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Performance and Analysis of AC Power Control by Using Micro-Controller Based Inverter

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ABSTRACT: Several techniques have been developed to control Alternating Current (AC) power. This Paper describes a simple low cost AC voltage controller used to Control AC loads which doesn't demand very high precisions several techniques have been developed to control Alternating Current (AC) power. A novel technique to design and implement a single phase PWM inverter using simple ATmega8 microcontroller rather than using Digital Signal Processor (DSP) controllers. The designed PWM inverter is tested on various AC loads like AC motor and intensity control of incandescent lamp in a closed loop environment.

KEYWORDS:PWM, ATMEGA8 MICROCONTROLLER, IGBT

I.INTRODUCTION

The pulse width inverters can be broadly classified as :
- Analog Bridge PWM inverter
- Digital bridge PWM inverters

Analog based PWM inverter controller provides excellent control, in the sense, the level of inverter output voltage can be adjusted in a continuous range and the throughput delay is negligible, but the disadvantages associated with Analog based PWM inverters are:
- Analog component output characteristics changes with the temperature and time.
- They are prone to external disturbances.
- Analog controller circuitry is complex and bulky.

They lag, the advantage of reprogrammablility, hence they are not flexible. Microcontroller based PWM inverter controller on the other hand makes the controller free from disturbances and drift, but the performance is not very much high due to its speed limitation, however to minimize throughput delay, some microcontroller based PWM inverters, retrieves switching patterns directly from memory so that calculation can be minimized, but at the same time demands more memory. This drawback can be eliminated if switching patterns are generated by executing simple control algorithms. Even after using simple control algorithms, sometimes throughput delay may be substantial. With the availability of advanced microcontrollers and DSP [Digital signal processor] controllers with many advanced features like inbuilt PWM generator, event managers, time capture unit, dead time delay generators, watch dog timers along with high clock frequency, the limitation of speed, associated with microcontroller based PWM inverters can be neglected to some extent.

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II. RELATED WORK

S.A. Hari Prasad [1] has described a novel technique to design and implement a single phase PWM inverter using simple 8051 microcontroller rather than using Digital Signal Processor (DSP) controllers. The main features of 8051 based PWM inverter are simpler design, low cost, maximum range of voltage control and compact in size.
Khaled A.Madi Ali [2] describes that the microcontroller in order to generate the variable frequency AC voltage to control the speed of the induction motor. This study investigates the microcontroller based variable frequency power inverter. The microcontroller provides the variable frequency pulse width modulation (PWM) signal that controls the applied voltage on the gate drive, which provides the required PWM frequency with less harmonics at the output of the power inverter.

Jiangmin Yao [3], has implemented the PIC17C756 microcontroller in a single phase induction motor adjustable speed drive control with hardware setup and software program in C code. The main feature used in this microcontroller was its peripherals to realize pulse width modulation in the single phase motor control. Furthermore, one chip and re-programmable ROM replaces the conventional complicated circuit solution. He concluded that this brought low cost, small size and flexibility to change the control algorithm without changes in hardware. The problem of this microcontroller was that it had no dead band register and only had a three PWM output. Therefore, additional logic analogue circuits were added to generate their complement signals and to generate dead time in order to avoid the overlapping of turn on for both upper and lower switches.

