Ever wondered what to do with the pile of free cameras you have accumulated from s***r-s**ps? One thing is for sure you won't to be seen dead using them in public, if you were brave enough to venture onto the streets with one the results obtained are not likely to pose a serious threat to the works of David Bailey (due to the limitations of the 126 film, fixed focus/fixed apperture cameras). So if you're not going to use the camera for your holiday snaps what can you do with it? One use I found for mine was a low cost automatic camera for applications such as time laps photography or, as in this example "security/surveylance". The circuit design used also provides a useful insite into a type of control circuit known as an **Algorithmic State Machine** or **ASM**.

Algorithmic State Machines

The control of equipment electronically requires a hardware unit which will accept commands, in the form of electrical inputs, to switch its available outputs according to the "program" it contains.

In the area of computing the program is often represented by a flow diagram, which provides an overview of the operation of the controller and the program can be logically derived from this. The algorithmic state machine provides a similar approach to the design of hardware control circuits.

Using the ASM technique a camera control circuit has been designed to demonstrate the principle. The circuit operates the camera when an "intruder" is detected. The sequence of operation is represented by a **state diagram**, which allows the stages of the program, and the inputs used, to be shown, see figure 1.

The circuit is designed to wait for an intruder to move into the field of the passive infra-red (PIR) detector, this causes the shutter to be released on the camera. The camera is then wound-on by the controller. The controller will wait until the intruder moves out of the field of the PIR detector before repeating the program (this prevent more than one photograph being taken of the person).

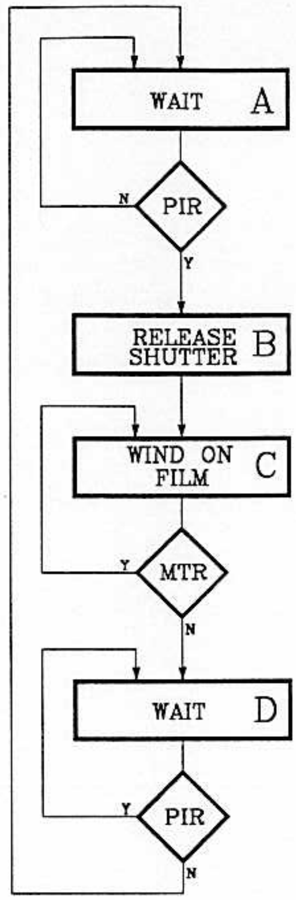

Figure (1) - Intruder Detector ASM State Diagram

The rectangular boxes on the diagram represent the "states" of the controller. Typically a state will generate an output and will also read an input, to determine the next state to be called in the machine cycle. The diamonds indicate an input is tested in a state (a test is associated with the state directly above it) and the input tested is shown in the diamond.

Each of the states in the ASM is realised by a D-type flip-flop. The input to each flip-flop is connected through appropriate combinational logic to relevant input signals. As an example take state A, it can be seen from the state diagram that this state is called if the previous state was state D and the PIR sensor inactive (no intruder), alternatively state A will be called if the previous state was state A and the PIR sensor inactive. A table containing the **current state, input condition** and **next state** is used to show this and it is, understandably, called a **state table**, (see Table 1). It should be noted that only one state can be active at any one time.

Current State	Condition	Next State
A	PIR.low	A
	PIR.high	B
B	-----	C
C	MTR.high	C
	MTR.low	D
D	PIR.low	A
	PIR.high	D

Table (1) - State transition table showing how the controller inputs determine the flow of control

From the state table the Boolean functions for the logic blocks is derived as below:

$D(A) = Q(A).\overline{PIR} + Q(D).\overline{PIR}$

$D(B) = Q(A).PIR$

$D(C) = Q(B) + Q(C).MTR$

$D(D) = Q(C).\overline{MTR} + Q(D).PIR$

Where D(**n**) is the input to flip-flop **n** and Q(**m**) flip-flop **m**'s output.

