Bulletin No. M-379F
November 1999
Raleigh, NC, USA

Data Bulletin

Replaces M-379E dated 11/84

Distant Control of AC Relays, Contactors, and Starters

GENERAL THEORY

When a relay, contactor, or starter is mounted a considerable distance from the device controlling it, problems are introduced that are not present when the distance is relatively short. The major problems that arise are due to the series impedance and shunt capacitance of the control wires and their effect upon the proper operation of the relay, contactor, or starter. Because of the inherent characteristics of AC operated magnets, these two problems are important at different times and can therefore be treated separately.

SERIES IMPEDANCE

Due to the series impedance effect of the control wires in series with the device coil, the current drawn through the control wires causes a voltage drop which subtracts from the voltage available to the relay, starter, or contactor coil. If the voltage drop due to this series impedance is large enough, the voltage available to the device coil may not be sufficient for the device to pick up and seal properly. If the device fails to pick up or seal, and the pickup signal is maintained, a coil burnout is likely.

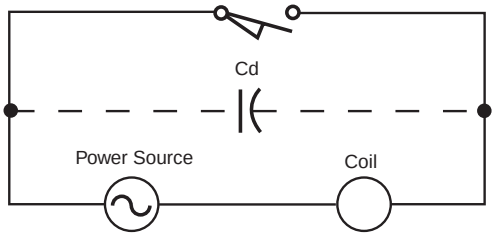

Figure 1: Control Device

The series impedance effect of the control wires is particularly important when inrush current is present in the wires, since this is usually the only time when the current is sufficient to cause an appreciable difference between the source voltage and the voltage available to the device coil. NEMA standards require AC operated magnetic devices to operate satisfactorily at 85% of the rated coil voltage. Allowing for a line voltage fluctuation of 10% below the rated voltage, the voltage drop caused by the series impedance effect of the control wires should be limited to 5% to insure satisfactory operation of the circuit.

The tables beginning on page 5 of this bulletin show the **maximum** distance in feet between the relay, contactor, or starter and the device controlling it, based on a maximum difference of 5% between the source voltage and the voltage available to the device coil during inrush conditions. This data is based on 60 Hz voltage sources only.

SHUNT CAPACITANCE

In addition to series impedance, the control circuit wires also exhibit a distributed capacitance. The effect of this shunt capacitance is particularly important when the relay, contactor, or starter circuit is opened and the device is to drop out. If the arrangement of the control circuit components is such that the control wire shunt capacitance is in parallel with the STOP button, limit switch, or other disconnect means controlling the relay, contactor, or starter, a large enough amount of capacitance will prevent the device from dropping out even though the control circuit was opened. This is a very serious condition and must be prevented.

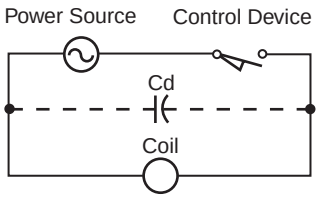

Figure 2: Power Source

To determine if the effects of the shunt capacitance of the control wires must be considered, refer to Figures 1 and 2.

If the control device is remote (see Figure 1), and the control circuit components are arranged so that the power source is adjacent to the device coil, the **distributed wire capacitance** will be in parallel with the control device (STOP button) and **must be considered**. Under these conditions, it is sometimes necessary to limit the length of the control wires so that the distributed capacitance between the control wires does not exceed the maximum permissible value for the proper operation of the control circuit.

This will shunt the device coil in the energized state even though the control circuit is open. (See Figure 2.)

If the power source is adjacent to the control device (STOP button), opening the control device contact will de-energize the distributed capacitance and the relay, contactor, or starter coil. The **distributed wire capacitance need not be considered** in determining the length of the control wire run, since the capacitance does not prevent the STOP button from functioning. In such cases, the series impedance effect of the control wires is the limiting factor.

APPLICATION

In practical applications, the system should not be installed first and then tried out later. Even though the circuit may work properly initially, conditions may change due to wear, aging, deteriorating insulation, humidity, or other factors, and the relay, contactor, or starter coil being controlled may not pick up or drop out at some critical moment. For this reason, it is important to calculate the maximum allowable control distance that permits continued reliable operation.

In evaluating long runs of control wire that are difficult to maintain and inspect, it may be impossible to know the exact location of the wires, the thickness of the insulation or other characteristics that can affect the impedance or capacitance of the control wires throughout the entire run. For this reason, any calculation of the maximum length of a wire run must be simplified. Figure 3 shows a normal three-wire control scheme with the source, hold, and coil wires and the conduit shown in cross section. Both L2 and the conduit are properly grounded.

