower than the quantity of data necessary for driving the whole line of heating elements (14).

3. A control circuit according to claim 1 or 2, **characterized in that** the microprocessor (2) writes data into the buffer storage (15) concurrently with the transmission of data from the buffer storage (15) into the register (13).

4. A control circuit according to any one of the claims 1 to 3, **characterized in that** the microprocessor (2) stops feeding data to the buffer storage (15) after



data for driving a complete line of heating elements (14) is transmitted, yet starts transmitting data of the subsequent line after at least part of the data is transmitted from the buffer storage (15) to the register (13).

5. A control circuit according to any one of the claims 1 to 4, **characterized in that** the buffer storage (15) is a first-in-first-out storage.

6. A control circuit according to any one of the claims 1 to 5, **characterized in that** the microprocessor (2) and/or the load state monitoring circuit (17) include(s) an output connected to an input of the print head (1) for a print release signal (e) for activating the heating elements (14) via a circuit (7) generating a signal comprised of an initial continuous pulse followed by rectangular pulses of a higher frequency.

7. A control circuit according to claim 6, **characterized in that** the thermal print head (1) includes a temperature sensor (8) connected to the microprocessor (2), and that the microprocessor (2) varies the duration of the pulses and/or the pulse spaces of the circuit (7) in dependence upon the output signal of the temperature sensor (8).

8. A control circuit according to claim 6 or 7, **characterized in that** the microprocessor (2) varies the duration of the pulses and/or the pulse spaces in dependence upon the printing speed and/or the type of the printed paper.

9. A control circuit for a printing machine, with a print head (1) adapted to be moved into contact with a





platen roll (12) driven by a stepping motor (11), with a microprocessor (2) including an output connected to the stepping motor (11), **characterized in that** a pulse generator (9) and a stepping motor driver (10) are inserted between the output of the microprocessor (2) and the stepping motor (11).

10. A control circuit according to claim 9, **characterized in that** for generating colored print images the microprocessor (2) controls an additional print head (23) and drives, via a further pulse generator (19) and via a further stepping motor driver (20) and a further stepping motor (21), a further platen roll (22) against which the additional print head (23) rests.

