



(12) **EUROPEAN PATENT APPLICATION**

(43) Date of publication:
02.06.2004 Bulletin 2004/23

(51) Int Cl.7: **F02D 41/26, F02D 41/22**

(21) Application number: **02425732.1**

(22) Date of filing: **28.11.2002**

(84) Designated Contracting States:
AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
IE IT LI LU MC NL PT SE SK TR
 Designated Extension States:
AL LT LV MK RO SI

• **Rivoli, Federico**
98168 Messina (IT)
 • **Ticli, Lucio**
95037 San Giovanni la Punta (Catania) (IT)
 • **Martorana, Rosario**
98123 Messina (IT)

(71) Applicant: **STMicroelectronics S.r.l.**
20041 Agrate Brianza (Milano) (IT)

(74) Representative: **Botti, Mario**
Botti & Ferrari S.r.l.,
Via Locatelli, 5
20124 Milano (IT)

(72) Inventors:
 • **Di Cola, Eusebio**
98168 Messina (IT)

(54) **Hardware architecture of an automatic system for driving injector of an internal combustion engines**

(57) The invention relates to a hardware architecture of a system (1) for driving injection in internal combustion engines (2), of the type intended to cooperate with an engine electronic control unit (ECU) by driving corresponding injection drivers (3). The system (1) comprises:

- a first I/O interface module (4) embedding a plurality of registers and receiving signals from said engine ECU;

- a second module (5) bi-directionally connected to the first module (4) from which it receives information at least on the injection times and the quantity of fuel to be injected for generating driving signals for said injection drivers (3), thereby actuating a desired injection profile;

- a third module (6) capable of emitting an interrupt signal toward said control unit (ECU) on the basis of signals received by said second module (5).

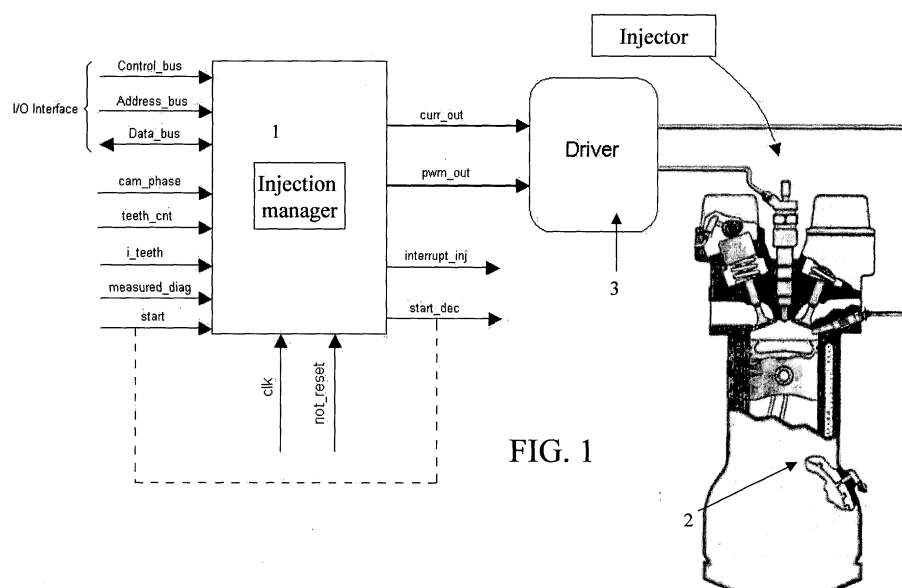


FIG. 1

DescriptionField of application

[0001] The present invention relates to a hardware architecture of an automatic system for driving injector of an internal combustion engine, in particular direct injection, four-stroke engines with automatic determination of the angular position of the drive shaft and of the operating phase.

[0002] More in particular, but not exclusively, the invention relates to an injection and/or ignition driving system in internal combustion engines, of the type structured to cooperate with an engine electronic control unit (ECU) by driving the corresponding injection drivers.

Prior Art

[0003] As it is well known in this specific technical field, the use of electronic control units for injection management in modern car engines has become usual. Reference shall be made, for example, to the European patent application No. 01830645.6 to the same Applicant.

[0004] Their use has become necessary to control some engine parameters in order to decrease the harmful emissions produced by the engine itself, on the basis of the regulations in force in many industrialised Countries, which set very restrictive limits to the maximum emissions allowed.

[0005] To comply with these limits imposed by law, major automotive companies are increasing the production of direct injection engines that allow the decreasing of the level of pollutants released in the environment and the improving of the engine performance. However, these engines require a more complex and advanced control system.

[0006] The recent introduction of multi-injection systems, for which the parameters to be considered, during the control phase, are characterised by more pressing time specifications, requires the use of a certain number of sensors of various type, whose signals are always processed by the current control units.

[0007] Accordingly, nowadays the current control units - which are also classified as ECU (Electronic Control Unit) - are required to carry out increasingly complex and elaborated control functions.

[0008] In the automotive field it is known the use ECU provided with a co-processor of the TPU (Time Processor Unit) type, specifically intended to be used for processing signals transmitted by a tone wheel sensor of the drive shaft and by a tone wheel sensor of the camshaft, so as to obtain the angular position of the drive shaft as well as the engine operating phase.

[0009] A lot of parameters are required for a better actuation of the injection process, controlled by the ECU or by the TPU co-processor. This implies a large computational load, both by the ECU and by the TPU co-processor.

[0010] In fact, both units manage a large number of signals having different priority levels. These signals must in any case be managed by software routines, started by interrupt signals in case of ECU, or by the occurrence of certain events, in case of the TCU co-processor.

[0011] In any case, a difference between the ideal injection time instant and the real time in which it is actuated occurs, to the detriment of an accurate combustion, which shall therefore generate a higher quantity of pollutants than expected.

[0012] The technical problem at the basis of the present invention is to devise a new hardware architecture for an automatic driving system for injectors in internal combustion engines, which architecture should exhibit such structural and functional features as to allow a better management of the signals transmitted by the various sensors depending on the engine control unit as well as a higher control over the means in charge of the injection and/or the engine ignition step.

Summary of the invention

[0013] The solution idea at the basis of the present invention is to provide a hardware module, operating in digital logic, which may be used as a peripheral device by the ECU in order to reduce its computational load.

[0014] Such hardware module should have the task of actuating the injection process, that is to say, following an injection profile stored therein.

[0015] In practice, the idea at the basis of the invention is to release the engine electronic control unit (ECU) from the injection and/or ignition actuation.

[0016] On the basis of such a solution idea, the technical problem is solved by a hardware architecture of an automatic injector driving system of the type mentioned above and defined in the characterising part of claim 1 attached herein-after.

[0017] The features and advantages of the architecture according to the invention will be more evident from the following description of an indicative and non-limiting example of embodiment, made with reference to the attached

drawings.