As can be seen from the circuit diagram a reset pulse will set output WAIT_INT to HIGH (as it is taken fron the inverted output of the flip-flop) and all other outputs to be LOW. This is so the ASM jumps to an initial state when a reset is applied, a reset would typically be a power-on reset.

Outputs to control a solenoid, which releases the shutter, and a motor, to wind on the film, can easily be taken from the outputs of the flip-flops, as figure (3) shows. Additional circuits to generate the required inputs are also shown.

The input MTR is produced by monitoring the voltage at the connection between the motor and the transistor. This works by detecting the large voltage drop across the motor when it is not turning. The motor will only drop a small voltage when turning, as there is a back EMF caused by the rotation of the motors coil in the magnetic field inside the motor. When the film is wound on the camera stops and prevents the motor from turning and hence no back EMF is generated and a larger voltage is seen across the motor, this pushes the voltage at the collector of T2 closer to zero and switchs the comparator.

The PIR input can be generated by circuits other than a passive infra-red detector, for instance a light beam across a doorway, broken by an intruder, or a pressure pad at the point to be photographed.

The clock input should be a square wave, of a period between 0.5 and 2 seconds, it can be produced be the simple circuit of figure(5).

The ASM design provides a control circuit that is easy to follow and easy to alter, where the control is centralized and the controller outputs are easily obtained from the state outputs.

