Yaskawa Electric America, Inc.

Modular Drive Component Selection Guide

MODEL G5 MODULAR DRIVE SYSTEM
(NON-REGENERATIVE, REGENERATIVE, SINGLE TYPES)
GENERAL-PURPOSE INVERTERS W/ FLUX VECTOR CONTROL

400V CLASS 200 to 800kW (300 to 1400kVA)
600V CLASS 300 to 1200kW (400 to 1600kVA)

P-MI#00007-HHP

DANGER HIGH VOLTAGE

Motor control equipment and electronic controllers are connected to hazardous line potentials. When servicing drives and electronic controllers, there may be exposed components with their cases and protrusions at or above line potential. Extreme care should be taken to prevent against electrical shock. Stand on an insulating pad and make it a habit to use only one hand when checking components. Always work with another person in case an emergency occurs. Disconnect power and wait the proper amount of time for the DC bus capacitors to discharge to a safe level of 50VDC or less before servicing the controller. Be sure equipment is properly grounded. Wear safety glasses whenever working on an electronic controller or electrical rotating equipment.

CAUTION

?Read this manual, VS-616G5 Series User's Manual (publication number TOA-S616-10.10), VS-616 G5 Series Instruction Manual (publication number TOE-S616-10.21) in its entirety before installation, operation, maintenance, or inspection of this equipment.

?Do not connect or disconnect wiring while the input power supply is **ON**.

?Do not perform a withstand voltage test or megger test on any part of this equipment. This electronic equipment utilizes power semiconductors and is vulnerable to high voltages. Failure to comply will result in non-warrantable damage to the equipment.

?Rotating shafts and above ground electrical potentials can be hazardous. Therefore, it is strongly recommended that all electrical work conform to National Electrical Codes and local regulations. Installation, alignment, and maintenance should be performed only be qualified personnel.

IMPORTANT NOTICE

No patent liability is assumed with respect to the use of the information contained herein. Moreover, because Yaskawa Electric America, Inc. is constantly improving its high-quality products, the information contained in this manual is subject to change without notice. Every precaution has been taken in the preparation of this manual. Nevertheless, Yaskawa Electric America, Inc. assumes no responsibility for errors or omissions. Neither is any liability assumed for damages resulting from the use of the information contained in this publication.

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1. INTRODUCTION

1.1 Purpose and Scope

This G5 Modular Drive Component Selection Guide is intended to assist in the design, assembly, and maintenance of the modular inverter G5 series drives models G5U4200, G5U4400, G5U4600, G5U4800, G5U5300, G5U5600, G5U5900, and G5U5C00. [1] This guide is intended to be used in conjunction with the VS-616G5 Series User's Manual (publication number TOA-S616-10.10), VS-616 G5 Series Instruction Manual (publication number TOE-S616-10.21), and G5 High Horsepower Inverter Product CD. This guide will provide the necessary information to properly design and construct a complete functioning inverter drive system. All design and construction should be undertaken only by qualified electrical and mechanical design personnel familiar with the principles of drive system application and design. Improper design could result in bodily injury and/or non-warrantable equipment damage. See G5 High Horsepower Inverter Product CD for component listings, bills of material, mechanical drawings, and electrical diagrams.

1.2 Receiving

Carefully and thoroughly unpack and inspect the individual components, which make up the modular drive system, for any damage which may have been sustained during shipment. If any obvious damage is noticed, do not accept shipment until you have contacted the freight company or agent. Have the agent note the damage on the freight bill before accepting the shipment. If you should happen to find any concealed damage during unpacking, you should again contact the freight company. Yaskawa Electric America, Inc. is not responsible for any damage which may have resulted during shipment.

1.3 Handling

CAUTION

The G5 modular drive system components contain Electrostatic Discharge (**ESD**) sensitive CMOS ICs. Special static control measures must be followed to prevent damage to the equipment

Equipment in excess of 20kg (45 pounds) should be moved by qualified personnel with a lifting apparatus.

Failure to observe the preceding may result in personal injury and/or equipment damage.

1.4 Storage

If the drive system components are to be stored for an extended period of time, it is recommended to observe the following precautions:

Store within an ambient temperature range of -4 to 140 ^{o} F (–20 to 60^{o} C)
Avoid direct sunlight (not outdoors)
Store in an area free from moisture, dust, vibration, and corrosive gases
Relative Humidity should not exceed 95%, non-condensing

By observing the above precautions, the G5 modular drive system components will be maintained with no degradation in performance.

[1] Model numbers are intended for reference only.

2. DESCRIPTION OF OPERATION

The G5 Modular Drive System incorporates a modular design style approach for inverter drive system designers. This enables the system designer the capability to provide an economical, flexible, compact, non-complex, user friendly, high performance solution for applications involving drive loads requiring constant torque ampacities of 400 to 1600Aac, and variable torque ampacities of 450 to 1800Aac. These modular drive systems are offered in two voltage categories; 400 and 600V CLASS.

Each system incorporates at least one inverter module utilizing third generation IGBTs capable of delivering 414A constant torque (CT), 450A variable torque (VT), 3-phase continuous output. This system has the capability to be expanded by paralleling up to three additional inverter modules (quadruplex) for a maximum continuous output current rating of 1600A CT, 1800A VT, 3-phase. This is made possible by the use of specially designed output interphase reactors along with the adoption of a newly designed gated array and a 32-bit RISC type MPU incorporating new technologies for parallel processing for synchronization of IGBT gate pulses minimizing the cross current flow between the inverter modules.

In the past, it has always been a disadvantage to achieve an efficient and economical design for parallel operation of multiple low-voltage IGBTs in very large-capacity inverters. But, with the advent of third generation devices, improved gating and cooling techniques, and an optimized cross current or current balance control method not only has the overall size of the inverter been decreased, but the output current balance factor has increased to over 98 percent.

Depending on the designer's requirements each drive system may incorporate a converter section supplying the necessary energy required for the inverter module(s). The converter module provides the necessary DC rectified voltage to meet the performance specification for the inverter module. When a maximum of two converter sections are used in parallel, it is necessary to combine the correct DC link and/or AC input reactor for each converter section to maintain proper load sharing of the individual converter sections. The converter design has also taken into consideration the requirements for input current harmonic distortion reduction and can be configured for up to 24 pulse operation. Refer to section 4 for additional details.

A single control unit assembly, consisting of a control power supply PCB, a control board, and a digital operator, provide the necessary control functions and I/O interface for all drive system configurations whether it be a single, duplex, triplex, quadruplex, 400V or 600V CLASS application. The software features and functions are identical as the standard VS-616 G5 series drives with the exception of a few additional factory parameters required for parallel operation.

