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# **BLACKBIRD WIRING MANUAL**

**VERSION ZX240 3/11 PTO**



**TO BE USED IN CONJUNCTION WITH A PTO  
INSTALLATION SUPPLEMENT**



## **System Capabilities**

The Blackbird provides 7000 watts of pure sine, alternating current for **resistive** loads. It is a split-phase system, and will provide

- two legs of 120VAC each 30 amperes (7000 watts), or
- 240VAC at 30 amperes (7000 watts), or
- a combination of both not to exceed 7000 watts.

Overall system voltage is maintained at 240 VAC leg-to-leg. Uneven loading of the output legs will cause the more greatly loaded leg to sag in voltage and the less loaded leg to rise, equaling a total 240 volts. Care should be taken to design and utilize 120 volt circuit legs in a manner which maintains as nearly a balanced load on legs as is practical.

### **Resistive Loads**

Examples of resistive loads are:

- lights
- heaters
- battery chargers
- power supplies (radios, computers, etc.)
- small power tools (tools with universal motors: drills, sawsalls, skill saws, etc.)

### **Inductive (reactive) loads**

When used in conjunction with a Raven Smart Circuit™ phase correction device, the Blackbird will start and run inductive motors up to 1/2 horsepower. These motors include:

- Standard fire service smoke ejectors
- Sump pumps
- Small refrigerators
- Most roof-top air conditioning when wired in conjunction with additional phase correction. (Contact Raven for details).

Multiple inductive motor loads may not be operated simultaneously without prior authorization by Raven Technology.

Note:

Due to the Blackbird's unique active control system, the feature that allows constant generator output at varying shaft speeds, the 7kW system is unable, in most cases, to smoothly run motors above 1/2 horsepower. These motors include:

- Electro-hydraulic rescue tools (Hurst, Holmatro, Amkus, etc.)
- Large-bore pumps (> 1 1/2" discharge.)
- Any motor above 1/2 horsepower

Inductive loads will require some amount of parallel resistive load to operate effectively. We encourage our customers to adopt SOPs which include running lighting as parallel load when operating inductive loads to assure maximum system stability. Between 1000 and 1500 watts usually suffices. The Blackbird thrives on resistive load, and will accept inductive load most readily when it is already carrying resistive load.



## **Raven Technology Smart Circuit™ System**

Inductive motors by nature return out-of-phase power back into the power feed line. When the Blackbird's™ unique microprocessor control system senses this return power, it attempts to adjust to it and system voltage instability results. This condition can, at times, cause damage or failure to the Blackbird™ and to electrical loads powered by the system. The Raven Smart Circuit™ is a phase correction circuit which stores this out-of-phase energy (normally wasted by electric induction motors) and sends it back into the load in-phase where it is then converted by the motor into useful magnetic energy for rotation. The result is overall system voltage stability and increased load efficiency: a standard fire service smoke ejector which normally draws around 6 amps when running, actually draws only around 4.5 amps at the power source when plugged into a Smart Circuit™. Parallel resistive load (lights or heaters) also lessen the chance of voltage instability, and should be used in conjunction with an inductive load.

### **Packaging:**

Smart Circuit™ is available both as the standard in-line SmartCord™, or, additional cost, a Smart Circuit™ dedicated circuit on a vehicle which can be used for any applicable device requiring phase correction. These circuits are, to a certain degree, load-specific. The standard SmartCord™ is sized for a typical fire service smoke ejector.

### **Uses and Restrictions:**

SmartCords™ or dedicated Smart Circuit™ outlets *should* be used for electric induction motors up to 1/2 horsepower, such as smoke ejectors, pumps with discharge of 1 1/2" or less, and small (dorm size) refrigerators. It also may be helpful in the smooth operation of microwave ovens.

