KOBELT

PA35 Accu-Steer Power Assist Steering

Owner's Operation, Installation & Maintenance Manual

Accu-Steer

May 2019

Kobelt Manufacturing Co. Ltd.

NOTES:

RECORD DATA BEFORE INSTALLATION FOR FUTURE REFERENCE	
Model #:	
Serial #:	
Date of Purchase:	
Date of Installation:	

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1 INTRODUCTION

1.1 CONTACT

Kobelt Manufacturing Co. Ltd.
8238 129th Street
Surrey, British Columbia
Canada, V3W 0A6

Sales Tel: +1-604-572-3935
Fax: +1-604-590-8313
Email: sales@kobelt.com
Website: www.kobelt.com

This document is intended to clearly present comprehensive product data and provide technical information to assist the end user in design applications. Kobelt reserves the right, without notice, to change the design, or construction, of any products and to discontinue or limit distribution of any products. Kobelt also reserves the right to change, or update, without notice, any technical information contained within this document.

Kobelt recommends that customers visit our website to check for updates to this Manual. Once a product has been selected for use, it should be tested by the user to ensure proper function in all possible applications. For further instructions, please contact our distributors or visit our website.

1.2 SAFETY

1.2.1 Safety Alerts

Throughout this manual, the following symbols, and their accompanying explanation, are used to alert the user to special instructions concerning a service or operation that may be hazardous if performed incorrectly or carelessly. The associated risk levels are stated below.

⚠ DANGER	This symbol indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.
⚠ WARNING	This symbol indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠ CAUTION	This symbol indicates a hazardous situation, which if not avoided, could result in minor or moderate injury.
NOTICE	This symbol informs the reader of events not related to personal injury but which there is a risk of damage to property or equipment.
SAFETY INSTRUCTIONS	This symbol informs the reader of safety-related instructions or procedures.

1.2.2 Notice to Installer

Disregarding the following safety measures can result in an accident causing severe injury to personnel and damage to material assets.

- Only use the product as directed in this manual.
- Never put the product into service if there is evidence of visible damage.
- Never put the product into service before fully completing installation and commissioning.
- Do not carry out any modifications to the product.
- Only use authentic Kobelt spare parts.
- Observe all local regulations, directives and laws during the installation of this product.
- All installation, commissioning, and maintenance work must only be conducted by qualified personnel. (For the purpose of this manual, qualified personnel are persons who are familiar with the assembly, installation, commissioning, and operation of the product and who have the qualifications necessary for their occupation.)
- Observe all specifications in this manual. If these guidelines are not followed and damage occurs, the warranty will be voided.

1.2.3 Product Hazards

⚠WARNING	**High Pressure Operation:** This PA35 unit generates high pressure hydraulics. Ensure all power sources are locked out prior to performing work.

⚠WARNING	**Equipment Starts Automatically:** PA35 units are controlled remotely and may activate suddenly causing bodily harm. Ensure all power sources are locked out prior to performing work.

⚠WARNING	**Disconnect Power:** Turn off power at distribution panel before beginning installation to protect installer from electrical hazards.

⚠CAUTION	**Voltage Compatibility:** Confirm that the power supply voltage is compatible with the voltage rating of the product variant. Connection of the wrong supply could cause fire or damage.

2 PRODUCT DESCRIPTION

The PA35 unit is a complete pump assembly consisting of a reversing gerotor gear pump, hydraulic lock valves, suction & make-up check valves, a valve-housing manifold, a DC electric motor, and an Electrical Junction Box.

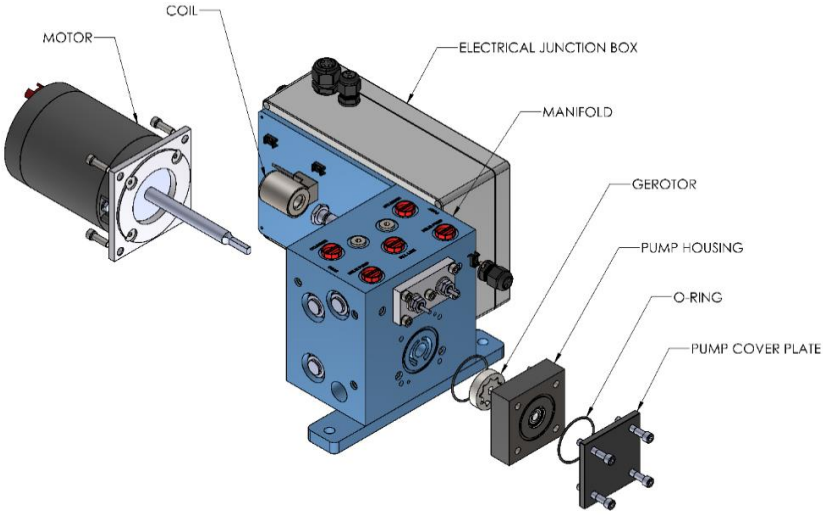


Figure 1: PA35 Overview Diagram

2.1 TECHNICAL DATA

Table 1: PA35 Technical Data

MODEL	PA35-12	PA35-24
KOBELT P/N	600-510	600-511
NOMINAL VOLTAGE	12 VDC	24 VDC
MAXIMUM HARDOVER CURRENT	70 A	35 A
OUTPUT FLOW RATE	3.5 in^3/sec [57 cc/sec]	
MAXIMUM PRESSURE **1. PORT & STBD PORTS** **2. T PORT**	 1000 PSI [51.7 bar] 50 PSI [3.4 bar]	
CYLINDER CAPACITY	35 - 60 in^3 [573 - 983 cc]	
SERVICE DUTY	Intermittent, 20% ON / 80% OFF	
NOISE EMMISION	75 dB (at max pressure)	
RECOMMENDED FLUID	ISO VG 32, VI 60 hydraulic oil	
PORT SIZES	-06 SAE ORB	
OPERATING TEMPERATURE	-14… 122°F [-10… 50°C]	
PRODUCT WEIGHT	30 lbs [13.6 kg]	

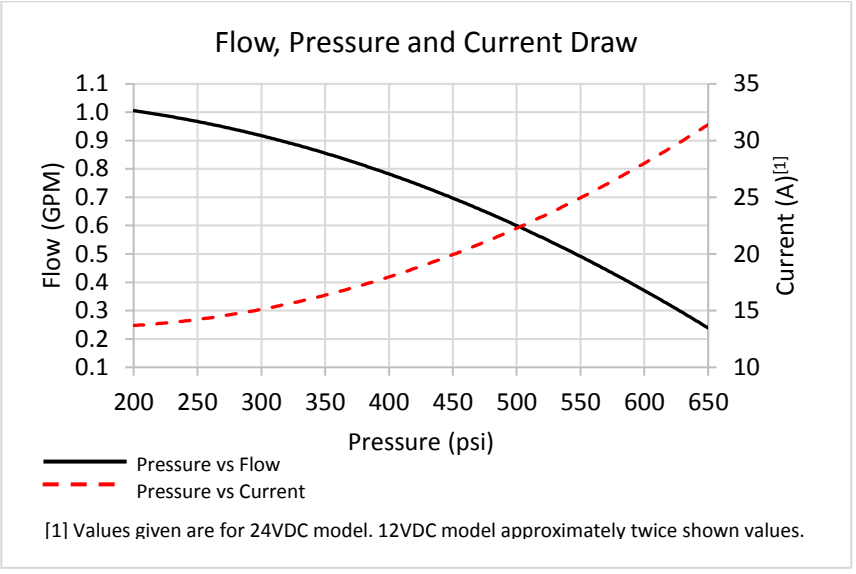


Figure 2: PA35 Flow, Pressure, and Current Draw

2.1.1 Cylinder Compatibility

The PA35 works with both balanced and unbalanced cylinders. When unbalanced cylinders are used it is recommended that a vented header tank is used to allow for the expansion and contraction from the unbalanced cylinder.

