Film Capacitors – AC Capacitors

Application note

Drive Circuit for Induction Motor Control, using EPCOS LCap Series and STMicroelectronics Triac or ACS

Series/Type: **B32350 LCap**

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Drive circuit for induction motor control, using EPCOS LCap series and STMicroelectronics Triac or ACS® (AC switches)

Summary

This document describes a highly cost-effective solution for electronic motor control in domestic appliances for bidirectional motors such as washing machines, dryers, gate / door openers, awning drives and blinds. This solution reduces the need for mechanical switches and relays, thereby improving the efficiency and reliability of these appliances.

Application

The standard bidirectional asynchronous induction motors used in appliances such as washing machines have two windings: main and auxiliary. A run capacitor is needed to start the motor into the required direction by phase shift. Electromechanical switches are used to control it (on-off, direction of rotation).

An electronic motor control can be used to reduce power consumption and relay noise, increase efficiency and reliability as well as eliminate mechanical switch constraints.

An effective way to enhance performance while remaining cost effective is to control the motor with a microcontroller unit (MCU) that drives two AC switches.

Compared to a circuit using electromechanical switches, this approach offers:

- Higher efficiency: No power is consumed by continuous current flowing through the relay coil. The AC switches are operated by a single pulse.
- Increased reliability: Longer operating life of AC switches
- Spark-free operation reduces electromagnetic interference (EMI)
- Noise reduction through elimination of mechanical relays

The AC switches of the latest generation are ideal for this application. They offer fast switching, spark-free and noiseless operation and a longer operating life, as they are driven by gate currents as low as 5 mA. The I_{TSM} (surge current) capability can sustain very high levels. Thus one 16 A AC switch can sustain a surge current of 160 A and a repetitive dI/dt of 100 A/µs. The phase angle can be easily controlled, whereas this would be hard to achieve for mechanical relays.

Purpose of the induction coil in series with the capacitor

If one AC switch is in the “on state” and the second one also goes to this state due to a perturbation (for example, EMI could force both switches to the “on state”), both switches will discharge the capacitor without any current limitation. This electrical overstress may damage the switches. To prevent this, an inductor is inserted in series with the capacitor to limit the current supplied by the capacitor during the period of electrical overstress.

Example

A typical AC switch current of 1000 A (see Figure 1) for the first peak lasting 25 µs is possible when both AC switches are forced to the “on state” simultaneously. This value is typical for a bidirectional asynchronous induction motor of 230 V, 50 Hz with a rated power of 150 W driven by a circuit with two AC switches using a phase shift capacitor of 10 µF. This high current exceeds the maximum value allowed for the AC switches.

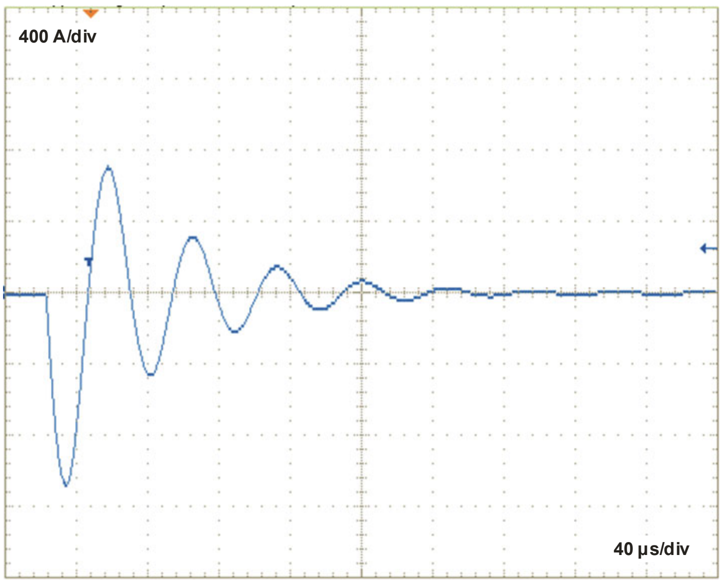

Figure 1: Peak current of -1073 A for 25 µs (without inductor in series with capacitor)