Smart Circuits™ are unnecessary and *should not* be used for resistive loads such as lights, heaters, battery chargers, hand tools, or computer power supplies. Additionally, SmartCords™ *should not* be used for motors larger than 1/2 horsepower. If larger motors, or loads not addressed here are indicated, contact Raven Technology (207-721-1044) for information on a custom Smart Circuit™ for your application.



## **Parts Included in Wiring Kit**

Before beginning installation, check the parts kit thoroughly against the parts inventory list, and make sure that every necessary part is in hand. If parts are missing or you have questions regarding the parts and components, contact Raven Product Support (207-721-1044) before beginning installation.

<b>Parts</b>	<b>Description</b>
Control Box	Including wiring terminals
Field Cable	8/3 SOW x 15' with Yellow Tape
Armature Cable 1	8/3 SOW x 15' with Blue Tape
Armature Cable 2	8/3 SOW x 15' with Purple Tape
Battery Cable	10/2 SOW x 15' Black/White Conductor
Control Cable	18/2 x 25'

## **General Instructions**

- **All installation steps must be completed before operating the system.**
- Vehicle battery cables should be disconnected during all mechanical and electrical installation steps.
- All hoses and wires moved or relocated during installation must be secured to prevent chafing and exposure to hot surfaces. At no time should wiring be secured to fuel or exhaust system components.



## Wiring the Generator Junction Box: See Figure 3:

Once the mechanical installation steps in the Installation Supplement are completed, the system may be wired and initial run-up performed. **Figure 1** shows system cable routing. Cut the appropriate lengths to route the cables between the Generator and the Raven Control Box. Keep in mind that a 10/2 battery cable and the 16/2 control cable will be routed to the Control Box as well. Route cables using approved practices. At no time should cables be routed with or attached to fuel or exhaust system components. Follow these guidelines when wiring the generator:

- Assure that the Field and Armature cables are color coded *on each end*: blue for armature cable 1, purple for armature cable 2, and yellow for the field cable.
- Connect the armature and field cables to the Generator terminals according to **Figure 3**. **Notice these terminals are #2 Robertson (square) drive.**
- Install the strain relief bar, assuring that the two fasteners are not in contact with individual wire conductors.

*Maintaining cable color codes will assist in making proper connections during installation and assist future troubleshooting or maintenance.*

### Generator Cable Ends:

#### Field

The Field Cable (#8AWG 3 conductor SEOOW with yellow tape) runs with armature cables 1 and 2 from the generator junction box to the Control Box. Strip the outer jacket of the generator end of the cable back 1 3/4". Use the supplied crimp connectors and colored shrink tubing to terminate the wires.

Follow the color code; this will aid in future maintenance and troubleshooting.

The white conductor is heat-shrunk red and the black is heat-shrunk yellow. **Figure 3**.

#### Armature

Two Armature Cables (SEOOW #8AWG 3-conductor with blue or purple tape) run with the Field Cable from the Generator to the Control Box. Strip the outer jacket of the end of the cable back 1 3/4". Use the supplied crimp connectors and colored shrink tube to terminate the wires.

Follow the color code; this will aid in future maintenance and troubleshooting. The three conductors in each cable may be connected to any terminal of the corresponding color: blue, blue, and purple, purple, purple. **Figure 3**.

## Locating and Wiring the Control Box: See Figures 1 and 2 :

### Control Box Location:

Select a location for the Control Box based on the following criteria: Avoid areas subject to splash and elements. Reasonable ventilation is required, and the fans and heat sink must not be obstructed. The 30 Amp 2-pole main breaker on the box should be accessible and visible. A frame grounding point must be available. System voltage regulation requires this frame grounding point. Cable routing to the Box must avoid fuel lines, moving parts, exhaust system and other hot components. Cable lengths from the Generator to the Control Box should not exceed 25 feet. Contact Raven Product Support (207-721-1044) if this restriction presents a problem.



## **Control Box Wiring:**

### **Battery Feed**

Assure that all vehicle batteries are disconnected. The first terminal on the main strip is vehicle battery positive (+). The white conductor of the battery cable (10AWG 2 conductor SEOOW) is connected to 12V battery positive or the secondary side of a battery switch (preferable).