2.1.2 Duty Cycle

The pump-set is designed as an intermittently operated unit for normal steering applications. High demand applications will overwork the motor and cause overheating.

2.1.3 Temperature Limits

The motor temperature has a maximum limit of 248°F [120°C]. Allowing the temperature to exceed this limit will permanently damage the motor windings. The maximum oil temperature limit is 149°F [65°C].

Observe the ambient temperature range of the unit (Table 1: PA35 Technical Data). Do not operate the unit if the ambient temperature where the unit is located exceeds this limit.

2.1.4 Pressure Range

The normal operating pressure of the unit is 0 to 600 psi. Avoid operating the unit against the rudder stops for prolonged periods of time.

3 INSTALLATION

3.1 MECHANICAL

Ideally, the location of the pump-set should satisfy the following conditions:

- Within 6 feet [1.8 m] of the steering cylinder.
- Below the steering cylinder for ease of connections and bleeding.
- Placed on a horizontal shelf or bracket.
- Not exposed to direct sunlight or any source of heat.
- Provide a foundation sturdy enough to prevent the transmission of excessive vibrations.

The PA35 is equipped with (2) two clearance holes for 3/8” (M10) bolts through the mounting feet. Ensure that the unit is securely fastened to a suitable foundation.

3.2 HYDRAULIC

The PA35 Power Assist Steering unit is equipped with -06 ORB SAE ports that are plugged for shipping. Ensure the plugs remain in place until the unit is ready for plumbing connection installation.

NOTICE	Ensure the plugs remain in place until the unit is ready for connection.

NOTICE	All piping and hoses must be flushed prior to connection. Failure to do so can result in damaged components and seals.

NOTICE	All hoses and piping must also be plugged or capped until ready for connection.

The piping to the steering cylinder should be 3/8” nominal size and no less than 1/4” with a suitable wall thickness to safely withstand the operating pressure. The port and starboard steering lines should have a pressure rating of 1000 psi minimum. Secure the piping against vibration with pipe clamps spaced every 3 feet [1 m] minimum.

The connections to the pump-set must be made by hoses of suitable rating to accommodate any movements, vibration, or thermal strain. Hoses are also required to prevent any pump noise from being transmitted to the steering system.

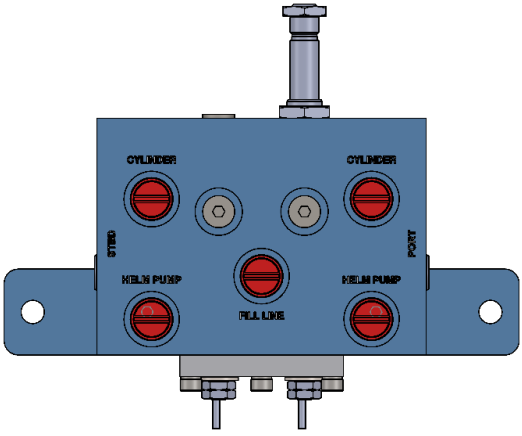


Figure 3: Connections in Top Face of Hydraulic Manifold

Five hydraulic connections are required to the PA35 manifold:

- Connect the ports marked with “PORT CYLIDNER” and “STBD CYLINDER” to the steering cylinder ports.
- Connect the ports marked with “HELM PUMP PORT” and “HELM PUMP STBD” to the helm pump ports.
- Connect the port marked with “FILL” as required for multi-station installations.

NOTICE	**Piping Connections:** The port/starboard direction of the cylinder and helm pump(s) **MUST** match the Port and Starboard labels on the manifold. Failure to do so will result in improper operation.

If more than one helm pump is used, a return/fill line must be installed to connect the cases of all the helm pumps together.

With steering systems where the fill/interconnect line is pressurized (e.g. - Hynautics or Teleflex) the recommended operating pressure is approximately 20 to 25 psi. The plumbing is connected as noted by the port names on the top of the unit shown in Figure 3.

NOTICE	The shaft seal on the PA pump-sets are rated to 50 psi. Exceeding this pressure with cause a shaft seal failure and void the warranty.

NOTICE	Do not connect the output lines (CYLINDER PORT, CYLINDER STBD) to the FILL port. Failure to observe this caution will cause a shaft seal failure and void the warranty.

3.3 ELECTRICAL

The main power source to the PA35 is to be connected into the terminal block located within the Electrical Junction Box on the side of the PA35. Cable glands are pre-installed to secure the positive and negative cables.

Kobelt recommends the use of a dedicated circuit breaker to provide power to the PA35. Size the breaker to trip the maximum current as required by the current outlined in Table 1: PA35 Technical Data. The breaker should trip after no more than 600 seconds.

The motor power source must have proper short circuit and overload protection. Ensure that electrical cable used is sized property to prevent excessive voltage drop. Refer to your local marine standards or other local governing wiring codes for guidance.

Electrical installation of the PA35 should proceed as follows:

⚠WARNING	**Disconnect Power:** Turn off power at distribution panel before beginning installation, or removing the Electrical Junction Box cover, to protect installer from electrical hazards.

1. Remove the Electrical Junction Box cover.
2. Wire electrical cables and power wires, as per the details in this section of the manual and according to Figure 4.
3. Visually inspect all wiring is correctly installed.
4. Replace the Electrical Junction Box cover.

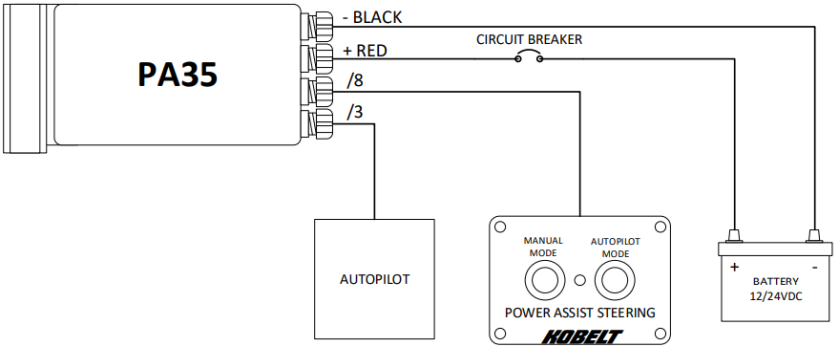


Figure 4: PA35 Wiring Diagram

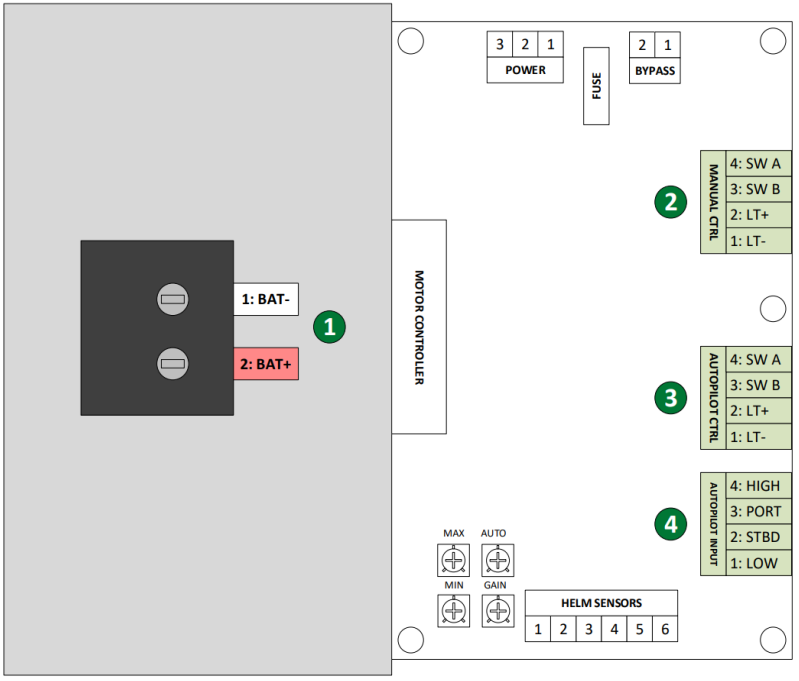


Figure 5: Internal PA35 Electrical Enclosure Connections

3.3.1 Field Wiring Connections

The Electrical Junction Box contains all the electrical connection points for the PA35 to interface with other on-board equipment including your Autopilot and Control Stations.

