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Automatic Motor Detection and Control System (A.M.D.A.C.S.)

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***Abstract* - This Rapid evolution of digital technology has improved the ease of access to increase the productivity and reduce production cost. For every motor to use it efficiently for various application first tasks is to control its speed with regulation and soft start. So, we decide to make such system which can control speed of all motor (e.g. AC, DC, Universal). Also to detect which motor is connected at load side with its regulation. Single phase alternating current (AC) motors are well known as general purpose motors. In many different situations they perform better. These AC motors work great for systems that are hard to start because they need a lot of power up front. Where speed needs to be controlled Direct current (DC) electric motors work for the situations. It has a stable and continuous current. In the industry DC motors were the first and earliest motors used. They were found, however, to not be as good at producing power over long lengths. Actually on the principle AC as well as DC Universal Motor can be controlled. So, we controlled Universal motor on the principle of DC motor. Some other Control techniques for mono phase motors i.e. Universal motor or any AC loads are based on phase-angle adjustment. This The TRIAC is turned ON by the control signal coming from the microcontroller by giving some delay after the zero crossing, and get turned OFF when its current reaches a zero value. This concept is the same for positive and negative voltage. For Detection of motor we used IR and depending upon voltage if motor get's its rpm we detect motor. Also for regulation we used IR pair as tachometer and detect rpm of motor so after connecting load if motor speed decreases, we check input rpm and then compare both and accordingly we maintain its rpm.**

***Keywords* - AC, DC, Universal, Detection, Speed Control.**

I. Introduction

Pulse-width modulation (PWM) or duty-cycle variation methods are commonly used in speed control of DC motors. The duty cycle is defined as the percentage of digital 'high' to digital 'low' plus digital 'high' pulse-width during a PWM period. Fig. 1 shows the 5V pulses with 0% through 50% duty cycle.

The average DC voltage value for 0% duty cycle is zero; with 25% duty cycle the average value is 1.25V (25% of 5V). With 50% duty cycle the average value is 2.5V, and if the duty cycle is 75%, the average voltage is 3.75V and so on. The maximum duty cycle can be 100%, which is equivalent to a DC waveform. Thus by varying the pulse-width, we can vary the average voltage across a DC motor and hence its speed. The recommended value of in-circuit resistance should be greater than 50 kilo-ohms but less than 2 mega ohms, while the capacitor value should be greater than 100 pF but less than 1 µf. Electric companies found using DC motors to generate electric did not work because the power was lost as the electric was transmitted. Brush DC motors use rings that conduct the current and form the magnetic drive that powers the rotor. Brushless DC motors use a switch to produce the magnetic drive that powers the rotor. Direct current (DC) motors are often found in appliances around the home.[1]

AC motor drives are widely used to control the speed of conveyor systems, blower speeds, pump speeds, machine tool speeds, and other applications that require variable speed with variable torque. The complete system consists of an ac voltage input that is put through a diode bridge rectifier to produce a dc output which across a shunt capacitor, this will, in turn, feed the PWM inverter. The PWM inverter is controlled to produce a desired sinusoidal voltage at a particular frequency, which is filtered by the use of an inductor in series and capacitor in parallel and then through to the squirrel cage induction motor. Three phase (also called polyphase) AC motors are usually found in industrial settings. These motors also have high starting power built transmit lower levels of overall power. AC power gets its name from the fact that it alternates in power. The amount of power given off by an AC motor is determined by the amount of power needed to operate the system. It controls the speed of the electric machine by converting the fixed voltage and frequency of the grid to adjustable values on the machine side. There are many types of inverters, and they are classified according to number of phases, use of power semiconductor devices, commutation principles, and output waveforms. This research interest in three-phase inverter circuit that changes DC input voltage to a three-phase variable-frequency variable-voltage output.

Three-phase inverters are also used in applications in which AC with a controllable frequency is required. In this application, three-phase AC is rectified into DC and then filtered to minimize the ripple content. The DC link is generally used for this purpose. This is a variable DC obtained by employing three-phase full controlled power transistors Bridge. This controlled DC is converted into controlled pulses by means of as voltage to frequency converter. These controlled pulses are fed to the inverter bridge for producing the variable voltage variable frequency output. This output is fed to the three-phase induction motor for controlling its speed.

