Date: 11-06-2008

Ref: Technical Overview of Power Requirements for Hot Runner Control Systems

By: Fred Schroeder, Sr. Product Engineer – Electronics, DME Company

Introduction:
Many customers ask often, I just want a DME Hot Runner Control System to run my DME Plastic Injection Hot Runner Mold Base. I have 240 Vac and have a 32 Cavity Mold. What do I need? Sounds simple enough? Well, there are issues that arise that should be considered. DME Company over many years of experience has put together standard product offerings which cover the majority of Hot Runner Control Systems, but are not guaranteed to be able to run all molds that have larger wattage requirements. This document is presented in a way to introduce some common electrical principles so you can better understand what you should consider when selecting a Hot Runner Control System. This is not a substitute for getting advice and having systems installed from a local electrician who knows local and national electrical codes for your community. Most of these Electricians understand the information presented in this document very well, but might not be familiar with the exact components used for injection molding Hot Runner Controls. Keep in mind that three phase balanced power cost less than single phase from the utility companies.

Step 1: Understanding Heater Loads and Watts versus VA ratings.

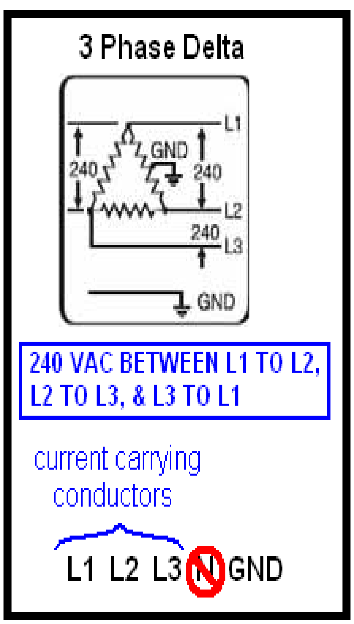
Resistive Heaters and Wattage Ratings: First off, Resistance Heaters are rated in Watts. Watts = Volts x Amps, and Volts = Amps x Resistance. Resistance is measured in Ohms and shown as Ω's on a meter. KΩ's are Kilo-Ohms = 1,000 Ohms. MΩ's are Mega-Ohms = 1,000,000 Ohms.

Inductive Loads and VA ratings: I will not dwell on Inductive Loads. These are not an important issue used in Resistive Heater Hot Runner Controls. However, many factory power transformers are rated in KVA. Inductive motors have start up power surges and power factor issues that purely resistive loads do not. When using Resistive Heater Hot Runner Loads then, VA ratings will equal Watt rating. Example: For Resistive heater loads, a 10KVA transformer = 10KW (10 Kilo-Watts or 10,000 Watts), which will run up to 10,000 Watts of heaters.

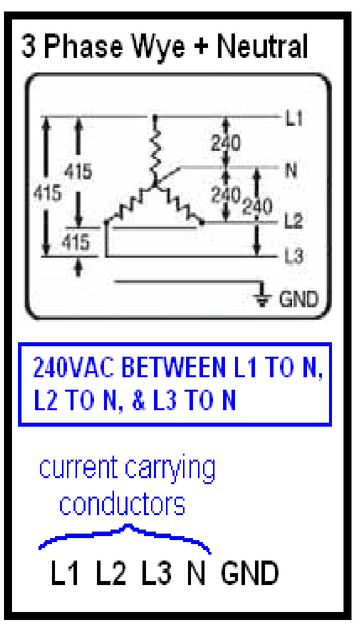
Loss of Heater Power versus Plant Power Line Voltage: This is simply shown by example. Take a 1,000 Watt Heater rated at 240VAC. If we run this heater in a plant that only has 208 VAC, then the heater can only deliver a Maximum of 750 Watts. The mold may have trouble controlling the temperature. Some transformers have "Line Voltage Taps" that can make small adjustments to the line Volts, but they cost more money up front. (see "Appendix A: Power Adjustment Factor for Heaters" that I wrote for further technical discussions on this topic)

