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(54) **Improvements in or relating to continuous inkjet printers**

(57) The invention provides a circuit for detecting solenoid valve operation in a CIJ printer. The circuit detects current draw by the solenoid coils and thus obviates the difficulties of determining solenoid operation by monitor-

ing downstream parameters. A single sensing circuit is preferably provided to detect the operation of all solenoids, the output of which can be compared to other printer functions to identify the particular source of an output signal.

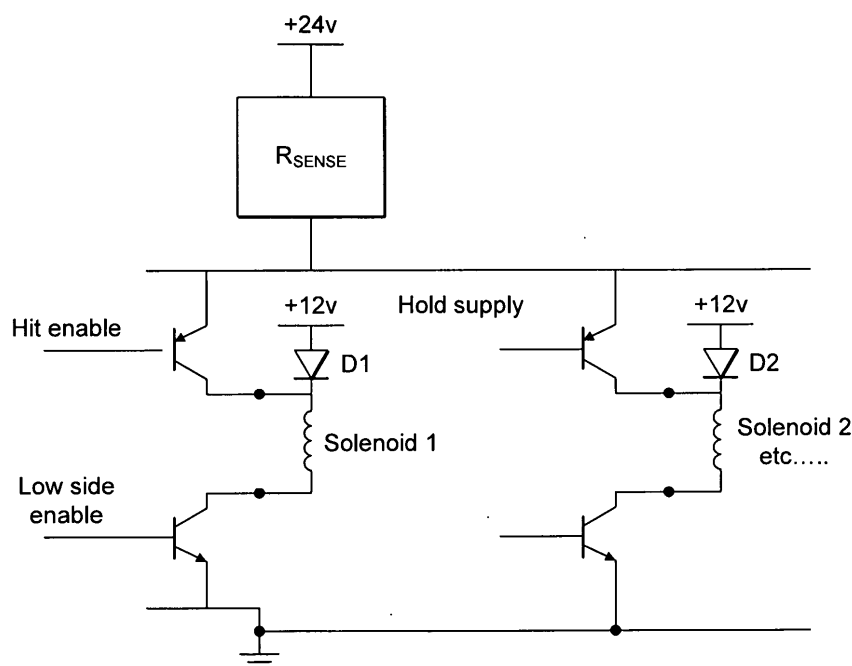


FIG. 1

Description

Field of the Invention

[0001] This invention relates to continuous inkjet (CIJ) printers and more particularly, though not necessarily solely, to CIJ printers used in industrial and/or commercial marking and coding applications.

Background to the Invention

[0002] A typical CIJ printer has an ink supply system having a number of functions. The system provides for ink to be drawn from a reservoir and supplied to the print-head. It also provides for unprinted ink to be re-circulated and, if necessary, supplemented with make-up fluid to maintain the ink at the correct viscosity for printing. The system may also provide for make-up fluid to be circulated through the system for cleaning or flushing purposes.

[0003] It is both convenient and typical to control the flow of fluids through the ink supply system by means of solenoid valves, and a typical CIJ printer will have up to eight solenoid valves controlling various printer functions. The correct operation of these solenoid valves is critical to the performance of the printer and thus checks must be incorporated in the system to ensure the solenoid valves are operational as signalled by the controlling electronics. These checks also play their part in diagnosing faults in the printer.

[0004] In the past, checks on solenoid valve operation have typically been conducted by monitoring various downstream parameters. For example, by monitoring ink pressure it is possible to establish if an ink supply valve is open or not. Similarly monitoring the presence of wet ink in the gutter at particular times can indicate if a valve is open at the correct time, and monitoring ink viscosity can indicate whether a valve which operates to mix ink and make-up fluid, is functioning correctly.

[0005] Systems which monitor these downstream parameters require the provision of various sensors. In the examples outlined above the system would require a pressure sensor, a capacitive or conductive sensor, and a viscometer. Providing these sensors adds cost and complexity and the sensors, in themselves, comprise further components which can malfunction.

[0006] It is an object of this invention to provide a method and/or apparatus which will go at least some way in addressing the aforementioned problems; or which will at least offer a novel and useful alternative.

Summary of the Invention

[0007] Accordingly, in one aspect, the invention provides a method of monitoring solenoid valve operation in a continuous inkjet printer, said method being characterised in that it includes the step of detecting the presence of current draw by said solenoid valve.

[0008] Preferably said method comprises detecting the presence of current draw as said solenoid valve is opened.

[0009] Preferably said method is applied to a printer having a plurality of solenoid valves, said method including using a single sensing circuit to detect the current draw as any of said plurality of solenoid valves is opened.

[0010] Preferably said method further comprises identifying the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve.

[0011] Said method may also further comprise monitoring current flow in said solenoid valve to thereby determine when said valve is closed.

[0012] In a second aspect the invention provides a continuous inkjet printer having at least one solenoid valve to control a function within said printer, said printer being characterised in that it includes sensing means operable to detect the presence of current draw by said solenoid valve.