Universal motors are widely used in household appliances like food processors, vacuum cleaners, sewing machines and most domestic appliances because it is cost effective in respect of volume/power and it has a good torque response. In the control of these motors, generally,

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providing stable speed control, preventing large currents and drawing minimum harmonic current from ac mains supply are required. To meet these requirements using AC chopper with current and speed feedback is preferred. In addition, a control system with low cost is desired. AC choppers that change the rms value of AC voltage feeding a load from a constant voltage AC source are in widespread use for purposes of power control in industrial applications such as-heating, lightning and ac motor speed control. For many years, AC power control has been done economically and simply up to very high powers using the phase control technique with naturally commutated ac chopper circuits made up of thyristors and triacs. In this form of power control it is known that depending on phase control angle, the load voltage harmonics increase, interruptions occur in load current and the ac mains power factor reduces. In this work, universal motor speed control system with PWM AC chopper is simulated and the system has been realized by using a microcontroller. In the system, AC mains power factor, motor speed, and current is analyzed.[2]

Design consideration for DC Motor Speed Control:

Now speed of DC Motor can be controlled by making variable power supply and give output of supply to DC motor and just vary the voltage speed of Dc motor can vary. But it is not case because dc motor are available in different voltage range so every time we have to design variable power supply for different voltage DC motor and it is also not safe for if back emf is introduced then power supply can get damage if proper protection is not there so, overall it became very costly and untrustworthy. So, we decide to make use of "MOSFET Bridge" to control speed of DC motor in both directions. We also decide to make use of PIC 18F458 microcontroller.

We use MOSFET IRF 840 which is N-channel mosfet.

Features:-

- 8A, 500V
- RDS (ON) = 0.850Ω

MOSFET BRIDGE DRIVER IR2110:

For making MOSFET Bridge we Use Mosfet half bridge driver IC IR2110 then by connecting these two half bridge we make full bridge. Diagram for half bridge with driver IC IR2110 is as shown.[3]

VCC is the low-side supply and should be between 10V and 20V. VDD is the logic supply to the IR2110. It can be between +3V to +20V (with reference to VSS). The actual voltage you choose to use depends on the voltage level of your input signals.

It is common practice to use VDD = +5V. When VDD = +5V, the logic 1 input threshold is slightly higher than 3V. Thus when VDD = +5V, the IR2110 can be used to drive loads when input "1" is higher than 3 point something volts. This means that it can be used for almost all circuits, since most circuits tend to have around 5V outputs. When you're using microcontrollers the output voltage will be higher than 4V (when the microcontroller has VDD = +5V, which is quite common). When you're using SG3525 or TL494 or other PWM controller, you are probably going to have them powered off greater than 10V, meaning the outputs will be higher than 8V when high. So, the IR2110 can be easily used. You may lower the VDD down to about 4V if you're using a microcontroller or any chip that gives output of 3.3V (e.g. dsPIC33). While designing circuits with the IR2110, I had noticed that sometimes the circuit didn't work properly when IR2110 VDD was selected as less than +4V. So, I do not recommend using VDD less than +4V. In most of my circuits, I do not have signal levels which have voltages less than 4V as high and so I use VDD = +5V. If for some reason, you have signals levels with logic "1" having lower than 3V, you will need a level converter / translator that will boost the voltage to acceptable limits. In such situations, I recommend boosting up to 4V or 5V and using IR2110 VDD = +5V.