III. BLOCK DIAGRAM

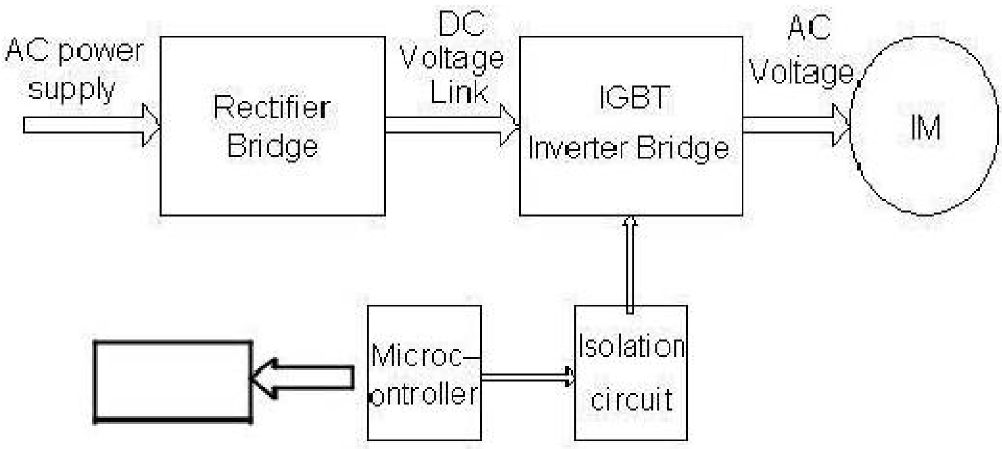

Figure 3: Block diagram

The above schematic figure (3) shows the Microcontroller based bridge PWM inverter. The speed in RPM [Rotation per Minute] is entered through the keyboard and corresponding to the key pressed, digital equivalent of that RPM is stored in memory. Through speed sensor, speed of the AC motor is sensed and the analog output given by the sensor is converted to digital data. Using ATMEGA8 microcontroller ports, the digital data is accepted and is compared with required speed's digital data. Proportional Algorithm is used to adjust the duty cycle of the PWM signal in accordance with the error. The generated PWM signal is used to generate two gate signals using interrupts required for bridge inverter circuit. Gate signals are passed through gate driver circuit to boost up the gate signal so that it can drive the IGBT switches of bridge inverter to the ON state. User can change the speed at any instant of time in accordance to his requirements. Many additional features can be further added like sensing the temperature of room and automatically controlling either the speed of the fan or the level of air conditioning required.

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A. METHODS OF SPEED CONTROL

- Stator voltage control.
- Frequency control.
- Rotor voltage control.
- Stator voltage and frequency control.

Stator voltage and frequency control method
N=Ns (1-s) and Ns=120f/p
So we can change the actual speed N by changing the synchronous speed .But synchronous speed Ns can be changed by changing stator supply frequency f1 .so theoretically we can control speed by changing only f1.
But only change in f1 keeping v1 constant .as an adverse effect on the air flux because air gap flux is given by

$\varphi ag \alpha$ (v1/f1)

So air gap flux φagproportional to (v1/f1) if f1 reduce by keeping v1 constant then there is a possibility of core saturation. Hence the ratio (v1/f1) is kept constant by changing stator voltage v1.and frequency f1 simultaneously These is necessary to keep air gap flux constant.
Hence these method called as constant (v/f) control method.

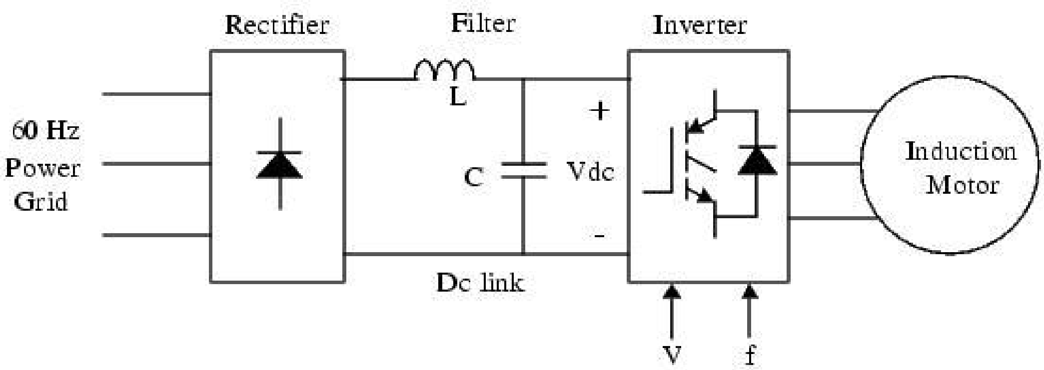

Figure 3.1: V/F method

Working:
The AC input of constant voltage and constant frequency is applied to an AC to DC converter which is rectifier. At the output of AC to DC converter we get a DC voltage. A capacitor bank is used to ripple contain in DC voltage. These DC voltage is applied at input of an inverter. The inverter is an electronic circuit which convert the DC voltage into three phase variable voltage variable frequency AC voltage. These voltage applied to stator winding of the motor. Thus we get constant v/f control.

