



OWNER'S MANUAL



IQ Series AC Power Inverter
OMD97854 Revision B 10/98

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1 INTRODUCTION

Thank you for purchasing a Vanner Power Group IQ Series Inverter or Inverter/Charger. We are confident that you will be satisfied with its performance and its many features. With proper installation and care, you can look forward to years of service from this high performance product.

IQ stands for Industrial Quasi-sine wave.

The IQ Series is a family of dependable inverters (IQ models) and inverter/chargers (IQC models) designed to meet the severe service requirements of the industrial market. All models of the IQ Series produce quasi-sine wave AC output power.

This document will describe the operation, technical specifications and installation procedures of the various models and accessories offered in this product family. We suggest that you familiarize yourself with the model numbers of the inverter and optional accessories you have purchased before proceeding with this manual. If you require additional information please contact your dealer, or contact us directly at the location shown on this inside cover of this manual.

WARNING: Before you install and use your IQ Series Inverter or Inverter/Charger be sure to read and save these safety instructions.

1.1 Model Listing

The IQ Series product line is designed to meet the requirements of a variety of applications. In order to meet these requirements we offer the following product models:

IQ Models (Inverter Only)

12 volt	24 volt
IQ12-2600	IQ24-2600
IQ12-3600	IQ24-3600

IQC Models (Inverter/Charger)

12 volt	24 volt
IQC12-2600	
IQC12-3600	IQC24-3600

NOTICE: All models of the **IQ Series** use the same front panel and therefore look identical. To identify the model number of your particular unit it is necessary to refer to the Specification Label located on the right side of the unit or to the Identification Label located on the inside of the unit's front cover.

PLEASE NOTE YOUR MODEL AND SERIAL NUMBER HERE FOR FUTURE REFERENCE

Model Number _____ Serial Number _____ Date of Installation _____

1.2 Specifications

Figure 1 Specifications

SPECIFICATIONS	Model Number			
	IQ12-2600 IQC12-2600	IQ24-2600 IQC24-2600	IQ12-3600 IQC12-3600	IQ24-3600 IQC24-3600
AC Output Power				
Continuous	2600 Watts	2600 Watts	3600 Watts	3600 Watts
Surge (3 sec) amps	65 Amps	65 Amps	80 Amps	80 Amps
Output Voltage - All Models	120 Volts +/- 5%			
Output Frequency - All Models	60 Hz +/- 0.1 Hz			
Output Waveform - All Models	Modified Sine Wave			
DC Input Voltage Range	10.5 - 16.0 VDC	21.0 - 32.0 VDC	10.5 - 16.0 VDC	21.0 - 32.0 VDC
DC Input Current Draw at no load				
Inverter OFF	60 ma	60 ma	60 ma	60 ma
Inverter ON in Load Demand Mode	160 ma	160 ma	160 ma	160 ma
Inverter ON - Load Demand OFF	1.8 amps		1.8 amps	
AC Output Wiring Method				
All IQ Models (inverter only) All circuits are breaker protected	1 GFCI Duplex Receptacle 1 - 15 amp output terminal 1 - 20 amp output terminal 1 - 30 amp output terminal			
All IQC Models (inverter/charger) All circuits are breaker protected	1 GFCI Duplex Receptacle 1 - 30 amp output terminal			
AC Input Wiring Method				
All IQC Models (inverter/charger) All circuits are breaker protected	1 - 30 amp input terminal for charging and feedthrough 1 - 30 amp input terminal for optional feedthrough only			
Battery Charger (IQC Models)				
Charging Output Current	120 amps	60 amps	120 amps	60 amps
AC Input current	Proportional to 30 amps 120VAC input @ 120 amps 12 volt output			
WET Bulk Charge Voltage	14.4 vdc	28.8 vdc	14.4 vdc	28.8 vdc
WET Float Charge Voltage	13.2 vdc	26.4 vdc	13.2 vdc	26.4 vdc
GEL Bulk Charge Voltage	14.1 vdc	28.2 vdc	14.1 vdc	28.2 vdc
GEL Float Charge Voltage	13.6 vdc	27.2 vdc	13.6 vdc	27.2 vdc
AC Input Voltage Tolerance for Transfer Switch				
Low Input Voltage Switchover Value	90VAC or 77VAC (Selectable)			
AC Input Voltage	120 VAC + 12 volts / - 30 or -43 volts (selectable)			
AC Input Frequency	60 Hz +/- 5 Hz			
Transfer Switch transfer time	30 ms			
System				
Ambient Temperature	Continuous output at -40 to +105 degrees F (-40 to +40 degrees C)			
Cooling Air	Thermostatically controlled exhaust fan			
Enclosure	White painted aluminum with noncorrosive hardware			
Dimensions All Models	8.4"H x 17.5"W x 14.0"D			
Unit Weight	60 lbs	60 lbs	75 lbs	75 lbs

1.3 Standard Features

1.3.1 Standard Features furnished on All Models in the IQ Series

1. 120 volt AC 60 Hz Quasi-sine wave output
2. Output Short circuit / overload protection through electronic sensing
3. Output circuit breakers
4. Automatic shutoff for Low Battery
5. Automatic shutoff for Overload
6. Automatic momentary shutoff/restart for Over temperature
7. All controls and AC connections accessible at the front of the inverter
8. AC input/output terminal strip
9. Load Demand including Automatic Throttle Control (1 amp ground signal)
10. Load Demand enable/disable switch
11. Built-in GFCI duplex receptacle protected by a 15 amp circuit breaker.
12. Jack to accept optional Remote Switch or Remote Operating Panel

1.3.2 Additional Standard Features furnished only on IQ Models -(inverter only)

1. Three output circuits with 15 amp, 20 amp and 30 amp output circuit breakers

1.3.3 Additional Standard Features furnished only on IQC Models - (inverter/charger)

1. Three Stage Battery Charger
2. Manually initiated Equalize Charging Cycle
3. Adjustable charge rate
4. Charging voltage settings for gel or wet batteries
5. No minimum battery voltage required for charging (will charge a Dead Battery)
6. Jack for optional Battery Temperature Compensation Sensor
7. Automatic Power Management (charger input power control)
8. Jack for optional Automatic Power Management Panel
9. Automatic Transfer Switch with 5 second acceptance time delay
10. Accepts one or two AC input circuits up to 30 amps each
11. Automatic acceptance of second AC input circuit
12. Inverter Disable switch to allow passthrough and battery charging only
13. Charger Disable switch to allow passthrough only
14. Passthrough capability while battery is disconnected
15. AC input voltage tolerance selector switch (90vac or 77vac switchover)

Please note: The Battery Charger, Automatic Transfer Switch and Automatic Power Management are operational only when AC input power (shore power) is present.

1.4 Accessories

Part Number	Name	Description
D07869	Remote Operating Panel	Remote ON/OFF Switch and Indicator Light Display Panel with 25ft modular cord.
D07905	Universal Remote Adapter	Screw terminal phone jack adapter and 2ft modular cord. Allows use of customer supplied SPDT center OFF momentary switch.
D07917	Remote ON/OFF Switch	SPDT center OFF momentary toggle switch, 25ft cord and includes D07905.
D07934	APM Panel	Auxiliary Power Management Panel with 25ft modular cord.
D07924	30 Amp AC Output Cord	30 amp Twist Lock receptacle mounted to 1ft long 10/3 cable with forked connectors.
D07923-03	Quick Connect DC Input for 3/0	For use with customer supplied 3/0 DC input cable. Includes 18" long 4/0 DC Input Cable with polarized 350 amp Quick Connector, and mating connector for 3/0 cable.
D07923-04	Quick Connect DC Input for 4/0	For use with customer supplied 4/0 DC input cable. Includes 18" long 4/0 DC Input Cable with polarized 350 amp Quick Connector, and mating connector for 4/0 cable.

1.5 Definitions

1.5.1 Quasi Sine Wave:

Quasi Sine Wave Inverters are sometimes called "modified sine wave inverters" or "modified square wave inverters." Quasi sine wave inverters produce an AC output wave different from the power produced by the electric utility companies and rotating generators. Although this wave form has a higher peak voltage than do square wave inverters, its peak voltage is not as high as a pure sine wave. Therefore, AC loads containing power supplies might not always operate properly on the quasi sine wave inverters.

1.5.2 Load Demand Feature and Load Demand Mode:

The Load Demand Feature is an energy conserving feature which allows the inverter to enter the 'Load Demand Mode' whenever the inverter is ON and the AC load has been less than 5 watts for approximately 5 seconds. While in the 'Load Demand Mode' the inverter does not produce 120 volts AC but instead produces pulses of reduced AC voltage which the inverter uses to look for a load. When an AC load greater than 5 watts is sensed, the inverter will turn fully ON to produce 120 Volts AC. The 'Load Demand Mode' is often also described as 'stand-by mode' or 'sleep mode'. While in the 'Load Demand Mode' the inverter consumes approximately 140 milliamps of 12 volt DC power.

The Load Demand Feature can be turned OFF by setting *Selector Switch 2* to the OFF position. This will cause the inverter to remain fully ON, producing 120 Volts AC, whenever the inverter switch is ON and regardless of AC load. It is desirable to do this when the device being powered draws less than 5 watts. An example of such a device is a plastic pipe fusion machine which draws less than 5 watts during the 'coupling cooling time'. With the Load Demand Feature turned OFF and operating no AC load the inverter consumes approximately 1.8 amps of 12 volt DC power.

1.5.3 Automatic Transfer Switch:

The Transfer Switch is a standard feature provided on all IQC models. The Transfer Switch automatically allows input power, from an external AC power source such as shore power or a generator, to pass through the inverter output circuit and be used to operate inverter loads.

1.5.4 Automatic Power Management:

The optional Automatic Power Management (APM) Panel, part number D07934, may be used with IQC Models only. The APM Panel allows the operator to set the maximum AC amps (10 amps, 15 amps, 20 amps or 30 amps) the battery charger may draw from shore power input AC1. The APM Panel is useful in preventing nuisance tripping of the shore power circuit breaker in motor home or similar applications, where the size of the shore power circuit breaker varies from campground to campground and occasionally be rated less than 30 amps. If the AMP Panel is not used the default setting is 30 amps.