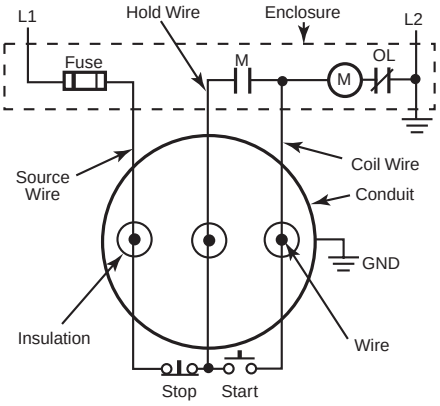

Figure 3: Three-Wire Separate Control—Properly Grounded

To maintain the proper operation of the circuit, always assume the worst case (See Figure 4). The worst case occurs when:

1. The conduit is filled with water due to condensation, flooding, or other accident.
2. The conduit and/or L2 are ungrounded.
3. The source wire (L1 to the stop station) is shorted at a termination point, or shorted to the conduit, due to the failure of the wire insulation.

These conditions can be present in the circuit without causing the control circuit fuse to blow.

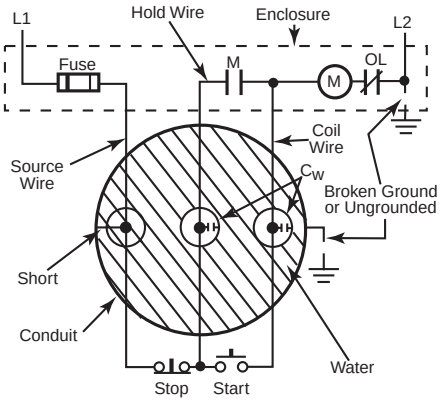

Figure 4: Three-Wire Separate Control in Water Filled Conduit—Not Properly Grounded

Figure 4 shows that the water and source wire are at the same potential (L1) due to the short. The coil and hold wires each exhibit a capacitance (C_W) between the wire and the surrounding water. The water acts as one plate of the capacitor; the insulation acts as the dielectric; and the wire acts as the other plate of the capacitor.

The distances shown in the tables in this bulletin are calculated by using manufacturers' specifications for machine tool wire (MTW) used in the control circuit at 60 Hz. A dielectric constant of 8 is assumed. Use of different wire or cable, such as “Romex” or coaxial cable, alters the conditions and makes the distance values shown in the tables incorrect. Consult your local Square D field office for assistance.

HOW TO USE THE TABLES

1. Determine whether the distributed wire capacitance is in parallel with the stop button (refer to Figures 1 and 2). If the capacitance is **not** in parallel with the stop button, the distributed wire capacitance need not be considered.
2. Refer to the table giving shunt capacitance and series impedance distances for the class and type of device in question.
3. Based on the control circuit voltage and wire size, determine the shunt capacitance (two or three-wire control) and series impedance distance from the appropriate table.

NOTE: All tables refer to American Wire Gauge (AWG) copper wire.

4. When the shunt capacitance distance is greater than the series impedance distance, the series impedance distance is the limiting value. (In this case, to avoid confusion, the shunt capacitance value does not appear in the table and reference to a footnote is made.)
5. When the shunt capacitance distance is less than the series impedance distance, the shunt capacitance distance is the limiting value.

ALTERNATE SOLUTIONS

Several methods can reduce the problems of series impedance and shunt capacitance caused by long runs of control wires. The control distance of a starter or contactor can sometimes be increased by using one of the methods shown in Figure 5.

Interposing AC Control Relay

Since the burden of a control relay coil is generally less than the burden of a starter or contactor coil, the starter or contactor's control distance can sometimes be increased by using an interposing control relay, provided the shunt capacitance of the control wires does not become the limiting factor. The control relay, which is used to pick up the starter or contactor at line voltage, can be powered from a control transformer, or from line voltage (see Figures 5 and 6).

After the control relay is sized, based on the line voltage and coil current, follow steps 1 to 5 under "How to Use the Tables" to determine the maximum control distance.

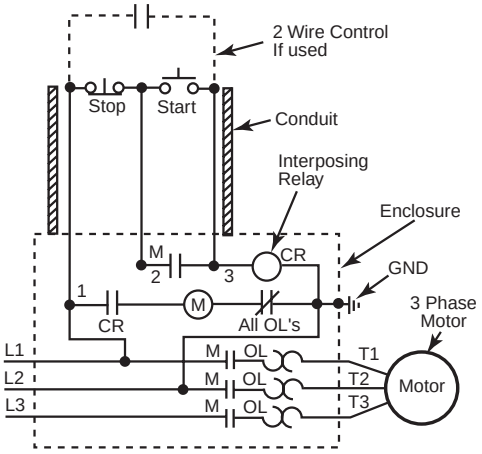

Figure 5: Interposing Control Relay at Line Voltage

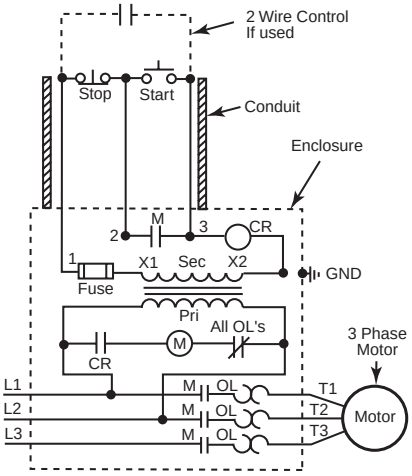

Figure 6: Interposing Control Relay and Transformer

Interposing DC Control Relay

If shunt capacitance becomes the limiting factor (since coils with a lower burden generally require less shunt capacitance to hold them in the energized position even though the control circuit is open) the arrangement using an interposing AC control relay can be altered to use an interposing DC control relay instead. If the voltage across the control wires is DC, the shunt capacitance cannot conduct; therefore, it does not cause a problem (See Figure 7). Series impedance then becomes the limiting factor.

