Fax Back Document #1200

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• Safety Standards

Okaya spark quenchers have been recognized by the following safety standards organizations:

Organization (country)		Applicable Standard	
		Household Appliances	Office Appliances and others
IEC		PUB 65	PUB 950
UL	(USA)	UL-1414 (capacitor)	UL-1283 (filter)
CSA	(Canada)	C22.2 No. 0 No. 1	C22.2 No.8
VDE	(Germany)	IEC384-14II(EN132400)	IEC384-14II(EN132400)
SEV	(Switzerland)	IEC384-14II(EN132400)	IEC384-14II(EN132400)
BS	(Great Britian)	IEC384-14II(EN132400)	IEC384-14II(EN132400)
SEMKO	(Sweden)	IEC384-14II(EN132400)	IEC384-14II(EN132400)
DEMKO	(Denmark)	IEC384-14II(EN132400)	IEC384-14II(EN132400)
NEMKO	(Norway)	IEC384-14II(EN132400)	IEC384-14II(EN132400)
EI	(Finland)	IEC384-14II(EN132400)	IEC384-14II(EN132400)
ÖVE	(Austria)	----------	IEC384-14II(EN132400)
IMQ	(Italy)	----------	IEC384-14II(EN132400)

- Electrical apparatus are classified roughly into two categories, i.e., (a) household appliances and (b) office appliances including office automation (OA) and others.
- The standards for noise suppression capacitors to be used in the household appliances are more strict than those in the office appliances and others.
- The products enumerated in the following pages (with a few exceptions) have been approved under standards applicable to the household appliances, so that you may use them for almost all applications.
- In order to avoid any accidents in machine applications which may experience unexpected abnormal surge voltage, or which are subjected to continuous 24-hour use, it is necessary to build in an extra measure of reliability. Here, the strict test conditions conducted by the above-mentioned safety standards organizations can be considered as one of the criteria from a reliability point of view.

• SPARK QUENCHERS INTRODUCTION RC NETWORKS

Recent developments in electronic equipment have shown the following trends:

- Increasing demands for numerical control machines, robotics and technically advanced appliances are requiring progressive electronic technologies.
- When employing integrated circuit and microcomputer technology, today's equipment is required to perform multifunctions in limited size.
- The denser the installation of components, the more the components must be miniaturized and of lighter weight.
- As a result, the following problems arise:

1) Functional limits of magnetic relays and switches have narrowed due to increasing contact amperage.

2) Miniaturization of electronic components has reduced their dielectric strength.

3) Circuit noise has increased as a result of the coexistence of signal and power lines.

4) Safety standards for electronic equipment and components have become increasingly restrictive.

Some key factors affecting circuit performance are:

1) Arcing between relay and switch contacts result in wear and binding.

2) Contact arcing, results in high frequency noise and abnormal high voltages.

3) The generation of back electromotive force (EMF) is due to the self-inductance of inductive loads.

4) The occurrence of high frequency noise is the result of contact chatter in magnetic relays and switches.

Back EMF, due to self-inductance, affects Silicon Control Rectifiers (SCRs) and Solid-state Relays (SSRs) and can result in the breakdown of other semi-conductor devices. Power line surges must also be carefully considered. Either may be a contributing factor in equipment malfunctions, failures and in extreme cases fire and/or electrical shock.

To illustrate these factors, consider that relay contact chatter is capable of inducing oscillations of several Kilohertz, contact arcing frequencies of several Megahertz and amplitudes 10 to 20 times normal circuit voltages. Voltage surges from external sources may approach thousands of volts.

To protect electronic equipment against costly failures or malfunctions, Okaya has developed advanced components to suppress contact arcing and filter unwanted electrical noise.

• DETERMINING RC VALUE

In general, the RC determining formula is regarded as quite complex, but since the RC combination has the decisive effect of integrating the rapid changes of the waveform to a smoothed average, the determination of RC values by complex formulas becomes unnecessary.

It is possible to select a suitable OKAYA Spark Quencher using the chart or the formulas shown below. Keep in mind that there is no one exact value of Spark Quencher which will satisfy all applications. The chart and formula are guide-lines to give the user a starting point from which to work. The final selection must be evaluated in the application to determine its acceptability.