Step 2: Understanding available power from different Three Phase Delta & Wye, Two Phase & Single Phase Power Sources.
(See Appendix B: Theoretical Calculations and formulas for 3 Phase, Two Phase and Single Phase Power)

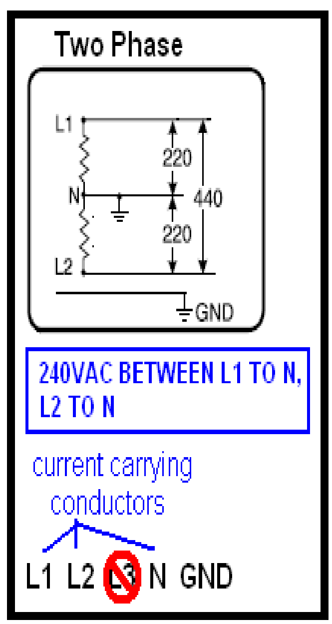
The way power is supplied in your plant is important. Some customers test the system out in one plant and move it to another plant. This could cause issues. Nominal 240 VAC (Typical Range 208 -240 VAC) Plant Power Supply are shown below:



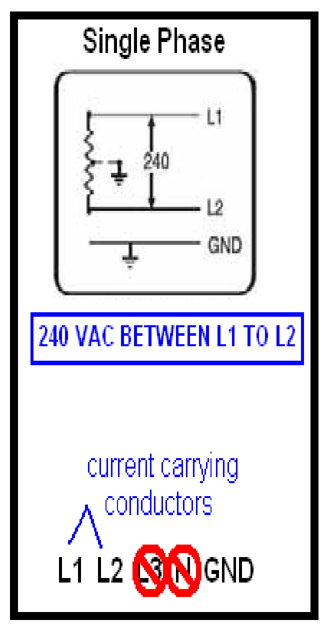
Typical North America



Typical European

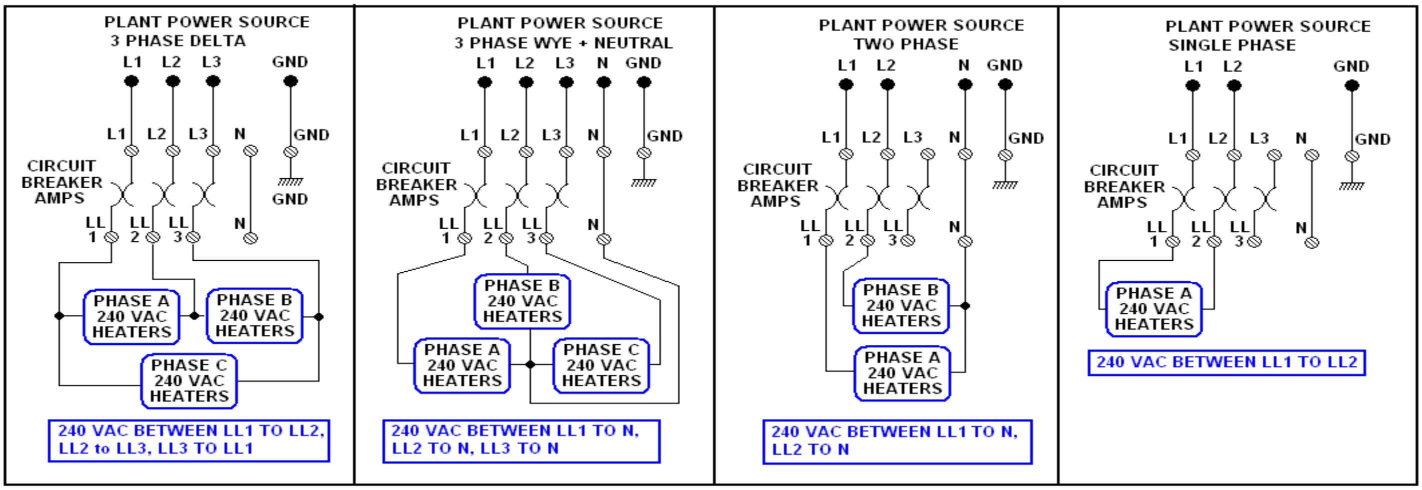


Very Rare in Plastics Ind.