1.5.5 Inverter Mode and Charger Mode

The following applies only to IQC Models. IQ Models do not have charger mode.

The IQC is in 'Inverter Mode' when it is functioning as an inverter. The unit is in 'Charger Mode' when it is functioning as a battery charger.

For all IQC models, the factor that determines whether the unit is in 'Inverter Mode' or 'Battery Charger Mode' is the presence or absence of 'in-tolerance' AC input power. Whenever 'in-tolerance' AC input power becomes available the IQC automatically switches from inverter mode to charger mode.

1.6 Important Safety Instructions

This manual contains important safety and operating instructions for the Vanner Power Group "IQ Series" Power Inverter and Inverter/Charger System as prescribed by Underwriters Laboratory (UL). The IQ Series Inverter and Inverter/Charger Family is listed as compliant with UL 458 (only if the UL/CUL symbol is on the front of the unit), Power Converters/Inverters and Power Converter/Inverter Systems for Land Vehicles (12 and 24 volt models only), and UL 1741 Power Conditioning Units for use in Residential Photovoltaic Power Systems. The Vanner Power Group "IQ Series" also is listed to the Canadian National Standard CSA – C22.2 No. 107.1 – 1951.

SAVE THESE INSTRUCTIONS

WARNING This equipment employs components that tend to produce arcs and sparks. To prevent fire or explosion, DO NOT install in confined areas or compartments that contain batteries or flammable materials.

- WARNING** Risk of electrical shock. Use only the ground fault circuit interrupter (GFCI) receptacle(s) or circuit breaker(s) specified in the installation and operating instructions supplied with this inverter. Other types may fail to operate properly when connected to this equipment.
- CAUTION** Read owners manual BEFORE wiring or powering up.
- CAUTION** DO NOT cover or obstruct ventilation openings. DO NOT mount in zero-clearance compartments. Overheating may result.
- NOTICE** The output of this device is not sinusoidal. The IQ SERIES inverter has a total harmonic distortion of 34.6 percent and maximum single harmonic of 24 percent.

1.7 General Precautions

1. Do not expose the Vanner IQ series Inverter to direct water spray or snow.
2. To reduce the risk of a fire hazard, do not cover or obstruct the ventilation openings.
3. Do not install this unit in a zero clearance compartment the result may be overheating or diminished performance.
4. To avoid the risk of fire, electric shock, or injury to persons, do not use attachments not recommended or sold by the Vanner Power Group
5. Vanner recommends that all DC and AC electrical wiring be performed by a certified electrician or technician to ensure compliance with all proper national and local wiring regulations.
6. To avoid a risk of fire and/or electric shock, always verify wiring connections are in good electrical condition. All external conductors must use proper wire size to avoid dangerous overheating or diminished performance.
7. If the Vanner inverter system has been dropped or damaged in any way, do not operate until its operation has been verified to be safe by a qualified technician.
8. To reduce the risk of electric shock always disconnect the AC and DC connections to the Vanner Inverter system before attempting any maintenance. Simply turning the unit off does not prevent electric shock.
9. The Vanner "IQ Series" inverter system must be properly grounded in accordance with local and national codes and ordinances before operation. For most installations the negative (ground) conductor should be bonded to the grounding system at one and only one point in the system.
10. Do not disassemble the IQ Series Inverter/Charger; see the service section of this manual for instructions on obtaining service for the IQ Series Inverter/Charger. Attempting to service the unit yourself may result in a risk of electrical shock or fire

1.8 Explosive Gas Precautions

1. This equipment contains components, which tend to produce arcs or sparks. To prevent fire or explosion do not install in compartments containing batteries or flammable materials or in locations, which require ignition, protected equipment. This includes any space containing gasoline-powered machinery, fuel tanks, or joints, fittings, or other connection between components of the fuel system.
2. Working in the vicinity of a lead-acid battery is dangerous. Batteries generate explosive gases during normal battery operation. To reduce the risk of battery explosion, follow these instructions and those published by the battery manufacturer and the manufacturer of the equipment in which the battery is installed.

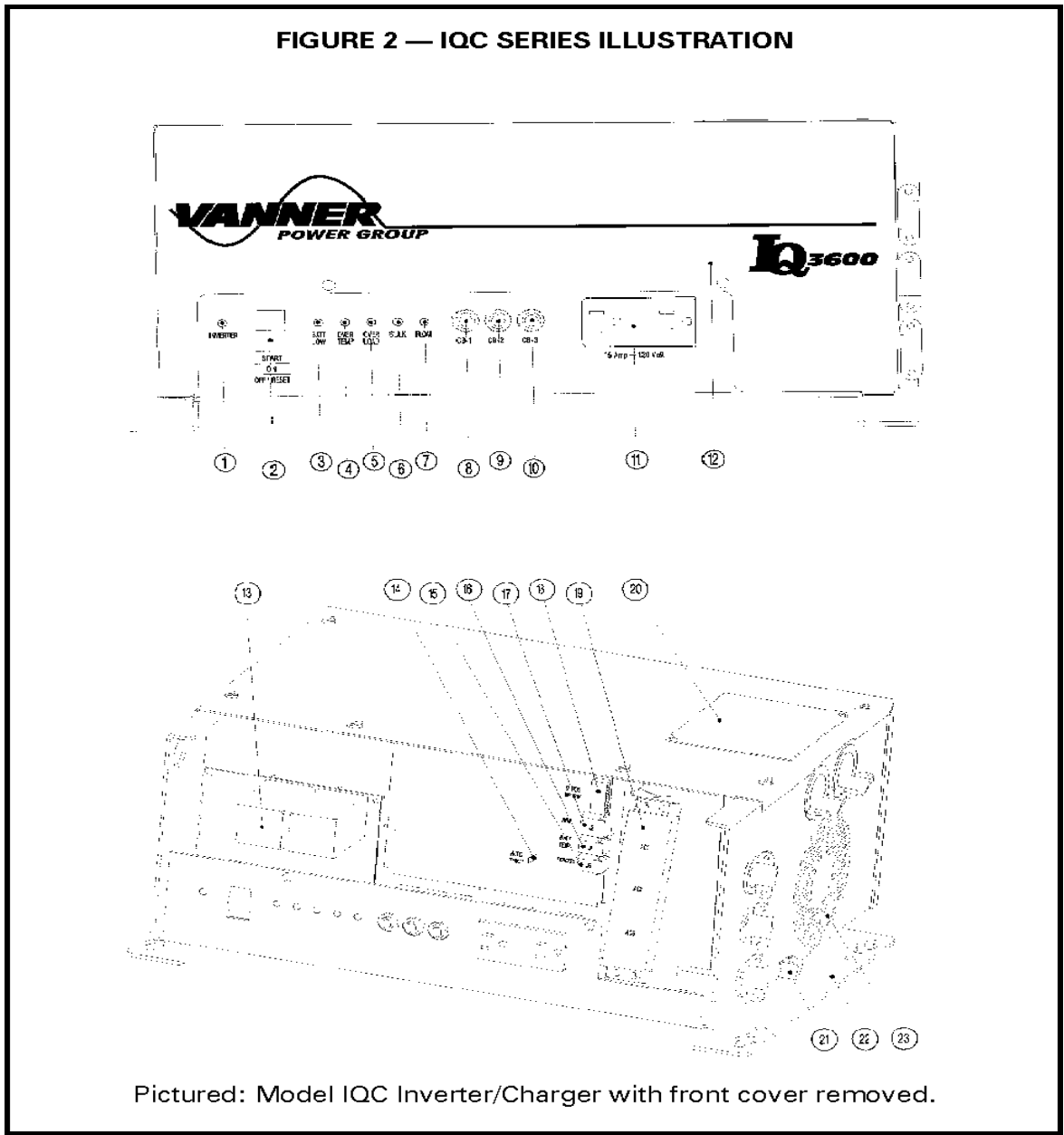
1.9 Precautions When Working with Batteries

1. Always have someone within range of your voice to come to your aid when you work near a lead-acid battery.
2. Have access to plenty of fresh water and soap nearby in case battery acid contacts skin, clothing, or eyes.
3. Always wear complete eye protection and clothing protection. Avoid touching eyes while working near batteries.
4. If battery acid contacts skin or clothing, wash immediately with soap and water. If acid enters eye, immediately flood eye with running cold water for at least 20 minutes and get medical attention immediately.
5. NEVER smoke or allow a spark of flame in the vicinity of batteries. Gases produced by batteries are explosive.
6. Be careful when working with metal tools around batteries. Potential for spark exists or short-circuit of the battery or other electrical part that may cause an explosion.
7. Never charge a frozen battery. Attempt to warm battery above 32 degrees F before charging.

2 COMPONENT IDENTIFICATION and DESCRIPTION of OPERATION

Numbered paragraphs in this section correspond with Figure 1 – Inverter Illustration

Figure 2 IQ Series Illustration



2.1 (1) INVERTER Indicator Light

All Models

<u>Light Action</u>	<u>Description</u>
Green Light is OFF	Inverter circuit is OFF
Solid Green	Inverter is ON (producing AC power)
Fast Blinking Light (2 blinks per second)	Inverter is in Load Demand Mode

IQC Models (Inverter/Charger) in Charger Mode (shore power is ON)

Slow Blinking Light (1 blink per second)	Inverter is standing by while shore power is supplying AC power to loads.
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2.2 (2) ON/OFF Switch

All Models

The ON/OFF switch is a three-position rocker switch whose function is similar to the ignition switch on a vehicle. The low position is OFF/RESET. The middle position is ON (RUN). The high position is START, which is a momentary position.

IQ Models and IQC Models in Inverter Mode (shore power is OFF)

- OFF: In the OFF position the inverter is locked OFF. The indicator lights do not function and the inverter cannot be started from a remote switch. (Please note that this does not disconnect power from the inverter system.) Approximately 50ma is being drawn from the battery.
- ON (RUN): The switch must be in the ON(RUN) position for the inverter to be operational and for remote switch capability to be enabled.
- START: Press the switch to the START position to start inverter operation.
- RESET: If the inverter has turned itself OFF due to overload or low battery, the switch must be moved to OFF/RESET before the inverter can be restarted.