**Fuse or breaker-protect this conductor at 30 amps.**

The second Control Box terminal is battery ground (-), and should connect to battery negative, an established upfitter grounding point, or, if this is not possible, the black conductor may be connected to a high-current grounding point on the engine or transmission. Avoid frame grounding of this conductor.

### **Field**

The field cable conductors connect to the third, fourth, and fifth terminals in the Control Box according to **Figure 3** and the color-coded label in the Box. The white conductor is heat-shrunk red and the black is heat-shrunk yellow, and the green, green.

### **Armature**

The three blue armature cable conductors connect to any of the three blue terminals on the right-hand side adjacent to the heat sink. The three purple conductors connect, in turn, to any of the three purple terminals.

### **Line Out**

Line 1 and line 2 terminals are protected by the 30 amp double-pole main breaker on the end of the Box. The line neutral and line ground terminals are internally bonded.

### **Control Cable:**

The gray #16 AWG 2-conductor wire runs from the Command Module to the Control Box terminals to the left of the main terminal strip, adjacent to the system fuses. Connect the 16/2 control wire to the Control terminals shown in **Figure 3**. Ring terminals and heat shrink tubing are supplied. *Care must be taken to maintain the polarity (red-red, black-black) of these wires or Control Box damage will result.*

### **Chassis Ground (by installer):**

Using care and accepted practice, establish a chassis ground and connect to the Raven Control Box ground terminal (**Figure 3**) using #10AWG or larger wire.