Connectors indicated as ❶, ❷, ❸, and ❹ are field installed. Connections to terminal block ❶ and connector ❷ are mandatory and required for operation of the PA35. Connectors ❸ and ❹ are optional and only required if an Autopilot unit is being installed along with the main hydraulic wheel.

Table 2: Power Supply Connector

1	SUPPLY		
Pin #	**Pin Name**	**Pin Type**	**Function**
1	BAT-	Power	Main Ground
2	BAT+	Power	Main Power Input (from Breaker)

Table 3: Manual Control Connector

2	MANUAL CTRL		
Pin #	**Pin Name**	**Pin Type**	**Function**
1	LT-	Power	Ground
2	LT+	Output	Manual Mode Lamp Output
3	SW B	Input	Manual Mode Switch Input
4	SW A	Power	DC Supply Output for Manual Mode Switch

Table 4: Autopilot Control Connector

3	AUTOPILOT CTRL		
Pin #	**Pin Name**	**Pin Type**	**Function**
1	LT-	Output	Autopilot Mode Lamp (open-drain)
2	LT+	Power	DC Supply Output for Autopilot Mode Lamp
3	SW B	Input	Autopilot Enable Button
4	SW A	Power	DC Supply Output for Autopilot Enable Button

Table 5: Autopilot Input Connector

4	AUTOPILOT INPUT		
Pin #	**Pin Name**	**Pin Type**	**Function**
1	LOW	Power	Negative Voltage Reference for Autopilots with *Common-Negative* Outputs
2	STBD	Input	Autopilot Starboard Command
3	PORT	Input	Autopilot Port Command
4	HIGH	Power	Positive Voltage Reference for Autopilots with *Common-Positive* Outputs

3.3.2 Autopilot Connection

The Autopilot Connector, 4, accepts multiple input types from autopilots. The control voltages supported are 12VDC or 24VDC.

NOTICE	Do not connect both the HIGH and LOW pins to the power supply. This will cause erratic behaviour. Ensure that only one of the HIGH and LOW pins is connected at any time.

The Autopilot connector accepts both Common Positive (Sinking) and Common Negative (Sourcing) style electrical connections to support a wide range of Autopilots. These two methods of connection are shown in Figure 6 and Figure 7 wiring diagrams.

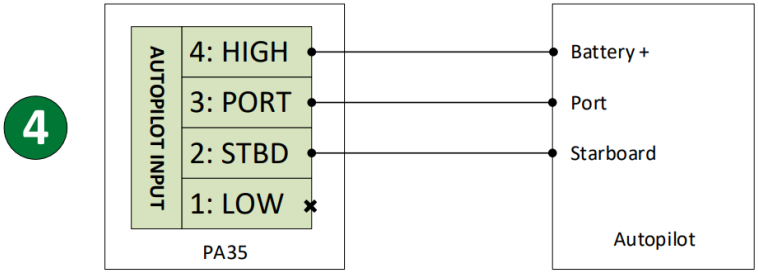


Figure 6: Generic Autopilot Wiring (Common Positive)

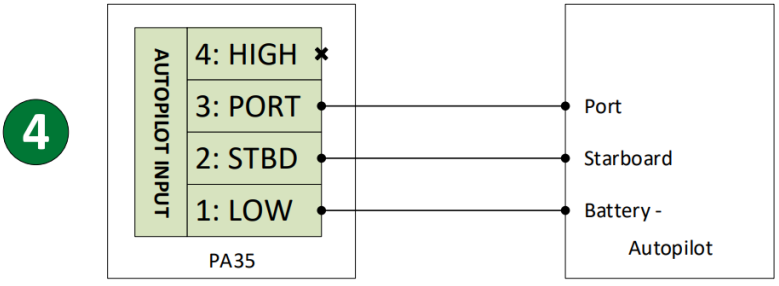


Figure 7: Generic Autopilot Wiring (Common Negative)

Autopilots that drive reversible pumps are supported but require the use of additional external diodes. Figure 8 shows how to connect the PA35 to an autopilot that drives reversible pumps with the position of the required diodes. Ensure the diodes are specified to handle at least 1A of current.

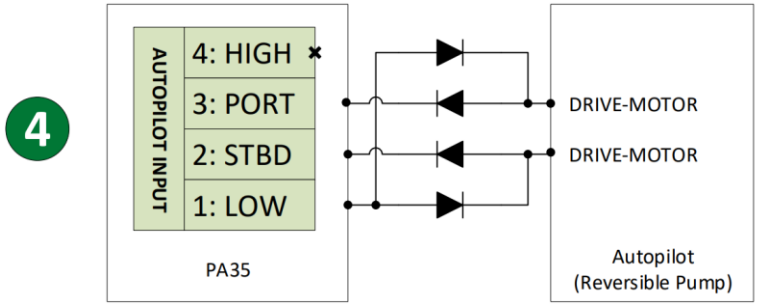


Figure 8: Generic Autopilot Wiring (Reversible Pump)

Example autopilot wiring diagrams are provided for reference below in Figure 9 thru Figure 11.

NOTICE	Remember to always follow the installation guidelines as provided by your autopilot manufacturers' manual.

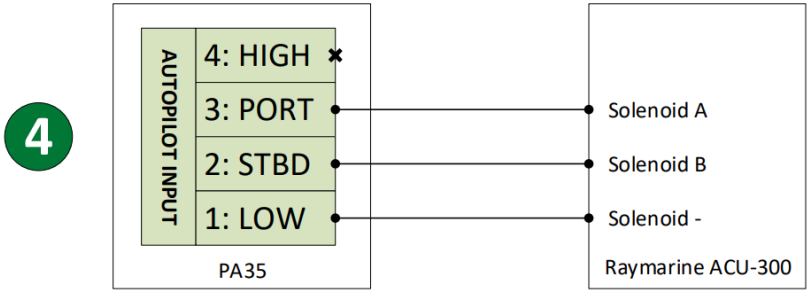


Figure 9: Example Autopilot Connection - Raymarine ACU-300

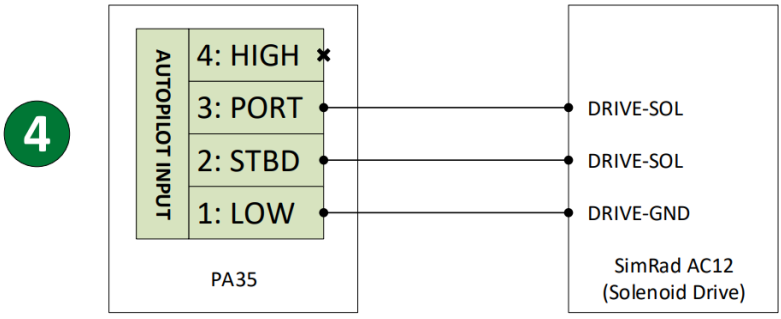


Figure 10: Example Autopilot Connection - SimRad AC12

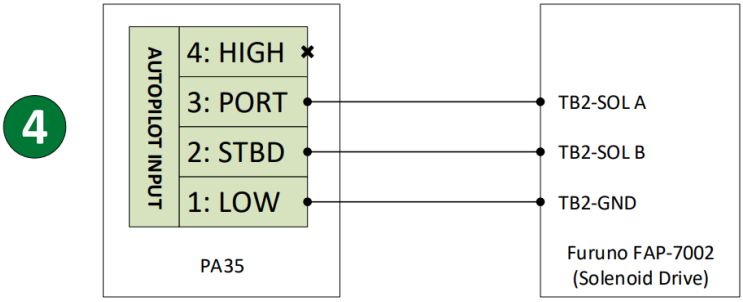


Figure 11: Example Autopilot Connection - Furuno FAP-7002

3.3.3 Jog Lever Connection

Alternatively, a Jog Lever, such as the Kobelt 7170, can be connected to the Autopilot Connector 4 to provide direct electronic jog control of the PA35 in-place of external Autopilot control signals.