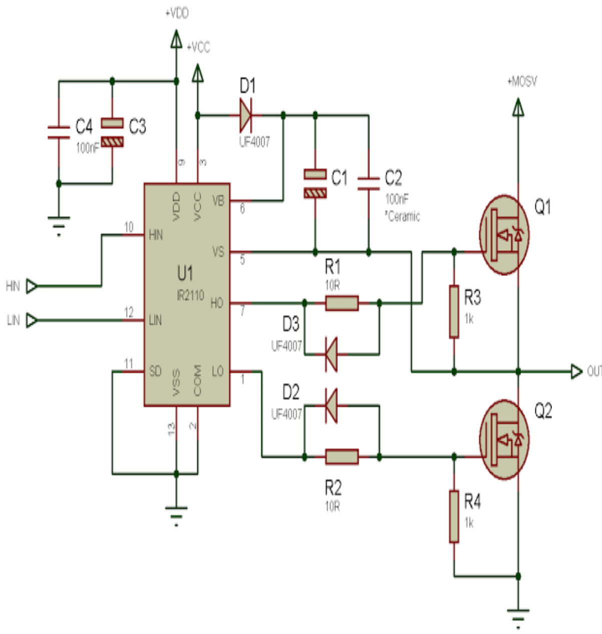

Fig.1. Half bridge driver using IR2110

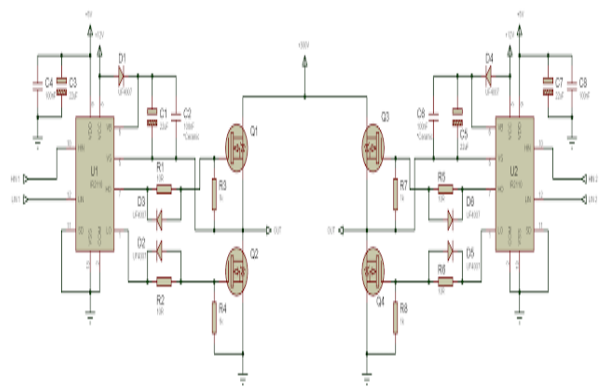

Fig.2. Full bridge driver using IR2110

Now let's talk about VSS and COM. VSS is the logic supply ground. COM is "low side return" – basically, low side drive ground connection. It seems that they are independent and you might think you could perhaps isolate the drive outputs and drive signals. However, you'd be wrong. While they are not internally connected, IR2110 is a non-isolated driver, meaning that VSS and COM should both be connected to ground. HIN and LIN are the

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logic inputs. A high signal to HIN means that you want to drive the high-side MOSFET, meaning a high output is provided on HO. A low signal to HIN means that you want to turn off the high-side MOSFET, meaning a low output is provided on HO. The output to HO – high or low – is not with respect to ground, but with respect to VS. We will soon see how a bootstrap circuitry (diode + capacitor) – utilizing VCC, VB and VS – is used to provide the floating supply to drive the MOSFET. VS is the high side floating supply return.

When high, the level on HO is equal to the level on VB, with respect to VS. When low, the level on HO is equal to VS, with respect to VS, effectively zero. A high signal to LIN means that you want to drive the low-side MOSFET, meaning a high output is provided on LO. A low signal to LIN means that you want to turn off the low-side MOSFET, meaning a low output is provided on LO. The output on LO is with respect to ground. When high, the level on LO is equal to the level of VCC, with respect to VSS, effectively ground. When low, the level on LO is equal to the level on VSS, with respect to VSS, effectively zero.SD is used as shutdown control. When this pin is low, IR2110 is enabled – shutdown function is disabled. When this pin is high, the outputs are turned off, disabling the IR2110 drive.

Now let's take a look at the common IR2110 configuration for driving MOSFETs in both high and low side configurations – a half bridge stage. D1, C1 and C2 along with the IR2110 form the bootstrap circuitry. When LIN = 1 and Q2 is on, C1 and C2 get charged to the level on VB, which is one diode drop below +VCC. When LIN = 0 and HIN = 1, this charge on the C1 and C2 is used to add the extra voltage – VB in this casep – above the source level of Q1 to drive the Q1 in high-side configuration. A large enough capacitance must be chosen for C1 so that it can supply the charge required to keep Q1 on for all the time. C1 must also not be too large that charging is too slow and the voltage level does not rise sufficiently to keep the MOSFET on. The higher the on time, the higher the required capacitance. Thus, the lower the frequency, the higher the required capacitance for C1. The higher the duty cycle, the higher the required capacitance for C1. Yes, there are formulae available for calculating the capacitance. However, there are many parameters involved, some of which we may not know – for example, the capacitor leakage current. So, I just estimate the required capacitance. For low frequencies such as 50Hz, I use between 47µF and 68µF capacitance. For high frequencies like 30kHz to 50kHz, I use between 4.7µF and 22µF. Since we're using an electrolytic capacitor, a ceramic capacitor should be used in parallel with this capacitor. The ceramic capacitor is not required if the bootstrap capacitor is tantalum. D2 and D3 discharge the gate capacitances of the MOSFET quickly, bypassing the gate resistors, reducing the turn off time. R1 and R2 are the gate current-limiting resistors.