The last essential item to complete the drive system design is the control power transformer assembly. A single 1400VA transformer provides all power to the control logic circuits as well as supplying power to the cooling fans for the converter, inverter, or regeneration module(s). A voltage tap PCB and power ride thru capacitors completes the assembly.

Minimal interconnect low power wiring for all drive system components is required but has been optimized and made simple. The wiring can be furnished by Yaskawa Electric America, Inc. in complete cable harness packaged assemblies. Main circuit and high power connections have been designed for quick and easy installation of wire conductors/cabling and bus bars.

The design requirements may incorporate the use of a regenerative front-end to supply power to the inverter during motoring conditions and send energy back to the power supply side during regeneration conditions. The regeneration module used in the drive system will meet IEEE-519 harmonic specifications. The regeneration modules can not be used in conjunction with the converter module(s). A DCCT is used on the output of the regenerative module(s) for current sensing and bus regulation. The input filter required is used for harmonic filtering and provides line surge protection. Refer to section 4 for further information.

3. SPECIFICATIONS

3.1 VS-616G5 Modular drive ratings

400V CLASS

Inverter Model CIMR-G5U (1)		VS-616G5			
		4200	4400	4600	4800
Output Characteristics	Nominal Motor Output (HP) (2)	350	650	1000	1300
	Capacity CT [VT] (kVA) (3)	330 [360]	635 [715]	995 [1075]	1275 [1435]
	Rated Output Current CT [VT] (A)	414 [450]	800 [900]	1200 [1350]	1600 [1800]
	Max. Voltage	3-Phase, 380/400/415/440/460V (Proportional to input voltage)			
	Rated Output Frequency	150 Hz			
	Max. Carrier Frequency	2.0kHz			
	Overload Capacity	150% of Rated Output Current for 1 minute			
Power Supply	Input Current CT [VT] (A)	450 [490]	820 [925]	1280 [1440]	1480 [1665]
	Voltage (V) Frequency (Hz)	3-Phase, 380/400/415/440/460 VAC 50/60Hz			
	Voltage Fluctuation	+10%, -15%			
	Frequency Fluctuation	+/- 5%			

(1) Model numbers are intended for reference only.

(2) HP ratings are based on Nema 4-pole motor data. However, when sizing a drive to match the motor, use the drive output current rating.

(3) kVA rating is based on 460V.

600V CLASS

Inverter Model CIMR-G5U*		VS-616G5			
		5300	5600	5900	5C00
Output Characteristics	Nominal Motor Output (HP)*	450	800	1200	1600
	Capacity CT [VT] (kVA)	430 [465]	830 [935]	1245 [1400]	1660 [1870]
	Rated Output Current CT [VT] (A)	414 [450]	800 [900]	1200 [1350]	1600 [1800]
	Max. Voltage	3-Phase, 500/575/600V (Proportional to input voltage)			
	Rated Output Frequency	150 Hz			
	Max. Carrier Frequency	2.0kHz			
	Overload Capacity	150% of Rated Output Current for 1 minute			
Power Supply	Input Current CT [VT] (A)	450 [490]	820 [925]	1280 [1440]	1480 [1665]
	Voltage (V) Frequency (Hz)	3-Phase, 380/400/415/440/460 VAC 50/60Hz			
	Voltage Fluctuation	+10%, -15%			
	Frequency Fluctuation	+/- 5%			

(1) Model numbers are intended for reference only.

(2) HP ratings are based on Nema 4-pole motor data. However, when sizing a drive to match the motor, use the drive output current rating.

(3) kVA rating is based on 600V.

3. SPECIFICATIONS *(continued)*

3.2 Common features

Control Characteristics	Control Method	Sine Wave PWM
	Starting Torque	150% below 1Hz (150% at 0 rpm with PG)
	Speed Control Range	100 : 1 (1000 : 1 with PG)
	Speed Control Accuracy	+/- 0.2% (+/-0.02% with PG)
	Speed Response	5 Hz (30Hz with PG)
	Torque Limit	Can be set by software: 4 steps available
	Torque Accuracy	+/- 5%
	Torque Response	20Hz (150Hz with PG)
	Frequency Control Range	0.1 to 120.0 Hz
	Frequency Accuracy	Digital command: 0.01%, Analog command: 0.1%
	Frequency Setting Resolution	Digital Operator reference: 0.01Hz Analog Reference: 0.03Hz (@60Hz)
	Output Frequency Resolution	0.01Hz
	Frequency Setting Signal	-10 to +10V, 0 to +10V, 4 to 20mA
	Accel/Decel Time	0.0 to 6000. 0 sec
	Braking Torque	Approx. 20%
Protective Functions	Motor Overload	UL/NEC recognized electronic thermal overload protection (I^2t)
	Instantaneous Overcurrent	Motor coasts to stop at approx. 200% rated output current
	DC Bus Fuse	Motor coasts to stop when at fuse clearing
	Inverter Overload	Motor coasts to stop after 1 min. at 150% rated output current
	Overvoltage	Motor coasts to stop if DC bus voltage exceeds 820Vdc (1040Vdc for 600V Class)
	Undervoltage	Motor coasts to stop if DC bus voltage drops below user adjustable value
	Momentary Power Loss	Immediately stop after 15ms of power loss 9setting mode before shipment). Continuous system operation during power loss less than 2 sec (equipped as standard).
	Heatsink Overheat	Thermistor - OH1, OH2
	Stall Prevention	Stall prevention during acceleration, deceleration and constant speed operation
	Ground Fault	Provided by electronic circuit (overcurrent level)
	Input Phase Loss	Single phase protection
Environmental Conditions	Location	Drive System Components to be protected against corrosive gases, dust and direct sunlight
	Ambient Temperature	+14 to 113^0F (-10 to 45^0C)
	Storage Temperature	-4 to 140^0F (-20 to 60C)
	Humidity	95% RH (non-condensing)
	Vibration	$9.8m/s^2$ (1G) less than 20Hz, up to $1.96m/s^2$ (0.2G) at 20 to 50 Hz

4. DRIVE SYSTEM MAIN COMPONENTS

4.1 INVERTER

The inverter module is a metal chassis equipped with bottom rollers for rack-out of the inverter enclosure. Enclosed in the chassis are the following main components:

A. DC bus capacitors
B. DC bus capacitor softcharge resistor
C. Softcharge resistor bypass contactor
D. IGBTs with associated snubber circuits
E. DCCT (output phase current sensors)
F. Gate drive PCB
G. DC bus fuse per phase
H. Heatsink assembly
I. Heatsink temperature monitoring device (thermistor)
J. Cooling fans

Refer to G5 High Horsepower Inverter Product CD for drawings and specific details.