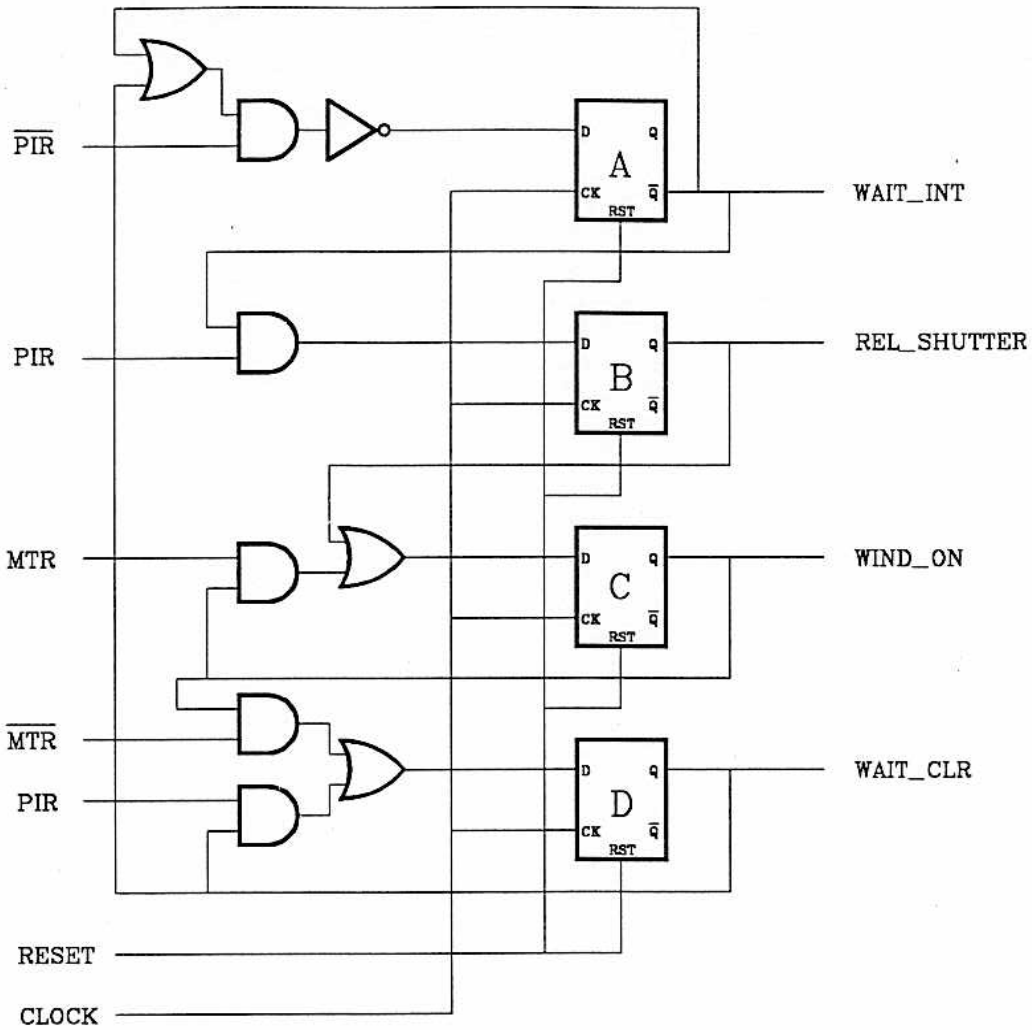

Figure (2) - Circuit to provide the control functions outlined in figure (1)

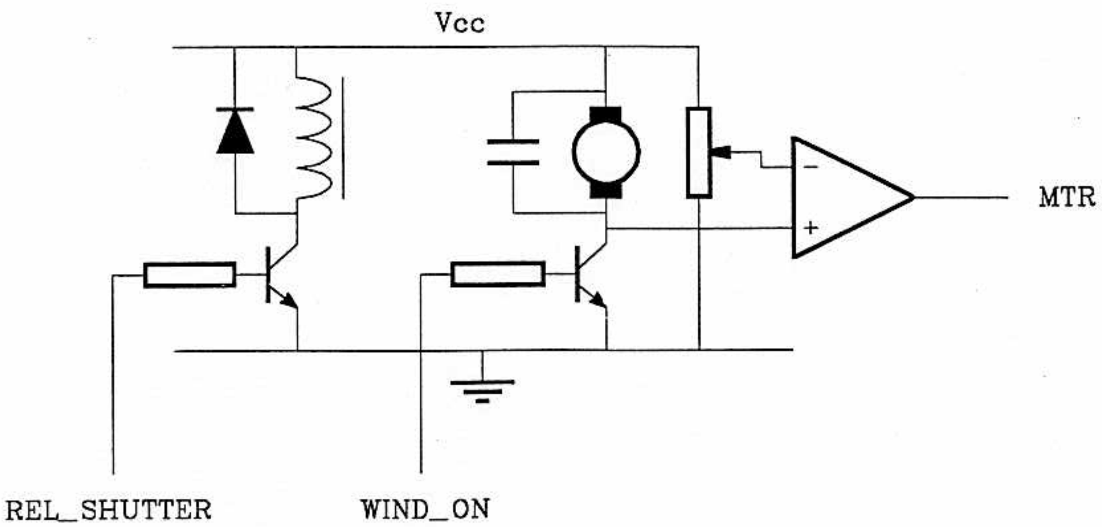

Figure (3) - Circuits to interface between camera and controller

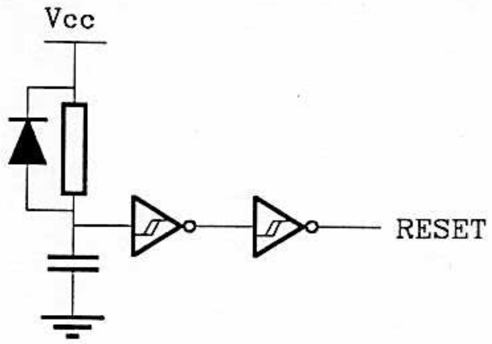

Figure (4) - Power-on reset circuit

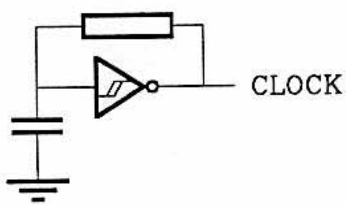

Figure (5) - Clock pulse generator