+MOSV can be up to a maximum of 500V.

+VCC should be from a clean supply. You should use filter capacitors and decoupling capacitors from +VCC to ground for filtering. Now let's look at a few example application circuits of the IR2110.

First we design a program in controller such a way that at a time at output port on four pin of controller we get PWM pulses. On first pin we get constant voltage pulse & on 2nd pin we get variable PWM pulse which after through IR2110 gives to 1st & 4th MOSFET as gate pulse. At this time other two MOSFET 2nd & 3rd kept off. In this way in clock wise direction speed of DC motor is controlled by varying POT. To control motor speed in other direction just change switch position & turn on 2nd & 3rd MOSFET & turn off 1st & 4th MOSFET. In this way speed of dc Motor is controlled in both directions.

Design consideration for Universal Motor Speed Control:

In principle a universal motor is similar to a serial DC motor. However, the universal motor is designed for AC operation. It is capable to operate at either AC or DC current. Therefore its construction is a little different. The magnetic circuits of stator and rotor consist from iron sheets reducing the electric losses caused by AC current or AC current component produced by a PWM chopper. Otherwise, the windings of the universal motor correspond to the windings of a common DC motor. The coils of the rotor winding are connected the commutator segments, which allows to maintain the direction of the rotor magnetic field nearly perpendicular to the stator magnetic field. Small universal motors usually have no compensation and commutation winding; they have two salient poles with excitation winding. The stator winding of the universal motor has low resistance and inductance allowing to operate the motor in serial connection of the rotor and stator windings. Unlike a DC motor with separate excitation or permanent magnet, the universal motor produces the electric torque proportional to the quadrate of the supply current. So the electric torque has the same torque direction at any current polarity as well as at AC current.

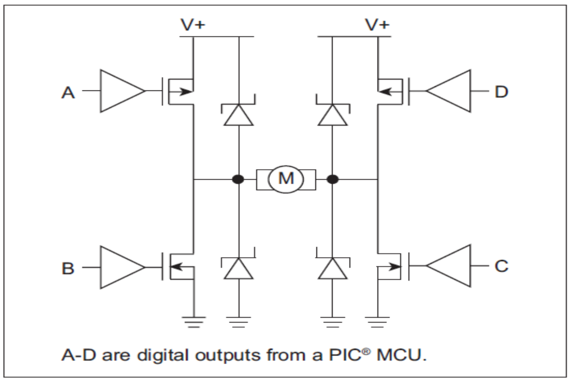


Fig.4. Circuit for universal motor control. [6]

Universal motors have some excellent properties. They are characterized by high power related to their size and weight, compared to induction motors. They have very good inherent control properties. They can be operated at extremely high speed and have very good starting torque, which makes them suitable for applications such as power drills, washing machines and dust extractors. On the other hand, universal motors have also their drawbacks. Universal motors are very loud. Compared to induction motors, they have lower life time due to wearing of the commutator. In addition, the commutator produces sparks which make these motors unsafe for use in flammable environment.[4]

Design consideration for AC Motor Speed Control:

For Ac motor speed control we use concept of firing angle control of TRIC. First we design ZCD i.e. Zero Crossing Detector. Output of this is feed to controller as interrupt when controller get this interrupt according to our program controller generate signal at controller output port pin such a way that by varying pot delay in input signal varies i.e. conduction and firing angle of signal changes. So, by applying this signal to Ac Motor speed of Ac motor changes.**[5]**

Operation:

To understand operation let us take a help of waveforms.