Cooling of the inverter module heatsink is accomplished by use of a heatpipe/heatsink assembly. The IGBT's are mounted on a large aluminum block in which the heat is transferred to a finned radiator by a heatpipe assembly. The heatpipe's thermal management media is provided in the form of 3M fluorine. In addition, honeycomb fins are attached to the heatpipe/heatsink assembly and cooled by use of front mounted fans. The warm air is then exhausted through a ductwork arrangement and out the top of the inverter module. It is therefore extremely important to mount the inverter module upright to achieve maximum thermal conductivity.

CAUTION: If disposal of the heatpipe/heatsink assembly is required, it is recommended to puncture a hole in the heatpipe(s) thus eliminating any chance of cylinder pressure build-up.

The interconnect cabling and bus bar arrangement is described below.

Power Wiring

Terminal Symbol	Terminal Material	Terminal Connection	Bus Bar Area sq. in. (mm^2)	Max. Torque lb-in (N?m)
+ BUS	tin plated copper	M12 (carriage bolt)	.294 (7.46)	350 (39.5)
- BUS	tin plated copper	M12 (carriage bolt)	.294 (7.46)	350 (39.5)
T1, T2, T3	tin plated copper	M12 (carriage bolt)	.294 (7.46)	350 (39.5)
Ground	zinc plated steel	M8 (hex head screw)	-	90 (10.2)

Control Wiring

Terminal/Connector Symbol	Terminal/ Connector Rating	Description (mating connector)	Wire Size AWG (mm^2)	Max. Torque lb-in (N?m)
7CN	150V, 0.5A	26 pin D sub miniature (3M) 10126-3000VE (connector) 10326-52A0-008 (backshell)	28 (0.08)	-
30CN	250V, 7A	3 pin (JST) VHR-3N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
15CN	250V, 7A	6 pin (JST) VHR-6N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
TB1	250V, 20A	M4 terminal screw	20-10 (0.5-5.5)	12.4 (1.4)
SG	-	M3.5 terminal screw	20-14 (0.5-2.0)	8.9 (1.0)

4. DRIVE SYSTEM COMPONENTS *(continued)*

4.2 CONVERTER (Diode-Type, Non-Regenerative)

The converter module is a metal chassis equipped with bottom rollers for rack-out of the inverter enclosure. Enclosed in the chassis are the following main components:

A. Surge suppressors (MOVs)
B. Diode modules
C. Heatsink temperature monitoring device(s) (thermistor)
D. Cooling fan(s)

Refer to G5 High Horsepower Inverter Product CD for drawings and specific details.

Cooling of the converter module heatsink is accomplished by use of a heatpipe/heatsink assembly. The diodes are mounted on a large aluminum block in which the heat is transferred to a finned radiator by an heatpipe assembly. The heatpipe's thermal management media is provided in the form of 3M fluorine. In addition, honeycomb fins are attached to the heatpipe/heatsink assembly and cooled by use of front mounted fans. The warm air is then exhausted through a ductwork arrangement and out the top of the inverter module. It is therefore extremely important to mount the inverter module upright to achieve maximum thermal conductivity.

CAUTION: If disposal of the heatpipe/heatsink assembly is required, it is recommended to puncture a hole in the heatpipe(s) thus eliminating any chance of cylinder pressure build-up.

The interconnect cabling and bus bar arrangement is described below.

Power Wiring

Terminal Symbol	Terminal Material	Terminal Connection	Bus Bar Area sq. in. (mm^2)	Max. Torque lb-in (N?m)
PA, PB	tin plated copper	M12 (carriage bolt)	.783 (18.73)	350 (39.5)
L1,L2,L3	tin plated copper	M12 (carriage bolt)	.487 (12.38)	350 (39.5)
L11,L21, L31	tin plated copper	M12 (carriage bolt)	.487 (12.38)	350 (39.5)
+1, -	tin plated copper	M12 (carriage bolt)	.783 (18.73)	350 (39.5)
Ground	zinc plated steel	M8 (hex head screw)	-	90 (10.2)

Control Wiring

Terminal/Connector Symbol	Terminal/ Connector Rating	Description (mating connector)	Wire Size AWG (mm^2)	Max. Torque lb-in (N?m)
TB1	250V,20A	M4 terminal screw	20-10 (0.5-5.5)	12.4 (1.4)
TB2	250V, 20A	M4 terminal screw	20-10 (0.5-5.5)	12.4 (1.4)

4. DRIVE SYSTEM COMPONENTS *(continued)*

4.3 CONVERTER (IGBT-Type, Regenerative)

The converter module is a metal chassis equipped with bottom rollers for rack-out of the inverter enclosure. Enclosed in the chassis are the following main components:

A. DC bus capacitors
B. DC bus capacitor softcharge resistor
C. Softcharge resistor bypass contactor
D. IGBTs with associated snubber circuits
E. DC Bus DCCTs and input phase current sensors
F. Gate drive PCB
G. DC bus fuse per phase
H. Heatsink assembly
I. Heatsink temperature monitoring device (thermistor)
J. Cooling fans

Refer to G5 High Horsepower Inverter Product CD for drawings and specific details.

Cooling of the converter module heatsink is accomplished by use of a heatpipe/heatsink assembly. The IGBT's are mounted on a large aluminum block in which the heat is transferred to a finned radiator by a heatpipe assembly. The heatpipe's thermal management media is provided in the form of 3M fluorine. In addition, honeycomb fins are attached to the heatpipe/heatsink assembly and cooled by use of front mounted fans. The warm air is then exhausted through a ductwork arrangement and out the top of the inverter module. It is therefore extremely important to mount the converter module upright to achieve maximum thermal conductivity.

CAUTION: If disposal of the heatpipe/heatsink assembly is required, it is recommended to puncture a hole in the heatpipe(s) thus eliminating any chance of cylinder pressure build-up.

The interconnect cabling and bus bar arrangement is described below.

