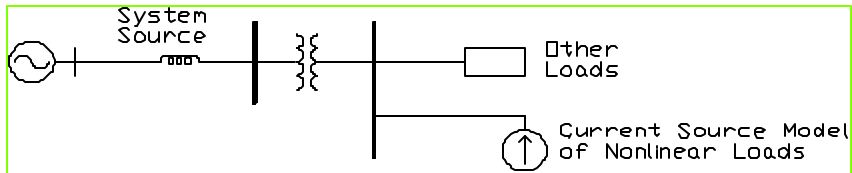
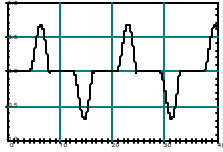
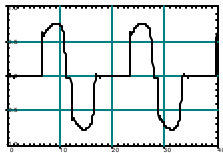
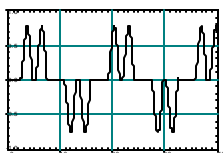
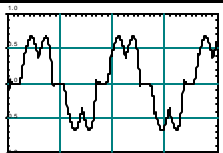
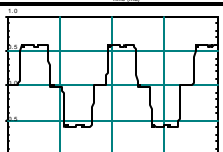
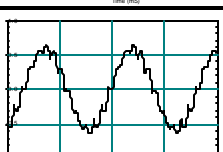
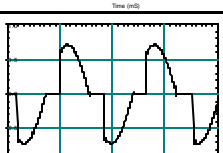
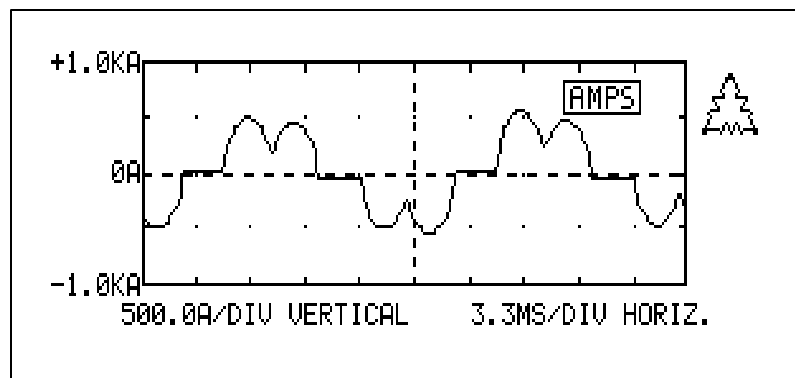


# Sources of Harmonics



Type of Load	Typical Waveform	Current Distortion	Weighting Factor ( $W_i$ )
Single Phase Power Supply		80% (high 3rd)	2.5
Semiconverter		high 2nd,3rd, 4th at partial loads	2.5
6 Pulse Converter, capacitive smoothing, no series inductance		80%	2.0
6 Pulse Converter, capacitive smoothing with series inductance > 3%, or dc drive		40%	1.0
6 Pulse Converter with large inductor for current smoothing		28%	0.8
12 Pulse Converter		15%	0.5
ac Voltage Regulator		varies with firing angle	0.7

# Example 1 - dc drive



VOLTAGE & CURRENT SNAPSHOT 11:21:16 AM

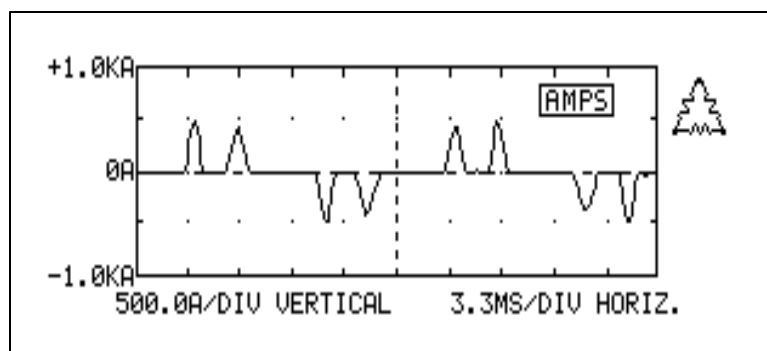
VOLTAGE		458.9 Vrms	
Phase A-B:	459.3 Vrms,	0°(ref)	
Phase B-C:	461.0 Vrms,	120°	
Phase C-A:	456.5 Vrms,	-121°	
Imbalance:	0.4%		
CURRENT		945.6 A rms	
Phase A:	339.5 A rms,	-75°	
Phase B:	347.8 A rms,	40°	
Phase C:	258.3 A rms,	157°	
Imbalance:	9.4%		