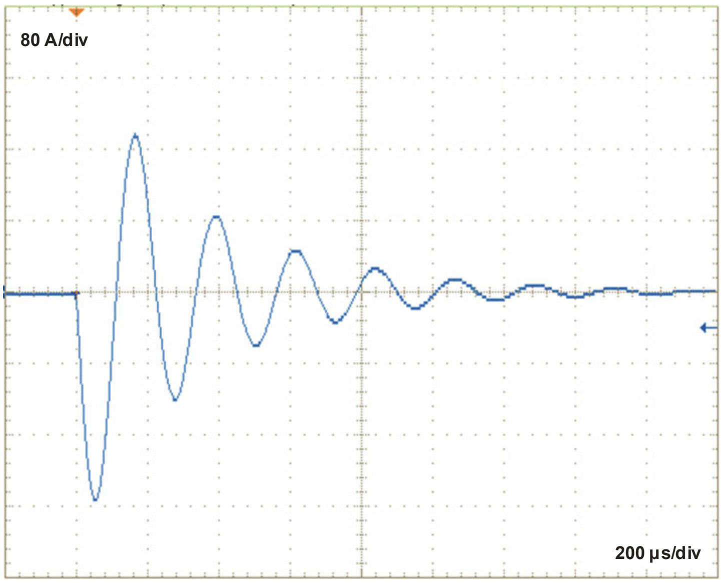

Figure 2: Peak current of - 232 A for 110 µs (with inductor in series with capacitor)

Solution

A series inductor limits the current peak. The dI/dt rate will be shifted to values that AC switches can handle without sustaining any damage. In the above example, an inductance of 80 µH reduces the first peak current to below 250 A (See Figure 2) with a duration of 110 µs.

Tests at the STMicroelectronics laboratories have shown best results when using an LCap from EPCOS, an integrated capacitor and inductor device combining the phase shift capacitor with the current limitation inductor in one case. This is seen as the best solution for assembly in production lines thanks to improved FMEA (failure modes and effect analysis) results due to fewer operations and a lower component count.

