

CTM Magnetics

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Subject: Capacitor Cable Length Adds Harmonics

Application: High Frequency Sine Wave Filters

Case Study: Reducing Total Harmonics

IMPACT OF CABLE LENGTH ON HARMONIC DISTORTION

The Problem with Cable Length:

Connection cables (figure 1) add significant harmonic distortion to the overall motor drive system. CTM discovered the effect of cable lengths on harmonic distortion through customer provided field data. Figures 4-6 on the following pages highlight the amount of distortion generated by these cables. Note that CTM Magnetics produces far less harmonics when compared to our competitors.

Due to the additional noise generated from the cables, CTM recommends purchasing an integrated panel package type because it reduces the length of the inductor to capacitor connection cables (figure 2).

There are additional cabling factors that impact the performance of your filter. These factors include cable length, gauge, insulation ratings, and system frequency. If these factors aren't taken into consideration, you risk premature failure or severely reduced system performance.

When selecting cable connections, CTM recommends following table 1 below. The information in this table came from the National Electrical Code's guidelines on allowable ampacities of insulated conductors. Additionally, CTM recommends using the shortest possible cable connections to reduce the total harmonic distortion of the system.

Capacitor Connection Cables

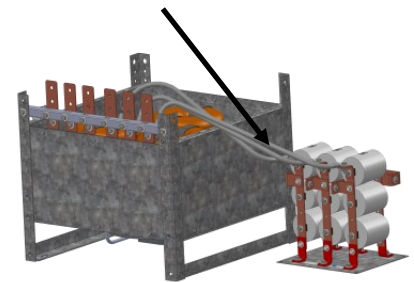


Figure 1. Air Cooled Modular Panel (With Capacitor Jumper Cables)

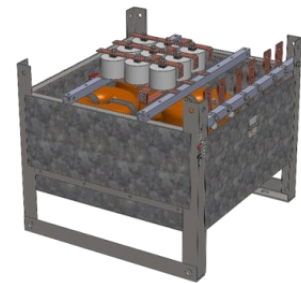


Figure 2. Air Cooled Integrated Panel (Shorter Capacitor Jumper Cables)

Insulated Cable Selection Table:

AWG	Diameter [inches]	Diameter [mm]	Area [mm ²]	Resistance [Ohms / 1000 ft]	Resistance [Ohms / km]	Max Current (30° C Ambient) [Amperes]			Max Current (40° C Ambient) [Amperes]			Max Frequency for 100% skin depth
						Temperature Rating of Conductor:			Temperature Rating of Conductor:			
						60° C (140° F)	75° C (167° F)	90° C (194° F)	60° C (140° F)	75° C (167° F)	90° C (194° F)	
0000 (4/0)	0.46	11.684	107	0.049	0.16072	195	230	260	160	204	236	125 Hz
000 (3/0)	0.4096	10.40384	85	0.0618	0.202704	165	200	225	135	177	205	160 Hz
00 (2/0)	0.3648	9.26592	67.4	0.0779	0.255512	145	175	195	119	155	177	200 Hz
0 (1/0)	0.3249	8.25246	53.5	0.0983	0.322424	125	150	170	102	133	155	250 Hz
1	0.2893	7.34822	42.4	0.1239	0.406392	110	130	145	90	115	132	325 Hz
2	0.2576	6.54304	33.6	0.1563	0.512664	95	115	130	78	102	118	410 Hz
4	0.2043	5.18922	21.2	0.2485	0.81508	70	85	95	57	75	86	650 Hz
6	0.162	4.1148	13.3	0.3951	1.295928	55	65	75	45	58	68	1100 Hz

Note: This table includes ampacity ratings of insulated conductors up to and including 2,000 V, 30 °C ambient temperature, and not more than three current-carrying conductors in raceway, cable, or earth per NEC guidelines.

Table 1. Cable selection chart based on ampacity and cable insulation rating

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Harmonic Distortion Created by Cable Connections:

Figures 4 through 6 compare the filter performance of CTM’s HighSine 350 filter against 2 other market standard high frequency sine wave filters. The data was provided by a customer who ran an identical test against all three sine wave filters.

After reviewing the test results, CTM identified the root cause of the harmonics shown encircled by the red bubble, on figures 4-6. The harmonics at that location were caused by the cable lengths connecting the inductor to the capacitor portion of the filter. It is for this reason CTM recommends our customers purchase an integrated panel package type as it reduces the length of the inductor to capacitor connection cables. This, in turn, increases the filter’s performance.