Brief description of the drawings

[0018]

- Figure 1 shows a schematic view of an endothermic injection engine associated to an injector driving driver associated to a system for driving and managing the ignition and/or injection process according to the present invention;
- Figure 2 shows a schematic block view of the architecture of the piloting system according to the present invention;
- Figure 3 shows a schematic view of a detail of the architecture of Figure 2;
- Figure 4 shows a diagram having the same time basis with a set of profiles corresponding to injection piloting signals for the system of the present invention;
- Figure 5 shows a wiring diagram of an injector driving circuit;
- Figure 6 shows a diagram with the time-based evolution of a PWM signal generated through the system of the present invention;
- Figure 8 shows a schematic view of a state machine that illustrates the operation of the driving system according to the invention (indicated with reference numeral 7 in figure 3);
- Figure 7 shows a further schematic view of a state machine that illustrates the operation of a subsystem of the driving system (indicated with reference numeral 8 in figure 3).

Detailed description

[0019] With reference to the above figures, 1 globally and schematically indicates the hardware architecture of an automatic system for driving and managing the injection and/or ignition of an endothermic engine 2, in particular a direct-injection four-stroke engine with automatic determination of the drive shaft angular position and of the operating phase.

[0020] System 1 is associated to an ECU, not shown since it is a conventional one, is widely used in automotive applications for controlling the ignition and/or injection of these types of engines. System 1 is schematised in figure 1 by the "Injection manager" block.

[0021] The main task of system 1 is to releasing the Engine control ECU of the task of enabling the piloting of the means in charge of the injection and/or ignition of engine 2.

[0022] In practice, the time instant in which injection or ignition should be actuated is a critical parameter since the optimum combustion conditions depend on it to generate the smallest quantity of polluting substances.

[0023] The object of the present invention is that of defining the architecture of a modular hardware system which should generate a series of signals useful for the drivers 3 in charge of driving the injectors. Given the variety of types of these drivers 3 and of the possible applications using a same driver, system 1 can be programmed so as to generate driving signals having the desired time pattern. This makes the system according to the invention very flexible and reusable in several applications.

[0024] Thanks to a standard I/O interface it is possible to store the sequence of the output logical states inside the module; such states may be of the PWM type, both steady at a logical level "0" or "1".

[0025] The internally stored injection profile can be described on the basis of angles and/or times, thereby allowing the shift from a logical output level to the other when the drive shaft reaches a fixed position, or after a certain time interval from the previous situation.

[0026] This peculiarity of system 1 makes it usable both in applications where the quantity of fuel to be injected is calculated in terms of time in which the injector is open, and in applications wherein the quantity of fuel is calculated in terms of the drive shaft angular position.

[0027] Figure 1 shows a layout of the invention.

[0028] System 1 exhibits a plurality of inputs and outputs described in the following Table 1:

Signals	Description
Input	
Control_bus Address_bus Data_bus (I/O)	Standard communication interface. The Data bus is bidirectional.
cam_phase	This indicates the engine operating phase
teeth_cnt	This indicates the drive shaft angular position with the precision given by the number of teeth of the drive shaft tone wheel.
i_teeth	This indicates an estimated angular position between two teeth of the drive shaft tone wheel
measured_diag	Diagnostic signals
start	Start signal for module internal state machines
Output	
curr_out	STEADY signals
pwm_out	PWM signals
Interrupt_inj	Interrupt signal
start_dec	This indicates if the internal start register is activated

[0029] The output signal "start_dec" can be connected to the input signal "start" to start the entire system by writing on the internal register "start", as highlighted by the broken line between the two signals in figure 1.

[0030] System 1 comprises three modules 4, 5 and 6, each performing a specific function in order to reach the object of the present invention. The entire system 1 is structurally independent and can be realised as integrated circuit and be housed on a standard bus interconnection and support board. Such board may also house the engine ECU.

[0031] Of course, nothing prevents system 1 and the ECU from being realised on a single integrated circuit of the "system on chip" type, even maintaining their functional independence.

[0032] A general diagram of the hardware architecture of the driving system 1 is shown in Figure 2.

[0033] The "Injection manager" block has a modular structure and comprises the three modules 4, 5 and 6, respectively called "dec_injection", "inj" and "pend_inj". Figure 2 shows such modules and their interconnections.

[0034] The task module 4 "dec_injection" should perform consists in providing a standard interface toward the ECU in order to exchange signals with such engine control units to regulate the activity of the "Injection manager"; this is obtained by suitably forcing the value of a set of registers internal to module 4 "dec_injection".

[0035] The values of the above registers represent the configuration parameters of module 5 "inj" which is the core of the entire system 1.

[0036] This module 5, during normal operation, forces a second set of registers internal to module 4 "dec_injection" from which it is possible to trace the internal status and to the results of module 5 "inj".

[0037] The set of signals **curr_out** and **pwm_out** allows the driving of a wide variety of car injector drivers 3 in order to actuate the desired injection profiles.

[0038] The task of module 6 "pend_inj" consists of generating an interrupt signal toward the engine injection control unit once the error signals generated by module 5 "inj" have been provided in input.

[0039] The generation of an interrupt signal also defines the value of the related register internal to module 4 "dec_injection", from which it is possible to detect the type of error generated by module 5 "inj".

[0040] The operation of module 4 "dec_injection" will now be described in deeper detail.

[0041] The task of module 4 consists of providing a standard Input/Output interface toward the ECU controller, so as to define the functionality of system 1 by suitably programming the registers embedded therein. Moreover, it transfers the value of these registers to module 5 "inj".

[0042] The following tables 2, 3, 4 and 5 describe the registers embedded in module 4 "dec_injection"; these registers can be read/written via the standard interface:

Table 2:

Register Type	Description
Output to module 5 "inj"	
start	Its status is reported by the output "start_dec"
stop	Stops the state machine implemented in "inj" restoring its original status waiting for a new start.
presc_conf	Prescaler of the timer internal to module "inj"
period	Period of the PWM signals to be generated
duty_high	Table containing a set of duty-cycle values of the PWM signals to be generated
security	This indicates if the security condition is enabled
compare_value	Watchdog value
time_diag	This indicates the instants in which diagnostics should be carried out
cfg_diag	This indicates if diagnostics should be carried out
index_diag	This indicates the element of the <i>time_diag</i> signal to be used for diagnostics
expected_diag	This indicates the value expected from the diagnostic check
cfg_diag_sec	This indicates if diagnostics should be carried out in security condition
index_diag_sec	This indicates the element of the <i>time_diag</i> signal to be used for diagnostics in security condition
expected_diag_sec	This indicates the value expected from the diagnostic check in security condition

Table 3:

Configuration data for the injection profiles to be actuated in normal conditions	
time_prof	Table containing the instants of variation of the injection profile
profile	Table containing the configuration values of signals curr_out and pwm_out for every instant of variation of the injection profile
cfg_time_prof	This indicates whether the actuation of the injection profile should be based on time or angles
cam_phase_conf	This indicates the phase in which injection should be carried out
num_shape	Number of shapes forming the injection profile

Table 4:

Configuration data for the injection profiles to be actuated in security condition	
time_prof_sec	Table similar to time_prof but valid in security condition
profile_sec	Table similar to profile but valid in security condition
cfg_time_prof_sec	This indicates whether the actuation of the injection profile in security condition should be based on time or angles
cam_phase_conf_sec	This indicates the phase in which injection should be carried out in security condition
num_shape_sec	Number of shapes forming the injection profile in security condition

Table 5:

Output to "pend_inj"	
Mask	Interrupt mask
Input from "inj"	
stato_out	This allows tracing the "inj" state
cfg_pwm	This indicates the current configuration of module "pwm_inj"
curr_out	This indicates the current configuration of the steady driver driving signals
Input from "pend_inj"	
pending	This indicates the type of error occurred

[0043] The operation of module 5 "inj" shall now be described in deeper detail.

[0044] The task of such module 5 consists of actuating the injection process according to the stored profile, which indicates both the time the injection should start and the quantity of fuel to be injected during the process. An example of injection profile to be actuated, intended as current profile to be applied to the injector is shown in figure 4.

[0045] On the other hand, an example of circuit used to generate the desired current profile is shown in figure 5. This type of electronic circuits, known as power drivers, can be driven by system 1 object of the present invention.

[0046] The circuit of figure 5 substantially is a bridge circuit wherein the current flow fed toward the injector is regulated by a first power transistor T1, driven by a signal P, and by a second transistor T2, driven by a PWM signal.

[0047] A third transistor T3, driven by a signal W, allows to close the current path toward earth, when needed.

[0048] In fact, signals P, applied to the gate of transistor T1, W, applied to the gate of transistor T3, and PWM, applied to the gate of transistor T2, allow to adapt the current driving of a wide variety of drivers for car injectors in a very flexible manner.

[0049] Moreover, this object is achieved by the architecture of figure 3, showing the internal structure of module 5 "inj", comprising a main block 7 indicated with the abbreviation "inject_fsm", and an auxiliary block 8 "pwm_inj", whose purpose is that of generating the desired PWM signals through configuration commands provided by the main block 7 "inject_fsm".

[0050] The operation of block 8 "pwm_inj" shall now be described in deeper detail.

[0051] The task of such block 8 is that of generating a square wave with desired duty-cycle, for example like the one shown in figure 6, with the possibility of obtaining both a high logical value and a low logical value in output.

[0052] The input signals of block 8 "pwm_inj" are as follows:

clk,

not_reset,

start,

period,

duty_high,

config.

[0053] The output signal is **pwmout**. The behaviour of module 6 can be described with a state machine 9 like that shown in figure 7.

[0054] The configuration parameters that allow to have the desired signal are given by signals **period**, **duty_high** and **config**.

[0055] The signals **period** and **duty_high** respectively indicate the period and the duty-cycle of the signal that must be generated.

[0056] The signal **config** allows to select whether the signal to generate should be PWM or a steady signal at the logical value 0 or 1.

[0057] The signal **duty_high**, on the other hand, is a table wherein the elements contain a predetermined series of duty-cycle values programmable by the user.

[0058] The signal **config** is used as index of the table indicated by **duty_high** to select the desired duty-cycle value; it can take two further values, which respectively indicate whether the signal **pwmout** must be a steady signal at the logical level 0 (**config** = min_val) or at the logical level 1 (**config** = max_val).

[0059] Upon start-up, or after resetting system 1, the state machine 9 is in its initial status, indicated in the figure by "idle".

[0060] If the signal **config** takes either the value min_val or the value max_val, the state machine 9 remains in the "idle" status and the signal **pwmout** is forced at the logical value 0 or 1.

[0061] On the other hand, if **config** takes a value comprised between min_val and max_val, by activating the signal **start**, the state machine 9 passes through the state "high_val" (transition T_0). In this status, the signal **pwmout** is forced at the logical level 1, a counter/timer is started and checked to see that it reaches the value indicated by the element **duty_high(config)**; when this condition occurs, the state machine 9 passes through the state "low_val" (transition T_2), the signal **pwmout** is forced at the logical level 0 and the timer is checked to see that it reaches the value indicated by the signal **period**.

[0062] When this condition occurs, the timer/counter is reset and the state machine 9 passes through the state "high_val" (transition T_3) so as to continue generating the desired signal. From the states "high_val" and "low_val" it is possible to stop the operation of the state machine and bring it back to the idle status by disabling the signal **start** (transitions T_1 and T_4).

[0063] The behaviour of block 7 "inject_fsm" embedded in module 5 is described through a state machine 10 shown in figure 8.

[0064] Block 7 "inject_fsm" can work in two modes, according to the status of signal **security**. These two modes are identical as regards the execution, but they use two different data sets; if the security mode is disabled, the set of data taken into consideration is that of table 2; on the other hand, if the security mode is enabled, the set of data taken into consideration is that of table 3.

[0065] The behaviour of the state machine 10 is described in this way with reference to the normal working condition only, and considering the injection profile shown in figure 4.

[0066] The initial status of the state machine 10 is, also in this case, called "idle", a status that is reached upon start-up and/or after resetting system 1.

[0067] By activating the signal **start**, the state machine 10 passes through the status "stand-by" (transition T_0), wherein the configuration of outputs **curr_out** and **pwm_out** is given by the first element of the table **profile** and it remains in such status until the value of the first element of table **time_prof** matches either the value of the internal timer, if the injection must occur on a time basis, or the values indicated by the signals **teeth_cnt** and **i_teeth**, if the injection must occur on an angle basis.

[0068] This event coincides with the point α of the injection profile shown in figure 4. When this event occurs, the state machine passes through the state "shap_succ" (transition T_1), where the next elements of tables **profile** and **time_prof** are selected, to return to the "stand-by" status again (transition T_2) and remain there until the event indicated with b in figure 4 occurs.

[0069] The transitions between the "stand-by" status and the "shape_succ" status follow one another up to considering the last elements of tables **profile** and **time_prof** (event indicated with e in figure 4).

[0070] At this point, the state machine passes through the status "fine_shape" (transition T_3), where an interrupt is generated to indicate that the injection process has been completed and the system is waiting for the signal **start** to be disabled so as to bring the state machine back to its "idle" status (transition T_4), where the next injection is expected.

[0071] Block 7 "inject_fsm" of module 5 allows to carry out a diagnostic process during the injection process, and this allows to check if this is being executed properly.