		LOAD CURRENT - AMPERES										
		0.05	0.1	0.2	0.3	0.5	1.0	2.0	3.0	5.0		
Source Voltage	125VAC or 125VDC	0.01 + 470	0.01 + 470	0.01 + 220	0.01 + 120	0.022 + 120	0.1 + 47	0.3 + 47	0.5 + 47	1.0 + 10	MFD + OHMs	R+C Values
	250VAC or 250VDC	0.01 + 470	0.01 + 470	0.01 + 470	0.01 + 470	0.022 + 120	0.1 + 120	0.3 + 120	0.5 + 47	1.0 + 47	MFD + OHMs	

$$C = \frac{I^2}{10}$$

$$R = \frac{V}{10\left(1+\frac{50}{V}\right) I}$$

C = Capacitance in MFD
I = Load Current in Amps
R = Resistance in Ohms
V = Source Voltage

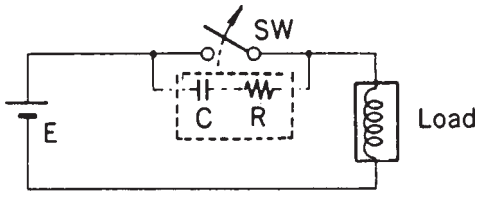
SPARK QUENCHERS

Spark Quenchers are easily selectable electronic components designed to prevent or substantially minimize the occurrence of arcing and noise generation in relay and switch contacts.

Spark Quenchers consist of specially designed capacitors and resistors connected in series. Spark discharges and induced noise are absorbed over a wide range by the accumulation characteristic and impedance of the capacitor, while the RC time constant delays and averages surge voltage and oscillations.

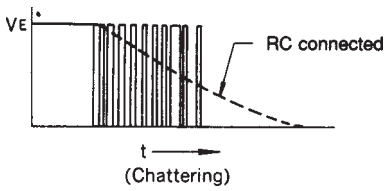
• EFFECT OF SPARK QUENCHER

Arc suppression



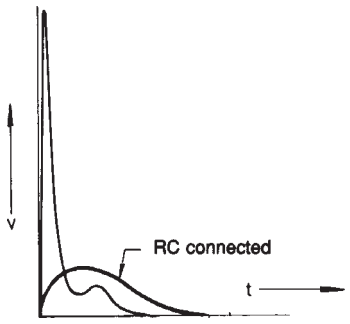
At the moment of switch opening, the RC combination absorbs and suppresses the energy of the arc by letting it bypass the switch.

Damping oscillation



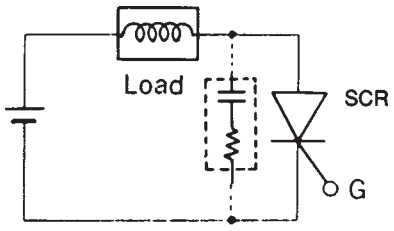
The RC combination absorbs the high frequency oscillations caused by mechanical vibrations such as relay contact chattering. Similarly the oscillations created by arcing are also averaged and suppressed by the RC combination regardless of their origin.

Back electromotive force suppression



With back electromotive force due to self-inductance, the surge voltage peak is suppressed by conducting it through the RC circuit on the low impedance side. The peak is absorbed by the capacitance of RC. The waveform is averaged and smoothed by the time constant of the RC; thus generated noise is eliminated or substantially minimized.

Dv/dt suppression



The RC combination allows the dv/dt of the “on” and “off” operation of thyristors or similar devices to decrease; thus surge voltages are suppressed and semi-conductor elements are protected. Even in the case of zero crossing circuits, such as AC circuits, protection is necessary since harmonic noise occurs when there is a gap between phases or current and voltage of the load circuit.

OKAYA Spark Quenchers have the following characteristics which make it possible to easily use them in a wide range of applications.

1) The Overload capacity is large.

2) They are not polarized; thus can be used in both AC an DC circuits.

3) They have a favorable effect on surge voltage and accompanying oscillations caused by contact chatter.

4) They are effective against spurious potentials having magnitudes below circuit voltage.

5) They offer a high degree of protection for semiconductor devices, and as thyristors and SCRs.

6) They improve the dv/dt ratio.

• OUTLINE OF CAPACITOR CLASS RATINGS

Capacitors are classified by the IEC into the following categories (these designations are used by most European countries):

Class Y: Capacitors used in applications where damage to the capacitor may involve the danger of electrical shock.

Class X: Capacitors used in applications where damage to the capacitor will not lead to the danger of electrical shock.

European Safety Agencies subdivide Class X into X1, X2 and X3 classifications. The test criteria for these subclasses is shown in the table.