IQC Models (Inverter/Charger) in Charger Mode (shore power is ON)

- OFF: In the OFF position the charger is locked OFF. The indicator lights do not function and the charger cannot be started from a remote switch. (Please note that this does not disconnect power from the inverter system.) No power is being drawn from the battery.

Power on AC1 input is being monitored for proper voltage and frequency but power on AC1 will not be accepted for charging or passthrough.

If both input AC1 and AC2 have power then power on AC2 will pass through. No power is drawn from the battery. The battery does not need to be connected for the power on AC2 to pass through,.

ON (RUN): The switch must be in the ON(RUN) position for the charger to be operational and for remote switch capability to be enabled.

START: Press the switch to the START position to initiate acceptance of AC1 input for charger/transfer switch function and to start charger operation.

2.3 (3) BATTERY LOW Indicator Light

All Models

<u>Light Action</u>	<u>Description</u>
Solid Red	Inverter is On and battery voltage has decayed to 11 or 22 volts DC warning imminent inverter shutdown unless battery voltage is increased by charging.
Blinking Red	Battery has decayed to 10.5 or 21.0 volts DC causing inverter shutdown. Battery must be recharged. Then, Inverter On/Off switch must be reset to activate.

2.4 (4) OVERTEMPERATURE Indicator Light

All Models

<u>Light Action</u>	<u>Description</u>
Solid Red	Inverter or Charger has shutdown due to over temperature. Shutdown may be caused by high ambient temperature or restricted cooling air flow to the inverter. Shutdown sensor will automatically reset when the unit has cooled.

2.5 (5) OVERLOAD Indicator Light

All Models

<u>Light Action</u>	<u>Description</u>
Solid Red	The inverter is ON and the inverter's AC output circuitry is sensing an overload condition. If the AC load is not reduced the inverter will shut itself OFF.
Blinking Red	The inverter is Off. An overload has occurred and the inverter has shut off to protect itself. Once shut off, the inverter On/Off switch must be cycled to reset the unit.

2.6 (6) BULK CHARGE Indicator Light

IQC Models

The light is present on all models but is functional only on IQC Models.
(See 'Battery Charger Theory of Operation' for charger performance details.)

<u>Light Action</u>	<u>Description</u>
Blinking Yellow	The unit is in Charger Mode (shore power is ON) and the charger is in either the BULK STAGE or ABSORPTION STAGE of the battery charging cycle.
Solid Yellow	The unit is in Charger Mode (shore power is ON) and the charger is in the EQUALIZATION CYCLE.

2.7 (7) FLOAT CHARGE Indicator Light

The light is present on all models but is functional only on IQC Models.
(See 'Battery Charger Theory of Operation' for charger performance details.)

IQC Models

<u>Light Action</u>	<u>Description</u>
Solid Green	The unit is in Charger Mode (shore power is ON) and the charger is in the FLOAT STAGE of the battery charging cycle.
Blinking Green	Both the Battery Charger and Inverter functions have been turned OFF by turning Program Switches 5 and 4 to the left position. Shore power is ON. (See PROGRAM SWITCH description.)

2.8 (8) AC CIRCUIT BREAKER

2.9 (9) AC CIRCUIT BREAKER

2.10 (10) AC CIRCUIT BREAKER

IQ Models (Inverter Only)

(8)	CB1	20 amp	Protects output circuit AC1.
(9)	CB2	15 amp	Protects output circuit AC2 and built-in GFCI receptacle.
(10)	CB3	30 amp	Protects output circuit AC3.

IQC Models (Inverter/Charger)

(8)	CB1	30 amp	Protects input circuit AC1.
(9)	CB2	15 amp	Protects built-in GFCI receptacle.
(10)	CB3	30 amp	Protects output circuit AC3.

2.11 (11) AC OUTPUT RECEPTACLE**All Models**

GFCI convenience receptacle, 120vac 1800 watt maximum output, protected by 15 amp circuit breaker CB2. (The GFCI is a 20 amp T-Slot receptacle but is protected by a 15 amp breaker in order to meet Canada's CSA requirements. If CB2 is changed to a 20 amp breaker the unit no longer meets CSA.)

2.12 (12) FRONT COVER**All Models**

The Front Cover must be removed to access the AC Wiring Terminal Strip, the Program Switches and remote control connections located on the control circuit board. **BE SURE THE INVERTER IS TURNED OFF AND ALL EXTERNAL SOURCES OF POWER ARE TURNED OFF BEFORE REMOVING THE FRONT COVER** to access the AC Wiring Terminal Strip.

2.13 (13) AUTOMATIC POWER TRANSFER SWITCH**IQC Models only**

The Automatic Power Transfer Switch is furnished only on IQC Models and consists of a circuit board containing two relays. (IQ Models do not have the transfer switch but instead have a terminal strip in this location.) See Automatic Power Transfer Switch Theory of Operation for performance details.

2.14 (14) AUTOMATIC THROTTLE CONTROL TERMINAL J31**All Models**

Terminal J31 is provided to be used on utility vehicles where the inverter needs to operate continuous heavy AC loads and the vehicle is equipped with an Automatic Throttle. Use J31 to turn ON the Auto Throttle to insure that the vehicle alternator is producing maximum output whenever the inverter is powering a load.

J31 is controlled by the Load Demand circuit therefore Programming Switch 2 must be in the ON position when Terminal J31 is used.

J31 is a 1/4" spade terminal located in the lower right midsection of the control circuit board. The terminal is designed to provide ground control for a Bosch relay, Vanner part number 05235 or equal. Install a 1 amp fuse in line near the inverter.

2.15 (15) REMOTE CONTROL JACK J9**All Models**

Jack J9 is an 8 wire modular jack for use with optional Remote Control Switch, Remote Control Adapter or Remote Operating Panel.

2.16 (16) BATTERY TEMPERATURE COMPENSATION CONTROL JACK J1

(Jack J1 is present on all models but is functional on IQC Models only.)

IQC Models

Jack J1 is a 4 wire modular jack for use with optional Battery Temperature Compensation Control, Vanner part no. D00000, to reduce charging voltage at higher battery temperatures.

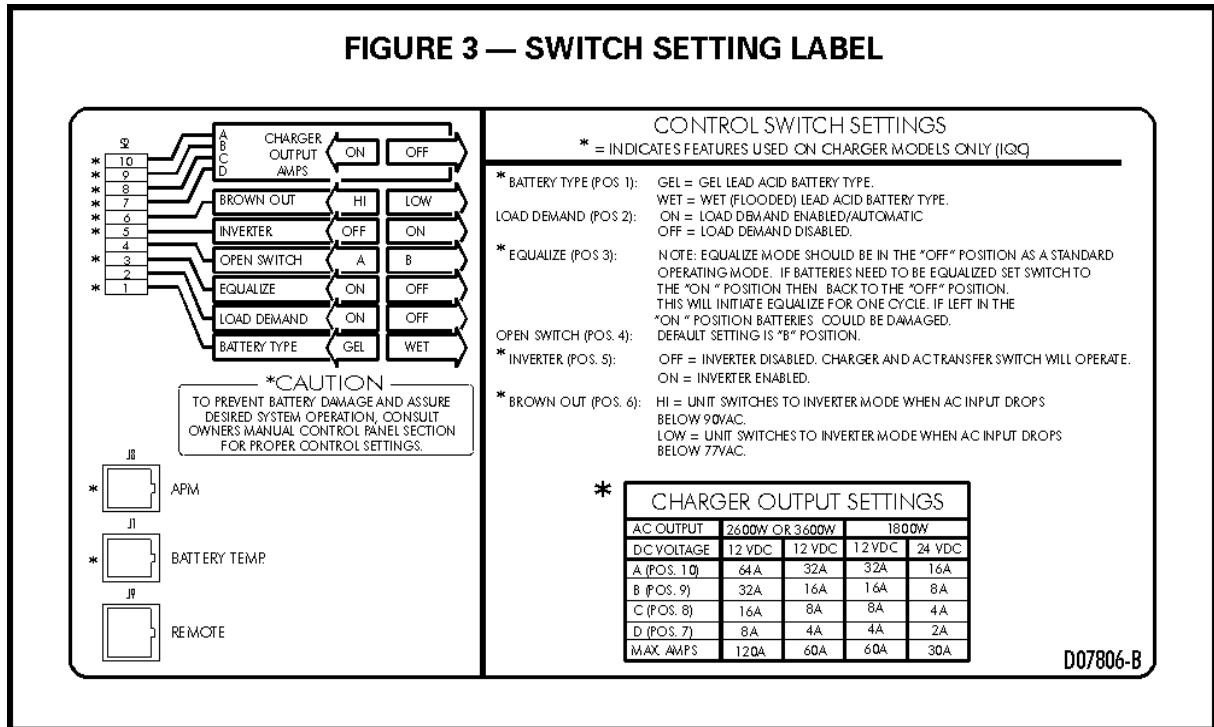
2.17 (17) AUTOMATIC POWER MANAGEMENT (APM) Panel JACK J8

(Jack J8 is present on all models but is functional on IQC Models only.)

IQC Models

Jack J8 is a 4 wire modular jack for use with optional Automatic Power Management (APM) Panel, Vanner part no. D07934. The optional APM Panel allows the 30 amp (default) APM Current Setting to be adjusted to match the circuit breaker at the shore power source (10 amps, 15 amps, 20 amps, or 30 amps). See Theory of Operation for performance details.

Figure 3 Programming Switch Instruction Label



2.18 (18) PROGRAMMING CONTROL SWITCHES

Located on the top right corner of the control circuit board is a 10 position DIP switch containing the 10 individually numbered slide-type Programming Switches in one housing. All switch functions are described below and on the label inside the front cover.

IQ Models (Inverter only)

Only Switch 2 of the Programming Switch is functional on IQ Models and is used to enable or disable the Load Demand Feature.

IQC Models (Inverter/Charger)

All positions of the Programming Switch are functional on IQC Models.