[0013] Preferably said sensing means is operable to detect the presence of current draw as said solenoid valve is opened.

[0014] Preferably said printer includes a plurality of solenoid valves, said sensing means including a single sensing circuit to detect the current draw as any of said plurality of solenoid valves is opened.

[0015] Preferably said printer further includes identification means operable to identify the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve.

[0016] Said printer may further include a facility to monitor current flow in said solenoid valve to thereby determine when said valve is closed.

[0017] Many variations in the way the present invention can be performed will present themselves to those skilled in the art. The description which follows is intended as an illustration only of one means of performing the invention and the lack of description of variants or equivalents should not be regarded as limiting. Wherever possible, a description of a specific element should be deemed to include any and all equivalents thereof whether in existence now or in the future.

Brief Description of the drawings

[0018] An embodiment of the invention will now be described with reference to the accompanying drawing in which:

Figure 1: shows, schematically, a circuit for determining solenoid valve operation in a continuous inkjet printer

Description of Working Embodiment

[0019] The present invention provides a low-cost effective means of determining solenoid valve operation in a CIJ printer. The essence of the invention is that solenoid valve operation is monitored directly by the solenoid driver electronics, in contrast to monitoring parameters downstream of the solenoid valve which could indicate if the valve is defective.

[0020] The invention relies on the assumption that a solenoid valve will be operating correctly providing the solenoid coil draws a current. In most instances this assumption will be true.

[0021] Typically a CIJ printer has a number of solenoid valves, each of which controls or influences different machine functions. Whilst the inventive concept described herein could be applied to each individual solenoid valve, in the preferred embodiment described, all solenoid valves are driven from a single source having a single detection circuit. In this way the invention can be implemented efficiently and at low cost.

[0022] Referring now to Figure 1, a control circuit is shown having two solenoid valves incorporated therein. It will be appreciated, however, that more than two solenoid valves can be incorporated and, indeed, a CIJ printer manufactured by the applicant typically has eight solenoid valves driven and controlled in the manner described.

[0023] Two voltages are used in the solenoid control circuit shown. Solenoid valves 1, 2 etc are turned on via the 24V supply and thereafter maintained on via the 12V supply. The extra power provided by the 24V supply is required to bring the solenoids into operation but the 12V supply is sufficient to hold the solenoid on once pulled in.

[0024] A sense resistor R_{sense} is placed in circuit from the 24V supply such that when turned on via the 24V supply all solenoid valves derive their power via this resistor. Each solenoid valve only needs to be powered for a short duration via the 24V supply for it to operate. Opening of each solenoid valve is effected by biasing on the appropriate HIT ENABLE transistor, and also the appropriate LOW SIDE ENABLE to sink current to ground. Typically a period of 30mS is sufficient to operate each solenoid.

[0025] Once pulled in, the solenoid valve is maintained on by maintaining the LOW side enable transistor on. In this configuration current is drawn only from the 12V supply through the diode D.

[0026] It will be appreciated that current is only drawn via R_{sense} during the turn-on period of the solenoid and hence sensing of the solenoid current may only be made during the turn-on period. This feature allows the same sensing circuit to be used to sense current for all solenoids as they are each turned on during different time slots.

[0027] An identical control (HOLD) circuit is provided for each solenoid. The diodes (D1 etc) are provided to prevent connection between the 12V and 24V supplies

(the 24V would otherwise connect directly to the 12V supply via the hit enable transistors and result in possible damage to the power supplies).

[0028] Details of the R_{sense} circuit are not shown in the circuit diagram but will be readily apparent to those skilled in the art. Various well known methods may be used for this function and these include the use of a comparator or the use of a transistor biased on by the voltage drop across the current sense resistor.

[0029] The R_{sense} circuit monitors current in the 24v supply and preferably outputs a pulse every time the total draw increases, as occurs when a solenoid valve is opened. The timing of these output pulses can be compared with expected events within the printer operation to identify a particular solenoid valve either operating correctly, or malfunctioning. This is advantageously effected digitally with each pulse being latched into a register within the operating device, e.g. an FPGA, which can be read by the operating software. So when the software commands a solenoid valve to open, it can then look to the register to see if a pulse of current was drawn by the R_{sense} circuit.

[0030] Further routines may be included in the printer operating system which would check the state of the solenoid valves at various times and compare them to their expected states.

[0031] If a malfunction in any of the solenoid valves is detected this is signalled to the operator and possibly used to initiate a shut-down of the printing system, depending on the significance of the malfunction.

[0032] A further enhancement of this system could include current sensing which would detect too much current as well as no (or not sufficient) current. This would use two current sensing circuits each of which are configured to sense either more than or less than a predicted voltage drop across R_{sense} .

[0033] It will thus be appreciated that the present invention, at least in the case of the working embodiment herein described, provides a method and/or apparatus which provides an effective low-cost means of monitoring solenoid valve operation in a continuous inkjet printer.