Subclass	Peak Voltage on Service (kV)	Peak Voltage Test 1.2/50 µsec. (kV)
X1	>1.2kV≤ 4.0kV	4.0kV
X2	≤ 2.5kV	2.5kV
X3	≤ 1.2kV	None

RC COMBINATION TABLE

µF \ Ω	10	27	33	47	50	68	100	120	150	160	200	220	470	500
0.01	XE XEB			XE XEB				XE XEB				XE XEB	XE XEB	
0.033	XE XEB AU			XE XEB AU				XA XE XEB AU				XE XEB	XE XEB	
0.1	XE XEB AU			XE XEB AU		CRH		XA XAB XE XEB AU			CRE	XE XEB	XE XEB	
0.2	XE XEB			XE XEB				XAB XE XEB	CRE			XE XEB		
0.22				CRH										
0.3	XE XEB			XE XEB		CRE 3CRE		XE XEB				XE XEB		
0.33			CRH 3CRH											
0.47		CRH 3CRH												
0.5	XE XEB			XE	CRE 3CRE 6CRE									
1.0	XE XEB													

SPARK QUENCHERS

- **GENERAL CONSTRUCTION**

Spark Quenchers must have the capacity to store surge voltages and current energy, and afford protection against inductively induced potentials. The dielectric material of the OKAYA capacitors, used in Spark Quenchers, affords a very high degree of voltage withstand strength. All resistors are non-inductive solid slug type to insure a high degree of protection against pulse potentials. To provide additional protection for equipment and users, especially when these components are used in AC applications, all OKAYA Spark Quenchers are packaged in cases which meet UL-94 Flame Class V-O.

- **SAFETY STANDARDS**

Safety standards for capacitors used in conjunction with AC power sources have recently been adopted by many world wide standards agencies. OKAYA Spark Quenchers are fully tested to these standards (see Chart). As well, Okaya is able to offer some products with 500 VAC ratings.

- **APPLICATIONS**

A) Protection for contacts and from noise during switching operations of equipment such as radio, TV, copiers, mixers, coffee grinders, dryers, tool machine equipment, etc.

B) Protection of electronic instruments during operation of relays, solenoids, motors, etc.

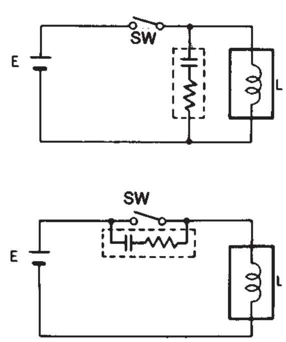
C) Electrical noise protection of semiconductor devices during control of triacs, thyristors, motors, welders, illumination equipment, etc.

- **FORM**

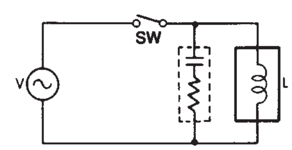
Line Voltage	Safety Standard	Lead Type	Forms	Model
125V/250V AC	UR · CSA · VDE	Bare wire/Flex PVC wire	a/b	XA series/XAB series
125V/250V AC	UR CSA VDE S +S FI D N	Bare wire	a	AU series
250V AC	UR CSA VDE S D N FI +S	Bare wire	a	XE series
250V AC	UR CSA VDE S D N FI +S	Flex PVC wire	b	XEB series
250V AC	UR	Flex PVC wire	d	CRE series
250V AC	UR	Flex PVC wire	e	3CRE series (3 phase delta connection)
500V AC	UR	Flex PVC wire	c	CRH series
500V AC	UR	Flex PVC wire	f	3CRH series (3 phase delta connection)
250V AC	UR	Flex PVC wire	g	6CRE series (3 individual circuits)

a. b. c. d. e. f. g.

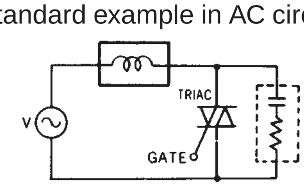
- **APPLICATION EXAMPLES**



Standard example in DC circuits.



Standard example in AC circuits.



For phase control circuits employing SCR or TRIAC, etc.

• DESIGN CAUTIONS

1) Using OKAYA Spark Quenchers will help prevent abnormal operation due to electrical noise and/or surge pulses. It is not recommended that these devices be used in circuits with frequencies greater than 70 Hz. When used in 3-phase, full wave rectified applications, care must be taken to insure that the Spark Quencher does not self heat by more than 5 degrees centigrade or permanent damage to the Spark Quencher may occur.