Low Wattage Requirements

PLANT POWER TO HOT RUNNER SYSTEM MAIN CIRCUIT BREAKER TO RESISTIVE HEATER OVERVIEW



3 Phase Delta - 240 Vac to Control Modules - Available Phase Amps and Phase Power in Watts				
Breaker Amp Rating	Max. Phase Amps	Max Phase Watts	Total Balanced Watts Available	Min. Transformer to Supply Max. Watts
10	5.77	1,386	4,157	>= 4.2 KVA
20	11.55	2,771	8,314	>= 8.4 KVA
30	17.32	4,157	12,471	>= 12.5 KVA
50	28.87	6,928	20,785	>= 20.8 KVA
70	40.41	9,699	29,098	>= 29.1 KVA
100	57.74	13,856	41,569	>= 41.6 KVA

3 Phase Wye + Neutral - 240 Vac to Control Modules - Available Phase Amps and Phase Power in Watts				
Breaker Amp Rating	Max. Phase Amps	Max Phase Watts	Total Balanced Watts Available	Min. Transformer to Supply Max. Watts
10	10	2,400	7,200	>= 7.2 KVA
20	20	4,800	14,400	>= 14.4 KVA
30	30	7,200	21,600	>= 21.6 KVA
50	50	12,000	36,000	>= 36 KVA
70	70	16,800	50,400	>= 50.4 KVA
100	100	24,000	72,000	>= 72 KVA

Two Phase - 240 Vac to Control Modules - Available Phase Amps and Phase Power in Watts				
Breaker Amp Rating	Max. Phase Amps	Max Phase Watts	Total Balanced Watts Available	Min. Transformer to Supply Max. Watts
10	10	2,400	4,800	>= 4.9 KVA
20	20	4,800	9,600	>= 9.6 KVA
30	30	7,200	14,400	>= 14.4 KVA
50	50	12,000	24,000	>= 24 KVA
70	70	16,800	33,600	>= 33.6 KVA
100	100	24,000	48,000	>= 48 KVA

Single Phase 240 Vac to Control Modules - Available Phase Amps and Phase Power in Watts				
Breaker Amp Rating	Max. Phase Amps	Max Phase Watts	Total Balanced Watts Available	Min. Transformer to Supply Max. Watts
10	10	2,400	2,400	>= 2.4 KVA
20	20	4,800	4,800	>= 4.8 KVA
30	30	7,200	7,200	>= 7.2 KVA
50	50	12,000	12,000	>= 12 KVA
70	70	16,800	16,800	>= 16.8 KVA
100	100	24,000	24,000	>=24 KVA

Step 3: Understanding Mainframe Slot Control Module Power Versus Standard Circuit Breakers.

This section is to evaluate if standard DME Hot Runnerless Control products will meet a particular Hot Runnerless Mold application. This will help one understand the limitations of the standard DME offerings. It should also help one to understanding what may be required if a special system configuration is required for there heater wattage requirements. See the applicable system power bullet item below with Worksheet Area for your use.

- **For all 3 Phase Systems with single wide zone slots Maximum of 15 Amp zones (3,600 Watts at 240 Vac)**

The following Table can be used to determine your needs by entering the Wattage requirement per zone in the table. This applies to DME Standard Hot Runner Control Systems with maximum 15 Amp (3,600 Watt at 240Vac) zone slots.

From Step 2,the following table is used for the Maximum Phase Watts Available.
The Next Table SUM A, SUM B and SUM C cannot exceed the Max. Phase Watts in this table.
Customer must choose either DELTA, WYE + NEUTRAL or pick the lowest Maximum if unknown.

Breaker Amp Rating	DELTA Max Phase Watts	WYE + NEUTRAL Max Phase Watts
10	1,386	2,400
20	2,771	4,800
30	4,157	7,200
50	6,928	12,000
70	9,699	16,800
100	13,856	24,000

The standard SmartSeries™ 5, 8 and 12 zone systems use a 50 AMP breaker standard.
The standard SmartSeries™ Stack Frames systems either 16, 20, 24, 28, 32, 36, 40, 44, or 48 use a 70 AMP Breaker.
SmartSeries™ Option A = DELTA plant power system
SmartSeries™ Option B = WYE + NEUTRAL plant Power Systems.