Item	Switch Number	Left / Right Position	Function
2.18.10	10	Add 64 (32) amps / 0	12Volt (24V) Bulk charge rate
2.18.9	9	Add 32 (16) amps / 0	12Volt (24V) Bulk charge rate
2.18.8	8	Add 16 (8) amps / 0	12Volt (24V) Bulk charge rate
2.18.7	7	Add 8 (4) amps / 0	12Volt (24V) Bulk charge rate
2.18.6	6	90VAC / 77VAC	Low AC Input Voltage switchover tolerance value.
2.18.5	5	Disable / Enable	Disable Inverter operation. While the inverter is disabled the battery charger and transfer switch remain operational.
2.18.4	4	Disable / Enable	Disable Charger operation. The charger will be disabled only if the inverter is also disabled at dip switch 5. The transfer switch remains operational.
2.18.3	3	Start / Off	Equalize Start
2.18.2	2	Enable / Disable	Load Demand
2.18.1	1	Gel / Wet	Battery Type

2.19 (19) 120 VOLT AC WIRING TERMINAL STRIP

CAUTION: BE SURE THE INVERTER IS TURNED OFF AND ALL EXTERNAL SOURCES OF POWER ARE TURNED OFF BEFORE ACCESSING THE AC INPUT/OUTPUT WIRING TERMINAL STRIP.

General

AC output and input wires will enter through the three (3) strain relief cable clamps located on the right side of the unit.

The installer should verify that all AC circuits connected to the unit output are an insulated neutral type as required by the National Electrical Code (NEC) article 551.

Vanner has designed the AC terminal block to accommodate spade or ring wire terminals and wire size up to 10 gauge. Refer to local codes for correct AC wire size appropriate for your inverter system and loads.

Ground Fault Circuit Interruption

Some installations require the installation of Ground Fault Circuit Interrupter (GFCI) type circuit breakers in the AC distribution system. Because the output waveform of the inverter is not the same as that supplied by a generator or the utility, some GFCI devices do not function properly. The following list of GFCI circuit breakers have been tested and function properly with this inverter system.

Table 6 - Approved Ground Fault Current Interrupters (GFCI Recommendations)

Manufacturer	Manufacturer Part Number
Pass & Seymour	2091-S, 2091-SI, 1591-R, 1591-SI
Hubbell	GF53521A
Bryant	GFR53FTI
Goldstar	GSM15SB
Square D	Q0230GFI
General Electric	THQL-1115GF
Electric Center (Siemens)	ECB120GF
Westinghouse	GFCB130
Murray (Siemens)	MP120GF

IQ Models (Inverter only)

- General AC1, AC2 and AC3 are all output circuits.
- AC1 AC output circuit protected by 20 amp circuit breaker CB1.
- AC2 AC output circuit protected by 15 amp circuit breaker CB2. (The built-in GFCI receptacle receives its power from AC2.)
- AC3 AC output circuit protected by 30 amp circuit breaker CB3.

IQC Models (Inverter/Charger)

- General AC1 and AC2 are input circuits. AC3 is the only output circuit.

The purpose of having two separate 30 amp AC inputs is to allow full 30 amp AC feed through capability while also allowing full battery charging capability. (The charger can draw 27.5 amps when set to the maximum charge settings.)

When the external source has less than 60 amps of input power available be careful that the battery charging power requirement combined with the AC loads do not overload the AC source. See Automatic Power Management (APM) Panel p/n D06791 to control the amount of input power used by the battery charger.
- AC1 Primary AC input circuit protected by 30 amp circuit breaker CB1. Input voltage and frequency are monitored for proper tolerance at all times on AC1. Input power supplied to AC1 is used for battery charging and, when power is not applied to AC2, for passthrough to AC3.

AC2 Optional AC input circuit used only for passthrough. Input power supplied to AC2 will pass through only while input power is supplied to AC1. When input power is supplied to both AC1 and AC2 then AC1 is used only for battery charging and AC2 is used only for passthrough.

The passthrough circuit automatically switches away from AC1 when input power is applied to AC2. The passthrough circuit automatically switches back to AC1 when input power is removed from AC2.

AC3 AC output circuit protected by 30 amp circuit breaker CB3. (The built-in GFCI receptacle receives its power from AC3 via CB2.)

Notice:

1. When the inverter/charger is connected to an external power source, the internal circuit breakers (CB1, CB2 and CB3) are considered supplemental and do not qualify as “branch rated” circuit breakers. External AC circuits carrying power to and from the unit must conform to National Electric Code and any other applicable codes.

2. The Automatic Power Transfer Switch switches both hot and neutral. For safety purposes the inverter output neutral (terminal #8) is connected to the inverter chassis ground only when the unit is in inverter mode. This is a requirement of the National Electric Code for all systems of this type that neutral should be connected to ground only at the source of AC power, which is the inverter when in inverter mode. When an external AC input (shore power, generator) is available, the IQC Transfer Switch system breaks the connection between neutral and inverter chassis ground. The neutral-to-ground connection for passthrough power is then provided by the AC input source.

2.20 (20) DC INPUT WIRING COMPARTMENT

All Models

The DC wiring enclosure is located on the top right side of the inverter and contains 5/16 “ diameter studs to permit connection of two cables from the battery.

BE AWARE that, as a large number of capacitors become charged upon completion of the DC circuit, **THERE WILL BE A LARGE SPARK** when the last battery connection is made. The spark is normal and will occur every time the batteries are connected.

2.21 (21) GROUND WIRING LUG

All Models

This is a compression type terminal requiring only a flat blade screwdriver to make the connection. This terminal has been provided for safety to prevent possible shock hazards. Connect a #8 AWG minimum size wire to this terminal and then to the vehicle chassis ground or to earth ground.

2.22 (22) MOUNTING BRACKETS**All Models**

The IQ Series utilizes detachable mounting brackets which offer a variety of mounting configurations.

WARNING: Do not remove the plastic mounting feet. All units requires 3/4" space minimum under the unit to allow air flow for proper cooling.

2.23 (23) COOLING FAN**All Models**

The cooling fan exhausts air out through the cooling fan opening. Cool air is drawn in from the bottom and left sides of the unit. Obstruction of the intake or exhaust air flow will create overheating problems which will diminish the performance of the unit.

3 INSTALLATION

3.1 Unpacking the Inverter

Inspect the shipping container and equipment for loose or damaged parts. If any damage is found, immediately notify the freight carrier.

3.2 Inverter Installation Considerations

The wiring of your inverter installation should conform to the National Electric Code (NEC) and any other state or local codes in effect at the time of installation. These codes have been written for your protection and their requirements should be followed.

Mounting

Locate a secure, dry, flat horizontal or vertical surface large enough to mount the inverter. The location should be as close to the battery as possible without being in the same compartment and should provide adequate ventilation to maintain room temperature while the inverter is operating. The location must allow unobstructed cooling air flow at sides and bottom of the unit, and the location must be free from road spray, dripping water or other moisture contamination. A recommended minimum clearance of 4 inches (102 mm) should be maintained on all sides of the unit.

3.3 DC Wiring Considerations

BE AWARE that, as a large number of capacitors become charged upon completion of the DC circuit, **THERE WILL BE A LARGE SPARK** when the last battery connection is made. The spark is normal and will occur every time the batteries are connected.

1. The DC cables should be as short as possible. It is more electrically efficient to run the lower current AC wiring longer distances (see battery cable sizing table for proper size)
2. Route the DC positive and negative cables as close together as possible, and use cable ties to keep them together. This reduces some electromagnetic radiation that could interfere with some sensitive electronics.
3. On vehicle installations do not use the vehicle chassis as the DC negative conductor. Use a cable the same size as the DC positive to go directly from the inverter to the battery negative.
4. Route the AC and DC power wiring separately, and with as much physical separation as possible, from low voltage wiring such as audio and video signal wires.
5. DC power input cables which pass through steel or other ferrous metal walls need to pass through the same hole. If two holes are required, cut a slot connecting the two holes to prevent a transformer effect.

WARNING: Do not allow wire fragments or metal shavings to fall into the DC wiring compartment or to enter the inverter in any way.

DC INPUT WIRING CONNECTIONS

A DC fuse is required to properly protect the inverter.

The DC wiring enclosure is located on the top right side of the inverter system to permit connection of the two cables from the battery. Cable clamps are provided to secure the cables after they are terminated in the wiring enclosure. A removable cover allows access to the wiring enclosure.

DC input studs have been provided to accommodate crimp or compression lugs (Vanner part no. 04505, ILSCO part no. TZ-250 #6-250 mcm or similar) with 5/16" hole with battery cable up to 4/0 awg cable. Good DC connections are critical for the performance and safe operation of the inverter system. Torque the DC input stud nut to 119 – 158 in. lbs. and repeat torque procedure after 30 days. The positive and negative cables enter the compartment through separate strain reliefs located at the upper right side of the unit.

Table below shows the recommended minimum cable size which should be used. Wire sizing charts published in the NEC may allow a greater amp capacity than we recommend. We have sized the cable for a maximum voltage drop to maintain better performance of your inverter installation. For best performance, wire the DC negative directly back to the battery, and in the case of a mobile installation, do not use the vehicle chassis as the DC negative conductor.

The wiring of your inverter installation should conform to the National Electric Code (NEC) and any other state or local codes in effect at the time of installation. Article 551 of the NEC requires any DC cable from a battery, which measures longer than 18 inches along its length, be protected by a fuse.