[0072] The register **cfg_diag** contains a flag for every element of the table **time_prof** that indicates, if it is active, that the diagnostics should be carried out after the event indicated by the current element of **time_prof**.

[0073] If a flag is active, the corresponding element of table **index_diag** indicates an element of the table **time_diag** that represents the time that must be waited for from the occurrence of the event indicated by the table **time_prof** before comparing the diagnostic signal **measured_diag**, transmitted by the injector drive, with the signal **expected_diag**, which indicates the expected value in case of correct operation. An interrupt is then generated if the value of **expected_diag** differs from that of **measured_diag**.

[0074] It is also possible to activate an internal timer-watchdog to report any problems in case nothing occurs for a fixed time interval and when in the states of "stand-by" and "shape_succ"; the signal **overflow** indicates the maximum limit to be reached by the internal timer-watchdog to report this type of problem.

[0075] The task of the auxiliary block 8 "pend_inj" associated to the main block 7 "inject_fsm" embedded in module 5 consists of generating an interrupt signal toward the ECU controller.

[0076] Such block 8 receives an input signal from module 5 "inj" indicating the type of error occurred, and it generates a signal for module 4 "dec_injection" to set properly the "pending" register, whose reading allows the controller to

determine the type of error so as to decide the action to be taken.

[0077] Thanks to the features described above, the driving system 1 can also be applied to a variety of engines, each provided with different injector driving drivers.

[0078] The piloting system 1 can be adapted to the wide variety of types of injection profiles for car injector drivers used in the automotive field, this thanks to the wide configurability of the parameters allowed by modules 4, 5 and 6. This makes the system according to the invention very flexible and reusable in several applications.

Claims

1. Hardware architecture of a system (1) for driving the injection and/or ignition in internal combustion engines (2), of the type intended to cooperate with an engine electronic control unit (ECU) by driving corresponding injection drivers (3), **characterised in that** it comprises:

- a first I/O interface module (4) embedding a plurality of registers and receiving signals from said engine ECU;
- a second module (5) bi-directionally connected to the first module (4) from which it receives information at least on the injection times and the quantity of fuel to be injected for generating driving signals for said injection drivers (3), thereby actuating a desired injection profile;
- a third module (6) capable of emitting an interrupt signal toward said control unit (ECU) on the basis of signals received by said second module (5).

2. Architecture according to claim 1, **characterised in that** the registers of said first module (4) can be accessed in writing and reading mode from said ECU by a standard interface.

3. Architecture according to claim 1, **characterised in that** the registers embedded in said first module (4) are:

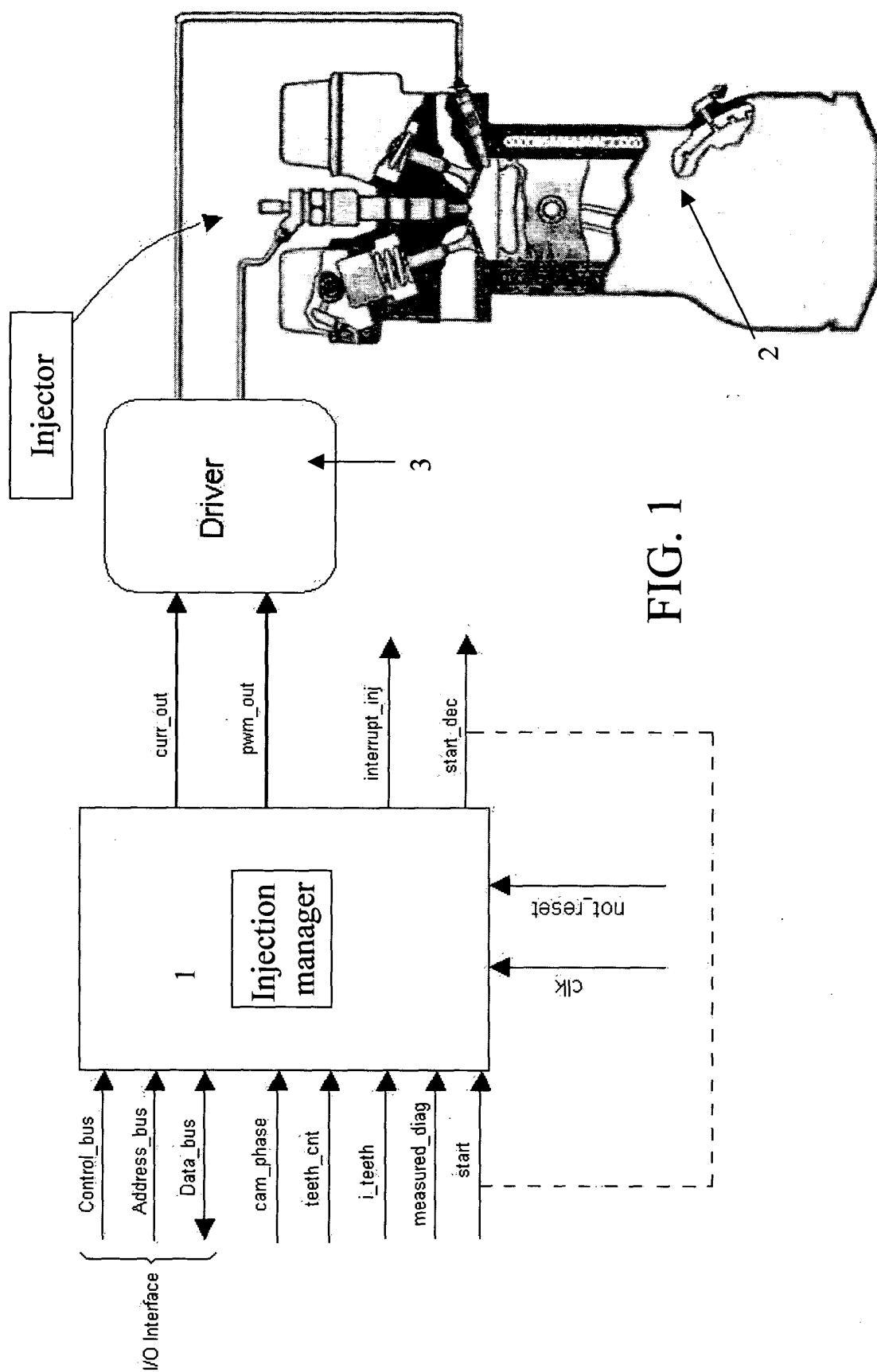
start	Its status is reported by the output "start_dec"
stop	Stops the state machine implemented in "inj" restoring its original status waiting for a new start.
presc_conf	Prescaler of the timer internal to module "inj"
period	Period of the PWM signals to be generated
duty_high	Table containing a set of duty-cycle values of the PWM signals to be generated
security	This indicates if the security condition is enabled
compare_value	Watchdog value
time_diag	This indicates the instants in which diagnostics should be carried out
cfg_diag	This indicates if diagnostics should be carried out
Index_diag	This indicates the element of the <i>time_diag</i> signal to be used for diagnostics
expected_diag	This indicates the value expected from the diagnostic check
cfg_diag_sec	This indicates whether diagnostics should be carried out in security condition
Index_diag_sec	This indicates the element of the <i>time_diag</i> signal to be used for diagnostics in security condition
expected_diag_sec	This indicates the value expected from the diagnostic check in security condition
time_prof	Table containing the instants of variation of the injection profile
profile	Table containing the configuration values of signals curr_out and pwm_out for every instant of variation of the injection profile
cfg_time_prof	This indicates whether the actuation of the injection profile should be based on time or angles
cam_phase_conf	This indicates the phase in which injection should be carried out