The control voltages supported are 12VDC or 24VDC. The connection methods accepted for Jog lever input signals are shown in Figure 12 and Figure 13.

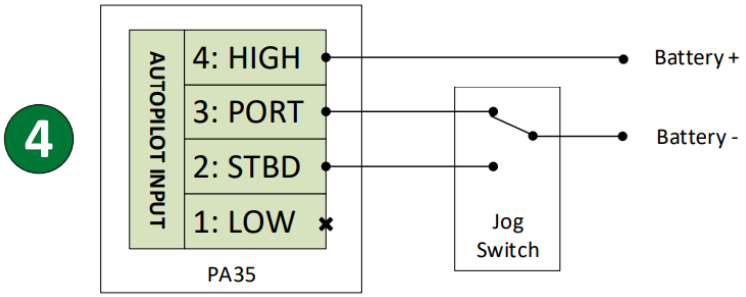


Figure 12: Active Low Jog Connection

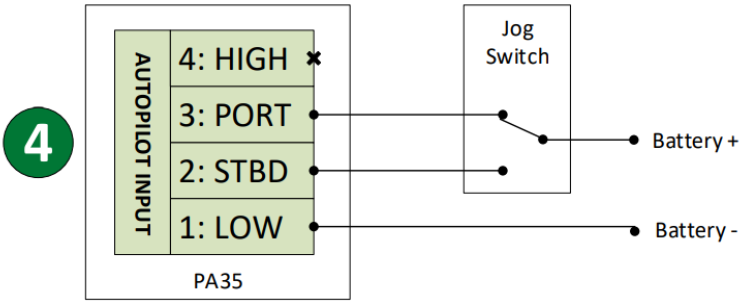


Figure 13: Active High Jog Connection

3.3.4 Control Panel Interface

The PA35 **requires** a normally-closed (NC) Manual Mode Switch for normal operation. Without this switch, the unit will not provide Power Assist steering.

If an external Autopilot (or Jog Lever) is being installed with the unit, the PA35 also requires a momentary normally-open (NO) Autopilot Enable Button.

Refer to Figure 14 and Figure 15 for wiring configurations of the Control Panel at single or multiple stations.

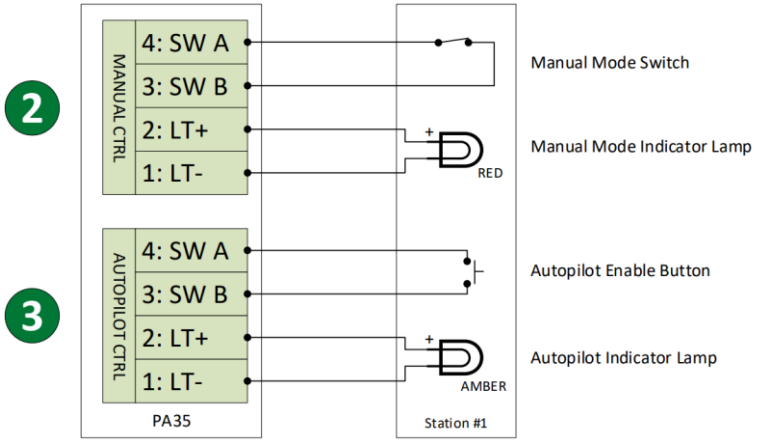


Figure 14: Single Station Control Panel Wiring

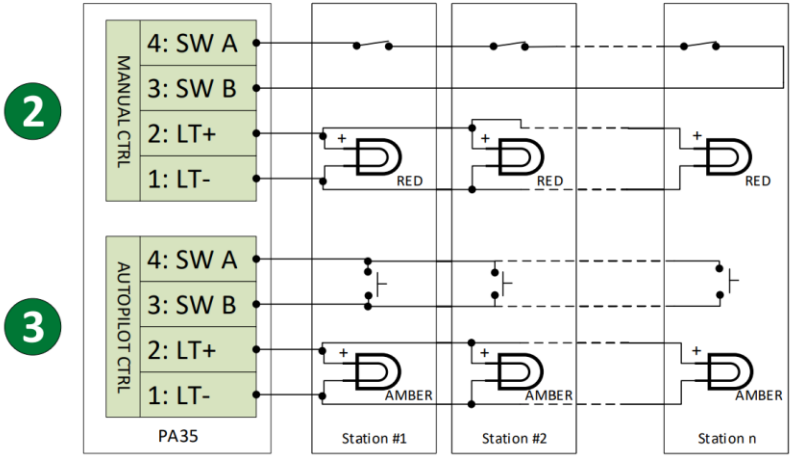


Figure 15: Multiple Station Control Panel Wiring

3.3.5 PA35 Control Panel Accessory

An optional Control Panel accessory, consisting of a Manual Mode Switch and Autopilot Enable Button (with indicator lights), is available as a standard console-mount panel.

Table 6: Control Panel Models

PA35 MODEL REFERENCE	PA35-12	PA35-24
CONTROL PANEL KOBELT PART #	600-513	600-512
VOLTAGE	12 VDC	24 VDC
INDICATORS	Red LED, Amber LED	
SWITCHES AND BUTTONS	NC Switch, Momentary NO Button	
PRODUCT WEIGHT	0.3 lbs [0.4 kg]	

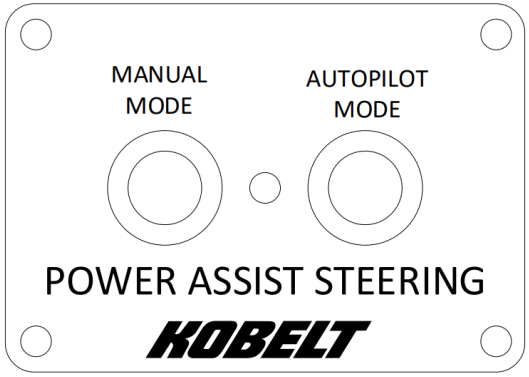


Figure 16: Optional Control Panel Accessory

The Control Panel can be installed in a single or multiple station configuration as described above. Refer to Figure 17 for wiring connection of the 600-512 or 600-513 panels.

Mechanical dimensions and mounting recommendations for the Control Panel are found in Appendix G: Control Panel Dimensions.