Figure 4 DC Cable and Fuse Sizing Chart

IQ SERIES DC Cable and Fuse Sizing Chart				
Model Number	IQ12-2600 IQC12-2600	IQ24-2600 IQC24-2600	IQ12-3600 IQC12-3600	IQ24-3600 IQC24-3600
	Distance from battery to inverter in feet (Length of cable needed is 2 times the distance.)			
Cable Size				
1/0	NR	12	NR	8
2/0	NR	15	NR	13
3/0	10	20	NR	16
4/0	14	20	10	20
250MCM	16	20	12	20
Fuse				
Bussman Fuse Vanner p/n	ANN400 04523	ANN200 04522	ANL500 03646	ANL250 03644
Bussman Fuse Holder Vanner p/n	4164 03637	4164 03637	4164 03637	4164 03637

3.4 DC Wiring Installation Procedure

Steps

1. Turn the inverter OFF and disconnect power to the wiring harness. Make sure power to the inverter is disconnected. Verify that the inverter is turned OFF (the ON-OFF/RESET Inverter switch is in the OFF-RESET position).
2. Select a location for the unit. An ideal installation location has the following characteristics:
 - a. Close to the battery (usually within six feet).
 - b. Protected from the weather.
 - c. Well ventilated.
3. Remove the cover plate on the DC cable compartment (#) exposing the positive and negative terminal studs.
4. Prepare DC cable end with appropriate terminals (crimped or compression lugs), verify battery positive cable is disconnected from battery, and insert DC cable through strain relief openings leading to DC cable compartment. Tighten DC cable stud nuts to 119-158 in. lbs. of torque. Tighten the two strain relief cable clamps.
5. After installation of DC cables, inspect the DC cable compartment to ensure that no foreign particles (copper wire fragments) are present.
6. Replace the cover plate over the DC cable compartment.
7. Tighten DC cable stud nuts to 119-158 lbs of torque.
8. Route the negative and positive DC input cables from the inverter to the battery but do not connect to battery at this time. Protect cables with grommets or other appropriate means where they may contact hard, sharp edges throughout the installation path.
9. Install the in-line fuse. Install an in line fuse in the red, positive DC input cable between the battery and inverter, within 18 in. of the battery or DC wiring bus system. Be sure to mount fuse in easily accessible location for replacement. It is also “good practice” to note on the inverter to check the fuse condition before involving any troubleshooting procedure.
10. Connect Bonding Lug. (see #). Use AWG No.8 or larger copper conductor to connect chassis bonding lug to the vehicle chassis and/or earth ground.
11. Do not connect the inverter to the battery at this time. Final battery connections will be made after all installation issues have been inspected.

3.5 AC Wiring Installation Procedure

1. Remove the front cover of the inverter exposing the AC wiring compartment. Identify location of AC wiring terminal block (see item 2.19).
2. Insert the AC line (input) and load (output) wires through the appropriate strain reliefs into the AC wiring compartment, and tighten the strain relief with a screwdriver.
3. Connect the AC output wire to the appropriate Hot, Neutral, and Ground terminals inside the AC wiring compartment using suitable wire terminators such as crimped spade or ring terminals.
4. Connect AC Inputs (IQC Models only). Install the two line input wires and connect them to the appropriate Hot, Neutral, and Ground terminals for AC1 and AC2. Tighten the strain reliefs with a screwdriver and replace the AC wiring compartment cover.

NOTE: AC Input 1 (AC1) and AC Input 2 (AC2) should be connected to two separate 30 amp branch-rated AC circuit breakers in the main AC input distribution panel (from shore/utility power or generator) if a 60 amp supply will be used. If a single 30 amp supply only will be used, it is only necessary to connect AC Input 1 (no connect to AC Input 2) to a single branch-rated circuit breaker in the main AC distribution panel. See Section 5.2, AC Power Transfer Switch for more details.

5. Verify Installation. Verify all connections are tight and secure for maximum safety and performance.

3.6 Remote Monitor and Control Panel Installation

Unpacking the Remote Monitor/Control Panel

Inspect the shipping container and equipment for loose, damaged, or missing parts. The remote panel includes a 20-ft. interconnecting cable. If any damage is found, immediately notify the freight carrier.

Steps

1. Locate a suitable place to install the remote panel such as a flat surface near the power control/distribution panel or driver's compartment. The mounting surface should have sufficient space to accommodate the remote panel's depth and cable routing. Cut surface material large enough to accommodate the remote control box leaving sufficient surface material to attach panel with #8 mounting screws.
2. Route the 20-ft. interface cable from the remote panel mounting area to the inverter being careful to avoid unprotected sharp corners or moving parts.
3. Plug the interface cable into the inverter's wiring panel (RJ-11 telephone-type jack labeled J9 on the control printed circuit board). Plug the other end of the cable into the rear of the remote panel.
4. Mount the remote panel using four #8 screws.

3.7 Automatic Power Management (APM) Panel Installation

Unpacking the Automatic Power Management (APM) Panel

Inspect the shipping container and equipment for loose or damaged parts. If any damage is found, immediately notify the freight carrier.

Steps

1. Locate a suitable place to install the APM panel such as a flat surface near the power control/distribution panel, shore power switch, or driver's compartment. The mounting surface should have sufficient space to accommodate the remote panel's depth and cable routing. Cut surface material large enough to accommodate the remote control box leaving sufficient surface material to attach panel with # 8 mounting screws.
2. Route the 20ft. interface cable from the remote panel mounting area to the inverter.
3. Plug the interface cable into the inverter's wiring panel (RJ-11 telephone-type jack labeled J8 on the control printed circuit board).
4. Plug the other end of the cable into the rear of the APM panel.
5. Mount the remote panel using four # 8 screws.

4 SYSTEM START-UP AND TESTING PROCEDURES

WARNING: THESE PROCEDURES ARE TO BE PERFORMED ONLY BY A QUALIFIED INSTALLER.

After the IQ series inverter has been properly mounted with sufficient ventilation, DC cables have been connected, AC wiring has been completed, and all remote connections have been checked, the Start-up and Testing procedure may now be performed .

4.1 Inverter Start-up and Testing

1. Place the System On/Off switch on the inverter and remote LED panel in the OFF position.
2. Remove the front cover of the inverter to access the Programming Switch.
3. Place the Load Demand switch on the internal Programming Switch 2 to the ON position to test Load Demand function. It can be changed later if this feature is not used.
4. Verify that the external GFCI breaker, breakers, or receptacles are reset and connect an AC load, such as a 100-Watt light.
5. FOR IQC MODELS - Place the Wet/Gel Setup switch to the correct position for the installed battery type and place the Equalizer Setup switch to the OFF position.
6. Connect both battery cables to battery and turn on the battery DC power to the inverter (if battery switch is used).
7. FOR IQC MODELS - Do not connect shore/utility (generator) power at this time.
8. Place the System On/Off switch on the Inverter panel to the START position.
9. Place the System On/Off switch on the Remote panel (if used) to the ON position.
10. Plug AC output test light (eg. 100 watt trouble light) into 15A convenience receptacle and turn on to verify inverter produces AC power and the Load Demand function powers up from stand-by mode. Applying any AC load greater than 5 Watts should start inverter from Load Demand "stand by" mode.
11. FOR IQC MODELS - Connect and activate AC shore/power (or generator).
12. FOR IQC MODELS – When shore/utility power (or generator) has been connected the inverter the following should occur:
 - If AC test light is off.
 - Inverter LED will blink slowly
 - Charge Bulk or Charge Float mode LEDs will illuminate. (If the battery is fully charged, it will advance from Bulk mode to Float mode after a time delay).
 - If AC test light is on.
 - Inverter LED will blink.
 - Battery charge stage LEDs will illuminate as described above.

- The AC output test light should be on, indicating the presence of shore power and correct operation of the AC Transfer switch.
13. FOR IQC MODELS - Disconnect the AC shore power input. The AC output test light blinks momentarily, indicating the operation of the Transfer switch connection to connect the AC loads to the inverter output.
 14. The Inverter LED on the inverter control panel has a solid green light indicating correct inverter operation. At this point, apply AC loads up to the models rated capacity to verify full-power operation.
 15. Disconnect all AC loads. The Inverter LED blinks, indicating that the inverter has returned to Load Demand mode.
 16. FOR IQC MODELS - Determine the correct charger output amps and place the Programming Switch (#) positions to match this value. Multiple switches can be activated at the same time to combine values.

For 12-Volt models, the output amps corresponding to the switch positions are:

A	8 Amps
B	16 Amps
C	32 Amps
D	64 Amps

For 24-Volt models, the output amps corresponding to the switch positions are:

A	4 Amps
B	8 Amps
C	16 Amps
D	32 Amps

Determine the combined value of switches that match the desired charger output amps and place these switches to the ON position. For example, on a 12-Volt system, for a charger output of approximately 80 Amps, the 64-Amps and 16-Amp switch positions would be ON and the 8-Amp and 32-Amp switch positions would be OFF.

If the Load Demand function is not appropriate for the intended application, reset the Load Demand Switch, Programming Switch 2, to the OFF position. This will allow the inverter to be fully On continuously unless switched off with the On/Off front panel switch or remote control.

Replace front cover of the inverter.

4.2 Procedure to Check Battery Charger Operation

Due to the amount of time to perform this procedure, verifying the battery charger function, it may be postponed to a convenient time.

To test the battery charger operations, first discharge the battery by placing a large AC load (approx. 50% of the units rated capacity) on the system and operating the inverter with shore power off. The AC load will discharge the battery over a time relative to the amount battery capacity, size of load, and ambient temperature.

When the battery charge level is low, the Battery Low LED turns on and will stay on until the battery voltage has dropped to the Battery Low shutdown stage the inverter shuts off and the LED begins to blink. The battery voltage has decayed to 10.5 Vdc (or 21.0 Vdc for 24 volt models). Now, apply shore power and observe the battery charger operation. The system begins with the Charger-Bulk Light blinking, indicating bulk charge operation. This supplies a constant current charge output. Connect an ammeter to the DC cables between the inverter and the battery to monitor the current (DC amps), and a volt meter to the battery to monitor the battery voltage rising.

After some time, the battery voltage rises to the Absorption voltage (14.4 VDC for wet batteries or 14.1 VDC for gel batteries). The Charger-Bulk light continues to flash, indicating the charger is in Bulk or Absorption mode. The battery voltage remains constant (Absorption voltage value), and the charger output current tapers off. After approximately twenty minutes, the charge advances to Float mode. The Charger Float LED turns ON and the battery voltage drops to the float voltage value (13.2 VDC for wet batteries or 13.6 VDC for gel batteries). The charger will remain in this stage until shore power is removed or until the battery will again accept the bulk charge amperage.

5 THEORY OF OPERATION

5.1 Battery Charger Operation

The IQ Series' Battery Charger incorporates an automatic, three-stage charger. This design enables the unit to automatically charge batteries, maintaining the battery's integrity and reducing the likelihood of premature failure. The battery charger is designed to be used with lead-acid type batteries including sealed and gel types, but not for nickel-cadmium (Ni-Cad) or nickel-iron types.

There are three automatic charge stages; Bulk, Absorption, and Float.

