Amphenol
Advanced Sensors

NTC Inrush Current Limiters
CL Series

February 11th, 2014

Inrush Current Limiter Q&A

1. **What is Current Limiting**?
   - Current limiting is the practice in electrical or electronic circuits of imposing an upper limit on the current that may be delivered to a load with the purpose of protecting the circuit generating or transmitting the current from harmful effects due to a short-circuit or similar problem in the load.
   - This term is also used to describe the ability of an overcurrent protective device (fuse or circuit breaker) to reduce the peak current in a circuit, by opening and clearing the fault in a sub-cycle time frame.
2. **What are Current Limiting Devices?**
   - For main current control, it is a simple as a fuse or circuit breaker.
3. **Why use a current limiter if fuses or circuit breakers can be used to protect the circuit**?
   - A fuse can be too slow for inrush current applications. By the time the fuse blows, it may damage critical components in the system.
4. **Why use a NTC thermistor to stop inrush current?**
   - Active circuits, resistors, varistors, etc. can be used. A NTC thermistor is a relatively low cost device and when at steady state it is relatively invisible to the circuit. This is due to the low resistance value of the NTC when power is applied.

Inrush Current Limiter Benefits

Cramped for Space? - Smaller inrush current limiters – high energy absorption capability

Smaller physical size NTC thermistors for limiting inrush and surge currents offer design-in benefits over larger passive components for ***circuit protection in power supplies***. Amphenol Thermometrics NTC Inrush Current Limiters CL Series, have one of the best capacitance ratings in the industry

Benefits

- UL approved
- Low cost, reliable device
- Excellent mechanical strength
- Suitable for PCB mounting
- Various lead configurations available

Inrush Current Limiter Applications

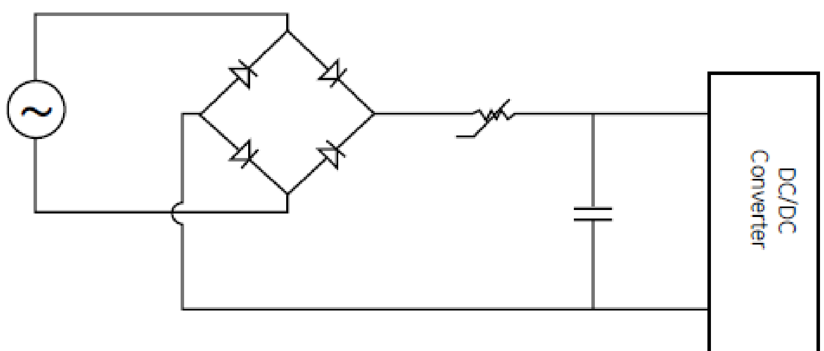
Applications
Control of the inrush current in …

- ➢ Switching Power Supplies
- ➢ Fluorescent Lamps
- ➢ Inverters
- ➢ Motors
- ➢ Etc.

Inrush Current Limiters

Inrush Current Limiters in Switching Power Supplies

- Current surges in switch-mode power supplies is caused by large filter capacitors used to smooth the ripple in a rectified AC wave form.
- In these cases, the large filter capacitors appear as shorts in the circuit.
- The energy required to charge these capacitors is calculated as ½ CV^2 where C is the capacitance and V is the peak line voltage



Typical Power Supply Circuit

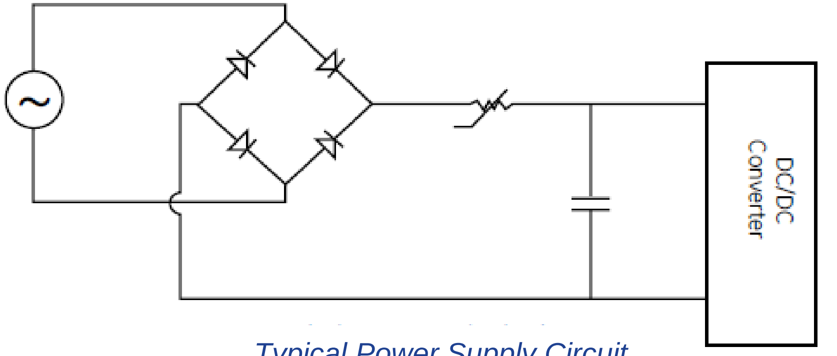
Large Capacitors in a Power Supply

Inrush Current Limiters

Capacitance

- Understanding the capacitance of the system at start up is important.
- Capability to suppress surge is key to qualification of ICL thermistors.
- Section 26 of UL 1434 specifies 3 critical parameters …

