POWER CONTROL WITH ST6210 MCU AND TRIAC

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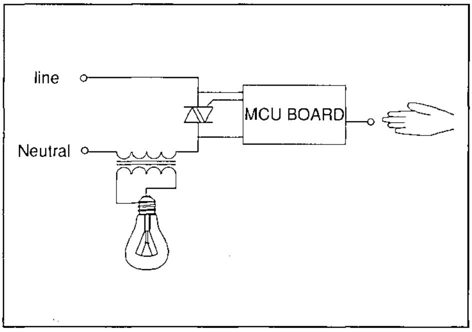
INTRODUCTION

Microcontroller (MCU) systems are progressively replacing analog controllers even in low cost applications. They are more flexible, provide a faster time to market and need few components.

With an analog IC, the designer is limited to a fixed function frozen inside the device. With a DIAC control, features such as sensor feedback or enhanced motor drive can not be implemented. With the MCU proposed in this note (ST6210), the designer can implement his own ideas and test them directly using EPROM or One Time Programmable (OTP) versions.

The LOGIC LEVEL triac BTA08-600SW is a good complement to this MCU for low cost off-line power applications. This triac requires a low gate current, and can be directly triggered by the MCU, while still maintaining a high switching capability.

This application note describes the main aspects of a highly flexible, low cost power application designed around an ST6210 MCU and a LOGIC LEVEL triac.



BOARD OPERATION

Basic function

Light dimmers with DIAC or analog controllers are currently used today. These circuits have the disavantage that they can not easily drive inductive loads like halogen lamps on the secondary of a 220V/12V transformer. They are also limited in the choice of user interfaces.

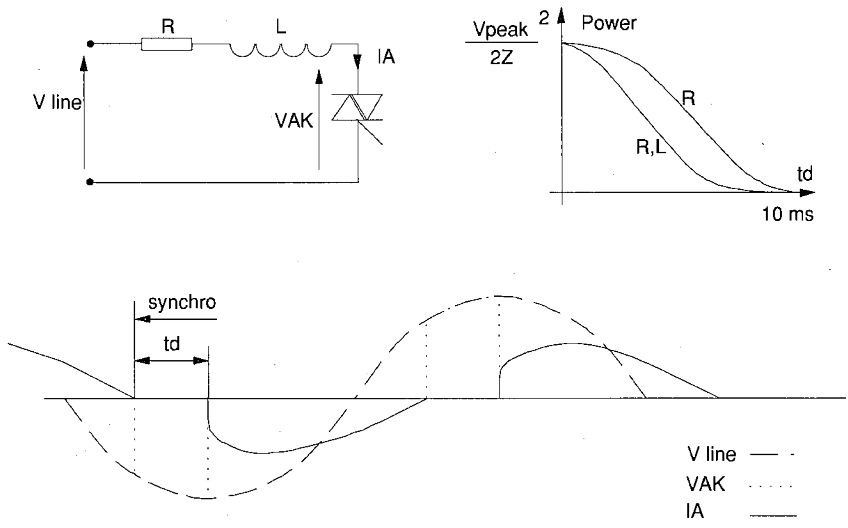
A light dimmer circuit, supplied directly from the 110V/240V mains, has been realized using a MCU ST6210 and a LOGIC LEVEL triac. This circuit drives both resistive and inductive loads (e.g. halogen or incandescent lamps, transformers). The control method is such that the same board can drive a universal motor. The user interface is either a touch sensor, a push button or a potentiometer. The board contains a minimum of components therefore saving cost and space. The auxiliary supply is derived from the voltage across the triac.

Power control

The output power is controlled by the phase delay of the triac drive. In classical designs, the delay is refered to the zero crossing of the line voltage. The detection of the zero voltage normally requires an additional connection to the mains neutral. In order to avoid this connection and connect the circuit directly in series with the load, the trigger delay is referred to the previous zero crossing of the current (fig.1).

BOARD OPERATION (Continued)

Figure 1. The Power Control Is Based On The Monitoring Of The Zero Crossing Of The Current



Mains synchronisation

When the current in the triac is zero, the mains voltage is re-applied across the triac. Synchronisation is achieved by measuring this voltage. This voltage is monitored in each halfwave, which allows the detection of spurious open load conditions. The triac is retrigged with multipulse operation if it is not latched after the first gate pulse.