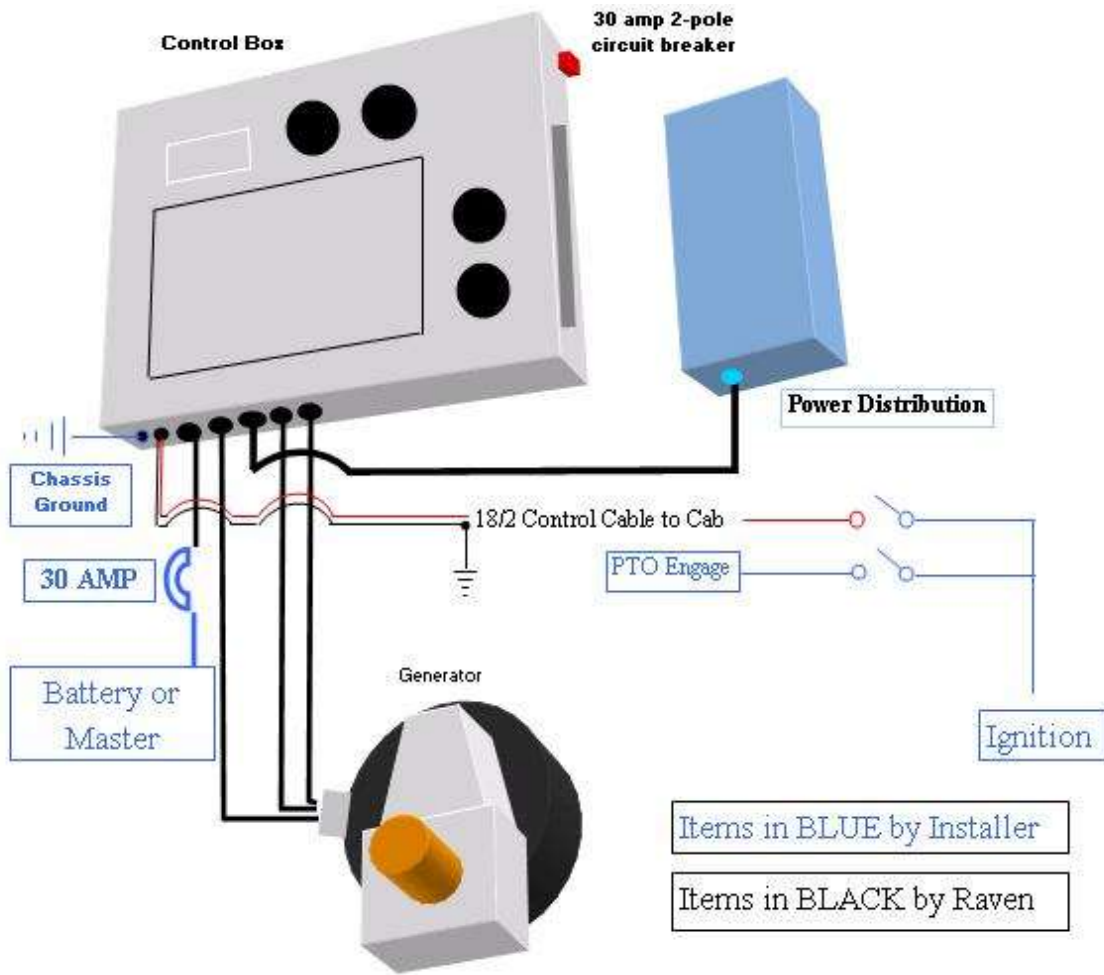
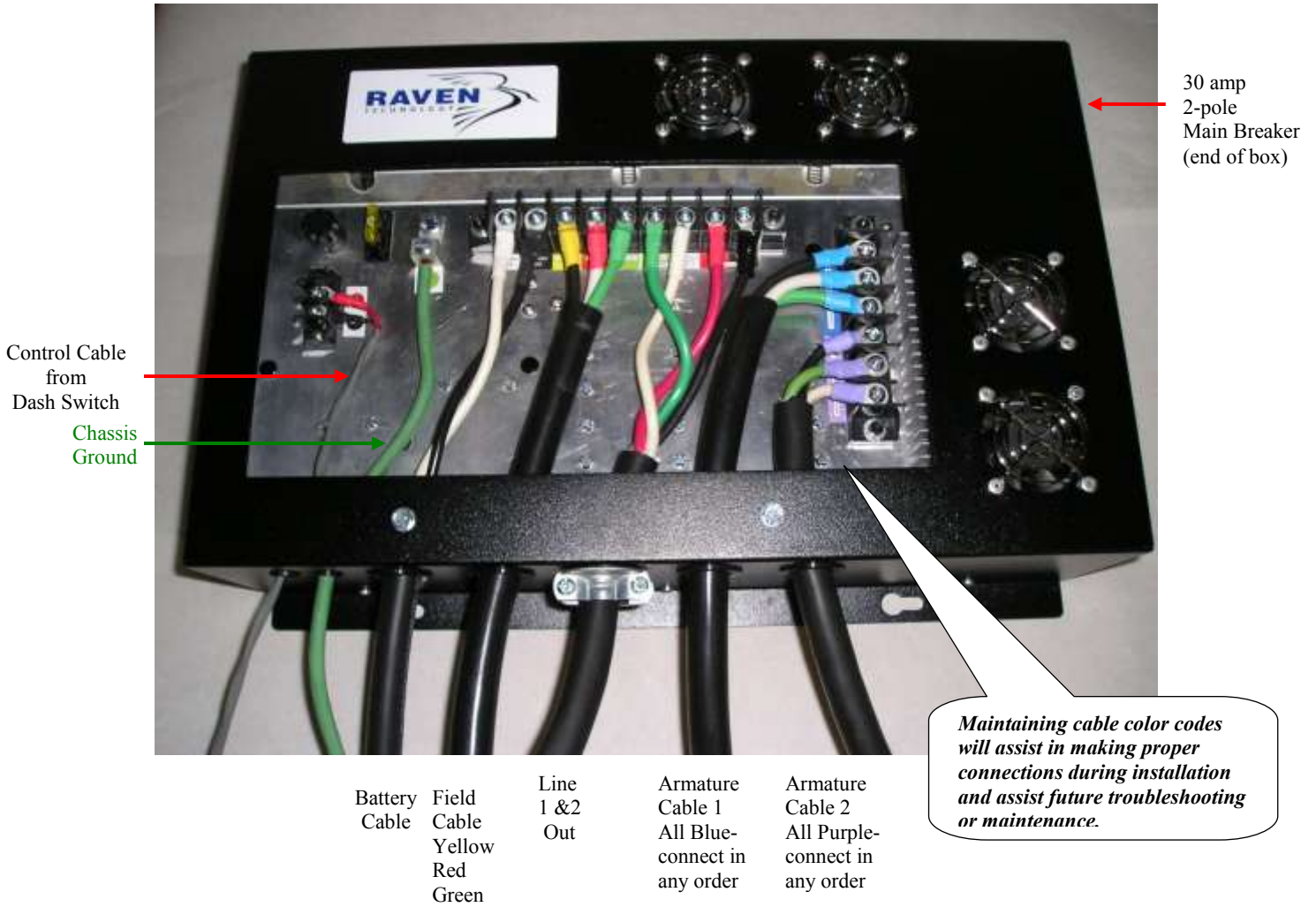