Power Wiring

Terminal Symbol	**Terminal Material**	**Terminal Connection**	**Bus Bar Area sq. in. (mm^2)**	**Max. Torque lb-in (N?m)**
+ BUS	tin plated copper	M12 (carriage bolt)	.294 (7.46)	350 (39.5)
- BUS	tin plated copper	M12 (carriage bolt)	.294 (7.46)	350 (39.5)
R,S,T	tin plated copper	M12 (carriage bolt)	.487 (12.38)	350 (39.5)
Ground	zinc plated steel	M8 (hex head screw)	-	90 (10.2)

4. DRIVE SYSTEM COMPONENTS *(continued)*

Control Wiring

Terminal/Connector Symbol	Terminal/ Connector Rating	Description (mating connector)	Wire Size AWG (mm^2)	Max. Torque lb-in (N?m)
7CN	150V, 0.5A	26 pin D sub miniature (3M) 10126-3000VE (connector) 10326-52A0-008 (backshell)	28 (0.08)	-
30CN	250V, 7A	3 pin (JST) VHR-3N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
15CN	250V, 7A	6 pin (JST) VHR-6N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
TB1	250V, 20A	M4 terminal screw	20-10 (0.5-5.5)	12.4 (1.4)
TB2	250V, 20A	M4 terminal screw	20-10 (0.5-5.5)	12.4 (1.4)
G	-	M3.5 terminal screw	20-14 (0.5-2.0)	8.9 (1.0)
CA1	600V, 30A	#10 terminal screw	10-14 (5.5-2.0)	20 (2.3)
CA3	250V, 7A	3 pin (JST) VHR-3N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-

4. DRIVE SYSTEM COMPONENTS *(continued)*

4.4 OUTPUT REACTOR

The output reactor acts as a load balancing impedance in conjunction with the active load balancing software in the inverter. The reactor itself is about 1% PU impedance to the output circuit, so this reactor does not provide any significant help with DV/DT issues. The reactor is physically designed to mount to the bottom of the inverter module support bracket and attach to the inverter module output terminals via short bus bar links.

4.5 DC LINK REACTOR

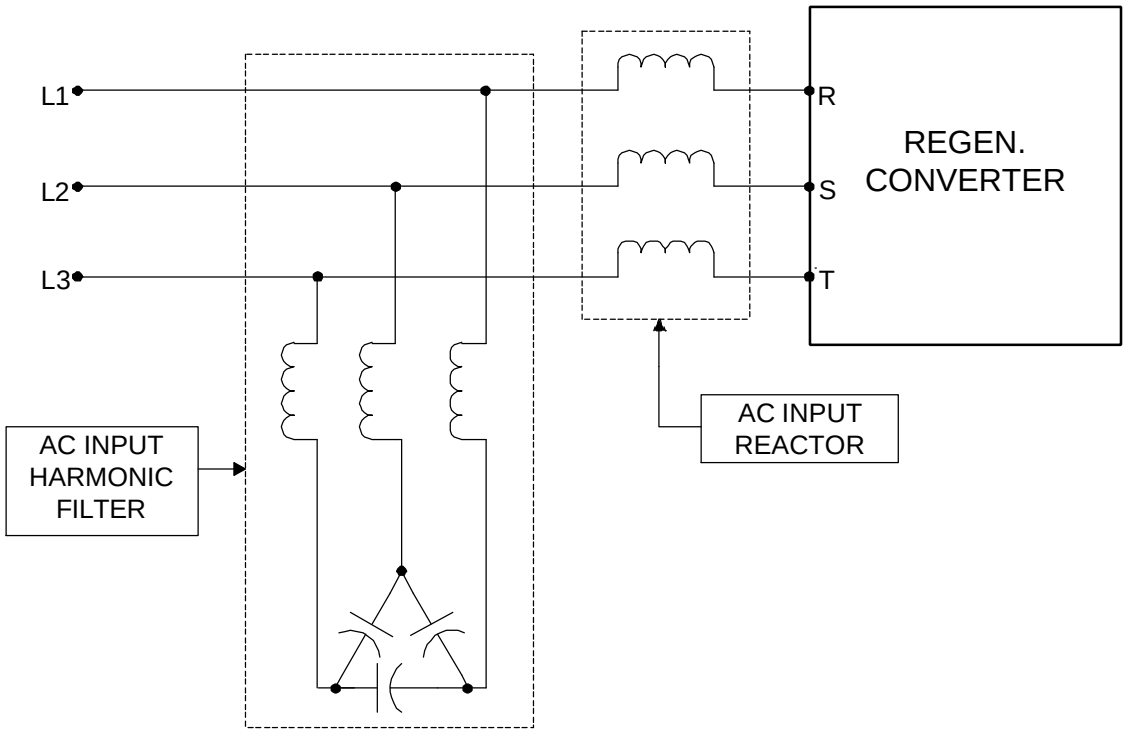
The DC link reactor is used to filter the DC Bus voltage and to provide load sharing when two converter modules are required. The reactor is wired to the converter module via terminals provided at the bottom of the converter module. There are three different sizes of reactors rated at 520ADC, 780ADC, and 1040ADC are used in the four different inverter rating configurations.

4.6 AC INPUT REACTOR (REGENERATIVE)

Input 3-phase reactors are necessary for the pulse width modulation (PWM) regenerative converters. The AC reactor filters the PWM waveform that is present at its load end so that the input AC voltage that is present at its line end is clean and devoid of PWM switching noise. The regenerative converter also behaves like a 3-phase boost converter, which needs to store energy in the AC inductors and transfer it to the DC bus. The reactor also helps in load sharing when multiple regenerative converters are connected in parallel and are being fed from a common AC source.

4.7 AC INPUT HARMONIC FILTER

The AC harmonic filter comprises of a 3-phase reactor and a 3-phase delta connected capacitor. Since the input AC side of a regenerative converter can contain some amount of PWM switching noise that can interfere with other loads connected to the same AC source, there could be a need for a small filter. One such shunt filter topology is provided as a recommended option for use with regenerative converters. The shunt filter topology is as shown below.



4. DRIVE SYSTEM COMPONENTS *(continued)*

4.8 CONTROL POWER SUPPLY AND TRANSFORMER

The control power supply consists of a control power transformer and power supply assembly which has a tap change printed circuit board attached to a bus capacitor bank assembly. The 1.4kVA rated power delivers 230VAC fan power, 330VDC power to the inverter gate drive PCB, and the G5 Control Assembly. The control power supply can accommodate various input power supply ratings ranging from 200 thru 460VAC for the 400 volt series and 500 thru 600VAC for the 600V series. Several fuses on the tap change board protect the power supply in the event of an overload or short circuit condition.

Refer to G5 High Horsepower Inverter Product CD for drawings and specific details.

Control Wiring

Terminal/Connector Symbol	**Terminal/ Connector Rating**	**Description (mating connector)**	**Wire Size AWG (mm^2)**	**Max. Torque lb-in (N?m)**
36CN,37CN	250V, 7A	4 pin (JST) VHR-4N SVH-21T-P1.1 (contact	28 (0.08)	-
30CN-1TRM to 30CN-4TRM	250V, 7A	3 pin (JST) VHR-3N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
31CN,32CN 33CN,34CN 35CN	250V, 7A	3 pin (JST) VHR-3N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
TB1	250V, 20A	M4 terminal screw	20-10 (0.5-5.5)	12.4 (1.4)

4. DRIVE SYSTEM COMPONENTS *(continued)*

4.9 CONTROL UNIT ASSEMBLY

The Control Unit Assembly is made up of a mounting panel, which is to be mounted on the door of the inverter enclosure. On the mounting panel are a control power supply, main control PCB, and the digital operator which is mounted such that the operator is accessible from outside of the inverter controller.