Bulk Charge Stage

The Bulk Charge Stage (fixed current) provides a fixed charging current for rapid charging of the battery bank. The charger output current is adjustable in 8-Amp steps (4-Amp steps on 24-Volt systems), up to the maximum charger rating, to match the charging requirements of the battery. The Bulk Stage is initiated when the battery will accept the charging amps selected. As the battery accepts charge the battery voltage will rise to the charger's Bulk Voltage value, 14.4 VDC for flooded batteries, or 14.1 VDC for gel batteries (on 24-Volt systems 28.8 and 28.2 respectively). When battery voltage reaches the Bulk Voltage Value the Bulk Charging Stage is complete. At this point, the battery is approximately 80-percent charged.

Absorption Charge Stage

During Absorption Charge Stage (fixed voltage), the charger's output voltage remains fixed at the Bulk Charge value and the output current will decrease as the battery becomes fully charged. The Absorption Stage ends after twenty minutes and the charger advances to the Float Stage.

Float/Maintenance Charge Stage

When the charger enters Float Stage, its output voltage is reduced to the float voltage value 13.2 VDC for flooded batteries, or 13.6 VDC for gel batteries (on 24-Volt systems 26.4 and 27.2 VDC respectively). This setting is sufficient to keep the battery charged, but not so high as to boil or over-charge the batteries. The charger will remain in Float Stage until the battery will accept the Bulk Charge Output Amps selected.

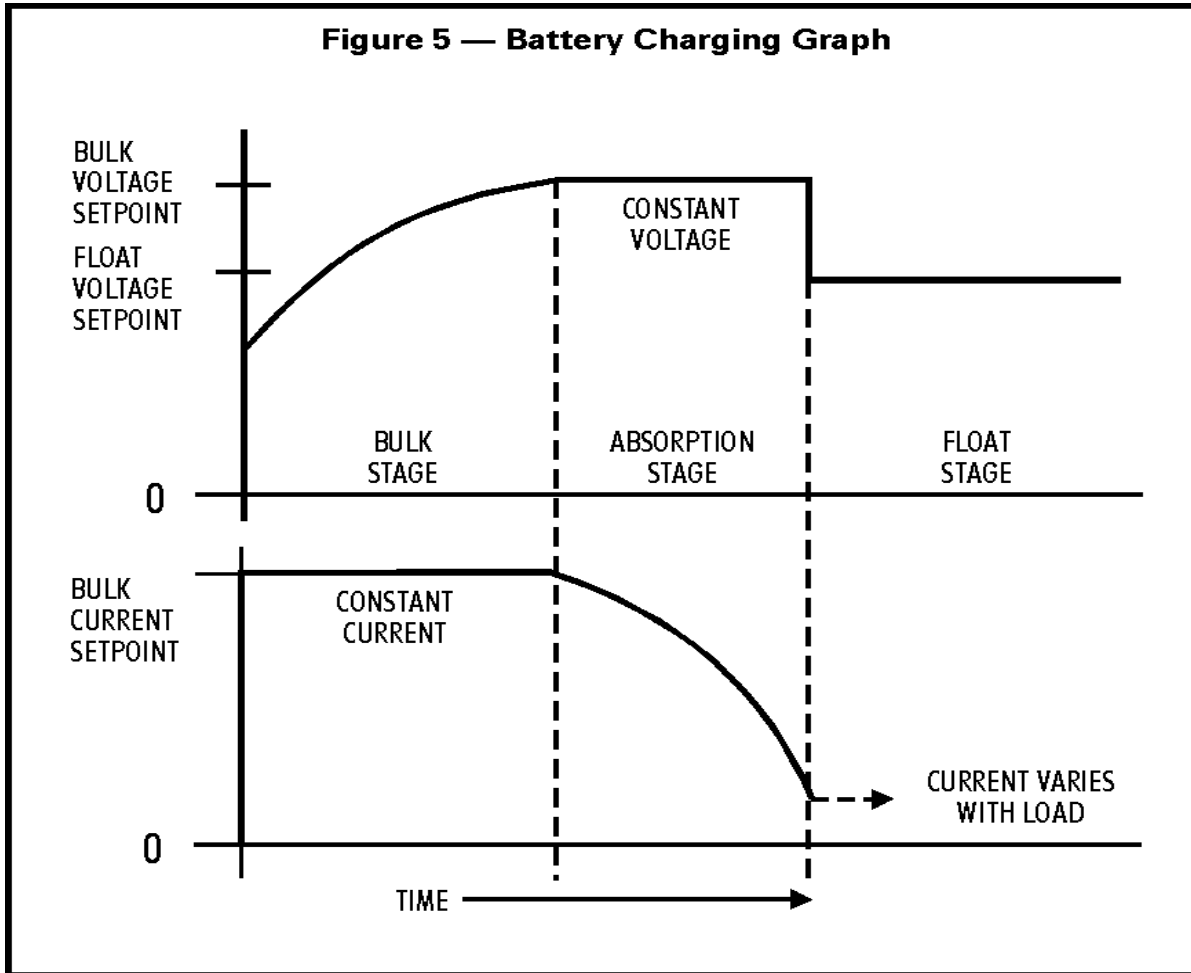
Equalization Cycle

This manually initiated cycle provides a 1 hour equalization charge at the Bulk Voltage level to boil the battery. This removes the sulfate build-up on the battery plates, and is used only on flooded lead acid batteries. Refer to the battery manufacturer for frequency recommendations.

WARNING: DO NOT USE WITH SEALED OR LEAD CALCIUM MAINTENANCE FREE BATTERIES.

The Equalization Charge Cycle is initiated by switching Program Switch 3 from OFF to the ON position. The Equalize Cycle is automatically terminated after 1 hour. The Equalize Cycle will be manually terminated by turning the Program Switch 3 to the OFF position or by turning the Main ON/OFF Switch OFF or by turning shore power OFF.

Figure 5 Battery Charging Graph



5.2 Automatic Power Transfer Switch Theory of Operation

The function of the Automatic Transfer Switch is to automatically accept AC input power from shore or generator, and use this power to operate inverter loads and to provide power for battery charging. Upon loss of AC input power, the transfer switch automatically switches the AC loads back to inverter power. Transfer time is approximately 30 milliseconds (0.030 seconds). The 0.030 second transfer time allows all but the most sensitive loads to transfer from inverter power to shore power and back to inverter power without interruption.

AC input voltage and frequency are monitored for proper tolerance at all times on AC1. When the AC input is within tolerance for approximately 5 seconds, the power is passed through to AC3 output circuit and the IQC automatically switches from inverter mode to battery charger mode. The IQC automatically switches back to inverter mode when input power is disconnected or when input power is no longer within tolerance. See IQ Series Specifications page for AC input voltage and frequency tolerances. The 5 second delay occurs only if the inverter is fully ON when input

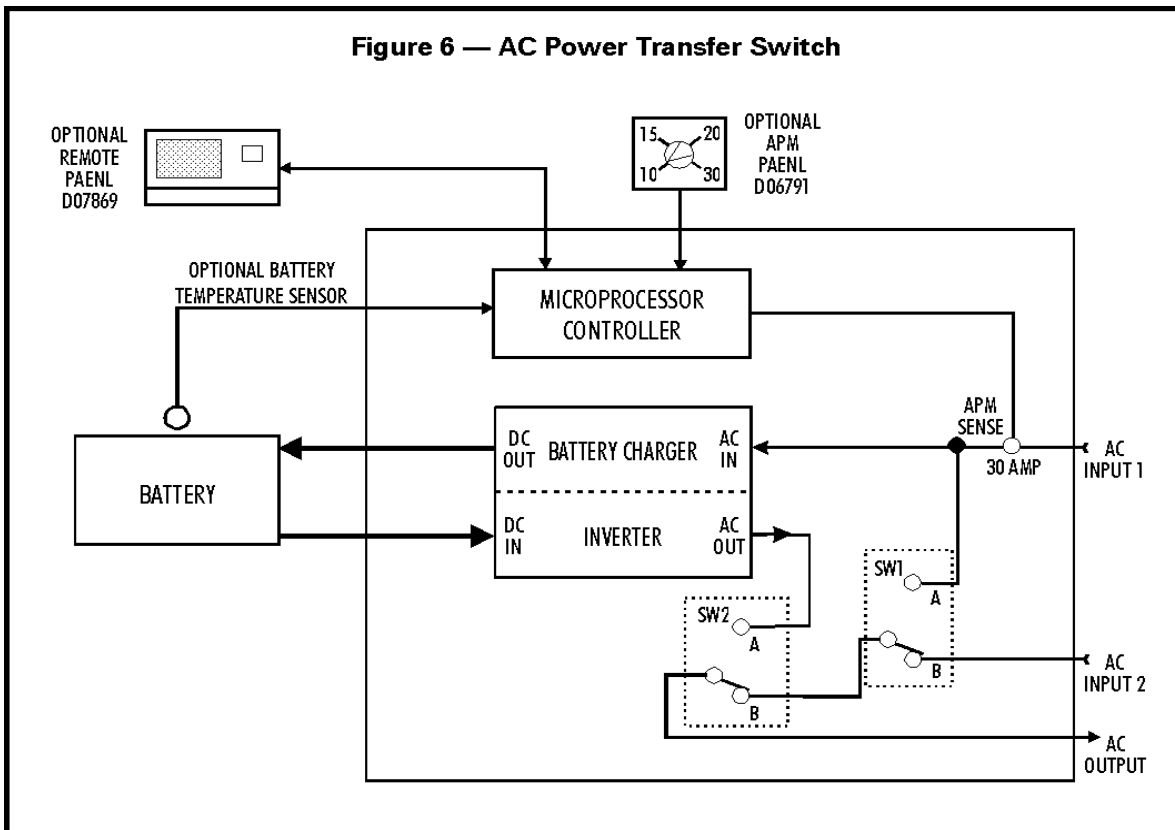
power becomes available. There is no 5 second time delay if the inverter is in the 'Load Demand Mode' when input power becomes available.

Switch 6 on the Programming Switch allows the user to select either 90 AC input volts or 77 AC input volts to be the Low AC Input Voltage switchover tolerance value. Set switch 6 to match the quality of AC being supplied. HI (90 VAC) is generally used on more stable AC power (Residential or Industrial Supplies). LOW (77VAC) is used with less stable AC power (motor generator, solar, rural supplies).