Changing operation from 50Hz to 60Hz can be achieved by making simple modifications to the microcontroller EPROM/ROM table defining the triac conduction angle versus the power level.

Operation with a transformer

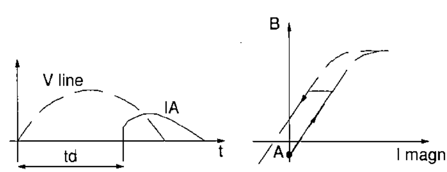
Low power halogen spots use low voltage lamps (12V typ.) usually supplied through a low voltage transformer. The light dimming of these lamps is simple with this circuit.

A phase lag between current and voltage as high as 90 does not disturb the circuit because the control method is based only on monitoring the zero current crossing.

The risk of saturation of the transformer core is avoided because the controller includes the following features:

At the start, the delay time between the first gate pulse and the synchronisation instant is greater than 5ms. This limits the induction in the transformer and hence reduces the risk of saturation.

Figure 2. First Gate Pulse Delay

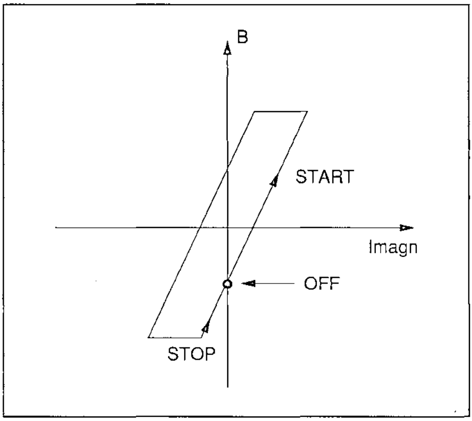


Saturation of the transformer at start is avoided.

BOARD OPERATION (Continued)

The circuit starts on a positive halfwave and stops on a negative halfwave (fig.3). So it starts with positive induction and stops after negative induction has been applied. This helps to minimize the size of the magnetic material.

Figure 3. Hysteresis Cycle in off/start/stop Phases



The timer is very precisely tuned in order to obtain precisely 10ms delay between two gate pulses. As a result, the triac is driven symetrically in both phases so continuous voltage in the transformer is avoided.

The voltage across the triac is monitored in order to detect a spurious open load condition on the secondary of the transformer.

The inrush current at the turn-on of a lamp (halogen or incandescent) is also reduced due to the soft start feature of the circuit (fig.8).

Triac drive

The triac is multi-pulse driven. Therefore, inductive loads can be driven without the use of long pulse drives. As a result, the consumption on the +5V supply can be minimized and the supply circuit made very small.

The pulse driving the triac is 50µs long. The LOGIC LEVEL triac is driven in quadrants QII and QIII with a gate current of 20mA provided by two I/O bits of the ST6210 in parallel. The LOGIC LEVEL triac has a maximum specified gate triggering current of 10 mA at 25°C.

Before supplying the first drive pulse, the triac voltage is tested. If no voltage is detected, a spurious open load or a supply disconnection is assumed to have occured and the circuit is stopped.

After the first driving pulse, the triac voltage is monitored again. If the triac is not ON, another pulse is sent. The same process can be repeated up to four times. Thereafter, if the triac is not ON, the circuit is switched off.

User Interfaces

There are three different user interfaces: a touch control, a push button or a potentiometer. Four modes can be selected on the board in order to define how the transmitted power is related to the user interface.