The control power supply changes the 330VAC to the +/- 15VDC and 5Vdc required for the main control PCB and the isolated portion of the gate drive PCB.

The main control board is the heart of the inverter. It provides all of the control, protection, and sequencing of the inverter and converter modules. The control cables are used to connect the power supply to all converter module(s) and inverter module(s). The customer I/O terminals are also remotely located as the control PCB itself does not have any terminals. A complete description of operation for the main control board can be found in section 5.1.

Refer to G5 High Horsepower Inverter Product CD for drawings and specific details.

Control Wiring

Terminal/ Connector Symbol	Terminal/ Connector Rating	Description (mating connector)	Wire Size AWG (mm^2)	Max. Torque lb-in (N?m)
13CN,14CN 31CN	250V, 7A	3 pin (JST) VHR-3N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
30CN-1TRM to 30CN-4TRM	250V, 7A	4 pin (JST) VHR-3N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
31CN,32CN 33CN,34CN 35CN	250V, 7A	6 pin (JST) VHR-6N SVH-21T-P1.1 (contact)	22-18 (0.33-0.83)	-
7CN-1TRM to 7CN-4TRM 10CN	150V, 0.5A	26 pin D sub miniature (3M) 10126-3000VE (connector) 10326-52A0-008 (backshell)	28 (0.08)	
9CN	150V, 0.5A	20 pin D sub miniature (3M) 10120-3000VE (connector) 10326-52A0-008 (backshell)	28 (0.08)	
TB1		4 Pin Phoenix MSTB2,5/4-ST	24-12 (.2-2.5)	
TB2		5 Pin Phoenix MSTB2,5/5-ST	24-12 (.2-2.5)	
SG, E	-	M3.5 terminal screw	20-14 (0.5-2.0)	8.9 (1.0)

5. INVERTER SOFTWARE

5.1 Control Board Configuration

The control board for the modular inverter consists of four microprocessor controllers on one main control board. Each microprocessor has it's own flash memory, ram memory, and interface circuits to an inverter module. The processors are configured as a master and 3 slaves. The processors communicate with each other through a dual port RAM scheme. The tasks for each processor chip are as follows:

A. Master:
   Provides operator keypad, serial communication, interface to options, interface to I/O, G5 sequence control, master control of inverter, and master fault control of inverter. Provides fault control, PWM, and current detection of inverter module #1.

B. Slave #1:
   Provides cross current control and dual port RAM control of communication between the 4 microprocessors . Provides fault control, PWM, and current detection of inverter module #2.

C. Slave #2:
   Provides fault control, PWM, and current detection of inverter module #3.

D. Slave #3:
   Provides fault control, PWM, and current detection of inverter module #4.

LED Indicators

There are five LED indicators on the bottom right-hand corner of the control board which are used to indicate status of the individual processors. The LED's are:

A. DS1 (M) red LED: This LED indicates a fault condition. When it is steady on, the inverter is in a fault state and the fault relay is energized. If no other LED is on, then inverter section #1 has a fault. When the LED is blinking, an alarm or fault condition exists, but the fault relay is not energized.
B. DS2 (M) green LED: This LED indicates that the inverter is in the run mode.
C. DS3 (SL1) green LED: This LED indicates that there is a fault with inverter section #2.
D. DS4 (SL2) green LED: This LED indicates that there is a fault with inverter section #3.
E. DS5 (SL3) green LED: This LED indicates that there is a fault with inverter section #4.

5. INVERTER SOFTWARE *(continued)*

5.2 Software Version

The current software version release is VSG110211. Software release VSG110211 is based on G5 standard software VSG101043 with changes as indicated in section 5.10.

Table 5.2.1 Software numbers for current release

DEVICE	CPU	FLASH
Master	5280A	VSG110211A
Slave #1	5280B	VSG110211B
Slave #2, Slave #3	5280C	VSG110211C

5.3 Start Up

After installation and mounting as described in VS-616 G5 Series Instruction Manual (publication number TOE-S616-10.21), the procedure after initial power on is as follows:

1. Set Access Level to Advanced (A1-01 = 4).
2. Access the kVA Selection (O2-04) and enter proper setting using the following table:

Table 5.3.1 kVA Selection

Inverter Capacity (400 Volt)	200	400	600	800
kVA Selection (O2-04)	81	82	83	84
Inverter Capacity (600 Volt)	300	600	900	1200
kVA Selection (O2-04)	91	92	93	94

3. Access the Initialization Mode Select and set to American Specifications (O2-09 = 1).
4. Initialize to factory settings (A1-03 = 2220 for 2-wire or 3330 for 3-wire initialization). Be sure to set parameters O2-04 and O2-09 before initializing.
5. Remove power from the inverter, allowing the keypad display to fade out completely.
6. Reapply power and follow standard trial operation as stated in VS-616 G5 Series Instruction Manual (publication number TOE-S616-10.21)

5. INVERTER SOFTWARE *(continued)*

5.4 Parameter Setting Range

The following describes the parameter setting ranges, which are different from the standard G5 software