2) When protecting contacts feeding small circuit loads, it is recommended that the Spark Quencher be placed in parallel with the load, rather than the contacts, for the most effective application.

3) In high speed circuits, the addition of a Spark Quencher may slow the response time of the circuit. For best response characteristics, do not use a larger Spark Quencher than is absolutely necessary to suppress the noise level.

4) Spark Quenchers should be connected as close as possible to the noise source. Excessive lead length may allow abnormal oscillation and/or decrease energy absorption capacity.

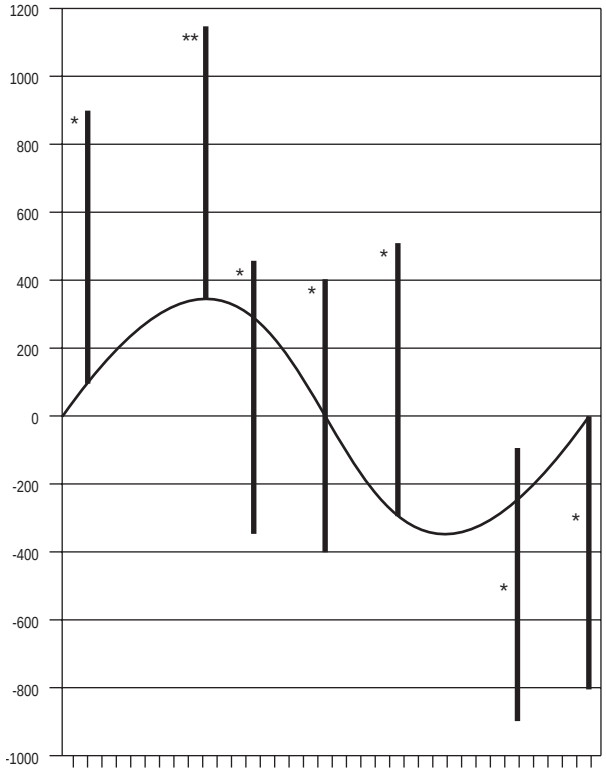
5) When a thyristor, triac or invertor circuit is to be protected by a Spark Quencher, care must be taken that high harmonic currents do not cause over heating of the Spark Quencher resistor. If heating occurs, we suggest the employment of a Spark Quencher with a lower resistance. The Spark Quencher must not self heat by more than 5 degrees centigrade. In invertor applications, it is recommended that an OKAYA noise suppression capacitor be used across the power lines, instead of the Spark Quencher.

6) While it may appear effective to protect contacts with a capacitor only, the capacitor discharge current will cause accumulative damage to the contacts when they close. The proper technique is to apply a Spark Quencher across either the contacts or the load.

• EXPRESSION OF RATED VOLTAGE

The rated voltage of OKAYA Spark Quenchers is expressed by the steady-state (line) voltage rating. They can, however, withstand much higher voltages from power surges. In this catalog, the maximum voltage (including the line voltage) that the Spark Quenchers can withstand is expressed as the “Peak Pulse Voltage”. For example, the XE series is rated 250VAC RMS (350VAC Peak) maximum line voltage, but can withstand surge voltages up to 1200VAC (including Peak line voltage). “Pulse Condition” means the maximum voltage that can be input between terminals of the Spark Quencher (excluding line voltage) during operation. For example, when the XE series is used in a 250VAC RMS (350VAC Peak) line voltage application, it can withstand surge voltages up to 800VAC (P-P) above the Peak line voltage. The following drawing shows examples of both “Peak Pulse Voltage” and “Pulse Condition” for clarification.

“Pulse Condition”

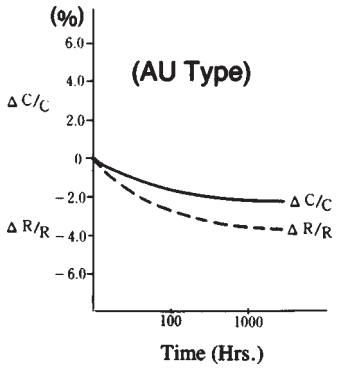


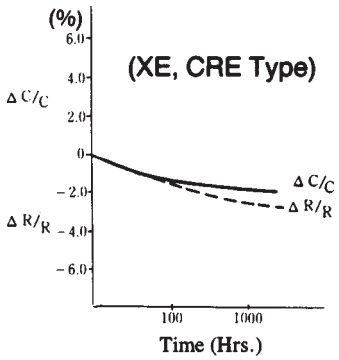
* Pulse Condition (Surge pulse p.p.)