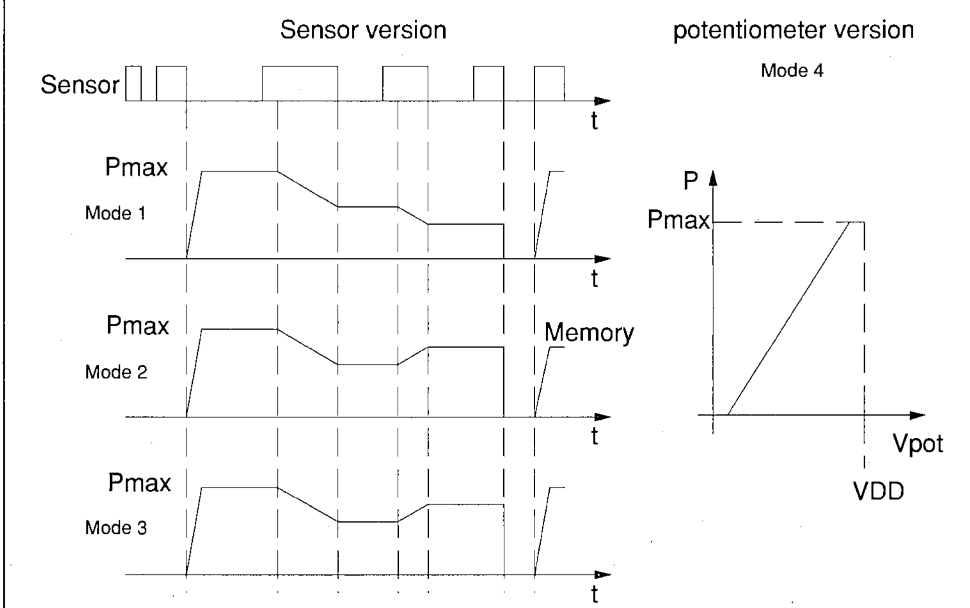
Three modes operate with the touch sensor or the push button. Dimming is obtained when the sensor or the button is touched for more than 400 ms. If the touch duration is between 60 ms and 400 ms, the circuit is switched on or off. A contact of less than 60 ms has no effect. Modes 1,2,3 differ in the way the ouput power is influenced by the contact on the sensor or on the button.

Mode 4 directly relates the transmitted power to the position of the potentiometer (fig.4).

All modes include a soft start function.

BOARD OPERATION (Continued)