1. V_{max}
2. I_{max}
3. Capacitance



Typical Power Supply Circuit

CL Series Selection Criteria

Step 1. Maximum Steady State Current, I_{max}

- CL Series is rated for maximum steady state current, I_{max}.
- The maximum steady state current is mainly determined by the acceptable life of the final products for which the thermistor becomes a component.

$Pdt = Hdt + \delta(T-T_A)$ reduces to $Power = I^2R = \delta(T-T_A)$

Where:
P = Power generated in the NTC
t = Time
H = Heat capacity of the thermistor
T = Temperature of the thermistor body
δ = Dissipation constant
T_A = Ambient temperature

Example:

- Power supply, 100 watts, is rated to an efficiency of 80%, 100% load is calculated to 125
- The maximum input current is calculated at the minimum power supply. In the case of a standard 120V supply, this would be 110V.
- I_{max} is calculated by 125 watts/110V = 1.14 Amps

CL Series Selection Criteria

Step 2. Maximum Inrush Current

- Review the components inline with the ICL, such as the diode bridge.
- In the case of the diode bridge rated at 200 Amps, one should select a CL that would limit the max surge current to 50% of the rating, therefore limit the surge to a maximum of 100 Amps.
- In the case of a 120V supply, the peak voltage is 170 V.
- R = V/I = 170 V/100 Amps = 1.7 ohms minimum
- NOTE: The listed maximum current flow is rated at 25°C, so derating is required if the ambient temperature is greater than 25°C.

Step 3. Bulk Capacitance of Device

- On power, the bulk capacitance of the device appears as a short to the system. The designer needs to understand bulk capacitance at the RMS voltage rating of the system.
- Assuming input capacitance is approximately 500 μFds, the selection of the CL needs to be able to absorb input energy.

CL Series Sample Selection

From Steps 1 through 3 in the previous slides, selection criteria results:

1. I_{max} > 1.14 Amps
2. Max allowable input current 100 amps @ 170 V peak = 1.7 Ω
3. Bulk Capacitance = 500 µF

With this example, multiple CL's could be selected. So, select the **smallest physical size CL with the lowest steady state resistance** to achieve the required protection.