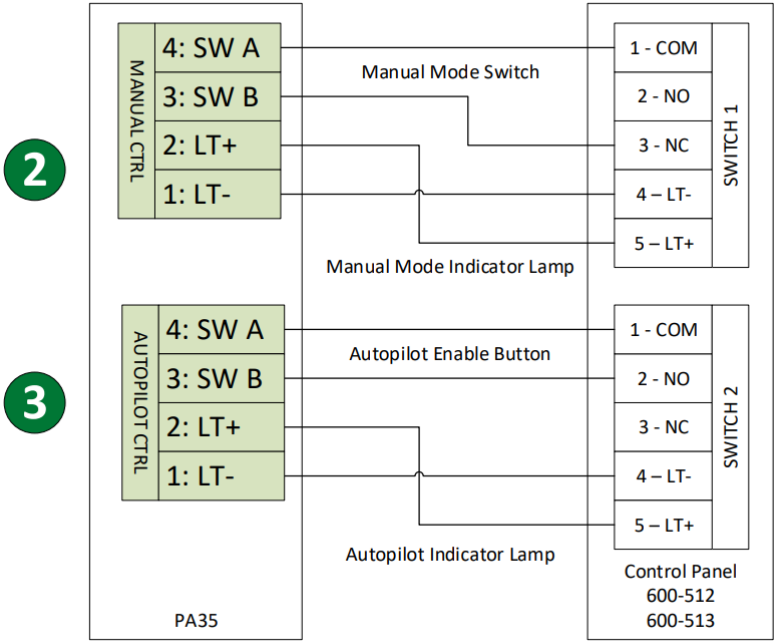


Figure 17: Kobelt PA35 Control Panel Wiring Diagram

4 COMMISSIONING

4.1 HYDRAULIC FILL & BLEED

Confirm that the hydraulic connections have been made, open all valves if installed, and allow sufficient time for the pump and lines to fill with oil.

Fill the steering system with an anti-wear petroleum-based fluid appropriate for the service conditions as recommended in this manual.

4.2 ELECTRICAL CHECK

⚠CAUTION	Ensure that the Electrical Junction Box cover is installed and secured before powering on the PA35.

- Confirm that the electrical connections to the PA35 have been made.
- Confirm that a breaker has been installed correctly and is turned ON.

4.3 CALIBRATION AND ADJUSTMENT

The steering **slow rate**, **fast rate**, **autopilot rate** and **gain** are adjustable to suit specific vessels. These settings are adjusted using trimpots inside the Electrical Junction Box.

⚠CAUTION	These adjustments should only be performed by qualified personnel, and only while the vessel is at dock. To adjust these trimpots, the Electrical Junction Box may need to be open while the PA35 is powered, creating an electrical short/shock hazard. **If you are unsure, turn off, and lock out the power to the PA35 unit before making any of these adjustments, and ensure the Junction Box Cover is installed prior to restoring power to the PA35.**

⚠CAUTION	To reduce the potential for electrical shock and to avoid damaging the PA35 electronics, **use a non-conductive screwdriver**, or other equivalent tool, to adjust the trimpots. Exercise caution when reaching in with the screwdriver. Do not let it touch any components other than the trimpots.

NOTICE	Ensure no oil or other contamination enters the Electrical Junction Box enclosure while its cover is removed.

1. Turn OFF the power to the PA35 prior to adjusting the trimpots.
2. Remove the Electrical Junction Box cover.
3. Use a **non-conductive** flathead or Phillips-head screwdriver to adjust the trimpots.
4. Rotate the trimpots to set the desired system response:
    a. Rotate clockwise to increase
    b. Rotate counter-clockwise to decrease
    c. Refer to the sections below for functional details of each trimpot.
5. Turn ON power.
6. Operate steering to verify desired response.
7. Repeat as necessary, until the PA35 functions as desired.
8. Replace the Electrical Junction Box cover.

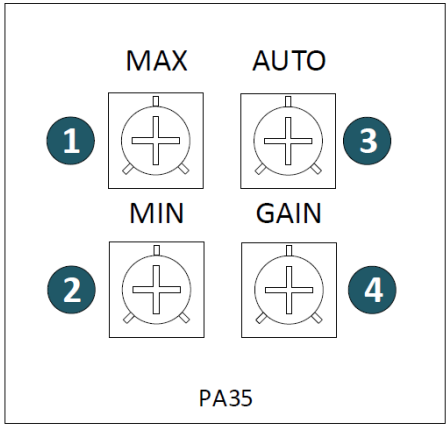
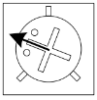
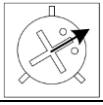
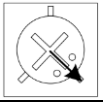


Figure 18: Calibration Trimpot Arrangement
(inside Electrical Junction Box; bottom-left corner of circuit board)

4.3.1 ❶ "MAX" Trimpot: Set Fast Rate

The "MAX" trimpot sets the **fast rate**, as a percentage of the PA35's maximum-possible flow rate. The rate is adjustable between 20% and 100% of max flow.

Table 7: "MAX" Trimpot Adjustment

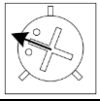
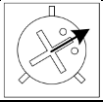
"MAX" Trimpot Position	**Power Assist Mode "fast rate"** [% of max flow rate]
Fully Counter-clockwise 	20% (slowest)
	40%
Centred 	60%
	80%
Fully Clockwise *(factory default position)* 	100% (fastest)

4.3.2 ② "MIN" Trimpot: Set Slow Rate

The "MIN" trimpot sets the **slow rate**, as a percentage of the PA35's maximum-possible flow rate. The rate is adjustable between 20% and 100% of max flow.

When the "MIN" trimpot is set higher than the "MAX" trimpot, the **slow rate** is limited to not exceed the **fast rate**. The PA35 will operate with only a single speed, governed by the "MAX" trimpot.

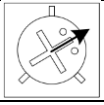
Table 8: "MIN" Trimpot Adjustment

"MIN" Trimpot Position	**Power Assist Mode "slow rate"** [% of max flow rate]
Fully Counter-clockwise 	20% (slowest)
	40%
Centred *(factory default position)* 	60%
	80%
Fully Clockwise 	100% (fastest)

4.3.3 ❸ "AUTO" Trimpot: Set Autopilot Rate

The "AUTO" trimpot sets the **autopilot rate**, as a percentage of the PA35's maximum-possible flow rate. The rate is adjustable between 20% and 100% of max flow.

Table 9: "AUTO" Trimpot Adjustment

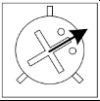
"AUTO" Trimpot Position	**Autopilot Mode "autopilot rate"** [% of max flow rate]
Fully Counter-clockwise 	20% (slowest)
	40%
Centred *(factory default position)* 	60%
	80%
Fully Clockwise 	100% (fastest)

4.3.4 ❹ "GAIN" Trimpot: Set Gain

The "GAIN" trimpot controls the two-speed performance of the Power Assist Mode (see 5.2.2). It adjusts the length of time pumping at the slow rate (the **slow rate delay)**, and the **duration of the slow-to-fast ramp**.

- At minimum gain, the PA35 pumps at the **slow rate** for 2 ½ seconds, then ramps up slowly to the **fast rate**.
- As the gain is increased, the time pumping at the **slow rate** shortens, and the ramp up to the **fast rate** accelerates.
- At maximum gain, the PA35 does not pump at the **slow rate**, and starts immediately at the **fast rate**. This sets the PA35 for One-Speed Power Assist operation (see 5.2.1).

Table 10: "GAIN" Trimpot Adjustment

"GAIN" Trimpot Position	**Time Held at Slow Rate** [ms = milliseconds]	**Duration of the Slow-to-Fast Ramp** [ms = milliseconds]
Fully Counter-clockwise *(lowest gain)* 	2500 ms (long time at **slow rate**)	750 ms (slow ramp)
	1875 ms	~550 ms
Centred *(factory default position)* 	1250 ms	375 ms
	625 ms (short time at **slow rate**)	~200 ms (very fast ramp)
Fully Clockwise *(highest gain)* 	No Slow Rate (**slow rate** is not used)	No Ramp (immediately starts pumping at **fast rate**)

4.4 FUNCTIONAL TEST

After installation perform the following function tests:

⚠CAUTION	The Function Test should be carried out while the vessel is still at dock and before it is taken out to sea after installation has been completed.