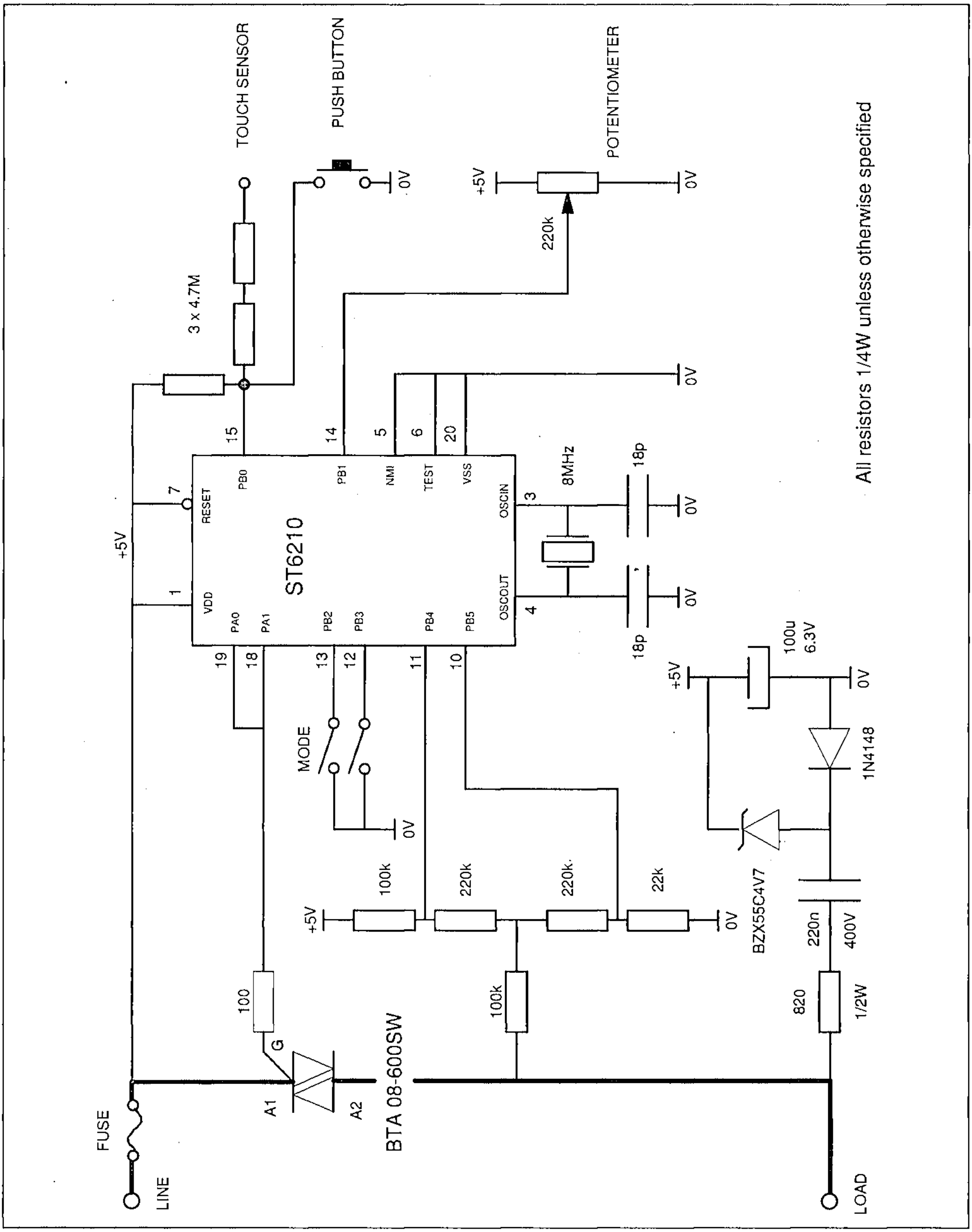
Figure 4. User Interface



Sensor Contact Duration	< 60ms	60ms to 400ms	> 400ms
Mode 1	No effect	Switched ON to full power or switched OFF	Same sense of variation as previous action
Mode 2	No effect	Switched ON to previous level or switched OFF	Opposite sense of variation to previous action
Mode 3	No effect	Switched ON to full power or switched OFF	Opposite sense of variation to previous action

BOARD OPERATION (Continued)

Figure 5. Circuit Diagram



HARDWARE

The circuit uses an 8 bit MCU ST6210 and a LOGIC LEVEL triac directly driven by the MCU (fig.5). It operates with 3 user interfaces, 4 modes of operation and 4 kinds of loads. When the board is dimming a resistive load, an RFI filter must be used in order to meet RFI standards (eg. VDE 875).

The ST6210 includes 2K ROM, 64 bytes RAM, an 8bit A/D converter that can be connected to eight different inputs, 4 I/O ports with 10mA sink current capability and a timer. Hysteresis protection is included in series with each I/O pin. The ST6210 is packaged in PDIP or SMD packages. The ports, timer and interrupts configurations can be chosen by software, providing great flexibility. With EPROM and OTP versions, the equipment development and preproduction can be carried out directly from the design lab thus providing a fast time to market.

The LOGIC LEVEL triac (BTA08-600SW) has been especially designed to operate with MCUs. It is a sensitive triac (I_{GT}=10 mA, I_L=50 mA) trigged in quadrants QII and QIII. In this application it is driven by two I/O bits of the ST6210 in parallel. This triac has high switching capabilities ([dI/dt]c=3.5 A/ms), ([dV/dt]c=50 V/µs), so in this circuit, it can operate without a snubber.

Total consumption of the board is less than 3mA with an 8MHz oscillator. The board receives its supply only when the triac is off. So a minimum off time of the triac (2ms) is necessary to ensure its supply.

The 5V supply capacitance is mounted as near as possible to the MCU with very short interconnecting tracks in order to maximize the RFI/EMI immunity.

The touch sensor is a voltage divider between line and neutral potentials. It operates when the supply of the circuit is connected at the line potential and not at the neutral. The user is protected from electrical shock by a very high impedance (10MΩ) connecting the sensor to the circuit.

SOFTWARE

All the features are included in a 700 byte program. More than 1kbyte of ROM is available for additional features. The architecture of the software is modular in order to provide maximum flexibility.