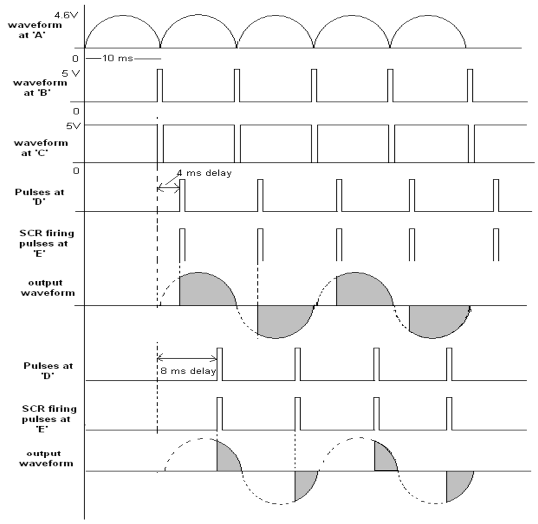


Fig.3. waveform for ac motor speed control

- As shown in figure the first wave form is full rectified wave that is fed to the base of Q1. Whenever this voltage falls below 0.7 V Q1 is switched off. So its output goes high.
- This will produce one very short positive pulse at 'B' as shown in figure as second waveform
- As this positive pulses are fed to Q2 which is again connected in switch configuration, it will produce one negative pulse at 'C' of same width of positive pulse. This is shown as third waveform
  - Now as this negative pulse output is given to interrupt pin of micro controller. It will generate interrupt every time.
  - After getting an interrupt micro controller will on the timer0. Timer 0 is used to generate a delay after some delay make P0.0 low. This is used to trigger (fire) TRIAC.
  - Depending upon the time delay in between interrupts and pulse on P0.0, the TRIAC is fired earlier or later.
  - As shown In figure I have given wave forms for two different cases one for 4 ms delay and second for 8 ms delay.
  - In the first case for 4 ms delay the output positive cycle of AC wave is 60% of input so only 60% current is delivered to load (the dotted line shows part of wave form that has been cut)
  - For second case 8 ms delay output cycle is 20% of input cycle so only 20% current is supplied to load

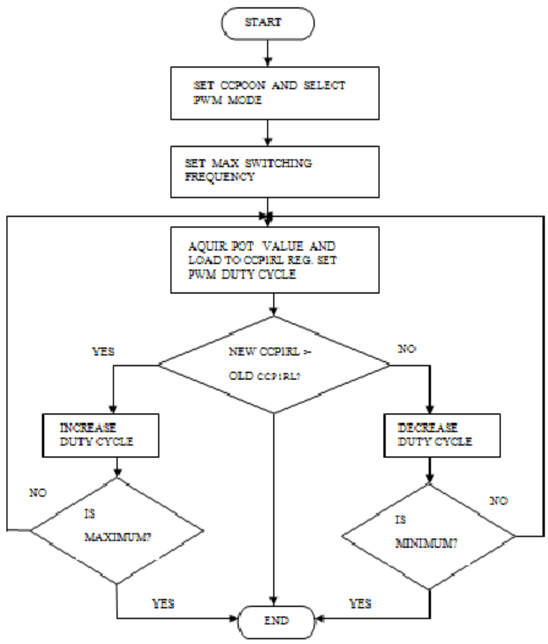
This change in delay is done through push buttons given. So let us see the functions of push button

Table I

Switch	Functions
Sw1	to switch on / off TRIAC
Sw2	S2 to increase delay by 1 ms
Sw3	to decrease delay by 1 ms

Variation in angle is displayed on bar graph display. If angle is more, less current supplied to motor and motor speed is reduced less bars appears on display. If angle is decreased, current supplied will be more, speed of motor is increased and more bars appear on display. The diodes D1, D2 and D3 are connected in such a manner that whenever any of three push buttons, is pressed it will generate external interrupt 1. When Sw1 is pressed first time it will enable the switching of TRIAC. After every 10 ms external interrupt 0 is generated and that will start the entire operation. Pressing Sw1 again will disable switching of TRIAC. Now no more pulses are generated on P0.0 and complete operation is shut off. On pressing Sw2 will increase delay by 1 ms (firing angle by 18^{o} deg). So firing of TRIAC is delayed by 1 ms and amount of current supplied to load is decreased by 10%. Maximum delay is 9 ms (max angle is 162^{o} deg). Bar is decreased by 1 step. In same manner when S3 is pressed delay is decreased by 1ms (firing angle by 18^{o} deg) and load current increases by 10%. Minimum delay is 0 means full positive cycle is applied. Bar is increased by 1 step. The bar graph displays the variation in phase angle. More bars means angle is small and motor speed is high and vice versa.