The Integrity™ Mainframe 12, 24 and 48 zone systems all use 100 Amp Breaker. When stacking Integrity, each New frame that is stacked has it's own 100 Amp Breaker.
Integrity™ Option A = DELTA plant power system
Integrity™ Option B = WYE + NEUTRAL plant Power Systems.

PHASE A		PHASE B		PHASE C	
Zone #	**Watts**	**Zone #**	**Watts**	**Zone #**	**Watts**
1		2		3	
4		5		6	
7		8		9	
10		11		12	
13		14		15	
16		17		18	
19		20		21	
22		23		24	
25		26		27	
28		29		30	
31		32		33	
34		35		36	
37		38		39	
40		41		42	
43		44		45	
46		47		48	
SUM A		**SUM B**		**SUM C**	

NOTE: The SmartSeries Stack Frames 16, 28 & 40 zone systems are different.
16 Zone Phases:
Sum A= 1,4,7,9, 12,15
Sum B= 2,5,8,10,13,16
Sum C= 3,6,11,14
28 Zone Phases:
Sum A= 1,4,7,10,13,16,19,21,24,27
Sum B= 2,5,8,11,14,17,20,22,25,28
Sum C= 3,6,9,12,15,18,23,26
40 Zone Phases:
Sum A=1,4,7,10,13,16,19, 22,25,28,31,33,36,39
Sum B=2,5,8,11,14,17,20, 23,26,29,32,34,37,40
Sum C=3,6,9,12,15,18,21, 24,27,30,35,38

Remember that SUM A Phase Watts <= Max. Phase Watts AND SUM B Phase Watts <= Max. Phase Watts AND SUM C Phase Watts <= Max. Phase Watts. Also, the Max. Phase Watts depend on the Breaker Size and the Plant Power Supply Type, Delta or Wye + Neutral from Table above.

- **<u>For all TWO Phase Systems with single wide zone slots Maximum of 15 Amp zones (3,600 Watts at 240 Vac)</u>**

Over the +30 years, DME has found this "TWO PHASE" option extremely rare. Almost all industrial plants have 3 phase power standard. The new DME Integrity Systems have therefore been designed not to include this option. The DME SmartSeries™ uses Option C to support "TWO PHASE".

The following Table can be used to determine your needs by entering the Wattage requirement per zone in the table. This applies to DME Standard Hot Runner Control Systems with maximum 15 Amp (3,600 Watt at 240Vac) zone slots.

From Step 2,the following table is used for the Maximum Phase Watts Available.
The Next Table SUM A and SUM B cannot exceed the Max. Phase Watts in this table.

Breaker Amp Rating	TWO PHASE Max Phase Watts
10	2,400
20	4,800
30	7,200
50	12,000
70	16,800
100	24,000

The standard SmartSeries™ 5, 8 and 12 zone systems use a 50 AMP breaker standard.
The standard SmartSeries™ Stack Frames systems either 16, 20, 24, 28, 32, 36, 40, 44, or 48 use a 70 AMP Breaker.
SmartSeries™ Option C = Two Phase plant power system

The Integrity™ Mainframes DO NOT support TWO PHASE Plant Power Inputs.

PHASE A		**PHASE B**	
Zone #	**Watts**	**Zone #**	**Watts**
1		**2**	
3		**4**	
5		**6**	
7		**8**	
9		**10**	
11		**12**	
13		**14**	
15		**16**	
17		**18**	
19		**20**	
21		**22**	
23		**24**	
25		**26**	
27		**28**	
29		**30**	
31		**32**	
33		**34**	
35		**36**	
37		**38**	
39		**40**	
41		**42**	
43		**44**	
45		**46**	
47		**48**	
SUM A		**SUM B**	

Remember that SUM A Phase Watts <= Max. Phase Watts AND SUM B Phase Watts <= Max. Phase Watts.
Also, the Max. Phase Watts depend on the Breaker Size and the Plant Power Supply Type, TWO PHASE from Table above.