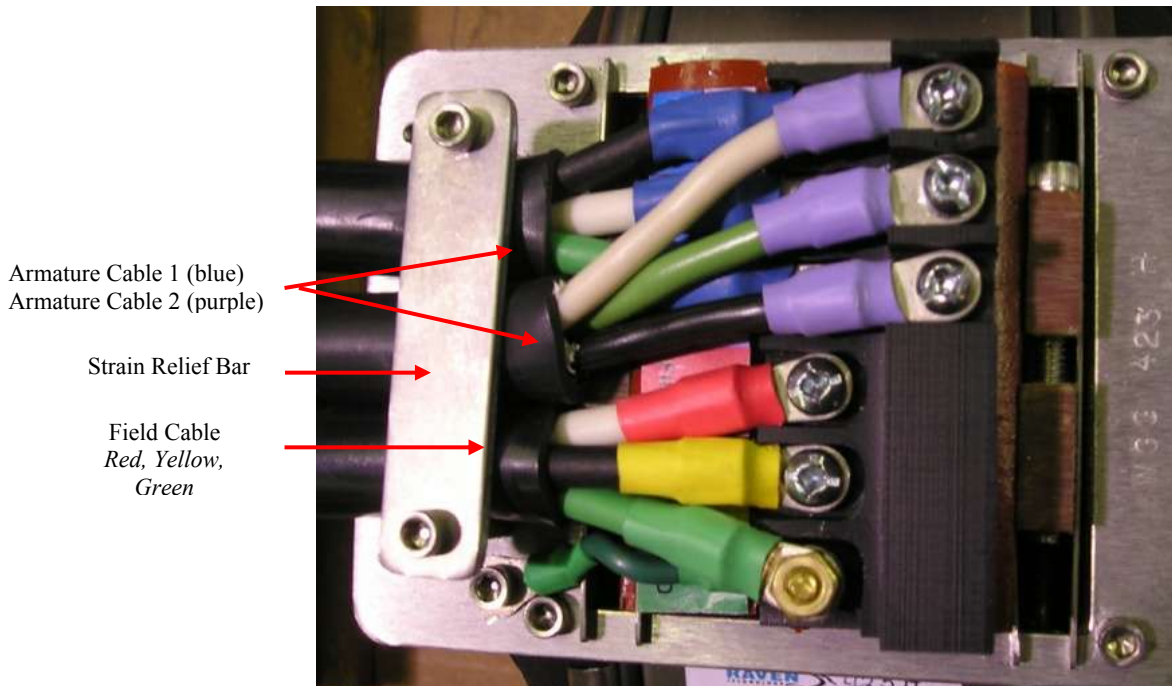