Flow chart for DC Motor



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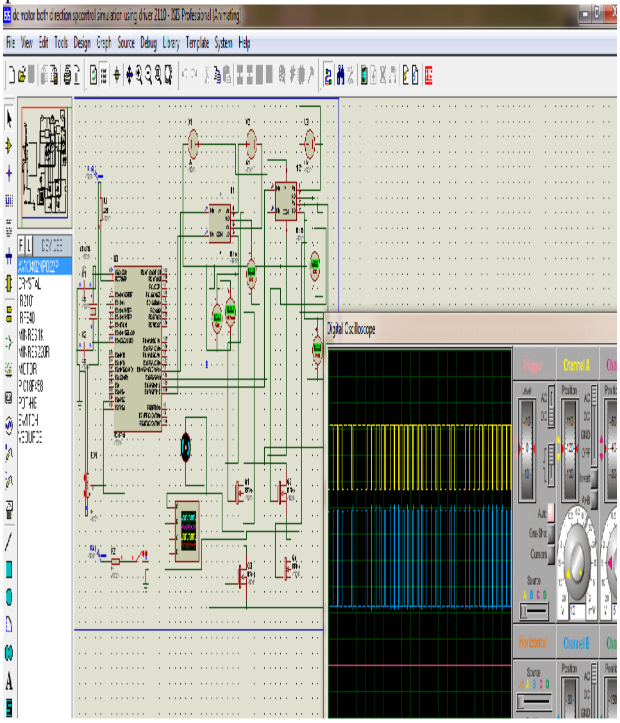
II. Result

In DC Motor speed control, we control it in both directions in clockwise and anticlockwise. Here is practical simulation for PWM pulses. For universal motor we used same principle as DC Motor to control its speed.

Simulation for PWM pulses used to control DC motor speed.



Simulation for detection motor

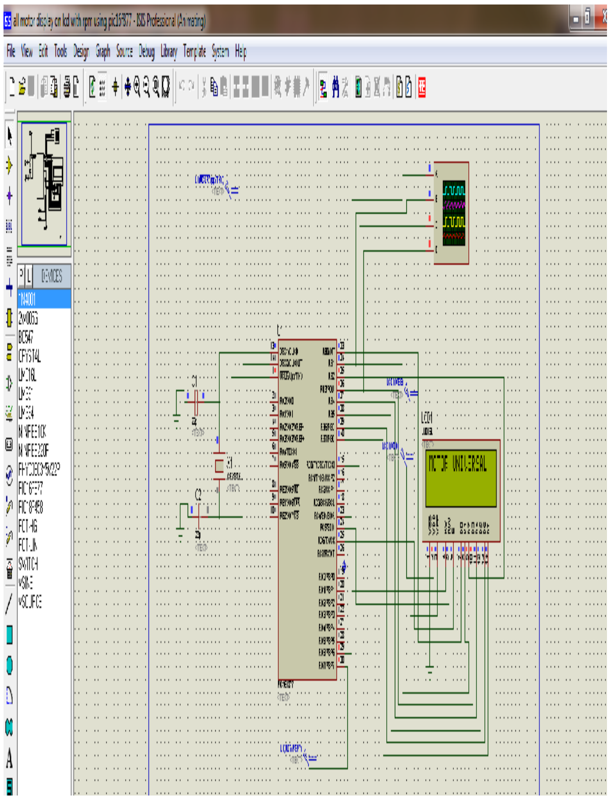


Table II

Pot Position in %	Voltage Across 12v DC Motor(volts)
0	0
40	4.12
80	7
100	12

III. Conclusion

A. M. D. A. C. S. is power based project & it is fully designed based so, we faced lots of problem while actual designing every part of it. First when we think that we have to control speed of DC Motor then decided that we will control DC motor in both direction, for that purpose we decided to use MOSFET bridge we faced lots of problem while practical implementation. But we succeed to control motor in both direction after lots of hard work. In AC motor we came to know that we have to control frequency along with voltage. After lots of experiment we get solution of ac, dc & universal motor speed control.

IV. Future Scope

This project is based on power especially on motors so it has bright future scope. It can be used in industries where automation needs to be done to reduce human efforts. It can used in railways, Airplanes etc. this project can be introduced everywhere motor has big applications.

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