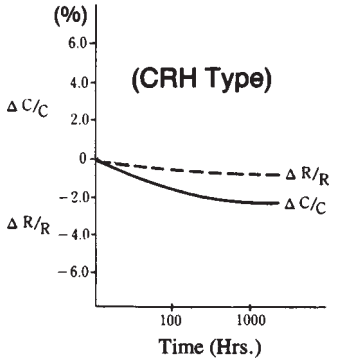
** Peak Pulse Voltage (Peak line voltage plus surge pulse)

• PERFORMACE CHARACTERISTICS

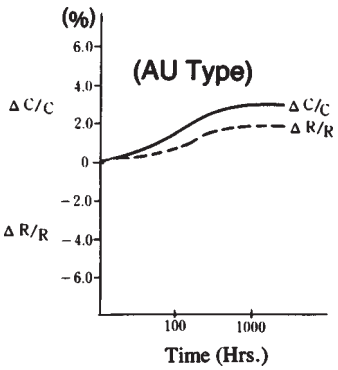
Temperature Endurance

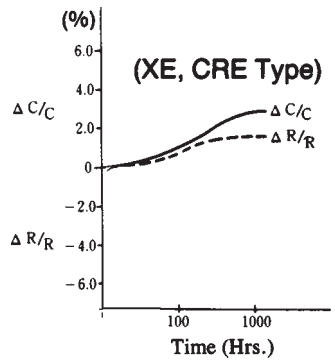


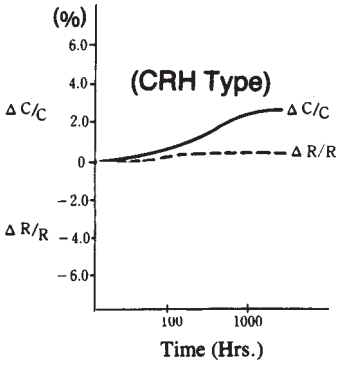




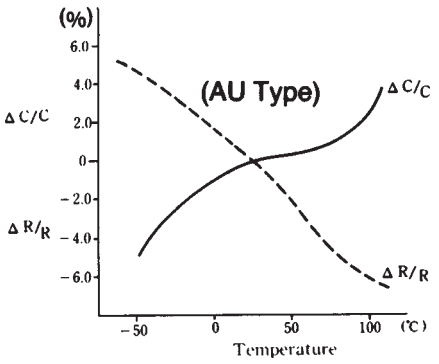
Damp Heat Endurance

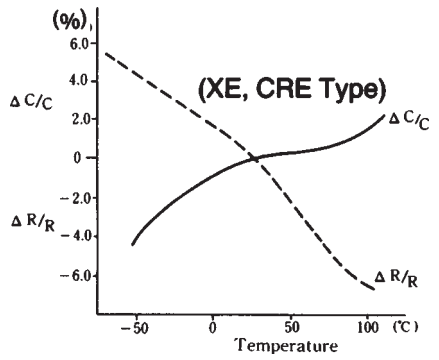


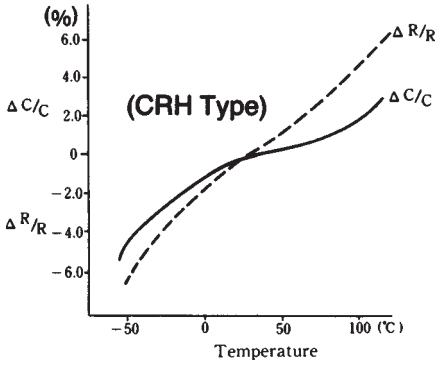




Temperature Characteristics







• TEST CONDITIONS

Temperature Endurance:

While operating at maximum rated temperature and at 125% of rated voltage, input the table voltages four times per hour for 0.1 second.

Model	Applied voltage
AU, CRE	880 Vrms
XE	1000 Vrms
CRH	1500 Vrms

Damp Heat Endurance:

60°C, 90~95% RH
100% Rated Voltage

Temperature Characteristics:

-50°C to~100°C
100% Rated Voltage

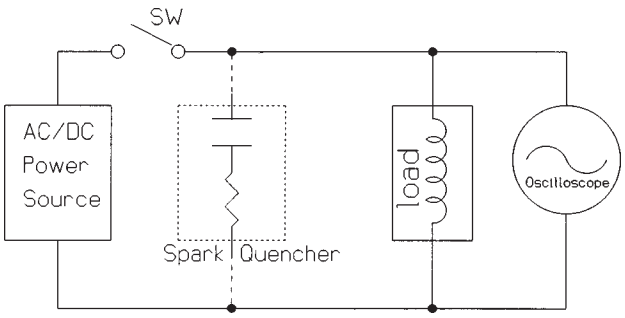
• EXAMPLES OF ABSORPTION OF NOISE

The following illustrations show examples of the operation of a variety of commonly used magnetic relays and contactors with and without a Spark Quencher. The ability of the Spark Quencher to integrate peak power surges and suppress high frequency oscillations is visibly demonstrated.