CTM sine wave filters are able to filter out more harmonics than any of our competitors. If your are looking at purchasing a sine wave filter to protect your motor, CTM’s sine wave filter product lines have the highest performance capabilities of any sine wave filter on the market. Higher performance, better quality, CTM.

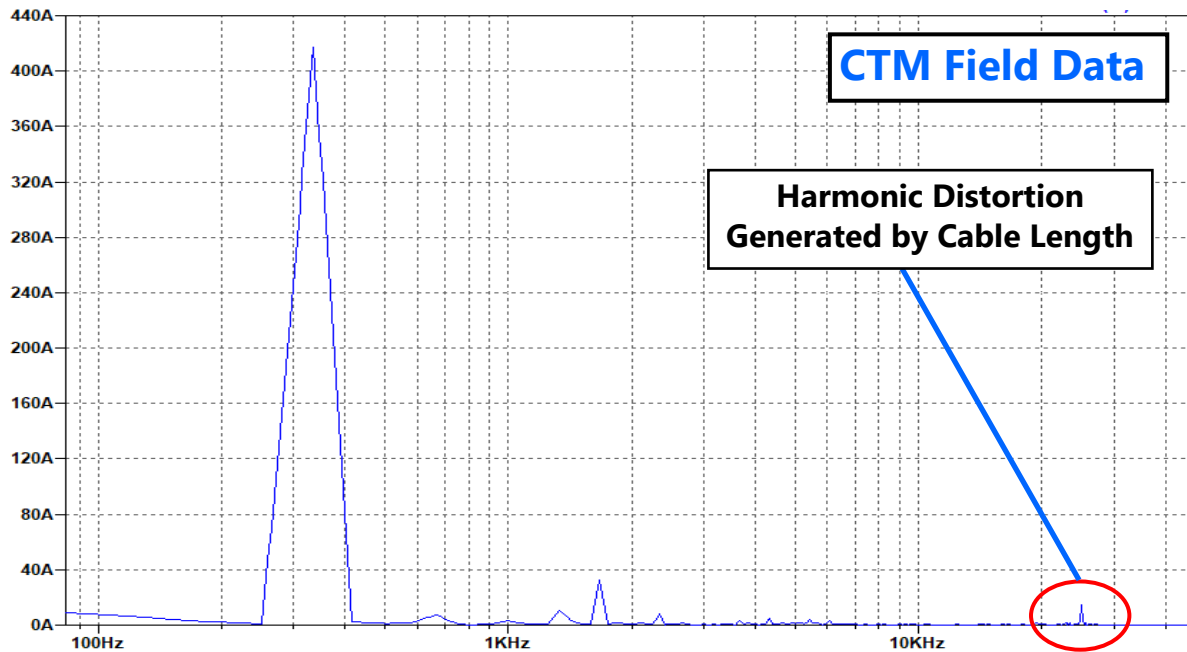