Frequency Control:
The induction motor speed variation can be easily achieved for a short range by either stator voltage control or rotor resistance control. But both of these schemes result in very low efficiencies at lower speeds. The most efficient scheme for speed control of induction motor is by varying supply frequency. This not only results in scheme with wide speed range but also improves the starting performance. If the machine is operating at speed below base speed, then v/f ratio is to be kept constant so that flux remains constant. This retains the torque capability of the machine at the same value. But at lower frequencies, the torque capability decrease and this drop in torque has to be compensated for increasing the applied voltage.

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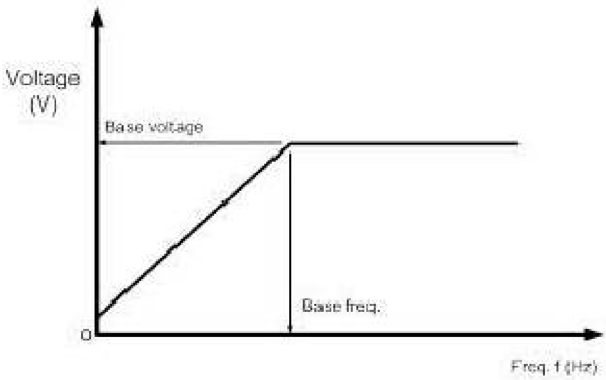

Figure 3.2: Frequency control

IV. PULSE WIDTH MODULATION

Pulse Width Modulation is a technique that confirms a signal width, generally pulses based on modulator signal information. PWM , has become a simple method for generating unique signals, due to the new innovation of microcontrollers and its power efficiency. To create a sinusoidal signal, PWM uses high frequency square waves with varying duty cycles. Duty cycle is the percentage of time the signal is on relative to the period. This means as the duty cycle increases, more power is transmitted.PWM requires rapid on and off signals, which can be achieved using high power MOSFETs [MOSFETs are ideal switches due to the low power loss when the device is activated. It should be noted, however, that when a MOSFET is in transition between on and off, the power loss can be significant. For this reason, the transition times and frequency should be engineered to be as short as possible. This can be achieved by minimizing the amplitude between the on and off stages and lowering the PWM frequency; however as the frequency decreases so does the signal quality.
Pulse width modulation inverter can be classified as

- Analog Bridge PWM inverter
- Digital bridge PWM inverter

B. ANALOG BRIDGE PWM INVERTER

In analog bridge PWM signal is generated by feeding a reference and a carrier signal to a comparator which creates the output signal based on the difference between the two inputs. The reference is a sinusoidal wave at the frequency of the desired output signal. The carrier wave is a triangle or saw tooth wave which operates at frequency significantly greater than the reference wave. When the carrier signal exceeds the reference the output is at high state and when the reference exceeds the carrier the output is at low state.

C. DIGITAL BRIDGE PWM INVERTER

It is also known as microcontroller based power inverter. It makes the controller free from disturbance and drift but the performance is not very high due to its speed limitation. However, to reduce through put delay some microcontroller retrieve switching pattern straight from memory so calculation can be minimized, but this technique demands more memory. This drawback can be eliminated by switching patterns executing simple control algorithms. With availability of advanced microcontroller and DSP (digital signal processor) controller that has advanced features like inbuilt PWM generator, event manager, time capture unit, dead time delay generator, watch dog timer along with high clock frequency, the limitation of speed associated with microcontroller can be neglected to some extent.