Without a Spark Quencher in the circuit, surge voltage becomes 10 to 30 times larger than the normal circuit voltage and the noise frequency approaches 10 MHz. Spark Quenchers effectively absorb high frequency oscillations induced by contact chattering and attenuate peak surge voltages.

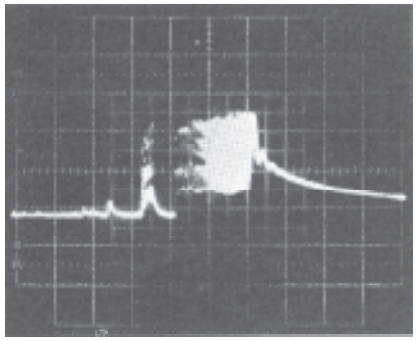
In general, inductive load circuit malfunctions occur as a result of component dielectric breakdown induced by excessive peak potential, or unnecessary radiation accompanied by occurrences of high frequency oscillations due to rapid changes of voltage. Spark Quenchers are effective in preventing both types of electrical noise.

In the following illustrations of noise waves, note that the time base is quite small compared with the normal 50/60 Hz line (16-20 msec.).

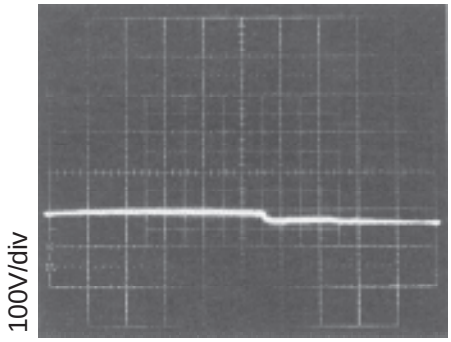


Example 1. Magnetic relay closed in 12VDC circuit.

Without Spark Quencher

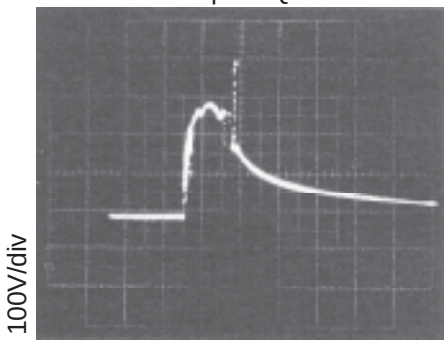


With XE-1201

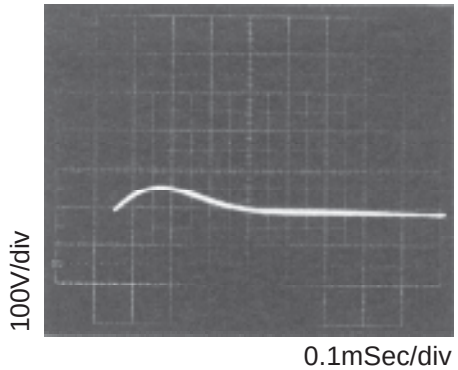


Example 2. Magnetic relay opened in 12VDC circuit.

Without Spark Quencher

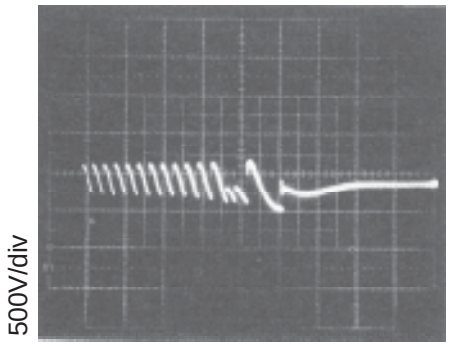


With XE-1201

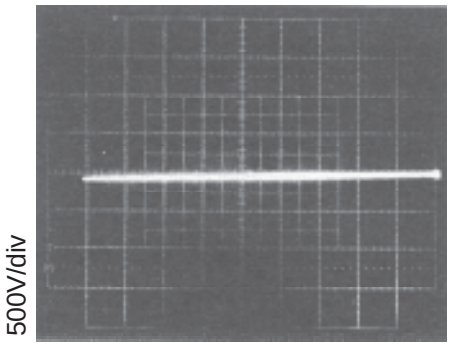


Example 3. Magnetic relay opened in 120VAC circuit.