1. Power ON the PA35.
2. Power ON the Autopilot (or connect the electronic jog lever if installed).
3. Command motion from the primary control Station.
4. Confirm that the operational mode has defaulted to Power Assist Mode as described in section 5.1.
5. Confirm that the pump is providing flow to the cylinder.
6. Confirm that the rudder operates in the expected direction.
7. Command motion from the primary Station in the opposite direction.
8. Confirm that the rudder operates in the expected direction.
9. Press the Manual Mode button on the Control Panel.
10. Confirm that the operational mode has change to Manual Mode as described in section 5.1.
11. Activate the Autopilot unit to command motion.
12. Press the Autopilot button on the Control Panel.
13. Confirm that the operational mode has changed to Autopilot Mode as described in section 5.1.
14. Repeat Steps 3 thru 13 for all on-board stations connected to the PA35 to ensure proper operation.
15. Operate the pump-set and note the ‘hard-over’ to ‘hard-over’ (HO to HO) time.
16. Verify that it is in the range of 10 to 16 seconds. Times outside of this range indicate a mismatched pump-set for the steering system.
17. Confirm that the unit develops rated pressure during operation.

5 OPERATION

The PA35 Accu-Steer Power Assist unit has three modes of operation – **Manual**, **Power Assist** and **Autopilot** – described in the following table:

Table 11: Modes of Operation

Mode	Description
Manual Mode	Completely-manual steering mode, using hydraulic helm pump only. *PA35 does not use its electric pump to assist rudder movement*; Port and Starboard helm lines are passed-through to cylinder lines. Automatic fail-safe mode when the unit is not powered (or power is lost), allowing for emergency manual steering.
Power Assist Mode	Power-assisted steering mode: the PA35 bypasses the manual helm pump and uses its gerotor pump to do the work of moving the steering gear. The PA35 detects when the Rudder has reached a mechanical end-stop and automatically stops pumping. The PA35 intelligently controls the helm bypass so the end-stop is felt in the steering wheel. Rudder movement speed is fully adjustable using trimpots inside the Electrical Junction Box. Supports one-speed and two-speed control.
Autopilot Mode	Autopilot-control of steering. The PA35 responds to Port and Starboard jog commands from an external Autopilot system. Takes the place of a solenoid directional valve or hydraulic reversing pump (HRP) typically used as the actuator for Autopilot steering. Rudder movement is one-speed only; the speed is set by a trimpot inside the Electrical Junction Box.

The following sections describe the hydraulic function of the PA35 in each of these modes. Refer to the PA35 internal hydraulics schematic in

Figure 19 below.

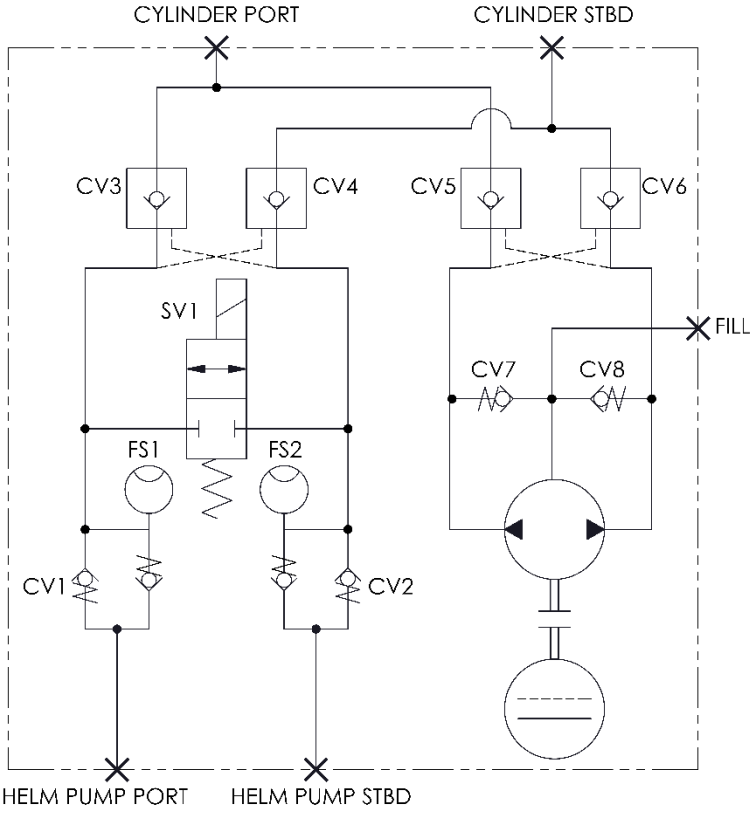


Figure 19: Internal Hydraulic Schematic

The PA35 has five (5) ports on its hydraulic manifold. These are clearly marked on the valve housing as:

1. HELM PUMP PORT
2. HELM PUMP STBD
3. CYLINDER PORT
4. CYLINDER STBD
5. FILL

“CYLINDER PORT” and “CYLINDER STBD” are the output lines and connect to the steering cylinder.

"HELM PORT" and "HELM STBD" are the input lines and connect to the hydraulic helm pump (or multiple helm pumps in parallel, if desired).

"FILL" is the tank suction make-up or return line.

NOTICE	Do not connect any output lines to the "FILL" port, or damage may occur.

5.1 Manual Mode

When the PA35 is in Manual Mode:

- The PA35 is completely passive and does not provide any power-assist function.
  - Steering behaves exactly like a traditional hydraulic steering system.
  - The helm pump(s) are in direct control of the steering cylinder.
- The bypass valve SV1 is always closed and the gerotor pump is never operated.

The PA35 operates in Manual Mode when either of the following are true:

1. The PA35 is NOT powered, OR,
2. The Manual Mode Switch is on, *meaning the switch inputs are open-circuit* (see 3.3.4).

When the PA35 is in *Manual Mode*, and the helm pump is turning to P*ort*:

1. Oil from the port side of helm pump enters at the "HELM PORT" manifold port on the PA35 manifold.
2. The oil passes through FS1 and CV3, before exiting from the "CYLINDER PORT" manifold port and going to the port side of the steering cylinder.
3. Oil returning from the starboard side of the cylinder enters at the "CYLINDER STBD" manifold port.
4. The oil passes through CV4 (opened by the operation of CV3) and CV2, before exiting from the "HELM STBD" manifold port and returning to the starboard side of the helm pump.

When the PA35 is in *Manual Mode* and the helm pump is turning to *Starboard*:

1. Oil from the starboard side of helm pump enters at the "HELM STBD" manifold port on the PA35 manifold.
2. The oil passes through FS2 and CV4, before exiting from the "CYLINDER STBD" manifold port and going to the starboard side of the steering cylinder.
3. Oil returning from the port side of the cylinder enters at the "CYLINDER PORT" manifold port.
4. The oil passes through CV3 (opened by the operation of CV4) and CV1, before exiting from the "HELM PORT" manifold port and returning to the port side of the helm pump.

5.2 POWER ASSIST MODE

When the PA35 is in *Power Assist Mode*:

- The helm pump can be turned with little effort, as it bypasses the cylinder through open valve SV1.
- The PA35's electric pump does the work to move the rudder.
    - The pump stops automatically when the cylinder reaches either end-stop.
    - The end-stop is felt in the helm wheel (wheel can't be turned any further).
- The flow rate of the pump is adjustable and can operate as a single-speed pump or as a two-speed pump.

The PA35 operates in *Power Assist Mode* only when ALL of the following are true:

1. The PA35 is powered, AND,
2. The PA35 is not in a faulted state (see 7.1), AND,
3. The Manual Mode Switch is off, *meaning the switch inputs are shorted together* (see 3.3.4), AND,
4. The Autopilot Mode is off (see 5.3).