Interposing DC Control Relay and Solid State Amplifier

An elaboration of the scheme above using an interposing DC control relay is to use a DC relay controlled by a solid state amplifier. This arrangement

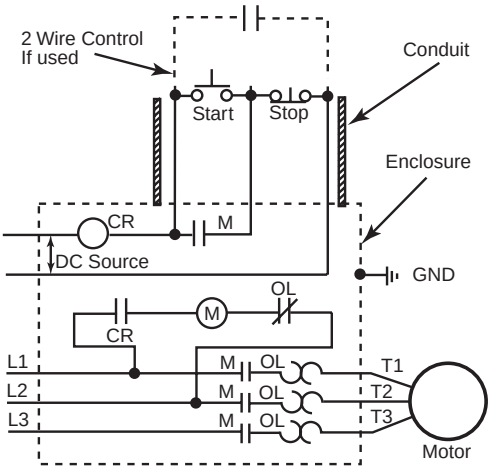

Figure 7: Interposing DC Control Relay

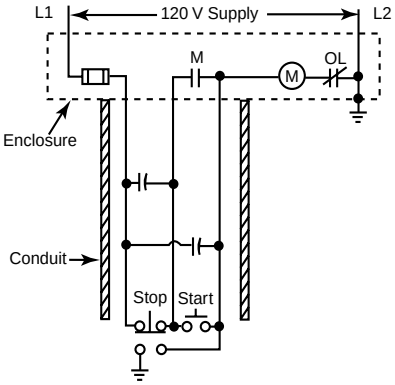

Figure 9: Capacitance Discharge Scheme

Discharging Shunt Capacitance

eliminates the problem of shunt capacitance, as well as greatly reducing the control circuit burden and, therefore, the effect of the series impedance.

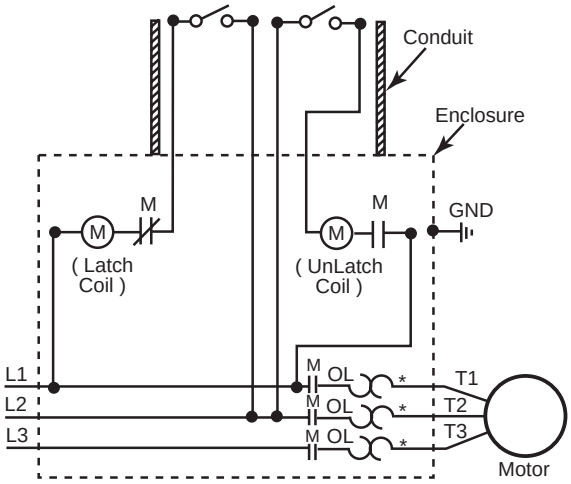

Figure 8: Mechanically Held Contactor or Relay
*** Overload Protection *not* Provided by Contactor**

If an interposing relay is not used and the distance limiting problem is due to the shunt capacitance effect on the control wires, a mechanically-held contactor or relay can be used, provided it has coil-clearing contacts (make sure that the relay or contactor selected will work properly with the use of coil clearing contacts). Since the coil clearing contacts are always located adjacent to the contactor coil, they are not shunted by the control wires' capacitance (see Figure 8). Series impedance becomes the limiting factor. Contact your Square D representative for help in selecting the proper mechanically-held device for your application (since the control distance depends upon the impedance of the latch and unlatch coils).

Figure 9 shows a circuit arrangement with an extra set of normally open contacts attached to the stop button. When the stop button is pressed, any current carried by the shunt capacitance is shorted to ground and bypasses the coil. When the stop button is released, the shunt capacitance again feeds the current to the starter coil, but it is very unlikely that the current value will be high enough for the coil to pick it up.

IMPORTANT! Always ensure that when the stop button is pressed, L1 is not shorted to ground as a result of arcing on the stop button contacts. For example, when using Class 9001 push buttons, the arc may transfer if a Type KA1 contact block is used. Instead, use a KA3 contact block for the stop button and a separate KA2 contact block to short the shunt capacitance to ground.

Resistance Sensitive Relays

Resistance sensitive relays are devices with input sensitivity that enables them to operate from substantially lower currents than standard electromechanical relays. Therefore, they are often able to operate over greater distances than electromechanical relays. Contact your Square D representative for complete application details.