Without Spark Quencher

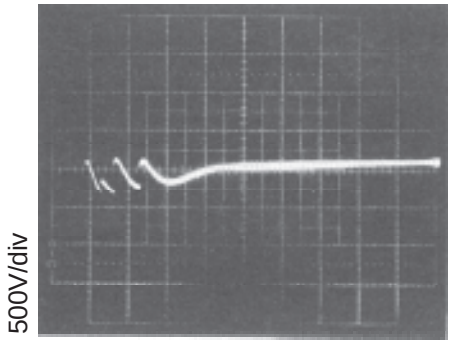


With XE-120033

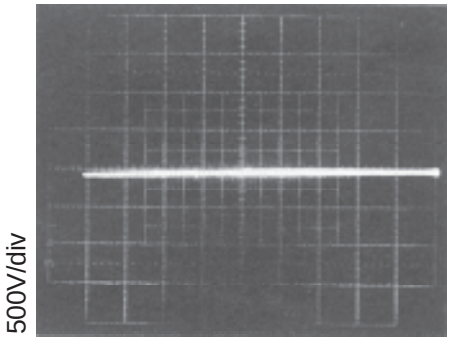


Example 4. Large magnetic relay opened in 120VAC circuit.

Without Spark Quencher

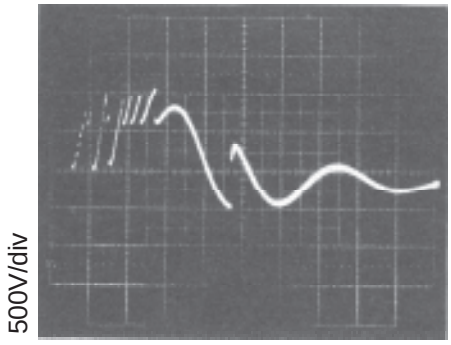


With XE-1202

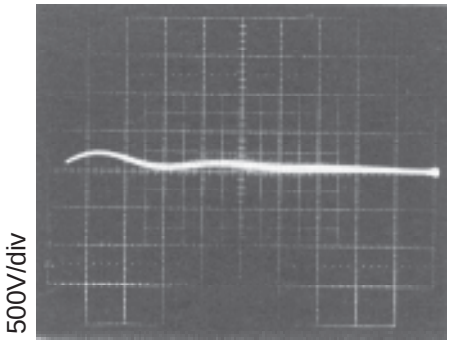


Example 5. Magnetic contactor opened in 240VAC circuit.

Without Spark Quencher

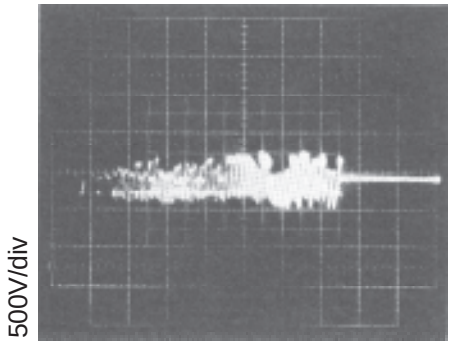


With XE-1202

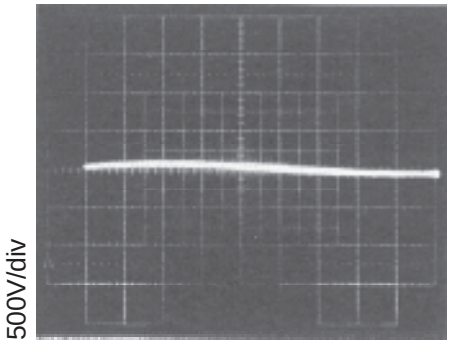


Example 6. Rotary solenoid opened in 120VAC circuit.