Table 5.4.1 Parameter Setting Ranges

No.	Name	Unit	400V class	600V class
C8-27	Inverter rated current	0.1 A	0.1 ~ 2000.0	0.1 ~ 2000.0
C9-04	CT/VT Selection	-	0 (CT) or 1 (VT)	0 (CT) or 1 (VT)
E1-01	Input voltage	1V	360 ~ 460	460 ~690
E1-04	Maximum frequency	0.1hz	50.0 ~ 150.0	50.0 ~ 150.0
E1-05	Maximum voltage	0.1V	0.0 ~ 510.0	0.0 ~ 765.0
E1-06	Maximum voltage frequency	0.1 Hz	0.0 ~ 150.0	0.0 ~ 150.0
E1-07	Middle output frequency	0.1Hz	0.0 ~ 150.0	0.0 ~ 150.0
E1-08	Middle output frequency voltage	0.1V	0.0 ~ 510.0	0.0 ~ 765.0
E1-09	Minimum output frequency	0.1Hz	0.0 ~ 150.0	0.0 ~ 150.0
E1-10	Minimum output frequency volts	0.1V	0.0 ~ 510.0	0.0 ~ 765.0
E1-11	Middle output frequency 2	0.1Hz	0.0 ~ 150.0	0.0 ~ 150.0
E1-12	Middle output frequency 2 volts	0.1V	0.0 ~ 510.0	0.0 ~ 765.0
E1-13	Base voltage	0.1Hz	0.0 ~ 510.0	0.0 ~ 765.0
E4-01	Motor 2 maximum frequency	0.1hz	50.0 ~ 150.0	50.0 ~ 150.0
E4-02	Motor 2 maximum voltage	0.1V	0.0 ~ 510.0	0.0 ~ 765.0
E4-03	Motor 2 maximum voltage frequency	0.1 Hz	0.0 ~ 150.0	0.0 ~ 150.0
E4-04	Motor 2 middle output frequency	0.1Hz	0.0 ~ 150.0	0.0 ~ 150.0
E4-05	Motor 2 middle output frequency voltage	0.1V	0.0 ~ 510.0	0.0 ~ 765.0
E4-06	Motor 2 minimum output frequency	0.1Hz	0.0 ~ 150.0	0.0 ~ 150.0
E4-07	Motor 2 minimum output frequency voltage	0.1V	0.0 ~ 510.0	0.0 ~ 765.0
L2-03	Minimum baseblock time	0.1 Sec	0.0 ~ 25.5	0.0 ~ 25.5
L2-05	Low voltage detection level	1V	300 ~ 420	450 ~ 750

5.5 Deleted Parameters

The following factory level parameters have been deleted from the standard G5 software set:

A. C8-13

B. L8-10

5. INVERTER SOFTWARE *(continued)*

5.6 Parameter Defaults

The following table shows the factory defaults based on inverter capacity

Table 5.6.1 400V class factory defaults based on KVA setting

No.	NAME	UNIT				
	Model Type G5X_____ (1)		4200	4400	4600	4800
	No. of inverter modules	-	1	2	3	4
	Inverter Capacity	kw	200	400	600	800
02-04	KVA selection	-	81	82	83	84
B3-04	V/F during speed search	%	80	80	80	80
C6-01	Upper limit Carrier Freq.	kHz	2.0	2.0	2.0	2.0
C6-02	Lower Limit Carrier Freq.	kHz	2.0	2.0	2.0	2.0
C6-03	Proportional gain of carrier	-	0	0	0	0
C7-03	Time constant of hunting	msec	30	30	30	30
C8-15	ON delay time	usec	15.0	15.0	15.0	15.0
C8-16	ON delay compensation	usec	11.0	11.0	11.0	11.0
C8-18	Power factor detect filter #1	msec	4	4	4	4
C8-19	Power factor detect filter #2	msec	4	4	4	4
C8-27	Inverter rated current	A	414	800	1200	1600
C8-28	DCCT Gain	-	1.162	1.122	1.122	1.122
C9-04	CT/VT selection	-	0 (CT)	0 (CT)	0 (CT)	0 (CT)
E2-01	Motor rated current	A	370.0	370.0	370.0	370.0
E2-02	Motor rated slip	Hz	1.30	1.30	1.30	1.30
E2-03	Motor no load current	A	96.0	96.0	96.0	96.0
E2-05	Motor line resistance	Ohm	0.020	0.020	0.020	0.020
E2-06	Motor leakage inductance	%	20.0	20.0	20.0	20.0
L2-02	Instant stop comp time	sec	1.0	1.0	1.0	1.0
L2-03	Minimum baseblock time	sec	4.0	4.0	4.0	4.0

(1) Model numbers are intended for reference only.

5. INVERTER SOFTWARE *(continued)*

Table 5.6.2 600V class factory defaults based on KVA setting

No.	NAME	UNIT				
	Model Type G5X_____ (1)		5300	5600	5900	5C00
	No. of inverter modules	-	1	2	3	4
	Inverter Capacity	kw	300	600	900	1200
02-04	KVA selection		91	92	93	94
B3-04	V/F during speed search	%	80	80	80	80
C6-01	Upper limit Carrier Freq.	KHz	2.0	2.0	2.0	2.0
C6-02	Lower Limit Carrier Freq.	KHz	2.0	2.0	2.0	2.0
C6-03	Proportional gain of carrier	-	0	0	0	0
C7-03	Time constant of hunting	msec	30	30	30	30
C8-15	ON delay time	usec	15.0	15.0	15.0	15.0
C8-16	ON delay compensation	usec	11.0	11.0	11.0	11.0
C8-18	Power factor detect filter #1	msec	4	4	4	4
C8-19	Power factor detect filter #2	msec	4	4	4	4
C8-27	Inverter rated current	A	414	800	1200	1600
C8-28	DCCT Gain	-	1.290	1.290	1.290	1.290
C9-04	CT/VT selection	-	0 (CT)	0 (CT)	0 (CT)	0 (CT)
E2-01	Motor rated current	A	370.0	370.0	370.0	370.0
E2-02	Motor rated slip	Hz	1.30	1.30	1.30	1.30
E2-03	Motor no load current	A	96.0	96.0	96.0	96.0
E2-05	Motor line resistance	Ohm	0.020	0.020	0.020	0.020
E2-06	Motor leakage inductance	%	20.0	20.0	20.0	20.0
L2-02	Instant stop comp time	sec	1.0	1.0	1.0	1.0
L2-03	Minimum baseblock time	sec	4.0	4.0	4.0	4.0
L2-05	Low voltage selection level	V	570	570	570	570

(1) Model numbers are intended for reference only.

5. INVERTER SOFTWARE *(continued)*

5.7 Default values for CT/VT

When the Constant Torque / Variable Torque (CT/VT) Selection is changed from the default of Constant Torque (C9-04 = 0) to Variable Torque (C9-04 = 1), the other default values change. See table 5.7.1 and 5.7.2 for parameter default values.

Table 5.7.1 400Volt Class

Parameter	**Name**	**C9-04 = 0 (CT)**				**C9-04 = 1 (VT)**			
-	Model Type G5X_____ (1)	4200	4400	4600	4800	4200	4400	4600	4800
O2-04	kVA Selection	81	82	83	84	81	82	83	84
C8-28	INV Rated Current (A)	414	800	1200	1600	450	900	1350	1800
C8-29	KDCCT Gain	1162	1122	1122	1122	1263	1263	1263	1263
L8-02	OH Pre Alarm Level	95?C				95?C			
L8-04	OH Level	105?C				105?C			
OL2	INV Overheat Pre-alarm	112% continuous 150% for 1 minute				112% continuous 120% for 1 minute			

Table 5.7.2 600Volt class

Parameter	**Name**	**C9-04 = 0 (CT)**				**C9-04 = 1 (VT)**			
-	Model Type G5X_____ (1)	5300	5600	5900	5C00	5300	5600	5900	5C00
O2-04	kVA Selection	91	92	93	94	91	92	93	94
C8-28	INV Rated Current (A)	414	800	1200	1600	450	900	1350	1800
C8-29	KDCCT Gain	1162	1122	1122	1122	1263	1263	1263	1263
L8-02	OH Pre Alarm Level	95?C				115?C			
L8-04	OH Level	105?C				125?C			
OL2	INV Overheat Pre-alarm	112% continuous 150% for 1 minute				112% continuous 120% for 1 minute			

(1) Model numbers are intended for reference only.