NOTE: Use two isolated contact blocks for this function.

Tables

Class 8501, Type C

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 1: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO1	B	1	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	3500	2800	3100	3300
				120	760	685	570	450	510	535
				208	250	220	190	150	165	175
				240	190	170	140	110	125	130

* Distance for series impedance is shorter and is the limiting value.

Table 2: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO1	B	1	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	5600	6300	6700
				120	1500	1300	1100	900	1000	1000
				208	500	455	380	300	330	355
				240	380	340	285	225	255	265

* Distance for series impedance is shorter and is the limiting value.

Table 3: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO1	B	1	6	25	35	60	90	140	215
				12	100	155	245	375	575	865
				24	400	630	980	1500	2300	3400
				48	1600	2500	3900	6000	9200	13800
				120	10000	15800	24600	37900	57800	86600
				208	30300	47500	73900	114000	173600	260400
				240	40300	63200	98400	151700	231200	346600

Class 8501, Type C

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 4: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO-5	A	1	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	1700	1400	1100	1200	1300
				120	305	275	230	180	205	215
				208	100	90	75	60	65	70
				240	75	65	55	45	50	50

* Distance for series impedance is shorter and is the limiting value.

Table 5: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO-5	A	1	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	2800	2200	2500	2700
				120	615	550	460	365	410	430
				208	205	180	150	120	135	140
				240	150	135	115	90	100	105

* Distance for series impedance is shorter and is the limiting value.

Table 6: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO-5	A	1	6	25	40	65	100	155	230
				12	110	170	265	410	620	920
				24	445	695	1000	1600	2400	3600
				48	1700	2700	4300	6500	9900	14700
				120	11100	17300	26900	41200	62200	92100
				208	33400	52200	80900	123800	186900	276700
				240	44500	69500	107700	164900	248800	368400

Class 8501, Type C

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 7: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO11	A	1	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	3100
				48	1100	1 000	840	665	750	790
				120	175	160	130	105	120	125
				208	55	50	40	35	35	40
				240	40	40	30	25	30	30

* Distance for series impedance is shorter and is the limiting value.

Table 8: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO11	A	1	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	2000	1600	1300	1500	1500
				120	355	320	265	210	240	250
				208	115	105	85	70	75	80
				240	85	80	65	50	60	60

* Distance for series impedance is shorter and is the limiting value.

Table 9: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO11	A	1	6	25	45	70	105	160	240
				12	115	180	280	430	655	970
				24	465	730	1100	1700	2600	3800
				48	1800	2900	4500	6900	10500	15500
				120	11700	18200	28300	43400	65600	97400
				208	35100	54900	85100	130500	197200	292600
				240	46800	73100	113300	173700	262500	389600

Class 8501, Type C

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 10: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO15, CO16	A	S DT	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	3440	2730	3070	3230
				120	730	660	550	435	490	515
				208	240	215	180	145	160	170
				240	180	165	135	105	120	125

* Distance for series impedance is shorter and is the limiting value.

Table 11: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO15, CO16	A	S DT	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	5465	6140	6465
				120	1465	1320	1100	870	980	1030
				208	485	435	365	290	325	340
				240	365	330	275	215	245	255

* Distance for series impedance is shorter and is the limiting value.

Table 12: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	CO15, CO16	A	S DT	6	25	40	60	95	145	220
				12	105	165	255	395	595	880
				24	425	670	1035	1585	2385	3520
				48	1715	2680	4145	6340	9545	14090
				120	10740	16760	25925	39625	59655	88080
				208	32275	50360	77890	119055	179230	264640
				240	42970	67045	103700	158505	238625	352335

Class 8501, Type H

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 13: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	H	A,B,C	2-8	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	1700	1300	1500	1600
				208	780	700	585	460	520	545
				240	585	525	435	345	390	410

* Distance for series impedance is shorter and is the limiting value.

Table 14:

Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	H	A,B,C	2-8	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	2700	3100	3300
				208	1500	1400	1100	925	1000	1000
				240	1100	1000	875	695	780	825

* Distance for series impedance is shorter and is the limiting value.

Table 15: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	H	A,B,C	2-8	6	1	3	4	7	10	15
				12	7	10	15	25	45	65
				24	30	45	75	115	180	270
				48	125	195	305	475	725	1000
				120	790	1240	1935	2900	4500	6900
				208	2300	3700	5800	8900	13600	20500
				240	3100	4900	7700	11900	18200	27300

Class 8501, Type HX

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 16: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	HX	C	8-12	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	2745	2890
				208	1365	1225	1025	810	910	960
				240	1025	920	770	610	685	720

* Distance for series impedance is shorter and is the limiting value.

Table 17: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	HX	C	8-12	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
				208	*	2455	2050	1625	1825	1925
				240	2050	1845	1540	1220	1370	1445

* Distance for series impedance is shorter and is the limiting value.