Figure 4. CTM HighSine 350 (420 A) Filter Output To Motor (11% THID) @ 71% Load

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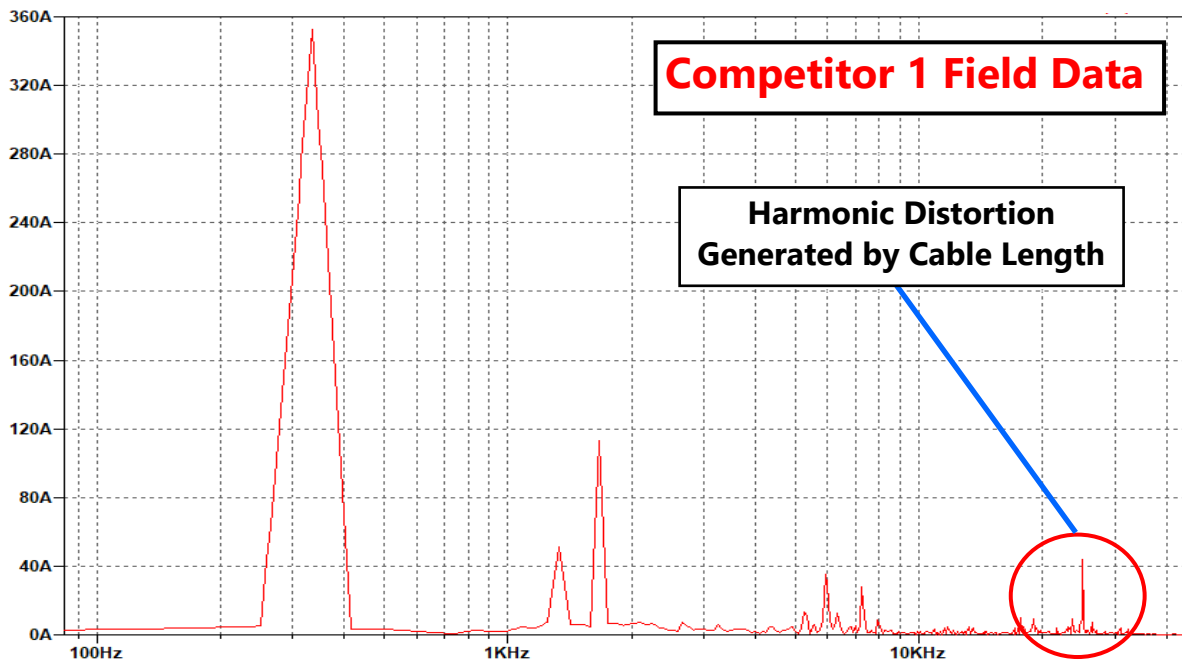


Figure 5. Competitor #1 (333 Hz - 420 A) Filter Output To Motor (40% THD) @ 65% Load

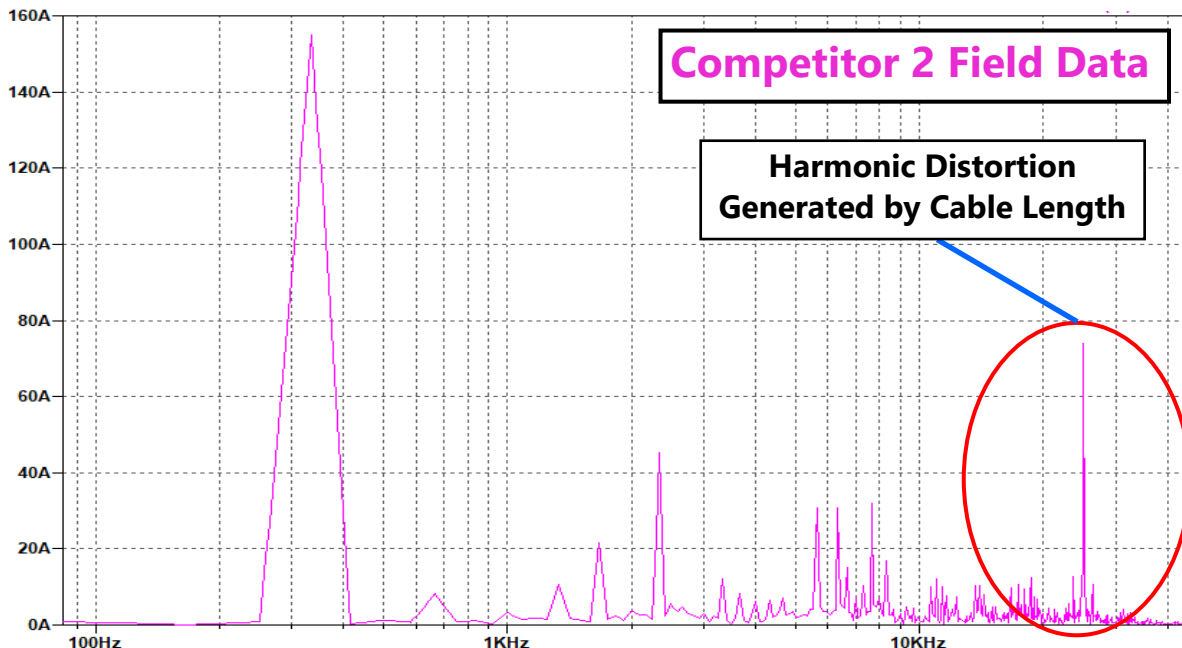


Figure 6. Competitor #2 (333 Hz - 420 A) Filter Output To Motor (75% THD) @ 32% Load