(continued)

num_shape	Number of shapes forming the injection profile
time_prof_sec	Table similar to time_prof but valid in security condition
profile_sec	Table similar to profile but valid in security condition
cfg_time_prof_sec	This indicates whether the actuation of the injection profile in security condition should be based on time or angles
cam_phase_conf_sec	This indicates the phase in which injection should be carried out in security condition
num_shape_sec	Number of shapes forming the injection profile in security condition
Output to "pend_inj"	
Mask	Interrupt mask
Input from "inj"	
stato_out	This allows to trace the "inj" state
cfg_pwm	This indicates the current configuration of module "pwm_inj"
curr_out	This indicates the current configuration of the steady driver driving signals
Input from "pend_inj"	
pending	This indicates the type of error occurred

4. Architecture according to claim 1, **characterised in that** said second module (5) directly receives an input signal (cam_phase) relating to the engine phase, and a further pair of signals (i_teeth; teeth_cnt) related to the angular position of the drive shaft (2).
5. Architecture according to claim 1, **characterised in that** when an interrupt signal is generated a relevant internal register of the first module is also updated (4) from which it is possible to trace the type of error generated by the second module (5).
6. Architecture according to claim 1, **characterised in that** said second module (5) comprises a main block (7) for driving the injection drivers (3) and an auxiliary block (8) adapted for generating PWM signals through configuration commands provided by the main block (7).
7. Architecture according to claim 6, **characterised in that** said auxiliary block (8) is in charge of generating both a square wave with the desired duty-cycle (PWM signal) and of obtaining either a high or a low logical value in output.
8. Architecture according to claim 7, **characterised in that** said main block (7) operates in two modes by using a corresponding set of data in said registers; one of said modes being a security mode for which the set of data taken into consideration is as follows:

time_prof sec	Table similar to time_prof but valid in security condition
profile_sec	Table similar to profile but valid in security condition
cfg_time_prof_sec	This indicates whether the actuation of the injection profile in security condition should be based on time or angles
cam_phase_conf_sec	This indicates the phase in which injection should be carried out in security condition
num_shape_sec	Number of shapes forming the injection profile in security condition