CL-120 is the selected Inrush Current Limiter

Amphenol's Thermometrics NTC CL Series

Type	Res. @ 25°C (Ω) ±25%	Max* Steady State Current (Amps RMS)	Max Disc Dia. in (mm)	Max Disc Thick in (mm)	C_x Max** (µ Farads)		Max Energy (Joules)	Equation Constants for resistance under load***			Approx. Res. Under Load at % Max Rated Current				Diss. Constant (mW/°C)	Time Constant (sec.)	Max Current Flow @ 25°C and 240 V Rms (Amps)
					@120 VAC	@240 VAC		X	Y	Current Range Min I / Max I	25%	50%	75%	100%			
CL-11	0.7	12	0.77 (19.56)	0.22 (5.59)	2700	675	19.44	0.5	-1.18	4.0 ≤I≤ 12	0.14	0.06	0.04	0.03	25	100	457
CL-21	1.3	8	0.55 (13.97)	0.21 (5.33)	800	200	5.76	0.6	-1.25	3.0≤I≤ 8.0	0.25	0.11	0.06	0.04	15	60	246
CL-30	2.5	8	0.77 (19.56)	0.22 (5.59)	6000	1500	43.20	0.81	-1.25	2.5≤I≤8.0	0.34	0.14	0.09	0.06	25	100	128
CL-40	5	6	0.77 (19.56)	0.22 (5.59)	5200	1300	37.44	1.09	-1.27	1.5≤I≤6.0	0.65	0.27	0.16	0.11	25	100	64
CL-50	7	5	0.77 (19.56)	0.26 (6.60)	5000	1250	36.00	1.28	-1.27	1.5≤I≤5.0	0.96	0.40	0.24	0.17	25	120	46
CL-60	10	5	0.77 (19.56)	0.22 (5.59)	5000	1250	36.00	1.45	-1.3	1.2≤I≤5.0	1.08	0.44	0.26	0.18	25	100	32
CL-70	16	4	0.77 (19.56)	0.22 (5.59)	5000	1250	36.00	1.55	-1.26	1.0≤I≤4.0	1.55	0.65	0.39	0.27	25	100	20
CL-80	47	3	0.77 (19.56)	0.22 (5.59)	5000	1250	36.00	2.03	-1.29	0.5≤I≤3.0	2.94	1.20	0.71	0.49	25	100	7
CL-90	120	2	0.93 (23.62)	0.22 (5.59)	5000	1250	36.00	3.04	-1.36	0.5≤I≤2.0	7.80	3.04	1.75	1.18	30	120	3
CL-101	0.5	16	0.93 (23.62)	0.22 (5.59)	4000	1000	28.80	0.44	-1.12	4.0≤I≤16	0.09	0.04	0.03	0.02	30	120	640
CL-110	10	3.2	0.40 (10.16)	0.17 (4.32)	600	150	4.32	0.83	-1.29	0.7≤I≤3.2	1.11	0.45	0.27	0.19	8	30	32
CL-120	10	1.7	0.40 (10.16)	0.17 (4.32)	600	150	4.32	0.61	-1.09	0.4≤I≤1.7	1.55	0.73	0.47	0.34	4	90	32
CL-130	50	1.6	0.45 (11.43)	0.17 (4.32)	600	150	4.32	1.45	-1.38	0.4≤I≤1.6	5.13	1.97	1.13	0.76	8	30	6
CL-140	50	1.1	0.45 (11.43)	0.17 (4.32)	600	150	4.32	1.01	-1.28	0.2≤I≤1.1	5.27	2.17	1.29	0.89	4	90	6
CL-150	5	4.7	0.55 (13.97)	0.18 (4.57)	1600	400	11.52	0.81	-1.26	1.0≤I≤4.7	0.66	0.28	0.17	0.12	15	110	64
CL-160	5	2.8	0.55 (13.97)	0.18 (4.57)	1600	400	11.52	0.6	-1.05	0.8≤I≤2.8	0.87	0.42	0.28	0.20	9	130	64
CL-170	16	2.7	0.55 (13.97)	0.18 (4.57)	1600	400	11.52	1.18	-1.28	0.5≤I≤2.7	1.95	0.80	0.48	0.33	15	110	20
CL-180	16	1.7	0.55 (13.97)	0.18 (4.57)	1600	400	11.52	0.92	-1.18	0.4≤I≤1.7	2.53	1.11	0.69	0.49	9	130	20
CL-190	25	2.4	0.55 (13.97)	0.18 (4.57)	800	200	5.76	1.33	-1.34	0.5≤I≤2.4	2.64	1.04	0.61	0.41	15	110	13
CL-200	25	1.7	0.55 (13.97)	0.18 (4.57)	800	200	5.76	0.95	-1.24	0.4≤I≤1.7	2.74	1.16	0.70	0.49	9	130	13
CL-210	30	1.5	0.40 (10.16)	0.2 (5.08)	600	150	4.32	1.02	-1.35	0.3≤I≤1.5	3.83	1.50	0.87	0.59	8	30	11

Data

*Maximum rating at 25°C (77°F) or

$I_{derated}=(\sqrt{(1.1425 - 0.0057 x T A)})$ x I_{max}@25°C

for ambient temperature other than 25°C (77°F)

**Maximum ratings

***$R_0 = X1^Y$

Resistance under load with respect to current draw can be calculated by using the constants listed in the table for the CL Series

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Amphenol's Thermometrics NTC CL Series

- CL's can be arranged in series to increase circuit protection
- Never arrange CL's in parallel as the resistance and dissipation differences in devices will allow more current to run through the lower resistance device. When this happens most of the energy will pass through this device and could damage it.

AMPHENOL ADVANCED SENSORS DIFFERENTIATORS

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