For all IQC models, the factor that determines whether the unit is in 'inverter mode' or 'battery charger mode' is the presence or absence of 'in-tolerance' input power. Whenever 'in-tolerance' input power becomes available the IQC automatically switches from inverter mode to charger mode.

The transfer switch switches both hot and neutral. For safety purposes the inverter output neutral (terminal #8) is connected to the inverter chassis ground only when the unit is in inverter mode. This is a requirement of the National Electric Code for all systems of this type that neutral should be connected to ground only at the source of AC power, which is the inverter when in inverter mode. When an external AC input (shore power, generator) is available, the IQC Transfer Switch system breaks the connection between neutral and inverter chassis ground. The neutral-to-ground connection for passthrough power is then provided by the AC input source.

Figure 6 AC Power Transfer Switch



5.3 Automatic Power Management (APM) Theory of Operation

Automatic Power Management (APM) Feature

When the IQC is connected to shore power and operating large AC loads it is possible that the AC loads combined with battery charging requirements may exceed 30 amps. To prevent nuisance tripping of the shore circuit breaker the Automatic Power Management circuit constantly monitors the AC current entering input AC1. (Input AC1 is used to power the battery charger and to power AC loads connected to the IQC output circuit when input AC2 is not used.) If the AC input current exceeds 30 amps the APM circuit automatically reduces power to the battery charger until either the AC1 input current is less than 30 amps or until the battery charger power is zero. The APM circuit will override the Program Switch Bulk Charge Output Amps Setting and proportionally reduce the battery charger output as necessary.

The optional APM Panel (Vanner part no. D07934) allows the operator to select the maximum AC amps the battery charger may draw from shore power input AC1. The APM Panel allows the Automatic Power Management Feature to be adjusted to match the size of the shore power circuit breaker, 10 amps, 15 amps, 20 amps or 30 (default) amps. In motor home or similar applications, where the shore power source varies from campground to campground, the APM Panel is useful in preventing nuisance tripping of the circuit breaker at the shore power source. This panel is usually installed near the shore power hookup.

Example 1: Input AC2 is not receiving power, the APM Panel switch is set at 15 amps and the AC output load is drawing 10 amps. Under these conditions the APM will allow the battery charger to draw up to 5 AC amps. If the AC output load is increased and exceeds the APM setting then the battery charger will be reduced to zero AC amps.

Example 2: Input AC2 is receiving power and the APM Panel switch is set at 15 amps. Under these conditions the battery charger will be allowed to draw up to 15 AC amps regardless of AC output load.

5.4 Automatic Throttle Control Terminal J31 Theory of Operation

Terminal J31 is provided on all model and is to be used on utility vehicles where the inverter needs to operate continuous heavy AC loads and the vehicle is equipped with an Automatic Throttle. Use J31 to turn ON the Auto Throttle to insure that the vehicle alternator is producing maximum output whenever the inverter is powering a load.

J31 is controlled by the Load Demand circuit therefore Programming Switch 2 must be in the ON position when Terminal J31 is used.

J31 is a 1/4" spade terminal located in the lower right midsection of the control circuit board. The terminal is designed to provide ground control for a Bosch relay, Vanner part number 05235 or equal. Install a 1 amp fuse in line near the inverter.

Symptom	BATTERY LOW lamp illuminates when AC load is applied.
Solution	Check battery connections. Check battery condition. Recharge battery if voltage is less than 10.5 VDC. Check the charging system for proper operation (vehicle alternator, PV array, generator).
Symptom	OVERTEMP lamp illuminates.
Solution	Something has caused the unit to overheat. Check for obstruction of air flow to the cooling fan or from ventilation holes. Verify AC load is within unit's rated capacity.
Symptom	OVERLOAD lamp illuminates with AC load applied.
Solution	Verify AC load is within unit's rated capacity.
Symptom	DC fuse blows when connecting DC input cables.
Solution	Check for reverse polarity: red cable to battery positive (+), black cable to battery negative (-) The unit may be damaged and require repair service.
Symptom	Excessive audible buzzing during inverter operation but inverter operates loads.
Solution	Check mounting bracket bolt tightness Remount inverter with rubber insulator washers
Symptom	AC loads do not seem to be fully energized when operating from inverter power
Solution	Check AC output voltage at convenience receptacle. Check for overheated DC or AC wiring
Symptom	Unit does not operate and a "burnt wire" smell emits from inverter
Solution	Disconnect AC loads and battery immediately Unit may require service

6.3 GFCI Test Record

For maximum protection against electrical shock hazard, operate the Test Switch on the Ground Fault Circuit Interrupter at least once a month.

ENTER YEAR	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC
19____												

7 APPENDICES

7.1 Inverter Overview

An inverter converts DC electrical power into AC power. This power can be used to operate various AC-driven appliances.

The most common battery systems are 12 or 24 volt. Some systems, however, operate on higher voltages such as 32, 36, 48, or 120 volts. The most common inverter AC output power is 120 volts at a frequency of 60 Hz, although some inverters are designed to produce 240 volts, or both 120 and 240 volts at 60 Hz. Because some countries use power of different voltage and frequency (e.g. 230 volts at 50 Hz), inverters are available to conform to these requirements.

Inverters use electronic circuits to switch DC input power at the required frequency, such as 60 Hz. This "switched" DC resembles AC power, and is then stepped up in voltage through a transformer. The result is a modified sine wave AC output of the required voltage and frequency that can power AC-driven equipment.

Inverter Types

The three available inverter types are distinguished by the type of AC output wave form they produce. This wave form affects the AC loads they operate. This section provides an overview of these inverter types, including the advantages and disadvantages associated with using each type.

Sine Wave Inverters

produce an AC output wave form like power produced by the electric utility companies and rotating generators. The sine wave inverter's wave form is characterized by the highest peak voltage and smooth voltage transitions (no square wave components). Such inverters are the most costly of the three inverter types because they contain extra electronics to produce the required wave form.

Modified Sine Wave Inverters

are sometimes called "quasi sine wave inverters" or "modified square wave inverters." Modified sine wave inverters produce an AC output wave different from the power produced by the electric utility companies and rotating generators. Although this wave form has a higher peak voltage than do square wave inverters, its peak voltage is not as high as a pure sine wave. Therefore, AC loads containing power supplies might not always operate properly on the modified sine wave inverter.

Square Wave Inverters

are low cost devices that produce a square wave AC power output. This AC power can be an accurate 60 Hz frequency if it is crystal controlled. It does not have the peak voltage necessary to properly operate many AC appliances that contain electronic power supplies (e.g. computers, TVs, and VCRs). The square wave is appropriate when operating AC loads such as resistive heating devices, lighting loads or universal motor loads.

7.2 Problem Loads

Although modified sine wave inverters will operate most AC loads, some loads may exhibit problems because the wave form is different than the pure sine wave of utility power. This is due to the square wave components and that the peak voltage is not quite as high as a pure sine wave. Loads that may exhibit problems include motor speed controls found on ceiling fans and air conditioner fans; light dimmer controls; clocks; microwave ovens (cooking time may vary and the clock may be erratic); video monitors and TVs (may have lines in the picture); AM radios (may pick a noise); laser printers; copying machines; fluorescent lights; and power supplies in some electronic devices. Rechargeable battery devices may also overheat and be damaged by the inverter. If you

desire to operate a rechargeable battery device on the inverter you should first power it up and closely observe it for a period of time to ensure that it does not run too hot.

7.3 Battery Types and Ratings

The batteries in general use for automotive, solar, and marine use are lead-acid storage batteries. They can be separated into two categories according to their use: engine cranking batteries and deep cycle batteries. The engine cranking battery is specifically designed to supply hundreds of amps for a short period of time to start an engine. Cranking an engine usually uses a small portion of the battery's total capacity and once the engine is running, the battery is quickly recharged by the engine's alternator. The deep cycle battery is specifically designed to deliver current for extended periods of time and can be almost totally discharged before recharging.

The "deep cycle" lead-acid battery is designed to withstand the deep discharge/recharge cycling that is typical of most inverter installations. These batteries are available in the "maintenance free" style where the electrolyte does not need to be checked or replenished and they also are available in the gelled electrolyte style or "Gel Cells". Deep cycle batteries are generally advertised for use in recreational vehicles or boats and are sometimes referred to as RV or marine batteries.

Battery Council International (BCI) is a voluntary industry organization which has helped to standardize battery ratings. Ratings in use at this date are: Cold Cranking Amperes (CCA), Marine Cranking Amperes (MCA), Reserve Capacity (RC) and Ampere-Hour (A-H). The first two of these ratings are used for sizing an engine cranking battery and have no bearing on a battery's cycling ability. Reserve Capacity is a rating given to cranking batteries to give a person some idea of how long the battery may last if the vehicle charging system were to break down and needed to continue driving the vehicle (to the nearest freeway off ramp or service station). This brings us to the oldest and probably least understood battery capacity rating, the ampere-hour. The ampere-hour is defined as follows:

Ampere-Hour (A-H):

A unit of measure for a battery's electrical storage capacity, obtained by multiplying the discharge current in amperes by the time in hours of discharge. The rating is usually for a discharge period of 20 hours and an end voltage of 10.5 volts. Example: A battery which delivers 5 amperes for 20 hours has a capacity of 100 A-H. 5 amperes x 20 hours = 100 Amp-Hr.)

The reason the A-H rating is misunderstood is simple. A battery that has a rating of 100 AH cannot always deliver 100 A-H. The underlying reason is the efficiency with which the battery converts its chemical energy into electric energy. The A-H capacity of a battery is affected in the following ways:

Discharge Rate:

A battery becomes less efficient as the discharge current increases. For example, a typical 100 A-H battery is specified to be able to deliver 5 amps for a period of 20 hours. If the discharge current were increased to 25 amps, the capacity will be reduced to approximately 75 A-H (25 amps x 3 hours = 75 A-H).

Operating Temperature:

A battery becomes less efficient at lower temperatures. Most battery manufacturers specify the battery A-H capacity at 80°F. At a temperature of 32°F, the same battery will have only about 65% of its rated capacity even though it may be fully charged. At a temperature of 0°F, a battery's capacity will be reduced to about 40% of its rated capacity.