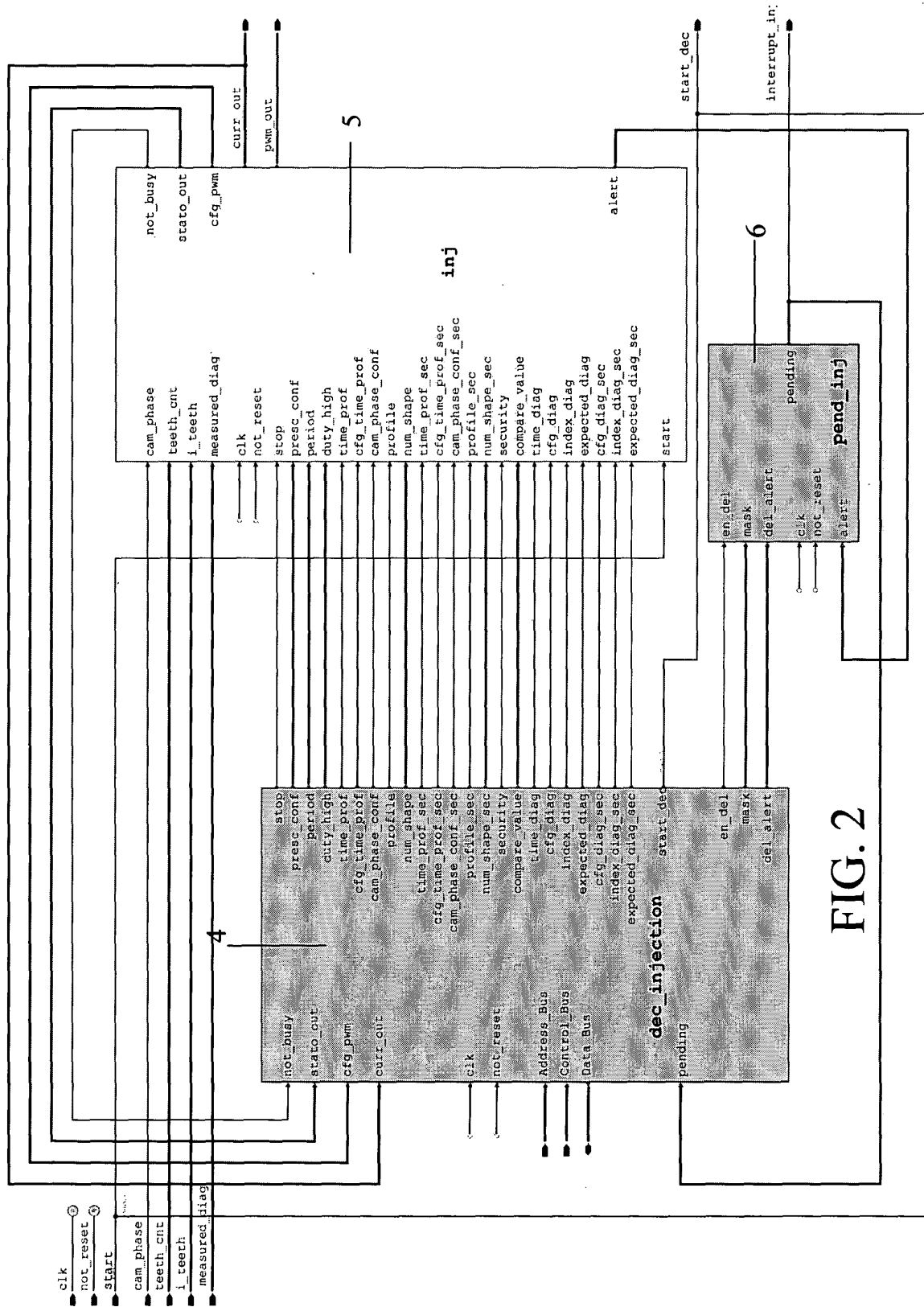


FIG. 2

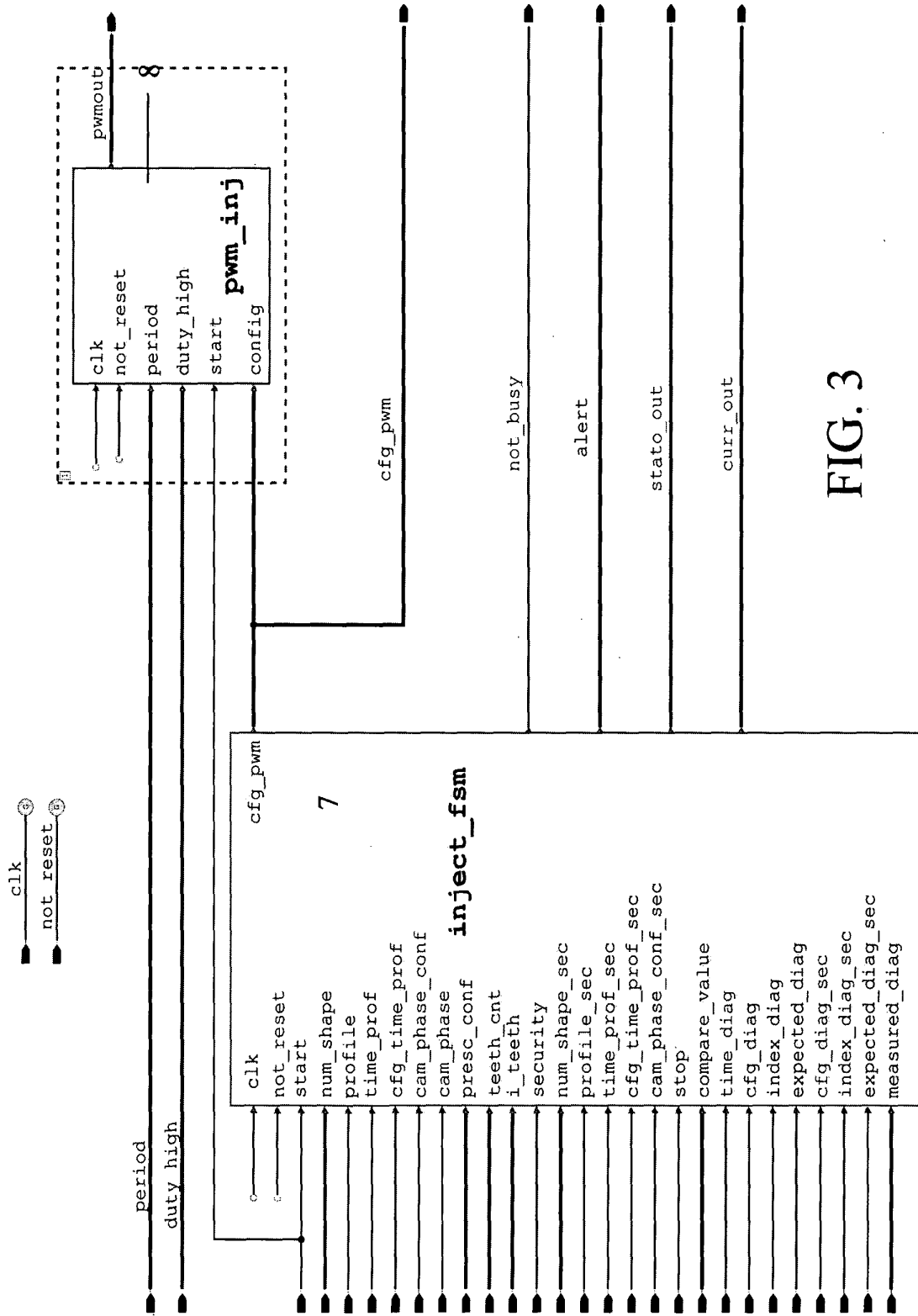