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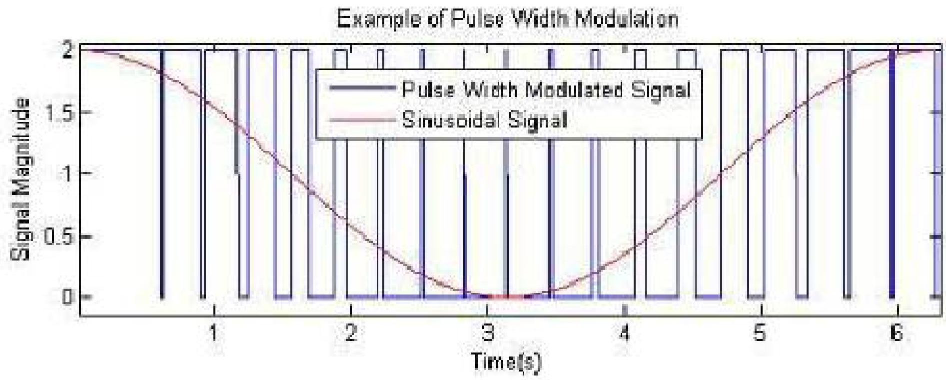

Figure 4: Pulse width modulation

D. **VARIABLE RESISTOR**

A variable resistor is a device that is used to change the resistance according to our needs in an electronic circuit. It can be used as a three terminal as well as a two terminal device. Mostly they are used as a three terminal device. Variable resistors are mostly used for device calibration.

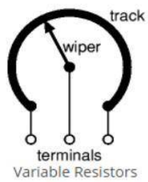

Figure 4.3 Variable resistor

As shown in the diagram below, a variable resistor consists of a track which provides the resistance path. Two terminals of the device are connected to both the ends of the track. The third terminal is connected to a wiper that decides the motion of the track. The motion of the wiper through the track helps in increasing and decreasing the resistance. The track is usually made of a mixture of ceramic and metal or can be made of carbon as well. As a resistive material is needed, carbon film type variable resistors are mostly used. They find applications in radio receiver circuits, audio amplifier circuits and TV receivers. For applications of small resistances, the resistance track may just be a coil of wire. The track can be in both the rotary as well as straight versions. In a rotary track some of them may include a switch. The switch will have an operating shaft which can be easily moved in the axial direction with one of its ends moving from the body of variable resistor switch. The rotary track resistor with has two applications. One is to change the resistance. The switch mechanism is used for the electric contact and non-contact by on/off operation of the switch. There are switch mechanism variable resistors with annular cross-section which are used for the control of equipment's. Even more components are added onto this type of a variable resistor so as to make them compatible for complicated electronic circuits. A high-voltage variable resistor such as a focus pack is an example. This device is capable of producing a variable focus voltage as well as a screen voltage. It is also connected to a variable.Resistance circuit and also a fixed resistance circuit [bleeder resistor] to bring a change in the applied voltage. For this both the fixed and variable resistor are connected in series.

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V.ATMEGA8 MICROCONTROLLER

The AtMega8 is advance version 8051 Microcontroller and it is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By performing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approximately reaching to 1MIPS per MHz, allowing the system designed to optimize power consumption versus processing speed. For protection circuit and monitoring for 1-cell and 2-cell Li-ion applications that require high security and authentication, accurate monitoring, low cost, and high utilization of the cell energy. These includes 8KB self-programming flash program memory, 512-Bytes SRAM, and 256-Bytes EEPROM, 1 or 2 cells in series, over-current, high-current and short-circuit protection, 12-bit voltage A/D converter, 18-bit coulomb counter current A/D converter, and debug Wire interface for on-chip debug. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel It is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications. This supported with a full suite of program and system development tools, including C compilers, macro assemblers, program simulators, and