PHASE A CURRENT SPECTRUM 11:20:42 AM

Fundamental amps: 319.6 A rms  
Fundamental freq: 60.0 Hz

HARM	PCT	PHASE	HARM	PCT	PHASE
FUND	100.0%	-75°	2nd	4.8%	-64°
3rd	1.2%	28°	4th	1.5%	164°
5th	33.6%	156°	6th		
7th	1.6%	29°	8th	1.7%	-170°
9th	0.4%	-91°	10th	0.3%	96°
11th	8.7%	49°	12th		
13th	1.2%	54°	14th	1.3%	86°
15th	0.3%	148°	16th	0.2%	51°
17th	4.5%	-57°	18th		
19th	1.3%	-46°	20th	1.1%	-18°
21st	0.3%	34°	22nd	0.3%	-31°
23rd	2.8%	-163°	24th		
25th	1.2%	-149°	26th	0.9%	-123°
27th	0.3%	-75°	28th	0.3%	-128°
29th	2.0%	90°	30th		
31st	1.0%	107°	32nd	0.8%	133°
33rd	0.3%	173°	34th	0.3%	135°
35th	1.4%	-17°	36th		
37th	1.0%	2°	38th	0.8%	28°
39th	0.3%	63°	40th	0.3%	31°
41st	1.1%	-123°	42nd		
43rd	0.9%	-104°	44th	0.8%	-75°
45th	0.3%	-47°	46th	0.3%	-70°
47th	1.0%	128°	48th	0.2%	102°
49th	0.9%	152°	50th	0.7%	-179°
ODD	35.4%		EVEN	5.9%	
THD:	35.9%				

# Example 2 - PWM drive, no choke



VOLTAGE & CURRENT SNAPSHOT 11:50:56 AM

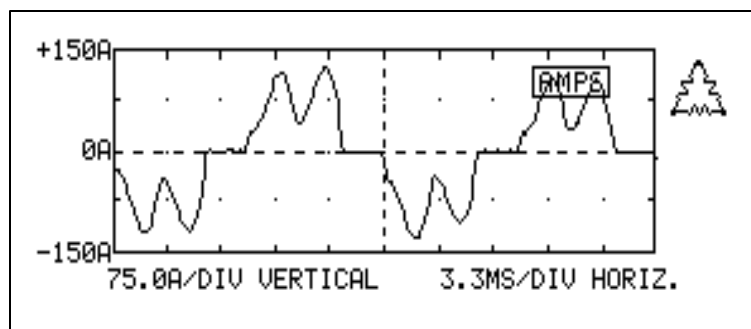
VOLTAGE		495.5 Vrms	
Phase A-B:	494.1 Vrms,	0°	(ref)
Phase B-C:	493.0 Vrms,	-120°	
Phase C-A:	499.3 Vrms,	120°	
Imbalance:	0.8%		
CURRENT		289.6 A rms	
Phase A:	171.5 A rms,	10°	
Phase B:	164.9 A rms,	-111°	
Phase C:	165.2 A rms,	131°	
Imbalance:	2.6%		

PHASE A CURRENT SPECTRUM 11:49:06 AM

Fundamental amps: 103.8 A rms  
Fundamental freq: 60.0 Hz

HARM	PCT	SINE PHASE	HARM	PCT	SINE PHASE
FUND	100.0%	10°	2nd	1.1%	78°
3rd	3.9%	-122°	4th	0.5%	167°
5th	82.8%	-125°	6th	1.7%	-56°
7th	77.5%	79°	8th	1.2%	131°
9th	7.6%	-80°	10th	0.7%	112°
11th	46.3%	-52°	12th	1.0%	-48°
13th	41.2%	149°	14th		
15th	5.7%	-26°	16th	0.3%	172°
17th	14.2%	19°	18th	0.4%	78°
19th	9.7%	-145°	20th	0.4%	-138°
21st	2.3%	19°	22nd	0.5%	-14°
23rd	1.5%	-148°	24th	0.5%	89°
25th	2.5%	108°	26th	0.7%	-135°
27th	0.9%	-29°	28th	0.3%	9°
29th	2.0%	-29°	30th	0.2%	55°
31st	2.0%	169°	32nd	0.3%	149°
33rd	0.5%	-19°	34th	0.4%	-61°
35th	0.3%	-147°	36th	0.1%	25°
37th	0.8%	75°	38th	0.3%	148°
39th	0.5%	-58°	40th		
41st	0.6%	-100°	42nd		
43rd	0.7%	114°	44th	0.1%	113°
45th	0.4%	-59°	46th	0.1%	-32°
47th	0.2%	165°	48th		
49th	0.4%	44°	50th	0.3%	144°
ODD	130.9%		EVEN	3.0%	
THD:	130.9%				