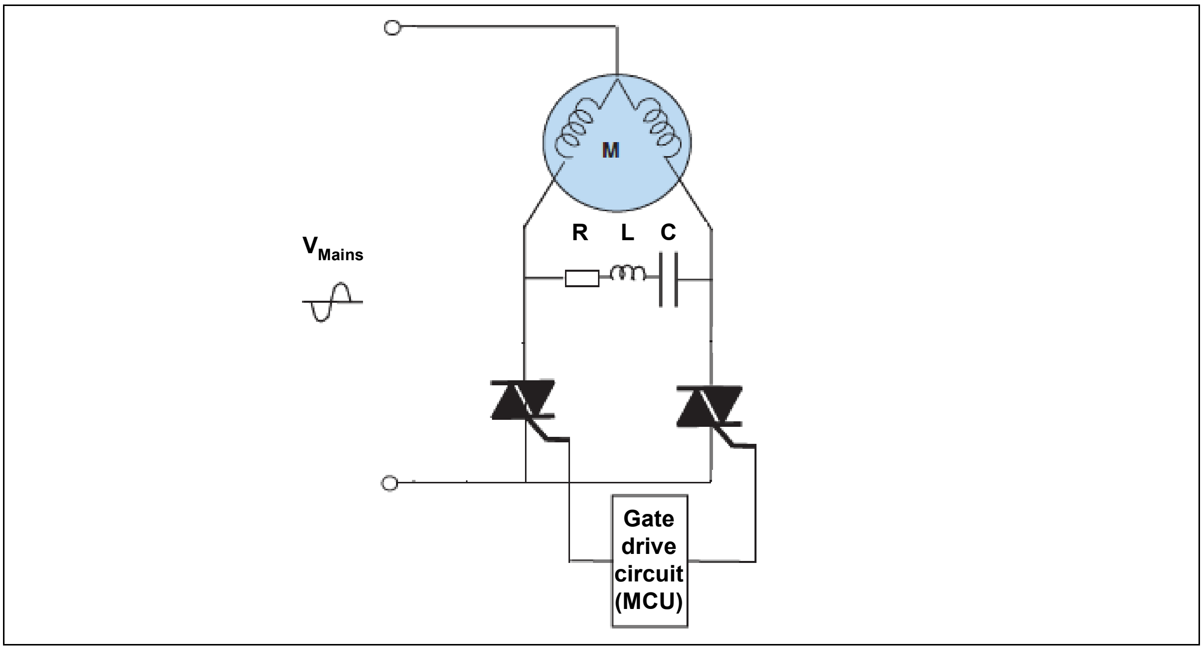

Figure 3: Schematic diagram for electronic motor control

In Figure 3, C is the motor run capacitor producing the phase shift for the auxiliary winding. The series impedance L is needed to protect the AC switches in case of false triggering causing both AC switches to be in the “on state”. The parasitic resistor R represents the total impedance of the branch (C+L).

Circuit design

The capacitor and inductor ratings depend on the motor characteristics (power, operating voltage, frequency). STMicroelectronics offers free selector guide software to help calculate and select the required characteristics of the Triacs or ACSs (AC switches). It is available upon request from the sales departments of STMicroelectronics.

Modes of application in washing machines

During washing mode, the drum is rotated in both directions by turning-on each AC switch alternately. One of the two windings of the induction motor is supplied directly by the mains voltage. The other is supplied through the capacitor C providing a phase shift and a high voltage across the capacitor, which can reach a peak value of 650 V.

During spin mode, only one AC switch will be turned on, since the drum will be spinning at maximum speed.

Advantage of EPCOS LCap compared to discrete capacitor / inductor combinations

- Low-rated parasitic resistor
- Long-term stability of narrow tolerances
- Highly rugged, maintenance-free
- Compact size
- Two connections instead of four
- Reduced assembly time

This technology is successfully used by global market leaders. It produces cost-effective, easy-to-mount solutions. The combination of an inductor coil and a capacitor in a single package allows narrow tolerances to be specified for both components.

Typical combinations for LCap, AC switches (Triac and ACS^{TM})

Motor power	B32350 LCap (EPCOS)		Triac and ACS^{TM} (STMicroelectronics)
	Capacitance	Inductance	Type
190 W/ 230 V 50 Hz (washing machine)	10 µF	80 µH	ACST1235* ACST1035* BTA12-800CW* High Tj Triacs*
250 W/ 230 V 50 Hz (washing machine)	50 µF	100 µH	ACST1635-8FP* BTA16-800CWRG* High Tj Triacs
120 W/ 230 V 50 Hz (fridge compressor)	4 µF	5 µH	ACST610-8* BTA06-800TWRG* BTB12-600TWRG* High Tj Triacs*

* Several packages are available, please check the respective datasheets

Table 1: Typical combinations of LCap and AC switches - actual values defined in each case

Products and pictures

EPCOS	STMicroelectronics	
		
B32350 LCap series (integrated capacitor / inductor device)	AC switches: Triac series BTA, high TJ (TxxxxH) and ACST	MCU

Table 2: EPCOS and STMicroelectronics products for this application

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Terms

Triac: Triode for alternate current

ACS: ST AC switch designed to sustain overvoltage without the need for a varistor

High TJ: Triac with a junction temperature capability of 150 °C

Important notes

The following applies to all products named in this publication:

1. Some parts of this publication contain **statements about the suitability of our products for certain areas of application**. These statements are based on our knowledge of typical requirements that are often placed on our products in the areas of application concerned. We nevertheless expressly point out **that such statements cannot be regarded as binding statements about the suitability of our products for a particular customer application.** As a rule, EPCOS is either unfamiliar with individual customer applications or less familiar with them than the customers themselves. For these reasons, it is always ultimately incumbent on the customer to check and decide whether an EPCOS product with the properties described in the product specification is suitable for use in a particular customer application.
2. We also point out that **in individual cases, a malfunction of electronic components or failure before the end of their usual service life cannot be completely ruled out in the current state of the art, even if they are operated as specified.** In customer applications requiring a very high level of operational safety and especially in customer applications in which the malfunction or failure of an electronic component could endanger human life or health (e.g. in accident prevention or life-saving systems), it must therefore be ensured by means of suitable design of the customer application or other action taken by the customer (e.g. installation of protective circuitry or redundancy) that no injury or damage is sustained by third parties in the event of malfunction or failure of an electronic component.
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