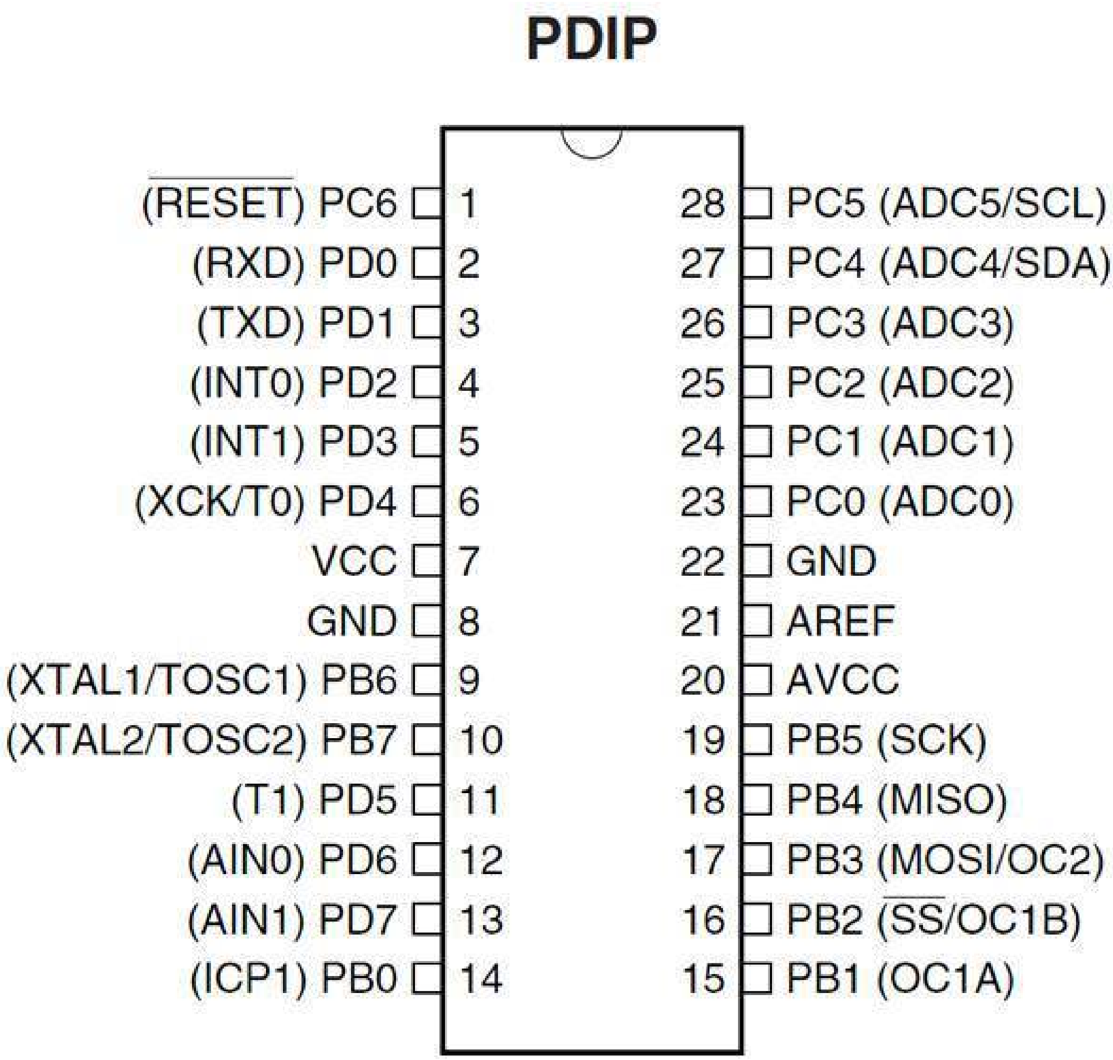

Figure 5: Pin Diagram

E. Microcontroller Pin Description:

All the pins of the Microcontroller support two signals except 5-pins. The Atmega8 microcontroller consists of 28 pins where pins 9, 10,14,15,16,17,18,19 are used for port B, Pins
23,24,25,26,27,28 and 1 are used for port C and pins 2,3,4,5,6,11,12 are used for port D.
Pin -1 is the RST (Reset) pin and applying a low level signal for a time longer than the minimum pulse length will produce a RESET.
Pin-2 and pin-3 are used in USART for serial communication
Pin-4 and pin-5 are used as an external interrupt. One of them will activate when an interrupt flag bit of the status register is set and the other will activate as long as the intrude condition succeeds.
Pin-9 & pin-10 are used as a timer counters oscillators as well as an external oscillator where the crystal is associated directly with the two pins. Pin-10 is used for low-frequency crystal oscillator or crystal oscillator. If the internal adjusted RC oscillator is used as the CLK source & the asynchronous timer is allowed, these pins can be utilized as a timer oscillator pin.
Pin-19 is used as a Master CLK o/p, slave CLK i/p for the SPI-channel.
Pin-18 is used as Master CLK i/p, slave CLK o/p.
Pin-17 is used as Master data o/p, slave data i/p for the SPI-channel. It is used as an i/p when empowered by a slave & is bidirectional when allowed by the master. This pin can also be utilized as an o/p compare with match o/p, which helps as an external o/p for the timer/counter.
Pin-16 is used as a slave choice i/p. It can also be used as a timer or counter1 comparatively by arranging the PB2-pin as an o/p.
Pin-15 can be used as an external o/p of the timer or counter compare match A.
Pin-23 to Pins28 have used for ADC (digital value of analog input) channels. Pin-27 can also be used as a serial interface CLK & pin-28 can be used as a serial interface data
Pin-12 and pin-13 are used as an Analog Comparator i/ps.
Pin-6 and pin-11 are used as timer/counter sources.