When the PA35 is in *Power Assist Mode* and the helm pump is turning to *Port*:

1. Oil from the port side of helm pump enters at the "HELM PORT" manifold port on the PA35 manifold.
2. The helm oil passes through FS1, SV1, and CV2 before exiting from the "HELM STBD" manifold port and returning to the starboard side of the helm pump. This is a low-resistance path, so the helm pump can be turned with very little torque.
3. The oil flowing through the FS1 sensor triggers the PA35 controller to run the pump motor in the port direction.
4. The pump pushes oil through CV5, out the "CYLINDER PORT" manifold port, to the port side of the steering cylinder.
5. Oil returning from the starboard side of the cylinder enters at the "CYLINDER STBD" manifold port.
6. The oil passes through CV6 (opened by the operation of CV5 and the lock valve spool), before returning to the suction side of the gerotor pump.
7. Make-up oil on the suction side is automatically pulled from the "FILL" manifold port, via check valve CV8.
8. *When the helm wheel stops turning*, sensor FS1 stops detecting oil flow, triggering the PA35 controller to stop the pump motor.

When the PA35 is in *Power Assist Mode* and the helm pump is turning to *Starboard*:

1. Oil from the starboard side of helm pump enters at the "HELM STBD" manifold port on the PA35 manifold.

2. The helm oil passes through FS2, SV1, and CV1 before exiting from the “HELM PORT” manifold port and returning to the port side of the helm pump. This is a low-resistance path, so the helm pump can be turned with very little torque.
3. The oil flowing through the FS2 sensor triggers the PA35 controller to run the pump motor in the starboard direction.
4. The pump pushes oil through CV6, out the “CYLINDER STBD” manifold port, to the starboard side of the steering cylinder.
5. Oil returning from the port side of the cylinder enters at the “CYLINDER PORT” manifold port.
6. The oil passes through CV5 (opened by the operation of CV6 and the lock valve spool), before returning to the suction side of the gerotor pump.
7. Make-up oil on the suction side is automatically pulled from the “FILL” manifold port, via check valve CV7.
8. *When the helm wheel stops turning*, sensor FS2 stops detecting oil flow, triggering the PA35 controller to stop the pump motor.

When the PA35 is pumping oil to the cylinder, but the steering cylinder can’t move because it’s reached a mechanical end-stop:

1. If the helm wheel continues to turn, the PA35 continuously pumps oil to the cylinder, moving it port or starboard.
2. The cylinder stops moving when it reaches the end of its stroke (or a mechanical end-stop).
3. The pressure in the cylinder rapidly increases, which is detected by the PA35 controller.
4. The controller stops pumping and temporarily closes bypass valve SV1.
5. The helm pump then “sees” the cylinder back-pressure and can no longer turn in that direction.
6. If the helm pump is then turned in the opposite direction, the PA35 controller re-opens bypass valve SV1 and starts pumping the cylinder in the opposite direction, away from the end-stop.
7. When the cylinder eventually reaches the opposite mechanical end-stop, the above behaviour repeats.

5.2.1 One-Speed Operation

The PA35 Power-Assist mode can be configured to operate as a *one-speed* hydraulic pump:

1. When the helm pump is turned, the PA35 immediately begins pumping in the corresponding direction at its **fast rate**.
2. The PA35 continues pumping at its **fast rate** until the helm pump stops turning, or the cylinder reaches its end-stop.

- The **fast rate** (aka “MAX rate”) is configured by adjusting the “MAX” trim pot inside the Electrical Junction Box (see 4.3.1).
    - The rate is fully adjustable between 20% and 100% of the pump’s theoretical maximum.
- The “MIN” trim pot (see 0) must be turned all-the-way counter-clockwise.
- The “GAIN” trim pot (see 0) must be turned all-the-way clockwise (maximum gain).

5.2.2 Two-Speed Operation

Alternatively, the PA35 Power-Assist mode can be configured to operate as a *two-speed* hydraulic pump:

1. When the helm pump is turned, the PA35 immediately begins pumping in the same direction at its **slow rate** (aka “MIN rate”).
2. The PA35 continues to pump at the **slow rate** for a 0–2.5 second **slow rate delay** (time is adjustable).
3. After the **slow rate delay**, the PA35 smoothly increases its flow rate from its **slow rate** to its **fast rate**.
4. The PA35 continues pumping at its **fast rate** until the helm pump stops turning, or until the cylinder reaches an end-stop.

- The **slow rate** is adjusted by turning the “MIN” trim pot inside the Electrical Junction Box (see 0).
    - Adjustable between 20% – 100% of the pump’s maximum rate.
- The **fast rate** is adjusted by turning the “MAX” trim pot inside the Electrical Junction Box (see 4.3.1).
    - Adjustable between 20% – 100% of the pump’s maximum rate.
- The length of time pumping at the slow rate (the **slow rate delay**), and the **duration of the slow-to-fast ramp**, are adjusted by turning the “GAIN” trim pot inside the Electrical Junction Box (see 0).
    - When the gain is at maximum, the PA35 operates in One-Speed Operation (see 5.2.1).

5.3 AUTOPILOT MODE

When the PA35 is in *Autopilot Mode*:

- The PA35 behaves like a Hydraulic Reversing Pump (HRP):
    - Responds to Port/Starboard steering commands from an external Autopilot system.
- The PA35’s electric pump does the work to move the rudder.
    - The pump stops automatically when the cylinder reaches either end-stop.
- Turning the helm wheel automatically cancels autopilot control and returns the unit to normal Power Assist steering mode.

The PA35 switches to *Autopilot Mode* when ALL of the following are true:

1. The PA35 is powered, AND,
2. The PA35 is not in a faulted state (see 7.1), AND,
3. The Manual Mode Switch is off (*the switch inputs are shorted together)* (see 3.3.4), AND,
4. The helm pump is *not turning*, AND,
5. The Autopilot Enable Button is pushed (see 3.3.4).

The PA35 reverts to *Power Assist Mode* when EITHER of the following occur:

- The Autopilot Enable Button is pushed (see 3.3.4), OR,
- Any helm pump is turned (in either direction)

When the PA35 is in *Autopilot Mode* and the autopilot commands a *port turn*:

1. The PA35 controller detects the electrical signal from the autopilot, triggering the pump to run in the port direction, at the **autopilot rate**.
    a. The **autopilot rate** (aka "AUTO rate") is configured by adjusting the "AUTO" trim pot inside the Electrical Junction Box (see 0).
    b. The rate is fully adjustable between 20% and 100% of the pump's theoretical maximum.
2. The pump pushes oil through CV5, out the "CYLINDER PORT" manifold port, to the port side of the steering cylinder.
3. Oil returning from the starboard side of the cylinder enters at the "CYLINDER STBD" manifold port.
4. The oil passes through CV6 (opened by the operation of CV5 and the lock valve spool), before returning to the suction side of the gerotor pump.
5. Make-up oil on the suction side is automatically pulled from the "FILL" manifold port, via check valve CV8.
6. *When the autopilot stops commanding the turn*, the PA35 controller stops the pump motor.

When the PA35 is in *Autopilot Mode* and the autopilot commands a *starboard turn*:

1. The PA35 controller detects the electrical signal from the autopilot, triggering the pump to run in the starboard direction, at the **autopilot rate**.
2. The pump pushes oil through CV6, out the "CYLINDER STBD" manifold port, to the starboard side of the steering cylinder.
3. Oil returning from the port side of the cylinder enters at the "CYLINDER PORT" manifold port.
4. The oil passes through CV5 (opened by the operation of CV6 and the lock valve spool), before returning to the suction side of the gerotor pump.
5. Make-up oil on the suction side is automatically pulled from the "FILL" manifold port, via check valve CV7.

6. *When the autopilot stops commanding the turn*, the PA35 controller stops the pump motor.

The PA35 automatically stops pumping when the cylinder reaches an end-stop and cannot move any further.

6 MAINTENANCE

6.1 PREVENTATIVE MAINTENANCE

- Monthly (12 times/year)
  - Inspect connections for leaks.
  - Test Manual Mode to ensure proper hand-over and operation.
- Quarterly (4 times/year)
  - Verify adequate oil level.
  - Inspect the motor brushes
  - Visually inspect wire and cable insulation for splits or damage.
- Every two years
  - Sample and analyze the oil in the steering lines.
  - Drain reservoir and clean out.
  - Verify pump develops rated pressure.
  - Verify insulation integrity of motor windings.
  - Confirm all electrical screw terminals are secured.
  - Confirm cable glands are secured to cables.