Battery Age:

As a battery is used, some of the active material on the battery plates will deteriorate and become useless. As the battery gets older, there will be less and less useful material left on the plates and the operating time will become noticeably shorter. A battery will age faster (lose active

material from its plates faster) if it is deeply discharged regularly, if it is left in a discharged state for extended periods of time, or if it is repeatedly overcharged.

7.4 Inverter Sizing

Power output is an important consideration when purchasing an inverter. Power is defined as the rate that a device produces (or uses) electrical energy. This rate is measured in watts or kilowatts (one kilowatt equals 1,000 watts), or sometimes in volt-amps. Volt-amps are obtained by multiplying volts times amps produced or used by a device.

The VA (volt-ampere) rating is always equal to, or greater than the power rating of the device. The difference between the power rating and the VA rating is called the "power factor" (PF), for example: Power Rating = VA x PF. The inverter will protect itself based on the output current, and therefore must be sized to handle the VA rating of the load.

To properly determine an inverter size (in watts) for your application, decide which AC loads you plan to operate. Inverter size is the sum of the wattages of the AC loads that you wish to run at the same time, plus a safety factor of 10 to 20 percent.

Inverter Power Ratings

Continuous Power is defined as the AC power in watts (or voltamps) an inverter can produce on a continuous basis. The ambient temperature can affect the continuous rating of the inverter, and is normally specified, e.g., 25 C.

Surge Power is the short term duration of AC power that the inverter can produce. It is often specified as the watts (or volt-amps) that can operate a resistive load for two or three seconds. Sometimes this is specified in AC amps because the inverter may allow its output voltage to drop (which would reduce its wattage). Like continuous power, the surge rating is affected by ambient temperature.

The surge power that the inverter can produce is dependent on the inverter surge rating, the battery size, and state of charge.

7.5 DC Power Consumption

An inverter takes in DC power, and produces AC power to operate attached loads. In general, we can see a direct relationship between DC input power and AC output power. This allows us to establish the following rule:

For every 10 watts of AC output power, an inverter requires one amp of DC input power on a 12 volt input inverter.

Example:

An inverter powering a 1,000 watt AC load requires 100 amps DC at 12 volts.

$1000 \text{ watts} / 10 = 100 \text{ amps}$

Using our rule, we can determine the requirements for an electrical system needed to power our inverter (typically, an alternator and battery combination, or a photovoltaic panel and battery combination).

7.6 Overall System Design Considerations

To get the best performance from your inverter, it must be installed properly and have an ample DC supply. We will not be able to cover all the possible situations encountered when installing a power inverter, but we will cover

the basic information required to properly size your vehicle alternator and inverter battery, as well as give some examples of AC power distribution systems which are commonly used. Keep in mind that if information in this manual directly conflicts with instructions from a specific battery or other equipment manufacturer, you should follow that manufacturer's recommendations.

Inverter DC Input Current Requirements

A DC to AC inverter converts DC power into AC power. For the purposes of this discussion, power (watts) is equal to the supply voltage (volts) multiplied by the current draw (amps) from the supply for both AC and DC circuits. For example, 2400 watts = 12 volts DC x 200 amps, and 2400 watts = 120 volts AC x 20 amps. From these two examples of 2400 watts at 12 volts and 2400 watts at 120 volts, it is easy to see that since there is a 1 to 10 voltage conversion (12 to 120), there is a 10 to 1 amp conversion (200 to 20). A more accurate relationship between the input power and output power is:

$$(DC\ Input\ Power) \times (Efficiency) = (AC\ Output\ Power)$$

This formal relationship has lead to the following rule of thumb for estimating the DC input amps for an inverter:

- For 12 volt DC inverters: output watts ÷ 10 = DC input current
- For 24 volt DC inverters: output watts ÷ 20 = DC input current

This rule of thumb can be used to estimate the minimum alternator size required for your application and is also used later in calculating the minimum size battery required when operating from battery only. The following examples should help to clarify the use of this rule of thumb.

Example A:

What is the DC current draw of a 12 volt DC input inverter when it is operating a vacuum cleaner with a name plate rating of 6 amps at 120 volts AC?

The appliance rating is given in amperes, so we must first calculate the power it consumes. Then the rule of thumb can be used to find the DC input current of the inverter.

Output power = 120 volts x 6 amps = 720 watts, and DC input current = 720 ÷ 10 = 72 amps DC.

Example B:

What is the DC current draw of a 24 volt DC input inverter when it is operating a toaster with a name plate rating of 1050 watts at 120 volts AC?

Since the appliance is rated in watts, the rule of thumb can be applied directly:

DC input current = 1050 ÷ 20 = 52.5 amps DC.

This information on estimating the DC input current requirement for an inverter will allow you to size an alternator or charging system to supply an inverter for continuous operation.

Sizing the Inverter Battery

Sizing a battery system for an inverter application can be a very tedious task if all the different variables, such as discharge rate, depth of discharge, and operating life time are included in the calculations. To simplify these calculations and get a reasonably correct battery size, we will assume: 1) A 50% depth of discharge for the purpose of obtaining a reasonable life time for a reasonable battery system cost, 2) there is no charge current into the battery system, 3) the batteries are in a fully charged state at the beginning of the discharge cycle, and 4) the DC current draw from the battery does not exceed 1/3 the battery C rate for any length of time.

Follow the steps listed below to find the A-H capacity required for your application.

Steps

1. Make a list of each appliance, its power requirement in watts, and the amount of time in hours it will be operating between charging cycles.

2. Calculate the watt-hours required for each appliance by multiplying the power requirement by the operating time of that appliance.
3. Calculate the total watt-hours needed by adding together the watt-hours of each appliance.
4. Find the amp-hours consumed by dividing the total watt-hours found in step 3 by 10 for 12 volt DC systems or by 20 for 24 volt DC systems.
5. Multiply the amp-hours consumed by 2 (for 50% depth of discharge) to get the battery amp-hour capacity desired.

DC Charging Systems

The DC charging system is a very important part of your inverter installation. The system consists of the primary charger (engine alternator or photovoltaic array), a secondary charger, if used, the battery, and other equipment which may be used such as battery isolator diodes. The complexity of the system depends on the way the inverter is used. In some cases, such as utility or service vehicles, the system may be as simple as the engine alternator and the cranking battery which also powers the inverter. In most cases, additional equipment is needed to provide additional DC power and/or protection. These systems can be grouped into two categories, the single battery and the dual battery systems.

In the single battery system, there is one battery which is shared for starting the engine and operating the inverter. This is a common practice in a service vehicle where the engine runs all the time and allows the alternator to provide continuous charging for the battery. In this case, the inverter's auxiliary batteries can be connected directly to the engine cranking battery. Great care should be used when operating this type of system. If the engine were to be shut off and the inverter operated, it would not take a very long time for the inverter to discharge the cranking battery and disable the vehicle! The most important detail of this system is the alternator output rating. The continuous output of the alternator needs to be at least as much as the total DC current draw on the system. The total DC current draw must include the inverter, warning lights, radios, engine controls, and any other device connected to the DC system.

The dual battery system uses two separate batteries, one for starting the engine and operating the vehicle's systems, and one for operating the inverter. The two batteries are usually referred to as the "cranking battery" and the "house battery" respectively. The two separate batteries are usually charged from the same source, the engine alternator, but are separated by a device called a battery isolator. The battery isolator allows DC current to flow from the alternator into each battery, but blocks current from flowing from one battery to the other. This is a must to protect the cranking battery in recreation vehicles, boats and other vehicles where the inverter needs to be operated when the engine (therefore the alternator) is not running.

Up to this point we have spoken of the battery as if it were a single battery. In some cases this may be true, but in general, the battery may be made up of several individual batteries electrically connected together to form a "Bank" of batteries. Batteries can be connected in series, parallel, or a combination of series and parallel as long as all of the batteries in the bank are of equal ratings, are from the same manufacturer, and are the same age. Old and new batteries should never be mixed in the same battery bank. A series connection is where two or more batteries are connected positive (+) to negative (-) and the total voltage of the battery bank is the sum of the voltage of each battery in the bank. For example, most large custom coaches require a 24 volt battery to crank the large diesel engine. The 24 volts is usually provided by connecting two 12 volt batteries in series, and sometimes by connecting four 6 volt batteries in series. The ratings of the series connected battery bank remain the same as the individual battery's rating. If the battery bank is made up of two 8D size batteries in series, each with a CCA of 1050 amps, 425 minutes RC, and amp-hour capacity of 200 A-H, then these individual battery ratings are also the ratings of the entire 24 volt battery bank. This unit is considered a 200 A-H battery system, but running at 24 volts.

Parallel connected batteries are batteries of the same voltage and rating which are connected positive to positive and negative to negative. They form a battery bank that has the same voltage as each individual battery. The ratings of a parallel connected battery bank, in general, are the sum of the individual batteries. For instance, if two 8D batteries are connected in parallel, and each battery has the ratings given in the paragraph above, then the ratings for the battery bank become 2100 CCA, 900 minutes RC, and approximately 400 amp-hours.

Inverter AC Wiring Applications

There are many different ways that an inverter can be installed and is probably only limited by ones imagination and wiring codes. There are only a few types which we will convey to you that use good engineering practices and will cover most needs in a recreational or service vehicle.

Inverter Only Installation

The term "inverter only" means that the inverter is the only source of AC power on board the vehicle. This type of installation is typical of a service vehicle which needs AC power to run power tools and other equipment during the work day and does not require the inverter to operate when the vehicle engine (and therefore the battery charging system) is not running. The AC power distribution system usually consists of an AC circuit breaker and one or more receptacles.

Inverter with Multiple AC Power Sources

In an installation where there are multiple AC sources, the system needs to be designed so that one and only one AC source can be connected to the distribution wiring at any one time. This is to prevent the selected power source from back feeding one of the other power sources. It may be accomplished by using a manual transfer switch, or an elaborate automated system which chooses and switches to the best available AC source. A very simple manual transfer system may consist of a cable which is plugged into the desired AC source. Please note that in all cases where a transfer switch is used, it must switch both the AC "HOT" and "Neutral". This will prevent many problems, especially when a Ground Fault Circuit Interrupter (GFCI) is used. Also note that the AC distribution panel must have an insulated neutral bus. The insulated neutral is a requirement of the Nation Electrical Code (NEC) Article 551-54(c).