Table 18: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	HX	C	8-12	6	1	2	3	5	8	10
				12	6	9	15	20	35	50
				24	20	35	60	90	140	210
				48	95	155	240	370	565	850
				120	620	975	1520	2340	3555	5310
				208	1875	2935	4565	7030	10680	15960
				240	2495	3910	6080	9360	14220	21250

Class 8501, Type KF

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 19: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	KF	C	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	4620	4865
				48	1725	1550	1295	1025	1155	1215
				120	275	245	205	160	180	190
				208	90	80	65	50	60	60
				240	65	60	50	40	45	45

* Distance for series impedance is shorter and is the limiting value.

Table 20: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	KF	C	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	3450	3105	2590	2055	2310	2430
				120	550	495	410	325	365	385
				208	180	165	135	105	120	125
				240	135	120	100	80	90	95

* Distance for series impedance is shorter and is the limiting value.

Table 21: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	KF	C	All	6	60	95	150	230	350	525
				12	245	385	600	925	1410	2115
				24	985	1545	2410	3710	5655	8470
				48	3950	6195	9640	14855	22620	33885
				120	24715	38725	60255	92860	141375	211805
				208	74260	116355	181030	279005	424760	636370
				240	98870	154910	241020	371455	565506	847235

Class 8501, Type KP, KU

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 22: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	KP, KU	C	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	3540	3980	4190
				48	1485	1335	1115	885	995	1045
				120	235	210	175	140	155	165
				208	75	70	55	45	50	55
				240	55	50	40	36	35	40

* Distance for series impedance is shorter and is the limiting value.

Table 23: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	KP, KU	C	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	8380
				48	2970	2675	2230	1770	1990	2095
				120	475	425	355	280	315	335
				208	155	140	115	90	105	110
				240	115	105	85	70	75	80

* Distance for series impedance is shorter and is the limiting value.

Table 24: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	KP, KU	C	All	6	75	115	180	280	430	645
				12	300	470	735	1135	1730	2590
				24	1205	1890	2945	4540	6920	10370
				48	4835	7575	11790	18175	27680	41480
				120	30230	47365	73705	113615	173010	259275
				208	90825	142315	221450	341355	519800	778990
				240	120920	189475	294835	454470	692045	—

Class 8501, Type LO

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

*NOTE: Distances shown below apply **only** to those Type L relays utilizing the 31111-400 series coils.*

Table 25: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	LO	A	2–8	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	1510	1200	1350	1420
				208	670	600	500	400	445	470
				240	500	450	375	300	335	355

* Distance for series impedance is shorter and is the limiting value.

Table 26: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	LO	A	2–8	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	2400	2700	2840
				208	1340	1250	1005	800	895	945
				240	1005	905	755	600	675	710

* Distance for series impedance is shorter and is the limiting value..

Table 27: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	LO	A	2–8	6	2	4	6	10	15	20
				12	10	15	25	40	60	90
				24	40	65	100	160	245	365
				48	170	265	415	640	980	1475
				120	1065	1670	2605	4025	6145	9240
				208	3205	5025	7835	12100	18470	27770
				240	4265	6695	10430	16110	24595	36975

Class 8501, Type R

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 28: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE			
					#16	#14	#12	#10
8501	R	A	4 DT	6	*	*	*	*
				12	*	*	*	*
				24	*	*	2515	1995
				48	835	750	625	495
				120	130	120	100	75
				240	30	30	25	15

* Distance for series impedance is shorter and is the limiting value.

Table 29: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE			
					#16	#14	#12	#10
8501	R	A	4 DT	6	*	*	*	*
				12	*	*	*	*
				24	*	*	*	3995
				48	1675	1505	1255	995
				120	265	240	200	155
				240	65	60	50	35

* Distance for series impedance is shorter and is the limiting value.

Table 30: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE			
					#16	#14	#12	#10
8501	R	A	4 DT	6	80	130	205	315
				12	330	520	820	1270
				24	1335	2095	3280	5090
				48	5340	8395	13125	20360
				120	33390	52485	82035	127250
				240	133560	209940	328145	509015

Class 8501, Type XO

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 31: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	XO	A	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	1170	975	775	870	915
				208	430	390	325	255	290	305
				240	325	290	240	190	215	225

* Distance for series impedance is shorter and is the limiting value.

Table 32: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	XO	A	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	1950	1550	1740	1835
				208	865	780	650	515	580	610
				240	650	585	485	385	435	455

* Distance for series impedance is shorter and is the limiting value.

Table 33: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	XO	A	All	6	3	4	7	10	15	20
				12	10	15	25	45	65	95
				24	45	75	115	180	265	390
				48	195	310	475	720	1075	1565
				120	1245	1935	2980	4520	6730	9805
				208	3745	5825	8960	13585	20230	29455
				240	4990	7755	11925	18085	26935	39220

Class 8501, Type XL

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 34: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	XL (Unlatch Coil ▲)	A	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	3875	4080
				120	925	830	695	550	620	650
				208	305	275	230	180	205	215
				240	230	205	170	135	155	160

* Distance for series impedance is shorter and is the limiting value.
▲ For information on pick-up coil, see “Class 8501, Type XO” on page 15.