- **For all SINGLE Phase Systems with single wide zone slots Maximum of 15 Amp zones (3,600 Watts at 240 Vac)**

The following Table can be used to determine your needs by entering the Wattage requirement per zone in the table. This applies to DME Standard Hot Runner Control Systems with maximum 15 Amp (3,600 Watt at 240Vac) zone slots.

From Step 2,the following table is used for the Maximum Phase Watts Available.
The Next Table SUM A cannot exceed the Max. Phase Watts in this table.

Breaker Amp Rating	SINGLE PHASE Max Phase Watts
10	2,400
20	4,800
30	7,200
50	12,000
70	16,800
100	24,000

The standard SmartSeries™ 5, 8 and 12 zone systems use a 50 AMP breaker standard.
The standard SmartSeries™ Stack Frames systems either 16, 20, 24, 28, 32, 36, 40, 44, or 48 use a 70 AMP Breaker.
SmartSeries™ Option D = Single Phase 240 VAC plant power system

The Integrity™ Mainframes DO NOT support TWO PHASE Plant Power Inputs.

COLUMN 1		COLUMN 2		COLUMN 3	
Zone #	**Watts**	**Zone #**	**Watts**	**Zone #**	**Watts**
1		**17**		**33**	
2		**18**		**34**	
3		**19**		**35**	
4		**20**		**36**	
5		**21**		**37**	
6		**22**		**38**	
7		**23**		**39**	
8		**24**		**40**	
9		**25**		**41**	
10		**26**		**42**	
11		**27**		**43**	
12		**28**		**44**	
13		**29**		**45**	
14		**30**		**46**	
15		**31**		**47**	
16		**32**		**48**	
SUM COL. 1		**SUM COL. 2**		**SUM COL. 3**	

SUM of PHASE A PHASE Watts = SUM COL. 1 + SUM COL. 2 + SUM COL. 3

Remember that SUM A Phase Watts <= Max. Phase Watts. Also, the Max. Phase Watts depend on the Breaker Size and the Plant Power Supply Type, SINGLE PHASE from Table above.

Step 4: Only if Transformer is Required

(NOTE: Also see other DME Technical Documents on Transformer Sizing available at www.dme.net/na)

If you need a transformer to reduce the Plant Power to 240VAC Volts nominal, then you have two options.

Option 1: Size the transformer for the maximum available Power which is limited by the Mainframe Breaker Size.

Option 2: Select the maximum phase wattage from the prior Step 3 Worksheet for your requirements and multiply by the number of phases. This will be the minimum KVA rating for your system. You must also make sure that this requirement does not exceed the maximum allowed by the mainframes breaker and power option (ie 50 Amp 3 Phase Delta)

End of Technical Note. Appendix Follows.

Appendix A: Power Adjustment Factor for Resistive Heaters (Fred Schroeder, Sr. Product Engineer, DME Company)

D-M-E COMPANY POWER ADJUSTMENT FACTOR FOR HEATERS 3/19/1991

THEORY: This program is a lookup table for power adjustment factor when line voltages vary from the standard 240 vac heater ratings.

The equation used is:

$$\text{Power} = \frac{(\text{Operating Voltage})^2 \times (\text{rated wattage})}{(\text{Rated Voltage})^2}$$

$$\text{The power adjustment factor} = \frac{(\text{Operating Voltage})^2}{(\text{Rated Voltage} = 240\text{ Vac})^2}$$

PRACTICAL USAGE: Look up the Operating Voltage on the chart and find the corresponding power adjustment factor. Now, simply multiply the Power Adjustment factor by the Rated heater power. This will give you the amount of power the heater can produce at the given operating voltage. (DERATED WATTAGE)

EXAMPLE: Step 1: get application information
- customer has 208 Vac line voltage
- the application requires 500 watts

Step 2: adjustment factor from table for 208 Vac = 0.7511111

Step 3: 500 watts ÷ 0.7511111 = 665.68 watts

Step 4: select the next highest DME wattage heater. A 700 watts heater should be used at 208 Vac to obtain 500 watts for the application.