The table relating the delay time to the power requirement contains 64 different levels. The conduction time of the triac can vary from 2ms to 8ms. The user can easily adjust the minimum and maximum power levels because the corresponding delay times change with smaller increments at the top and bottom of the table.

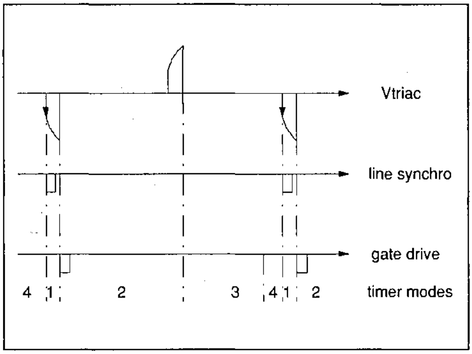
The table can be easily modified in the ROM/EPROM space to meet different conditions e.g. 60Hz operation or varying loads.

Software versions cover the four user interface modes of operation without hardware change.

All inputs are digitally filtered, so that an input is valid only if it remains constant for 10µs or more. This reduces the number of passive components required.

The mains supply carries disturbances (e.g. glitches, telecommand signals) which can disturb the triac drive and generate lamp flickering. For this

Figure 6. Internal Timer Operation

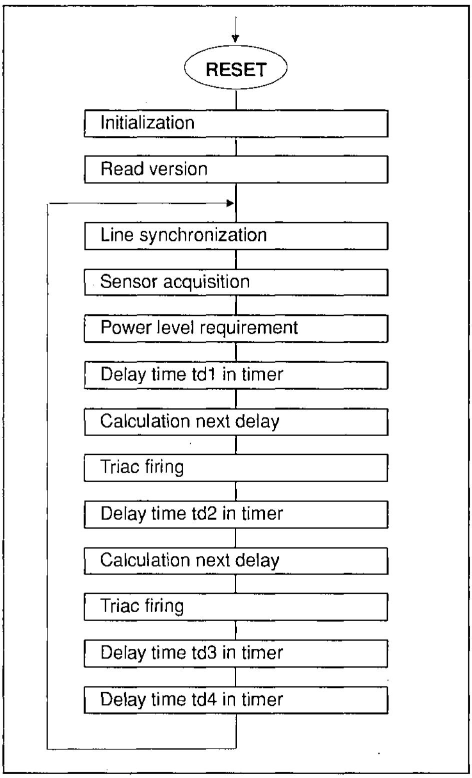


SOFTWARE (Continued)

reason, the triac voltage is not used directly as the synchronisation parameter. The timing is carried out internally by the MCU timer. The period of operation can be slowly modified to follow the variations of the mains frequency but not the spurious disturbances. The mains synchronization signal is received every cycle. The corresponding mains period is measured and compared to the internal timer period. If a difference remains for a long time, the timer period is modified to follow the mains. This block acts like a low band filter which saves external filtering components.
Each 50Hz period, the timer operation is separated in four steps (fig.6). The triac voltage synchronisation can only be validated during phase 4.

The software has been written with modular blocks (fig.7). It can be enlarged to other applications such as motor speed regulation, telecommand input or IR remote control with additional blocks.

Figure 7. Major Steps of the Software



PRACTICAL RESULTS

Figure 8 shows the soft start operation with a halogen lamp operating from the secondary of a low voltage transformer and with a tungsten filament lamp.