Claims

1. A method of monitoring solenoid valve operation in a continuous inkjet printer, said method being **characterised in that** it includes the step of detecting the presence of current draw by said solenoid valve.
2. A method as claimed in claim 1 comprising detecting the presence of current draw as said solenoid valve is opened.
3. A method as claimed in claim 2 when applied to a printer having a plurality of solenoid valves, said method including using a single sensing circuit to detect the current draw as any of said plurality of

solenoid valves is opened.

4. A method as claimed in claim 3 further comprising identifying the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve. 5
5. A method as claimed in any one of claims 1 to 4 further comprising monitoring current flow in said solenoid valve to thereby determine when said valve is closed. 10
6. A continuous inkjet printer having at least one solenoid valve to control a function within said printer, said printer being **characterised in that** it includes sensing means operable to detect the presence of current draw by said solenoid valve. 15
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7. A continuous inkjet printer as claimed in claim 6 wherein said sensing means is operable to detect the presence of current draw as said solenoid valve is opened. 25
8. A continuous inkjet printer as claimed in claim 6 or claim 7 including a plurality of solenoid valves, said sensing means including a single sensing circuit to detect the current draw as any of said plurality of solenoid valves is opened. 30
9. A continuous inkjet printer as claimed in claim 8 further including identification means operable to identify the operation of a particular one of said plurality of solenoid valves by associating the timing of a detection of current draw by said sensing circuit with the timing of a particular operating command associated with said particular solenoid valve. 35
10. A continuous inkjet printer as claimed in any one of claims 6 to 9 further including a facility to monitor current flow in said solenoid valve to thereby determine when said valve is closed. 40

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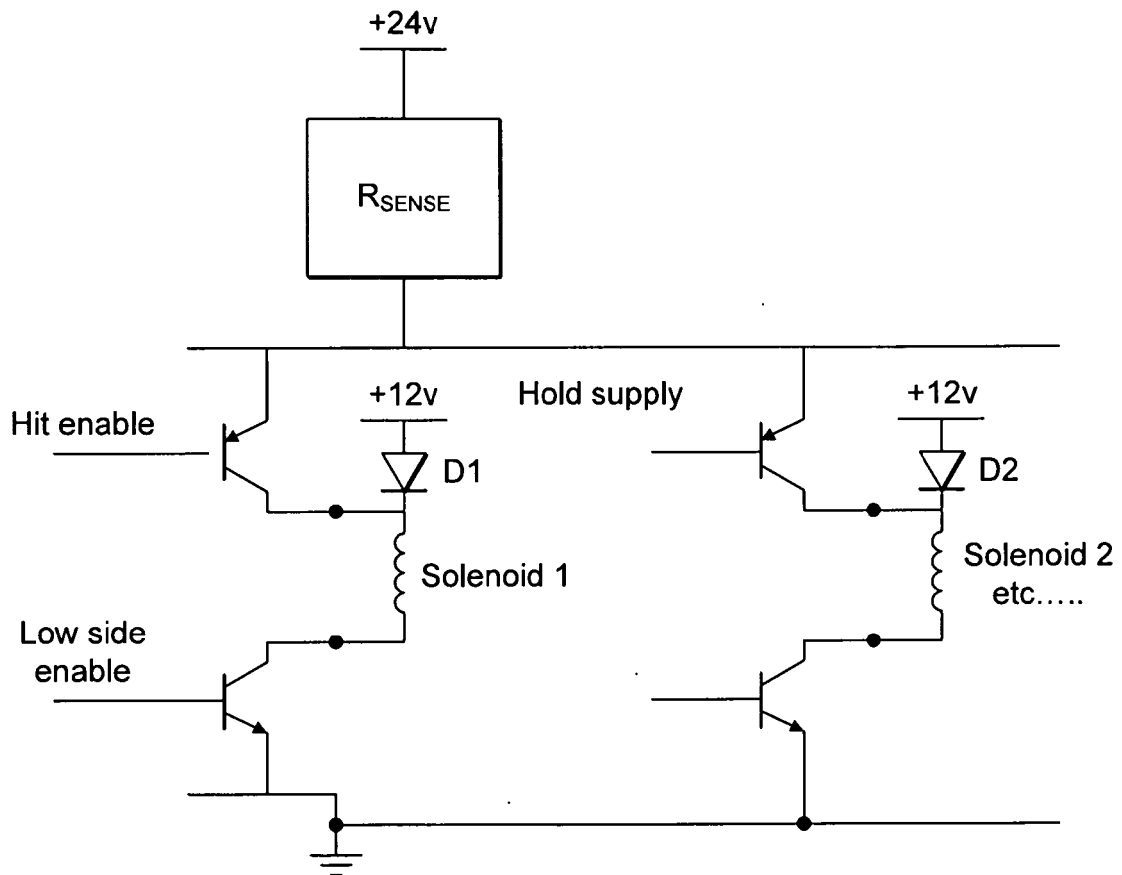


FIG. 1