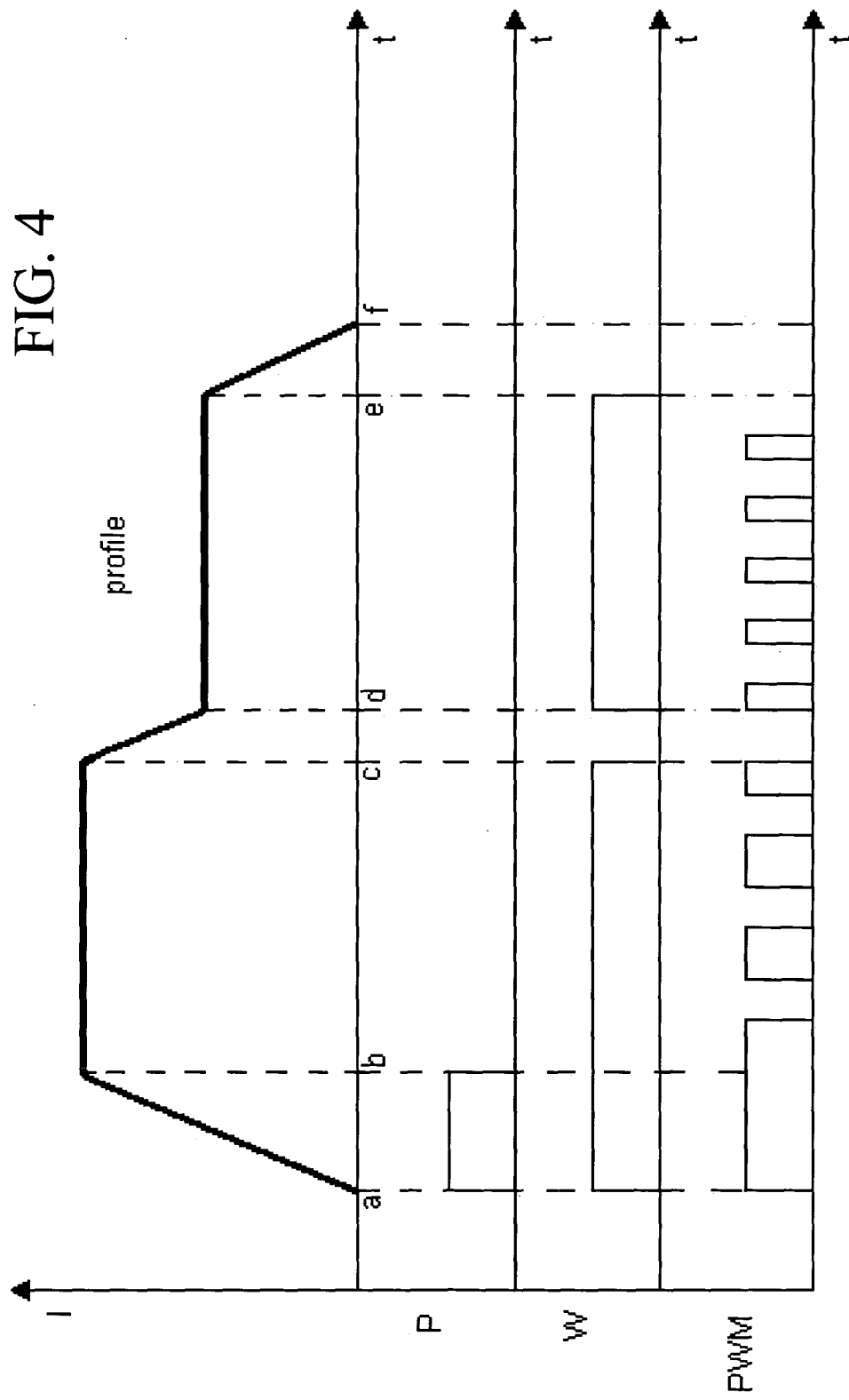
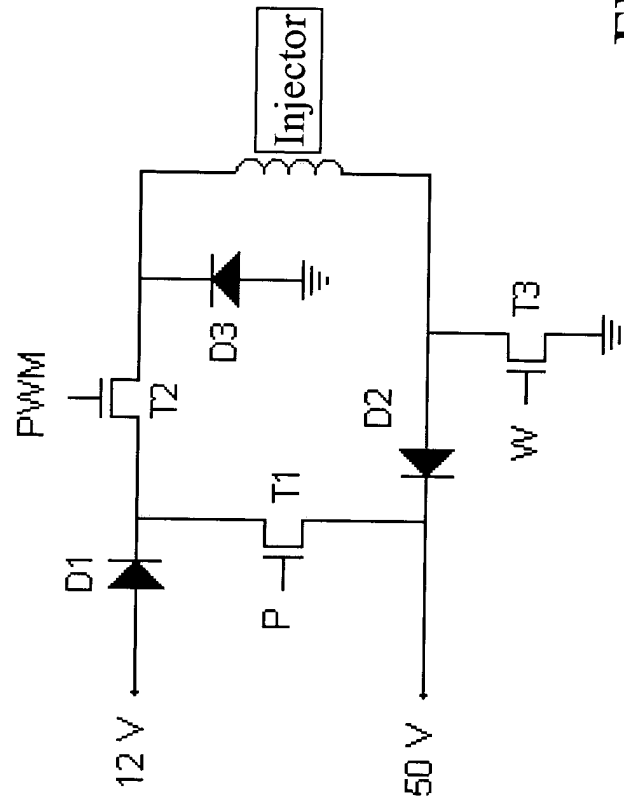