Figure 1



**Figure 2**





**Figure 3**

**Initial Mechanical Run-up** (Generator will not generate power during these tests):

- 1 Check all mechanical components to ensure correct installation.
- 2 Assure that the operator's switch is in the 'OFF' position.
- 3 Shut off engine and check belt tension. Correct any alignment or travel problems.
- 4 Disconnect and isolate the red control wire from its terminal in the Control Box.
- 5 Start the engine and engage the PTO. Observe PTO and shafting, as well as the Generator belt train.
- 6 When satisfied that shaft and belt train are correct, turn off the PTO and Generator control and reconnect the red control wire to its terminal in the Control Box.

**Initial Electrical Run-up**

1. Assure that all electrical connections are made and system grounds are established. Output power should be connected to an approved distribution system on the vehicle.
2. Apply a 60 watt or greater load to the output, and assure that the 30 amp circuit breaker on the Control Box is in the 'ON' position. Engage the Generator using the operator's switch. The clutch will engage, the Control Box cooling fans will operate. The Generator will begin generating. Line-to-line voltage will stabilize at 240 VAC. Frequency is locked at 60Hz and will not vary with load or engine speed. Voltage will briefly follow engine speed as changes occur, but will return to 240 volts within a second or so. Under no-load conditions, line-to-neutral voltage may appear up to 130 volts, depending on the meter used, and the output will be a square wave rather than pure sine. This is a normal no-load condition.



### **Testing and Troubleshooting the Blackbird™**

In the unlikely event of a system malfunction or failure-to-start, there are some preliminary tests which can be performed by a qualified electrician or mechanic. Do not hesitate to contact Raven (207-721-1044) before performing any tests if there are any questions. Aside from the vehicle wiring and fuses providing circuits to the Raven Control Box and Command Module, there are no user-serviceable parts.

#### **Test for DC power supply to Field:**

With operator control off: Using a multi-meter measure DC voltage between terminals 1(+) & 2(-) in the Raven Control Box. Voltage must be +12.5 to +15 VDC.

#### **Test for System Resonance:**

**Caution: very high voltages occur in the Control Box during this test!**

With the engine off and the Control Box 30 Amp circuit breaker off:

Remove and isolate the red control cable wire from its terminal in the Control Box. Jump power from the positive battery feed (terminal 1) to the positive (red) Control terminal. The Control Box cooling fans should operate, and the Generator should hum at 60 Hz. Using a voltmeter, measure the AC voltage between the third and fourth terminals (yellow and red) in the Control Box. Voltage should be at least 180VAC. Remove the jumper and reconnect the control wire to its terminal.

#### **Test for Phase Output:**

**Caution: very high voltages occur in the Control Box during this test!**

Start the engine and start the Generator. Assure that the 30 amp main breaker on the end of the box is 'on'. Using a multi-meter measure the AC voltage between each blue and each purple armature lead to the chassis ground in the Box. Voltage should be at least 80 VAC on each terminal.

#### **Test for AC Output:**

**Caution: very high voltages occur in the Control Box during this test!**

Start the engine and the Generator. Assure that the 30 amp main breaker on the end of the box is 'on'. Using a multi-meter measure the AC voltage between line 1 out and line 2 out in the Raven Control Box. This should read 240 VAC. (Note with no load, the waveform will not be a true sinusoid and the meter reported voltage may vary somewhat from 240 VAC. A 60 watt load is sufficient to restore proper output waveform.) If this is not the case, assure that all conditions are met:

- PTO is engaged
- There is *at least* 12.5VDC at the control terminals and the cooling fans are operating
- There is *at least* 12.5 VDC at the battery terminals in the Control Box
- The 30 amp circuit breaker is on

If these conditions are met and there is no output, contact Raven Product Support (207) 721-1044.

Questions or comments should be addressed to Andy Bertocci, Manager, Product Support, at 207-721-1044, or [abertocci@raventechpower.com](mailto:abertocci@raventechpower.com)