# Example 3 - PWM drive with choke2

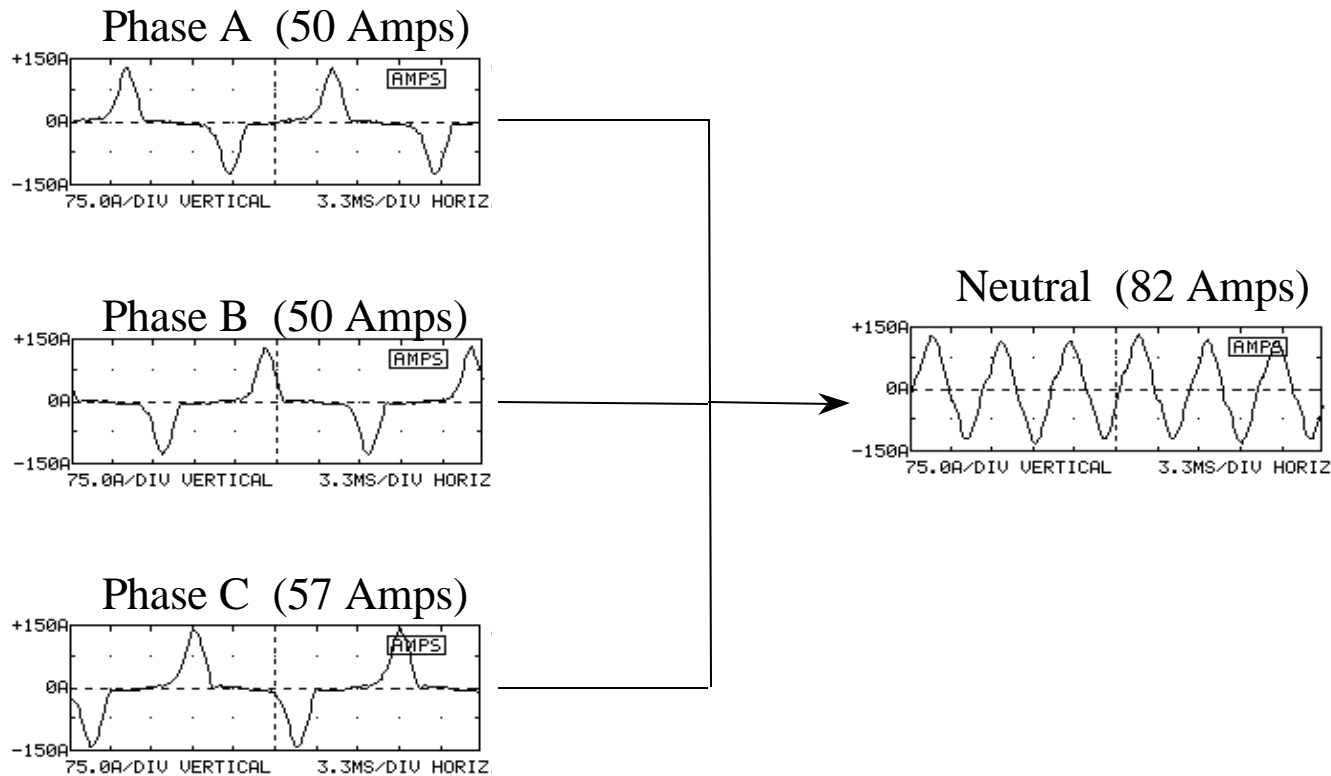


HARMONICS SNAPSHOT		2:22:55 PM
Fundamental freq:	60.0 Hz	
VOLTAGE THD	3.3% THD avg	
-----		
Phase A-Nm Volt:	3.2% THD	
Phase B-Nm Volt:	3.3% THD	
Phase C-Nm Volt:	3.4% THD	
CURRENT THD	47.6% THD avg	
-----		
Phase A Current:	49.8% THD	
Phase B Current:	45.1% THD	
Phase C Current:	48.0% THD	

PHASE B CURRENT SPECTRUM						2:23:40 PM
Fundamental amps:		61.2 A rms				
Fundamental freq:		60.0 Hz				
HARM	PCT	SINE PHASE	HARM	PCT	SINE PHASE	
FUND	100.0%	-128°	2nd	1.0%	145°	
3rd	3.9%	-149°	4th	0.4%	-57°	
5th	39.7%	-122°	6th	0.8%	175°	
7th	18.9%	122°	8th	0.2%	10°	
9th	0.8%	47°	10th	0.2%	159°	
11th	6.8%	67°	12th	0.4%	-27°	
13th	3.8%	-118°	14th	0.3%	111°	
15th	0.4%	-140°	16th	0.4%	6°	
17th	3.2%	-144°	18th	0.4%	109°	
19th	2.3%	10°	20th	0.3%	2°	
21st	0.3%	29°	22nd	0.2%	141°	
23rd	1.8%	11°	24th	0.2%	-79°	
25th	1.7%	145°	26th	0.2%	124°	
27th	0.2%	-165°	28th	0.1%	-81°	
29th	1.1%	160°	30th	0.1%	68°	
31st	1.3%	-74°	32nd	0.1%	-112°	
33rd	0.2%	-32°	34th	0.1%	81°	
35th	0.7%	-49°	36th	0.1%	-114°	
37th	1.0%	67°	38th			
39th	0.2%	153°	40th			
41st	0.5%	96°	42nd	0.1%	-1°	
43rd	0.8%	-147°	44th	0.1%	134°	
45th	0.2%	-59°	46th			
47th	0.4%	-112°	48th			
49th	0.7%	-5°	50th			
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ODD	45.1%		EVEN	1.6%		
THD:	45.1%					

# Example 4 - Switched mode power supply currents

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See notes for spectrum

# Example 5 - electronic ballast

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