Table 35: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	XL (Unlatch Coil ▲)	A	All	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	1850	1665	1390	1100	1240	1305
				208	615	555	460	365	410	430
				240	460	415	345	275	310	325

* Distance for series impedance is shorter and is the limiting value.
▲ For information on pick-up coil, see “Class 8501, Type XO” on page 15.

Table 36: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8501	XL (Unlatch Coil ▲)	A	All	6	10	15	30	45	70	105
				12	45	75	120	185	285	435
				24	195	310	485	750	1155	1745
				48	790	1240	1940	3010	4620	6990
				120	4950	7780	12150	18825	28875	43690
				208	14875	23370	36505	56570	86765	131275
				240	19805	31120	48605	75315	115515	174760

* Distance for series impedance is shorter and is the limiting value.
▲ For information on pick-up coil, see “Class 8501, Type XO” on page 15.

Class 8502/ 8536, Type SA

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 37: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SA	B	2-3	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	1800	1430	1605	1690
				208	800	715	600	475	535	560
				240	600	540	450	355	400	420
				277	450	405	335	265	300	315
				480	150	135	110	85	100	105
				600	95	85	70	55	60	65

* Distance for series impedance is shorter and is the limiting value.

Table 38: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SA	B	2-3	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	2860	3215	3385
				208	1600	1435	1200	950	1070	1125
				240	1200	1080	900	715	800	845
				277	900	810	675	535	600	635
				480	300	270	225	175	200	210
				600	190	170	140	110	125	135

* Distance for series impedance is shorter and is the limiting value.

Table 39: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SA	B	2-3	6	2	3	5	7	10	15
				12	8	10	20	30	45	70
				24	30	50	80	125	190	286
				48	135	210	330	505	770	1150
				120	850	1335	2070	3185	4825	7185
				208	2565	4015	6230	9570	14505	21595
				240	3415	5345	8295	12745	19310	28755
				277	4550	7120	11055	16975	25725	38305
				480	13675	21390	33195	50980	77250	115020
				600	21365	33420	51870	79660	120705	179720

Class 8502/8536, Type SB and SC
Class 8903, Type SM (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 40: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
				6	*	*	*	*	*	*
				12	*	*	*	*	*	*
8502	SB			24	*	*	*	*	*	*
8536	SC			48	*	*	*	*	*	*
				120	*	*	*	1500	1700	1800
		A	All	208	880	795	660	525	590	620
				240	660	595	495	395	440	485
8903	SM			277	495	445	370	295	330	350
				480	165	145	120	95	110	115
				600	105	95	75	60	70	70

* Distance for series impedance is shorter and is the limiting value.

Table 41: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
				6	*	*	*	*	*	*
				12	*	*	*	*	*	*
8502	SB			24	*	*	*	*	*	*
8536	SC			48	*	*	*	*	*	*
				120	*	*	*	*	*	3700
		A	All	208	*	1500	1300	1000	1100	1200
				240	1300	1100	995	790	885	935
8903	SM			277	995	895	745	590	665	700
				480	330	295	245	195	220	230
				600	210	190	155	125	140	145

* Distance for series impedance is shorter and is the limiting value.

Table 42: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
				6	1	2	3	5	7	10
				12	5	8	10	20	30	45
8502	SB			24	20	30	50	80	120	185
8536	SC			48	85	135	210	325	495	745
				120	535	845	1300	2000	3100	4600
		A	All	208	1600	2500	3900	6100	9300	14000
				240	2100	3300	5200	8100	12400	18600
8903	SM			277	2800	4500	7000	10800	16500	24900
				480	8600	13500	21000	32500	49700	74700
				600	13400	21100	32900	50900	77700	116800

Class 8502/8536, Type SD
Class 8903, Type SP (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 43: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SD	A	2 & 3	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	2600	2700
8903	SP			208	1300	1100	980	780	875	920
				240	980	885	735	585	655	690
				277	735	665	550	440	490	520
				480	245	220	180	145	160	170
				600	155	140	115	90	105	110

* Distance for series impedance is shorter and is the limiting value.

Table 44: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SD	A	2 & 3	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
8903	SP			208	*	2300	1900	1500	1700	1800
				240	1900	1700	1400	1100	1300	1300
				277	1400	1300	1100	880	985	1000
				480	490	440	365	290	325	345
				600	315	280	235	185	210	220

* Distance for series impedance is shorter and is the limiting value.