5. INVERTER SOFTWARE *(continued)*

5.8 Major Changes from the Standard G5 Software

5.8.1 Braking transistor control software has been eliminated.

5.8.2 Fault signals added/changed:

A. FU Fault. Checks all inverter modules for fuse open. Signal is logical OR'd from each module

B. UV1,UV2, UV3 Faults. Checks all inverter modules for power circuit, control circuit, and MC answer back for low voltage. Signal is logical OR'd from each module.

C. SC Fault. Checks all inverter modules for short circuit fault. Signal is logical OR'd from each module.

D. OC Fault. Checks all inverter modules for over current fault. Signal is logical OR'd from each module

E. OV Fault. Checks all inverter modules for power circuit overvoltage. Signal is logical OR'd from each module.

F. OH, OH1 Fault. Checks all inverter modules for heatsink overheat warning and fault. Signal is logical OR'd from each module.

G. OL2 Fault. Uses current from all operating modules for calculation.

H. UV4 Fault. Checks for fault in control assembly power supply.

NOTE: When any of the above faults occur, the LEDs DS1 to DS5 on the rear of the main control board will indicate which module had the fault indicated on the operator display. If inverter module #1 has a fault, only the RED (M) LED will be on steady. If inverter modules #2, #3, & #4 have a fault, the appropriate green LEDs (SL1 ~ SL3) will be "on" as well as the red (M) LED. If an inverter reset (keypad or contact) has been input and the fault still exists, the red LED (M) will flash and if the fault is in inverter modules #2 ~ #4, the appropriate LED will be on.

I. UNBC Fault. This checks the differential current between any of the operating inverter modules. This fault will occur when the magnitude of circulating current between modules exceeds C9-05 (Unbalanced current detect level) for the amount of time set in C9-06 (unbalanced current detect time). This fault is disabled if O2-04 is set for 81 H (200 KW) or 91 H (300 KW).

J. OH4 Fault. This fault occurs when any of converter heatsinks reaches 105 deg. C.

K. CPF07 Fault. This fault occurs when the PWM synchronizing signal between the processors falls out of tolerance.

L. CPF08 Fault. This fault occurs when a BCC check fails during DPRAM communication between processors.

M. CPF09 Fault. This fault occurs when there is a general communication fault in the DPRAM communication between processors.

N. CPF10 Fault. This fault occurs when there is an error in writing data to a DPRAM during DPRAM communication between processors.

6. APPENDIX

6.1 Flash memory writing procedure

This procedure is used when it is required to write to the flash memories of the G5 modular control card. The only flash data files that will work are ones specifically designed for the modular inverter. It should be noted that this procedure covers the writing of all four flash memories. Most software changes and updates may only require the writing of the master and/or slave #1. When required flash memories are finished, the remainder of the procedure can be bypassed. A read me file covering any software update will instruct the user which flash memories must be re-written.

1. Make sure power is switched off to the inverter and the DC power supplies are completely discharged. Connect the flash write cable to the digital operator port (cable part no. UWR00100-1). The flash write software must be compatible with the modular inverter.
2. Remove the metal rear cover on the control board assembly. There are five suitcase jumpers by the connector 1CN. These jumpers are used to select which flash memory is to be programmed. Make sure the jumper is in the M or master position.
3. With the switch on the cable in the flash or "on" position, power up the inverter. The red LED (M) will be on. Write the master flash file using the flash writing software. While the flash memory is being written, the green (M) LED will flash rapidly. When the software is finished writing to the flash, power down the inverter.
   Note: If at any time during a flash write to the control PCB an error occurs, power down the inverter and then re-apply power and again re-write the flash memory.
4. Move the jumper to the SL1 position. Power up the inverter. The red LED (M) will be "on." Write the slave #1 flash file using the flash writing software. While the flash is being written, the green (SL1) LED will flash rapidly. When finished writing the flash, power down the inverter.
5. Move the jumper to the SL2 position. Power up the inverter. The red LED (M) will be "in." Write the slave #2 &3 flash file using the flash writing software. While the flash is being written, the green (SL2) LED will flash rapidly. When finished writing the flash, power down the inverter.
6. Move the jumper to the SL3 position. Power up the inverter. The red LED (M) will be "on." Write the slave #2&3 flash file using the flash writing software. While the flash is being written, the green (SL3) LED will flash rapidly. When finished writing the flash, power down the inverter.
7. Move the jumper back to the (M) position. Reinstall the metal cover on the rear of the control assembly. Disconnect the flash write cable and reinstall the LCD operator in its pocket. Power up the inverter and check that the LCD operator comes up to the default monitor display.