Step 5: amperage is now calculated by: 700 watt X .7511111 = 525.8 watts will be available at 208 Vac. Now 525.8 watts ÷ 208 Vac = 2.53 amps.

POWER ADJUSTMENT FACTOR TABLE:

FOR 240 Vac RATED HEATERS ONLY * - for 240 Vac factor is 1.00

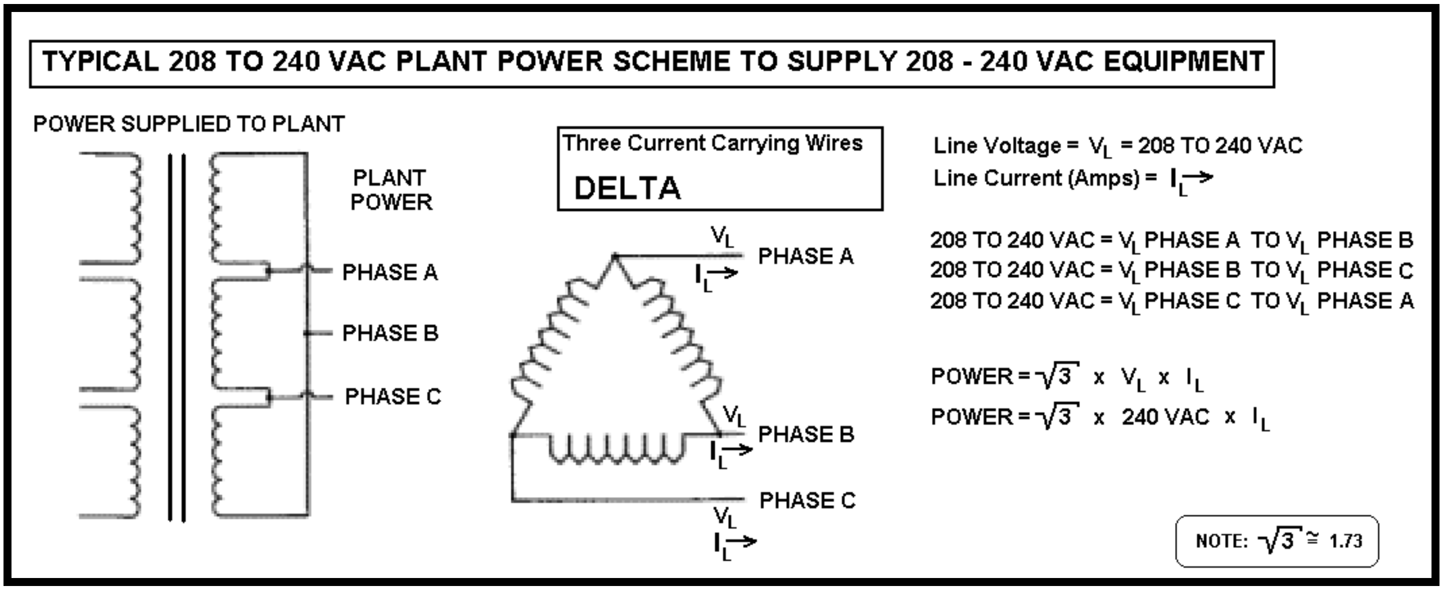
Oper. Volts	+0	+2	+4	+6	+8
80	.1111111	.1167361	.1225	.1284028	.1344445
90	.140625	.1469445	.1534028	.16	.1667361
100	.1736111	.180625	.1877778	.1950695	.2025
110	.2100695	.2177778	.225625	.2336111	.2417361
120	.25	.2584028	.2669445	.275625	.2844445
130	.2934028	.3025	.3117361	.3211111	.330625
140	.3402778	.3500694	.36	.3700695	.3802778
150	.390625	.4011111	.4117361	.4225	.4334028
160	.4444445	.455625	.4669445	.4784028	.49
170	.5017361	.5136112	.525625	.5377778	.5500695
180	.5625	.5750695	.5877778	.600625	.6136111
190	.6267361	.64	.6534028	.6669445	.680625
200	.6944445	.7084028	.7225	.7367361	.7511111
210	.765625	.7802778	.7950695	.81	.8250695
220	.8402778	.855625	.8711111	.8867361	.9025
230	.9184028	.9344444	.950625	.9669444	.9834028
240 *	* 1	1.016736	1.033611	1.050625	1.067778
250	1.085069	1.1025	1.12007	1.137778	1.155625
260	1.173611	1.191736	1.21	1.228403	1.246944
270	1.265625	1.284445	1.303403	1.3225	1.341736
280	1.361111	1.380625	1.400278	1.42007	1.44