Table 45: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SD	A	2 & 3	6	1	2	3	4	7	10
				12	5	8	10	15	25	40
				24	20	30	50	75	110	165
				48	80	125	200	305	455	670
				120	515	810	1200	1900	2800	4200
8903	SP			208	1500	2400	3700	5700	8500	12600
				240	2000	3200	5000	7600	11400	16800
				277	2700	4300	6600	10100	15200	22400
				480	8300	12900	20000	30500	45700	67200
				600	12900	20200	31200	47600	71500	105100

Class 8502/8536, Type SD
Class 8903, Type SP (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 46: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SD	A	4 & 5	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	1960	2065
8903	SP			208	975	875	730	580	650	685
				240	730	660	550	435	490	515
				277	550	495	410	325	365	385
				480	180	165	135	105	120	125
				600	115	105	85	65	75	80

* Distance for series impedance is shorter and is the limiting value.

Table 47: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SD	A	4 & 5	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
8903	SP			208	*	1755	1465	1160	1305	1375
				240	1465	1320	1100	870	890	1030
				277	1100	990	825	655	735	775
				480	365	330	275	215	245	255
				600	230	210	175	135	155	165

* Distance for series impedance is shorter and is the limiting value.

Table 48: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SD	A	4 & 5	6	0	1	2	3	5	7
				12	3	5	9	10	20	30
				24	15	20	35	55	80	120
				48	60	95	145	220	330	485
				120	380	595	915	1395	2090	3060
8903	SP			208	1150	1790	2760	4200	6280	9195
				240	1530	2385	3675	5590	8360	12245
				277	2040	3175	4895	7445	11140	16310
				480	6125	9540	14700	22365	33450	48980
				600	9575	14905	22975	34945	52270	76530

Class 8502/8536, Type SE
Class 8903, Type SQ (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 49: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SE	A	2 & 3	24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
				208	*	*	1000	870	980	1000
				240	*	990	825	655	735	775
8903	SQ			277	825	740	620	490	550	580
				480	275	245	205	160	180	190
				600	175	155	130	100	115	120

* Distance for series impedance is shorter and is the limiting value.

Table 50: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SE	A	2 & 3	24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
				208	*	*	*	1700	1900	2000
				240	*	*	1600	1300	1400	1500
8903	SQ			277	*	1400	1200	980	1100	1100
				480	550	495	410	325	365	385
				600	350	315	260	205	235	245

* Distance for series impedance is shorter and is the limiting value.

Table 51: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SE	A	2 & 3	24	9	14	20	30	50	70
				48	35	55	85	135	200	295
				120	230	360	555	845	1200	1800
				208	695	1000	1600	2500	3800	5600
				240	925	1400	2200	3300	5000	7400
8903	SQ			277	1200	1900	2900	4500	3700	9900
				480	3700	5700	8900	13500	20300	29900
				600	5700	9000	13900	21200	31800	46700

Class 8502/8536, Type SE
Class 8903, Type SQ (Electrically Held)

Class 8502/8536, Type SF
Class 8903, Type SV (Electrically Held)

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Maximum Control Distance

Table 52: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SE	A	4 & 5	24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
8903	SQ			208	*	*	*	1500	1700	1800
8502 8536	SF	A	All	240	*	*	*	1100	1300	1300
				277	*	*	1100	885	995	1000
8903	SV			480	495	445	370	295	330	345
				600	315	285	235	185	210	220

* Distance for series impedance is shorter and is the limiting value.

Table 53: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SE	A	4 & 5	24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
8903	SQ			208	*	*	*	*	*	*
8502 8536	SF	A	All	240	*	*	*	*	2600	2700
				277	*	*	*	1700	1900	2000
8903	SV			480	990	890	740	590	660	695
				600	630	570	475	375	420	445

* Distance for series impedance is shorter and is the limiting value.

Table 54: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SE	A	4 & 5	24	5	9	10	20	30	45
				48	20	35	55	85	125	185
				120	145	230	355	540	805	1100
8903	SQ			208	445	695	1000	1600	2400	3500
8502 8536	SF	A	All	240	595	925	1400	2100	3200	4600
				277	795	1200	1900	2800	4200	6200
8903	SV			480	2300	3700	5700	8600	12800	18700
				600	3700	5700	8900	13500	20100	29300

Class 8502/8536, Type SGO
Class 8903, Type SXO (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 55: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SGO	B	All	120	*	*	*	*	*	*
				208	*	*	*	*	*	1790
				240	*	*	*	*	1280	1340
8903	SXO			277	*	*	*	850	960	1010
				480	480	430	360	280	320	340
				600	940	845	705	560	630	660

* Distance for series impedance is shorter and is the limiting value.

Table 56: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SGO	B	All	120	*	*	*	*	*	*
				208	*	*	*	*	*	*
				240	*	*	*	*	*	*
8903	SXO			277	*	*	*	*	1920	2000
				480	950	860	720	570	640	670
				600	1800	1600	1400	1100	1200	1300

* Distance for series impedance is shorter and is the limiting value.