6. APPENDIX *(continued)*

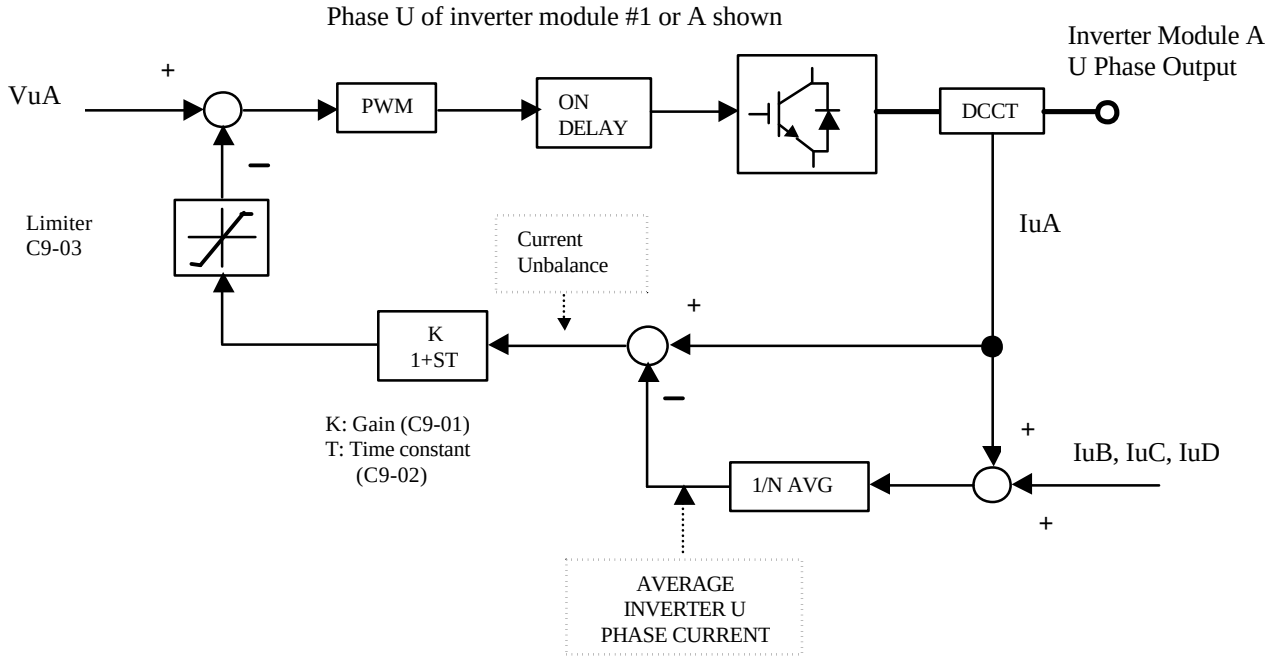
6.2 Unbalance Current Control

When two or more inverter modules are connected in parallel, a means to control current unbalance and circulating current between inverter modules is required. This is accomplished in the G5 modular inverter by an active current unbalance regulator in software. There are current unbalance regulators for each connected inverter module. Each regulator compares the average of all of the inverter module's output currents against its output current. The result of this comparison is the module output current difference. This difference is then sent to a PI controller.

The proportional and integral of this controller are set in C9-01 and C9-02 respectively. The output of the PI controller passes through a limiter (which is set by C9-03) and then goes to the PWM generator of that particular module as a signal called inverter module output voltage trim. This signal trims the voltage reference to finely adjust the inverter output voltage. This change in voltage results in a change of output current .

An unbalance detector for each inverter module monitors the level of that module's output current difference. If the difference is higher that the level set by parameter C9-05 for a time greater than the time set in C9-06, an unbalance fault will be detected and the inverter will fault.

Figure 5.0 Unbalanced current controller



6. APPENDIX *(continued)*

6.3 Parameters for unbalance current control

The following parameters in the software VSG110211 are used to control current unbalance and circulating current between inverter modules during paralleling operation. These parameters are in the factory level and should not be adjusted without consulting Yaskawa Electric America, Inc.

Table 5.7.1

Parameter	Name	Set range	Units	Default	Modbus adr
C9-01	Circ current gain	0.0 ~ 25.5	0.1 %	1.0 %	580 H
C9-02	Circ current time	0.3 ~ 25.5	0.1 ms	2.0 ms	581 H
C9-03	Circ current limit	0.0 ~ 25.5	0.1%	.5%	582 H
C9-05	UNBC level	0 ~ 50	1%	10%	584 H
C9-06	UNBC time	0.01 ~ 5.0	.01 sec	2.00 sec	585 H
C9-07	PWM timer flt	20 ~ 50	1/1 clock	20	586 H
C9-08	A/D fault detect.	0 ~ 50	1%	10%	587 H
C9-09	V Limit AVR out	0 ~ 1	-	0	579 H

Description of parameters:

A. C9-01: This parameter controls the gain of the unbalance regulator PI controller.
B. C9-02: This parameter controls the integral time constant of the unbalance regulator PI controller.
C. C9-03: This parameter controls the error or correction limit of the compensation for unbalanced current.
D. C9-05: This parameter controls the unbalanced current fault trip level.
E. C9-06: This parameter controls the amount of time during an unbalanced condition. This unbalanced condition must be above the level set in C9-05 before an unbalance fault trip occurs.
F. C9-07: This parameter sets the level where the timing between processors becomes out of synchronization.
G. C9-08: This parameter sets the level where the A/D converters on the control board are considered out of tolerance.
H. C9-09: This parameter enables/disables voltage limiting after the AVR circuit.

6. APPENDIX *(continued)*

6.4 Heat loss data

The following tables 6.4.1 and 6.4.2 shows a detailed list of heat loss through each component in the modular drive system according to their kVA ratings.

Table 6.4.1

Component	400 Volt Heat Loss Data CT [VT] (watts)*			
	200KW	400KW	600KW	800KW
Input Diode	1030 [1230]	2050 [2450]	3030 [3620]	4110 [4900]
IGBT	2510 [3000]	5020 [5990]	7530 [8980]	10040 [11980]
Main Capacitor	700 [840]	1400 [1670]	2100 [2510]	2800 [3340]
MC	40 [50]	80 [100]	120 [150]	160 [200]
Fuse	130 [160]	260 [320]	390 [480]	480 [640]
Discharge Resistor	50 [50]	100 [100]	150 [150]	200 [200]
PCB's	50 [50]	100 [100]	150 [150]	200 [200]
CPT	80 [80]	80 [80]	80 [80]	80 [80]
DC Link Choke	150 [190]	370 [470]	700 [840]	740 [890]
Output Choke	0	1480 [1880]	2220 [2650]	2960 [3750]
Total	4740 [5650]	10950 [13160]	16470 [19610]	21770 [26180]

*NOTE: Cooling fans excluded (Efficiency of fans is very high, approximately 43watts)

6. APPENDIX *(continued)*

Table 6.4.2

Component	600 Volt Heat Loss Data CT [VT] (watts)*			
	300KW	**600KW**	**900KW**	**1200KW**
Input Diode	1030 [1230]	2050 [2450]	3030 [3620]	4110 [4900]
IGBT	3440 [4110]	6880 [8210]	10320 [12320]	13760 [16420]
Main Capacitor	750 [900]	1500 [1790]	2250 [2690]	3000 [3580]
MC	40 [50]	80 [100]	120 [150]	160 [200]
Fuse	130 [160]	260 [320]	390 [480]	480 [640]
Discharge Resistor	90 [90]	180 [180]	270 [270]	360 [360]
PCB's	50 [50]	100 [100]	150 [150]	200 [200]
CPT	80 [80]	80 [80]	80 [80]	80 [80]
DC Link Choke	150 [190]	370 [470]	700 [840]	740 [890]
Output Choke	0	1480 [1880]	2220 [2650]	2960 [3750]
Total	5760 [6860]	12980 [15580]	17530 [23250]	25850 [31020]

*NOTE: Cooling fans excluded (Efficiency of fans is very high, approximately 43watts)