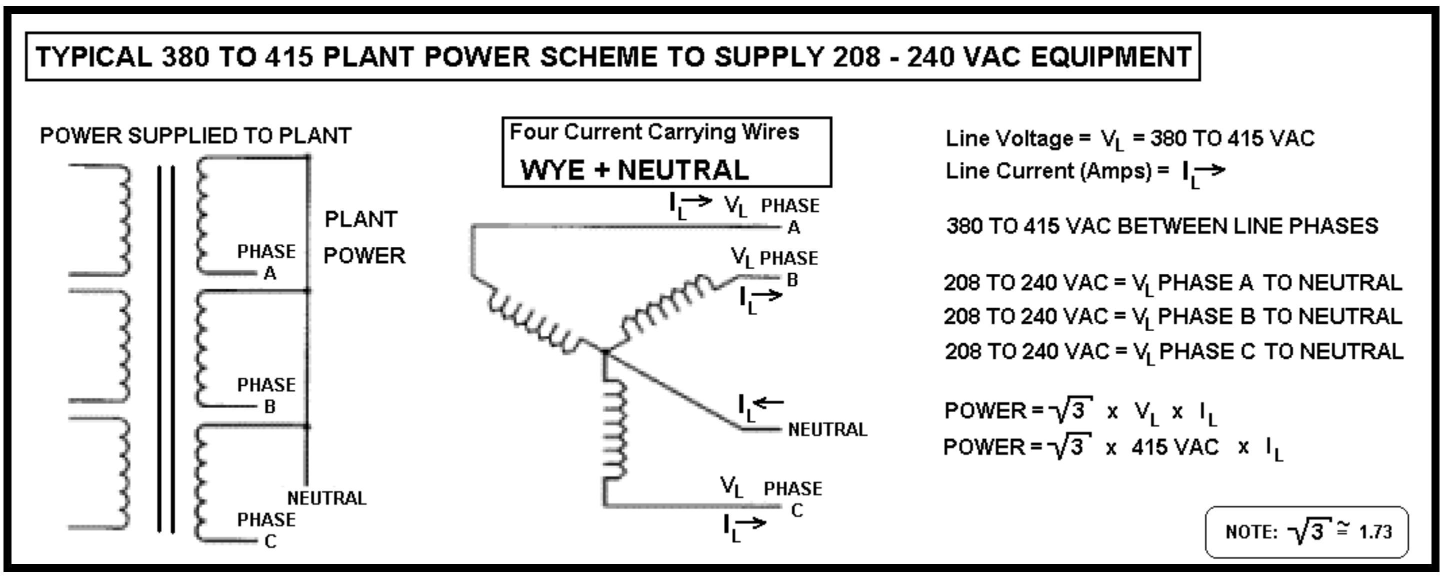
Appendix B: Theoretical Calculations and formulas for 3 Phase, Two Phase and Single Phase Power

Simple 240VAC ex. shown, other reference on 3 Phase are available on the Web, one found is: http://www.3phasepower.org/

Basic 3 Phase Power Calculations:

Three Phase Power (in Watts) = $\sqrt{3}$ x Line Volts x Line Amps = 1.73 x V_L x I_L





<u>Basic TWO and SINGLE Phase Power Calculations:</u>