Table 57: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536	SGO	B	All	120	65	105	165	260	410	640
				208	200	320	500	790	1240	1920
				240	270	420	670	1050	1640	2600
8903	SXO			277	355	565	890	1400	2200	3400
				480	1070	1700	2700	4200	6600	10200
				600	2100	3300	5000	7500	11000	15600

Class 8502/8536, Type SH
Class 8903, Types SY, SZ (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 58: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502	SH	A	All	120	*	*	*	*	*	*
8536				208	*	*	*	*	*	*
				240	*	*	*	*	1200	1300
8903	SY, SZ			277	*	*	*	850	955	1000
				480	475	425	355	280	315	335
				600	305	270	225	180	200	215

* Distance for series impedance is shorter and is the limiting value.

Table 59: Maximum control distance in feet due to Shunt Capacitance (2-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502	SH	A	All	120	*	*	*	*	*	*
8536				208	*	*	*	*	*	*
				240	*	*	*	*	*	*
8903	SY, SZ			277	*	*	*	*	1900	2000
				480	950	855	715	565	635	670
				600	610	545	455	360	405	430

* Distance for series impedance is shorter and is the limiting value.

Table 60: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502	SH	A	All	120	65	105	165	255	390	585
8536				208	200	315	495	765	1100	1700
				240	265	420	660	1000	1500	2300
8903	SY, SZ			277	355	560	880	1300	2000	3100
				480	1000	1600	2600	4000	6200	9400
				600	1600	2600	4100	6300	9700	14700

Class 8502/8536, Type SJ
Class 8903, Types SJ (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 61: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536 8903	SJ	A	All	120	*	*	*	*	*	*
				208	*	*	*	*	*	960
				240	*	*	*	610	685	720
				277	*	*	575	455	510	540
				480	255	230	190	150	170	180
				600	160	145	120	95	105	115

* Distance for series impedance is shorter and is the limiting value.

Table 62: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536 8903	SJ	A	All	120	*	*	*	*	*	*
				208	*	*	*	*	*	*
				240	*	*	*	*	*	1440
				277	*	*	*	915	1025	1080
				480	510	460	380	305	340	360
				600	325	295	245	195	215	230

* Distance for series impedance is shorter and is the limiting value.

Table 63: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8502 8536 8903	SJ	A	All	120	40	70	110	175	275	430
				208	130	210	335	525	830	1295
				240	175	280	445	700	1105	1730
				277	235	375	590	935	1470	2300
				480	710	1125	1780	2810	4420	6920
				600	1110	1760	2785	4395	6910	10810

Class 8903, Type L (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 64: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8903	L	B	2-6	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	1700	1300	1500	1600
				208	780	700	585	460	520	545
				240	585	525	435	345	390	410

* Distance for series impedance is shorter and is the limiting value.

Table 65: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8903	L	B	2-6	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	2700	3100	3300
				208	1500	1400	1100	925	1000	1000
				240	1100	1000	875	695	780	825

* Distance for series impedance is shorter and is the limiting value.

Table 66: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8903	L	B	2-6	6	1	3	4	7	10	15
				12	7	10	15	25	45	65
				24	30	45	75	115	180	270
				48	125	195	305	475	725	1000
				120	790	1240	1935	2900	4500	6900
				208	2300	3700	5800	8900	13600	20500
				240	3100	4900	7700	11900	18200	27300

* Distance for series impedance is shorter and is the limiting value.

Class 8903, Type L (Electrically Held)

Maximum Control Distance

The maximum control distance in feet between the device and its control station is shown. Calculations take into account two or three lengths of wire and the values shown represent the actual distance between the device and control station. Shunt capacitance distances are based on full source voltage. Series impedance distances are based on a difference of 5% between the coil and source voltage during inrush conditions. All values shown are for 60 Hz only.

Table 67: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8903	L	B	8-12	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	2745	2890
				208	1365	1225	1025	810	910	960
				240	1025	920	770	610	685	720

* Distance for series impedance is shorter and is the limiting value.

Table 68: Maximum control distance in feet due to Shunt Capacitance (3-wire control in water filled conduit)

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8903	L	B	8-12	6	*	*	*	*	*	*
				12	*	*	*	*	*	*
				24	*	*	*	*	*	*
				48	*	*	*	*	*	*
				120	*	*	*	*	*	*
				208	*	2455	2050	1625	1825	1925
				240	2050	1845	1540	1220	1370	1445

* Distance for series impedance is shorter and is the limiting value.

Table 69: Maximum control distance in feet due to Series Impedance

Class	Type	Series	Poles	Voltage	WIRE GAUGE					
					#16	#14	#12	#10	#8	#6
8903	L	B	8-12	6	1	2	3	5	8	10
				12	6	9	15	20	35	50
				24	20	35	60	90	140	210
				48	95	155	240	370	565	850
				120	620	975	1520	2340	3555	5310
				208	1875	2935	4565	7030	10680	15960
				240	2495	3910	6080	9360	14220	21250

Square D Company
8001 Hwy 64 East
Knightdale, NC 27545
888-SquareD (778-2733)
www.squared.com