FIG. 3





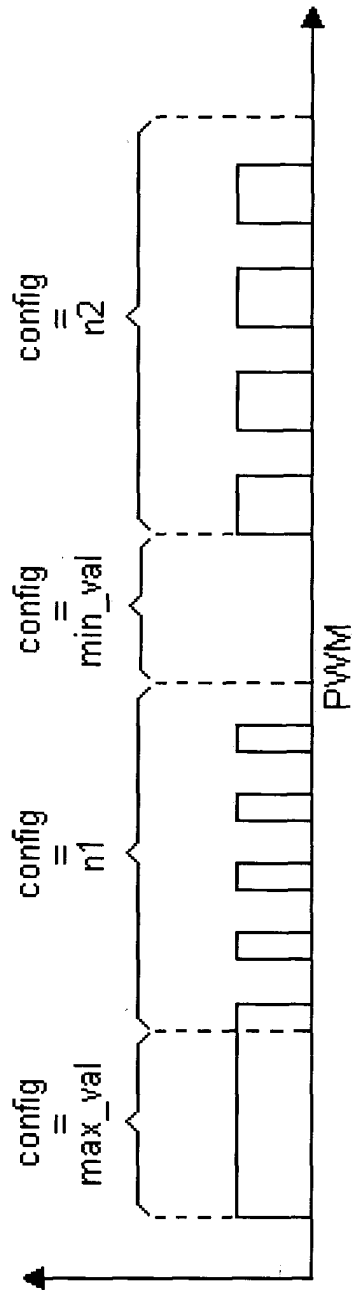


FIG. 6

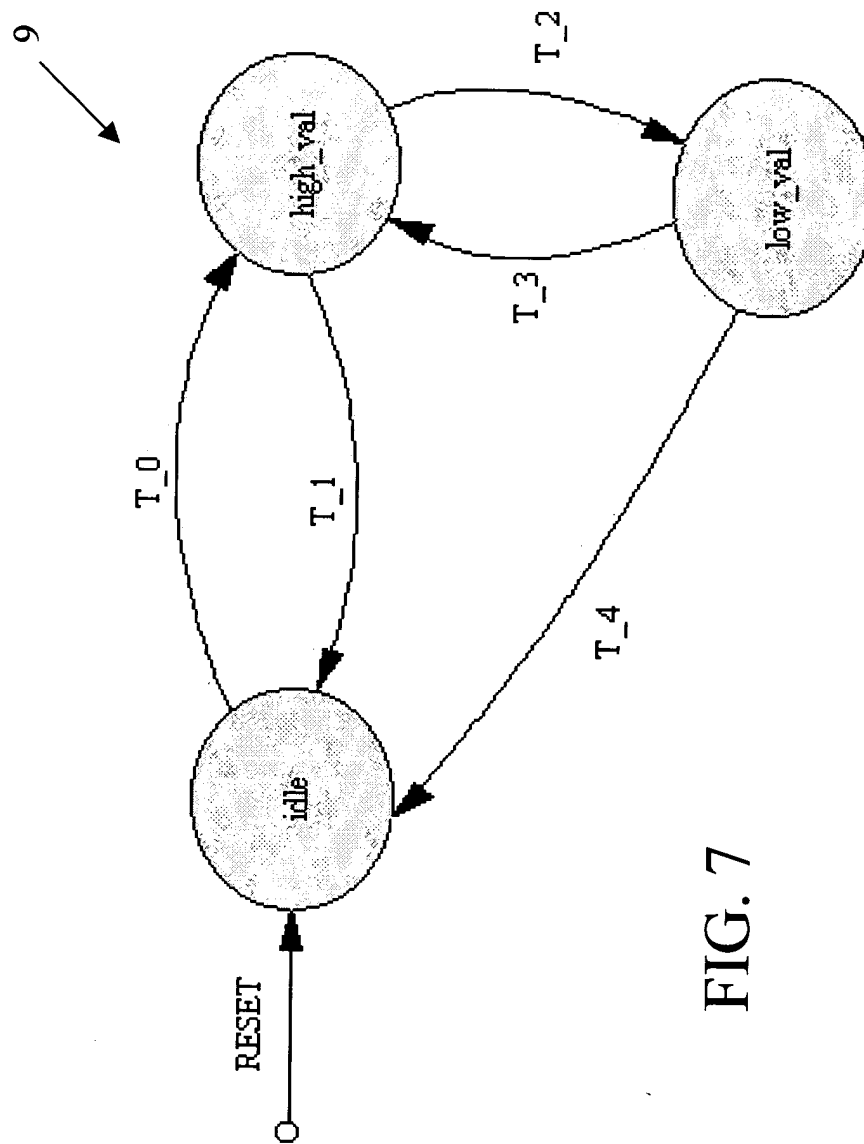


FIG. 7

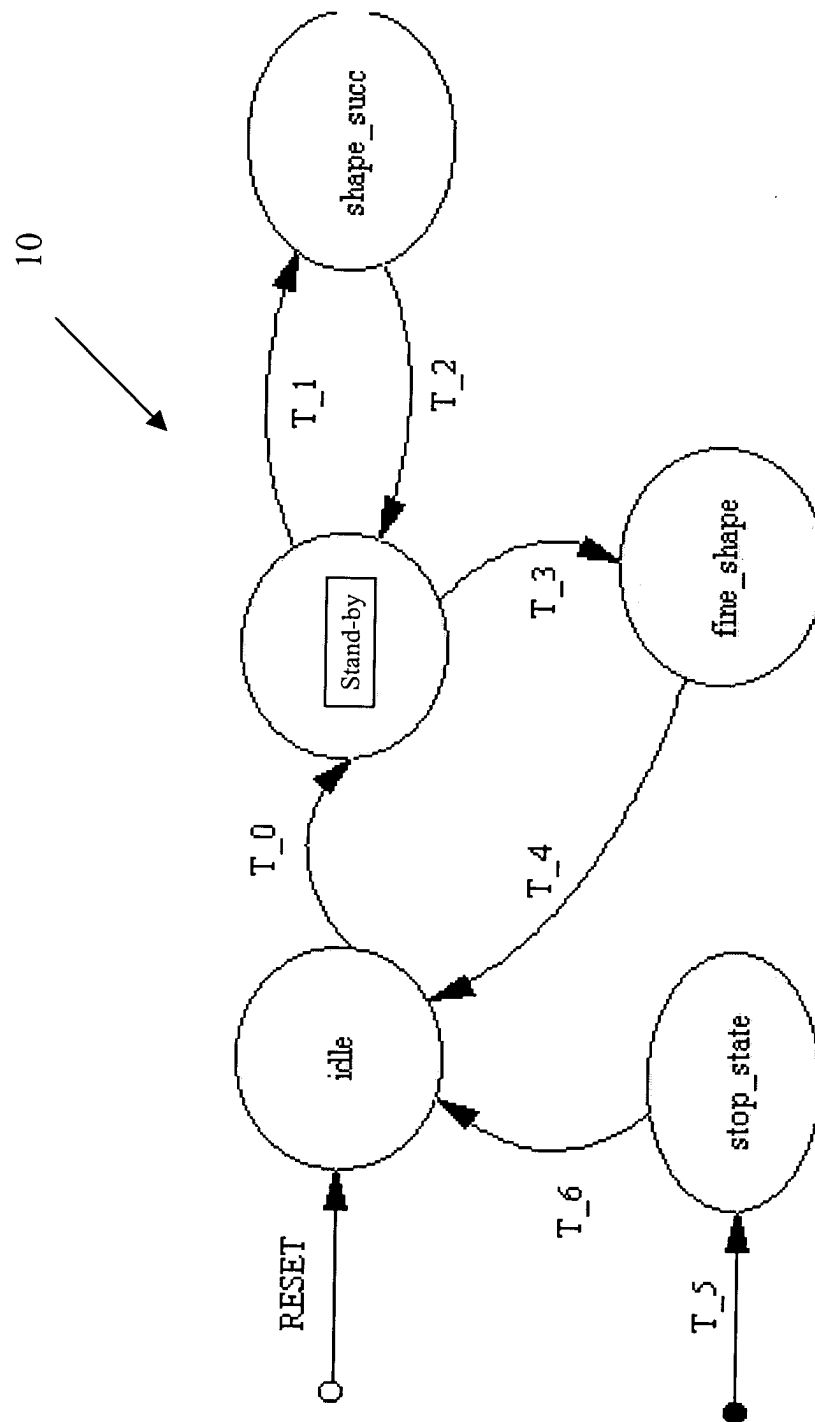


FIG. 8



European Patent
Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 42 5732

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.CI.7)
X	US 5 829 412 A (BECKMANN JOERN ET AL) 3 November 1998 (1998-11-03)	1, 2, 4	F02D41/26 F02D41/22
Y	* abstract * * column 6, line 35 - column 7, line 15 * * column 8, line 38 - column 10, line 16 * ---	5	
Y	DE 41 00 751 A (VDO SCHINDLING) 16 July 1992 (1992-07-16) * abstract * * column 4, line 17 - line 43 * ---	5	
A	US 5 201 296 A (DAVIS ERROL W ET AL) 13 April 1993 (1993-04-13) * figure 2 * * column 8, line 14 - line 61 * ---	1	
A	US 5 233 964 A (JAMOUA SAAD A ET AL) 10 August 1993 (1993-08-10) * column 7, line 16 - column 9, line 54 * ---	1	
A	DE 100 41 448 A (BOSCH GMBH ROBERT) 7 March 2002 (2002-03-07) * the whole document * -----	1	TECHNICAL FIELDS SEARCHED (Int.CI.7) F02D
The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 17 April 2003	Examiner Röttger, K
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

EPO FORM 1503 03.B2 (P04C01)

**ANNEX TO THE EUROPEAN SEARCH REPORT
ON EUROPEAN PATENT APPLICATION NO.**

EP 02 42 5732

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

17-04-2003

Patent document cited in search report		Publication date		Patent family member(s)	Publication date
US 5829412	A	03-11-1998	DE	4444751 A1	20-06-1996
			CN	1141068 A ,B	22-01-1997
			WO	9618812 A1	20-06-1996
			DE	59509115 D1	26-04-2001
			EP	0755483 A1	29-01-1997
			JP	9509464 T	22-09-1997

DE 4100751	A	16-07-1992	DE	4100751 A1	16-07-1992

US 5201296	A	13-04-1993	CA	2130914 A1	14-10-1993
			DE	69228568 D1	08-04-1999
			DE	69228568 T2	07-10-1999
			EP	0678158 A1	25-10-1995
			JP	7506411 T	13-07-1995
			WO	9320345 A1	14-10-1993

US 5233964	A	10-08-1993	NONE		

DE 10041448	A	07-03-2002	DE	10041448 A1	07-03-2002
			WO	0216746 A1	28-02-2002