Without Spark Quencher

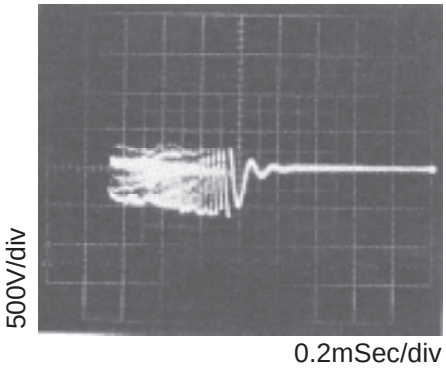


With XE-1201

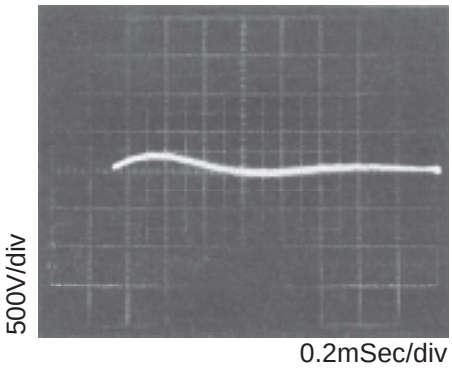


Example 7. Motor timer opened in 120VAC circuit.

Without Spark Quencher

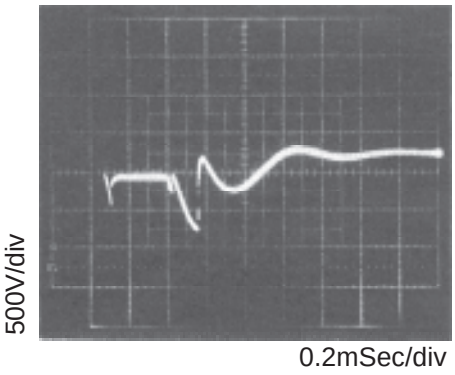


With AU-1201

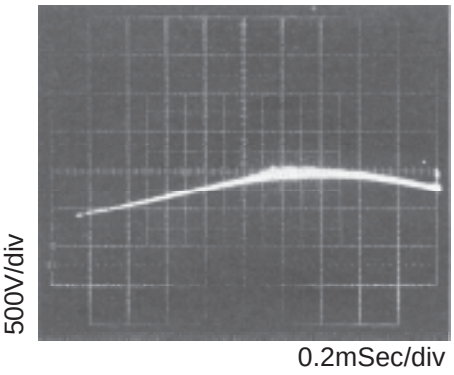


Example 8. Induction motor opened in 240VAC circuit.

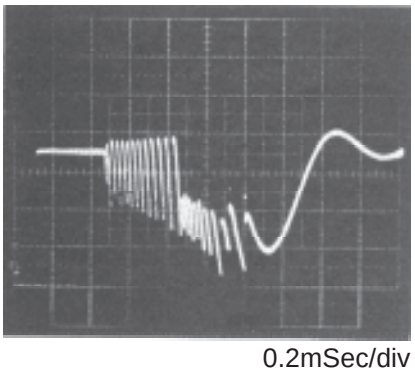
Without Spark Quencher



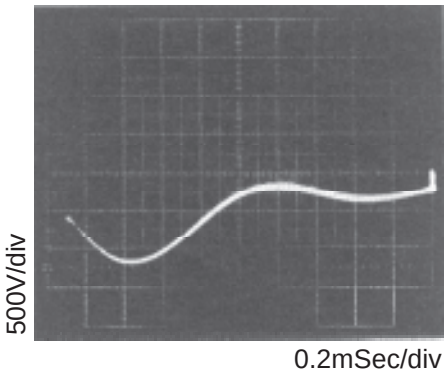
With XE-1201



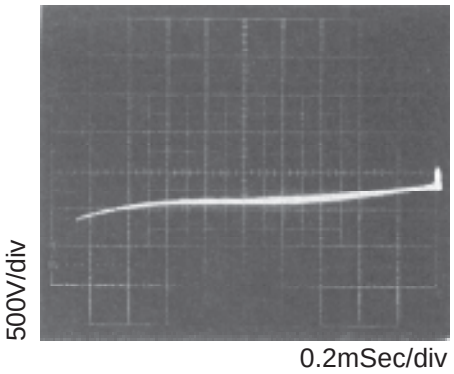
Without Spark Quencher



With XE-120033



With XE-1202



Two of the illustrations in example 8 are the result of the switch opening without Spark Quencher protection. The variation in the wave forms is due to the difference in the AC voltage at the instant of circuit opening.

Three of the noise-graph illustrations are the result of the switch opening with Spark Quencher protection. Noise that occurs at the time of load disconnect is absorbed by the LRC loop. Proportionally as the capacitor becomes larger, the noise prevention becomes more effective.