VI.RESULT AND DISCUSSION

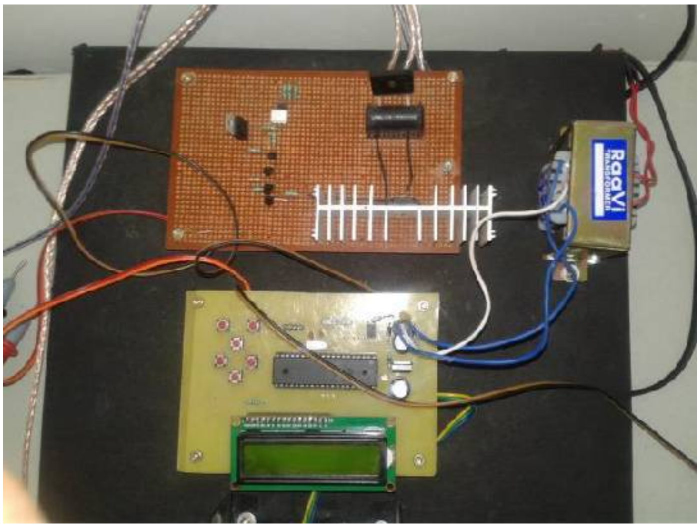

Figure 6: Circuit diagram

The above figure shows the schematic representation of circuit diagram of AC power control by using ATmega8 microcontroller based inverter. A single phase 230 V supply is given to step down transformer. The Transformer step downs 230V supply to 12 V supply. This 12 V AC supply is given to center tap rectifier. It converts AC supply into DC supply. As there is some ripple contain in the supply to remove these ripples, we used capacitor as filter. These pure

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12V DC supply is given to voltage regulator, which converts 12V DC to 5V DC. This 5V DC supply is given to microcontroller. Through the microcontroller these 5v pulse is given to Driver circuit. These circuit boost up 5V pulse to 12V pulse and it is given to the gate terminal of IGBT. A Parallel 230 V AC supply is given to bridge rectifier which converts 230V AC to 230 V DC supply. These supply is given to drain terminal of IGBT through induction capacitor. The AC load is connected across the IGBT. Here we are using Capacitor start capacitor run motor. The variation of speed can be seen on LCD display. And variation of frequency is displayed on frequency meter.

VII .FUTURE SCOPE

In this Paper, we try to show some advancement which can significantly boost the practicality and effectiveness of solution provided by our project are:

- We can implement V/f control method for various types of load such as incandescent lamp, induction motor etc.
- We can control speed of different motors at the same time

VIII.CONCLUSION

The designed application is tested by designing 60V IGBT bridge inverter. The performance of application is tested on various A.C loads and the plots of the same are as shown in Figure-3. The design shows good results for the load values of 50 ohm and 100 mH/ 10mH. A simple PWM technique is used rather than using the most often used sinusoidal PWM technique (For Single-phase inverters) which increases software and hardware complexity. Also it avoids the usage of dead time delay generators, since the required gate turn on delay is generated through interrupt. With small modifications the same work can be used to automatically control light intensity, temperature etc., and the accuracy can be improved further by using high resolution ADCs and the delay involved in the software can be overcome using higher versions of controllers.

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