Figure 8. Soft Start With Lamps

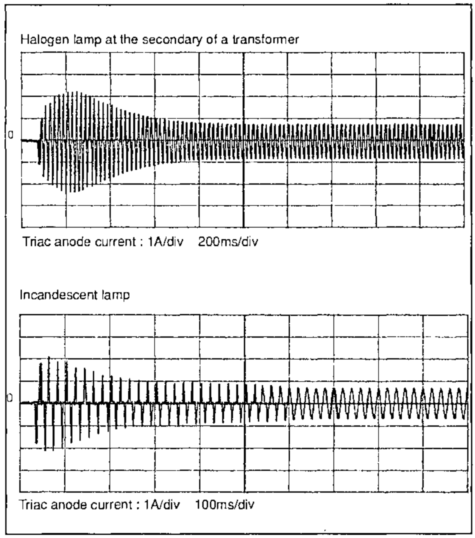
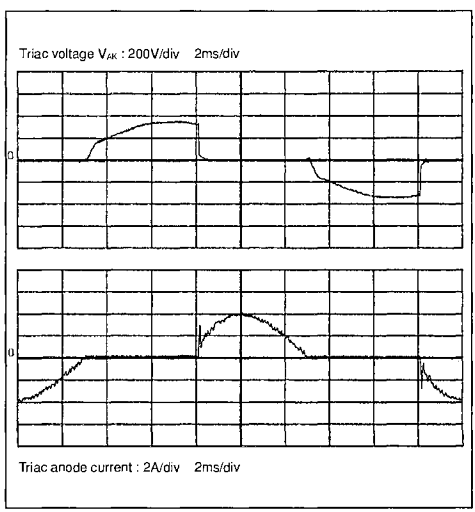


Figure 9. Universal Motor Drive



PRACTICAL RESULTS (Continued)

Due to the soft start, the peak in-rush current is about 3 times the nominal current compared with 10 to 15 times without soft start. This extends the lamp life time and prevents the input fuse from blowing.

The figure 9 shows the current and voltage in a triac driving a universal motor.

SUMMARY

Microcontrollers (MCU) are in common use in most areas of electronics. They now penetrate the very cost sensitive arena of home appliance applications.

The application described in this paper shows that enhanced appliance circuits can be designed with fast prototyping time using a ST6210 MCU and a BTA08-600SW LOGIC LEVEL triac. These circuits are low cost and provide more features with less components than classical solutions.

The circuit presented is an enhanced light dimmer operating from the 120V/240V mains. It drives incandescent and halogen lamps supplied either directly from the mains or through a low voltage transformer. The same circuit can also drive a universal motor. It includes soft start and protection features. Different user interfaces can be chosen: touch sensor, push button or potentiometer.

All this is achieved with only few components: a ST6210 MCU in PDIP/PSO package with a BTA08-600SW LOGIC LEVEL triac in TO220 package and some passive components.

Additional features like presence detection, IR remote control, homebus interface, motor speed control or 60Hz operation can be implemented from the existing solution.

Bibliography

Thyristors and triacs application manual 1989
Microcontroller based universal motor speed control . M.Querol / SGS-Thomson Microelectronics

Application Note:

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ANNEX : Choice of a triac driven by a MCU.

When the software includes a soft start, the inrush current in the load and therefore the current rating in the triac can be reduced.

When using a LOGIC LEVEL or a SNUBBERLESS triac the current rating of the triac can be reduced, keeping fast commutation characteristics. For instance, a LOGIC LEVEL triac BTA08-600SW can drive a 600W lamp and a SNUBBERLESS triac BTA10-600BW a 1200W universal motor.

LOGIC LEVEL triacs are optimized on the drive view point. Therefore they can be driven directly by the ST621X I/O.

SNUBBERLESS triacs are optimized on the power view point, so they can drive loads which generate very strong dynamic contraints.

These triacs are specified in a way that their behaviour can be pre-determined. The tables below present with two examples the relation between the major application constraints and the key parameters of the triac.

LIGHT DIMMER

Constraint	Key parameters on a LOGIC LEVEL triac BTA08-600 SW
Simple Drive	I_{GT} = 10mA - V_{GT} = 1.5V
No flicker	I_H = 25mA
Max power on the load	I_{RMS} = 8A
Max inrush current	$(dI/dt)_C$ = 4.5A/ms
No flashing (1)	I_{TSM} = 80A
Flash over (filament failure)	

Note 1 : When the lamp is cold (start or low light intensity), there must not be spurious turn-on of the triac (flashing) due to a high commutation dI/dt.

UNIVERSAL MOTOR DRIVE

Constraint	Key parameters on a SNUBBERLESS triac BTA10-600 BW
Simple drive	I_{GT} = 50mA - V_{GT} = 1.5V
Max. start current	I_{TSM} = 100A I_{RMS} = 10A $(dI/dt)_C$ = 9A/ms dV/dt = 500V/µs
Max. power on the load	
Fuse sizing	I^2t = 50A^2.s