6.2 RECOMMENDED SPARE PARTS

As a minimum Kobelt recommends the following spare parts are on-hand:

Table 12: Recommended Spares

RECOMMENDED SPARES		
QTY	**ITEM**	**KOBELT PART #**
1	PA35 REPAIR KIT (12 VDC/24 VDC)	600-510-RK
1	MINI BLADE FUSE (2A 32VDC) *	6009-8402
1	MINI BLADE FUSE (3A 32VDC) **	6009-8403

** Fuse for 24 VDC variant of PA35*
*** Fuse of 12 VDC variant of PA35*

When purchasing spare parts refer to Appendix B: Parts List at the back of this manual for Kobelt component Part Numbers. See instructions at the end of this manual for shaft seal replacement.

NOTICE	It is recommended that any required service work on an Accu-Steer unit be performed by a factory authorized service representative. Please contact the nearest Kobelt authorized distributor for assistance.

7 TROUBLESHOOTING

If you encounter problems with the operation of your product, please refer to the trouble-shooting suggestions before contacting Kobelt for assistance. If the steps below do not resolve your issue, please reach out either Kobelt directly or our Dealers in your area.

Table 13: Common Solutions

Problem (Issue encountered)	Cause (What it means)	Corrective Action (What to do)
PA35 does not turn ON	Blown fuse or circuit breaker Wiring is not correct	1. Replace external fuse. Replace internal fuse. Reset circuit breaker. 2. Check wiring diagram and ensure that all connections are correct.
Wheel feels soft	Air present in Hydraulic System	1. Bleed hydraulic system to remove trapped air.
Steering is backwards	Hydraulic connections are reversed	1. Correct hydraulic connections.
Helm is very stiff	Unit not turned on Manual mode enabled Broken hydraulic connections Shut off valve is not open	1. Turn on the unit. If the unit does not turn on, see fault 1. 2. Disable manual mode from the control panel. When enabled the helm functions without power-assist. 3. A hydraulic line could be plugged 4. Shut off valve should be open
Motor/solenoid is very hot	Normal operation	1. This occurs during normal operation of the PA35. Do not touch the motor or solenoid with bare hands while operating.
Autopilot Mode indicator lamp is blinking	An error has been detected	1. See section 7.1 for error code patterns.

7.1 Error Code Patterns

The Autopilot Mode indicator lamp flashes to report error codes to the user when the system isn't functioning correctly. The following table outlines these codes:

Table 14: Alarm Indicator Error Codes

Alarm Indicator	Cause (What it means)	Corrective Action (What to do)
2 Flashes	PA35 motor controller has over-heated	Wait for unit to cool and test for normal operation. Ensure duty cycle of unit is not being exceeded.
3 Flashes	Power supplied to PA35 is dangerously high (>32 VDC)	Inspect wiring to unit. Measure voltage with multi-meter to confirm it is within normal operating limits.
4 Flashes	PA35 motor outputs shorted (possible causes include: faulty controller, faulty motor wiring or faulty motor)	Inspect wiring to unit. Check for frayed wires, damaged insulation, or burn marks on components or wiring. Check for (and remove) any external objects touching motor wiring or motor terminals.
5 Flashes	Internal Fault	Contact your Kobelt/Accu-Steer technical representative for support.

8 WARRANTY

Kobelt Manufacturing Co. Ltd. (“Kobelt”) warrants the Products and Parts manufactured by Kobelt to be free from defects in workmanship or material and that said products are designed mechanically and functionally to perform to specifications.

This warranty is effective providing:

- The equipment is used within the intended operating conditions and in accordance with Kobelt recommendations
- The equipment is installed according to equipment diagrams, specifications and recommendations which Kobelt has provided

This warranty becomes invalid if the factory supplied serial number has been removed or altered on the product. This warranty does not cover cosmetic damage or damage caused by an act of God, accident, misuse, abuse, negligence or modification of any part of the product. This warranty does not cover damage due to improper operation or maintenance, connection to inappropriate equipment or attempted repair by anyone other than an authorized Kobelt representative.

Upon identification of a potential issue or defect with a Kobelt Product or Part, the Warranty Applicant (“Applicant”) must immediately contact Kobelt and describe the issue in writing, by letter, fax, email or other electronic conveyance. Kobelt will then assess the cause of the defect and determine warranty applicability and appropriate remediation.

If any part is found to be defective, Kobelt will replace said part FOB the Kobelt factory provided that any such defective part is returned by the Buyer with freight and applicable forwarding charges prepaid by the Buyer. Kobelt’s sole obligation to the Applicant will be to repair or replace the defective part with same or similar product, to a maximum value of the list price of the product or part. The Kobelt warranty does not cover labour charges, travel or any other associated expenses.

All Products and Parts manufactured by Kobelt, are subject to a warranty against manufacturer’s defects in materials or workmanship for a period of two (2) years from the date of purchase.

Kobelt will be responsible for all Products or Parts sold by Kobelt but manufactured by 3rd party manufacturing companies. However, these products and parts are subject to applicable 3rd party warranties and may not be the same as the Kobelt warranty.

9 APPENDIX A: INSTALLATION DIMENSIONS

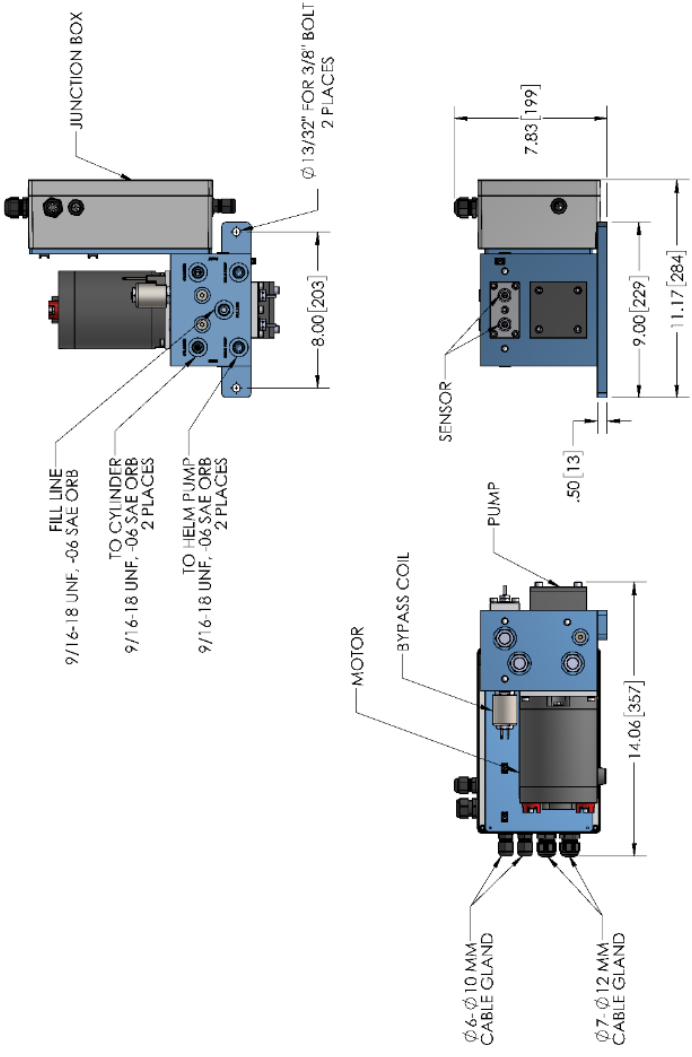


Figure 20: PA35 Installation Dimensions

10 APPENDIX B: PARTS LIST

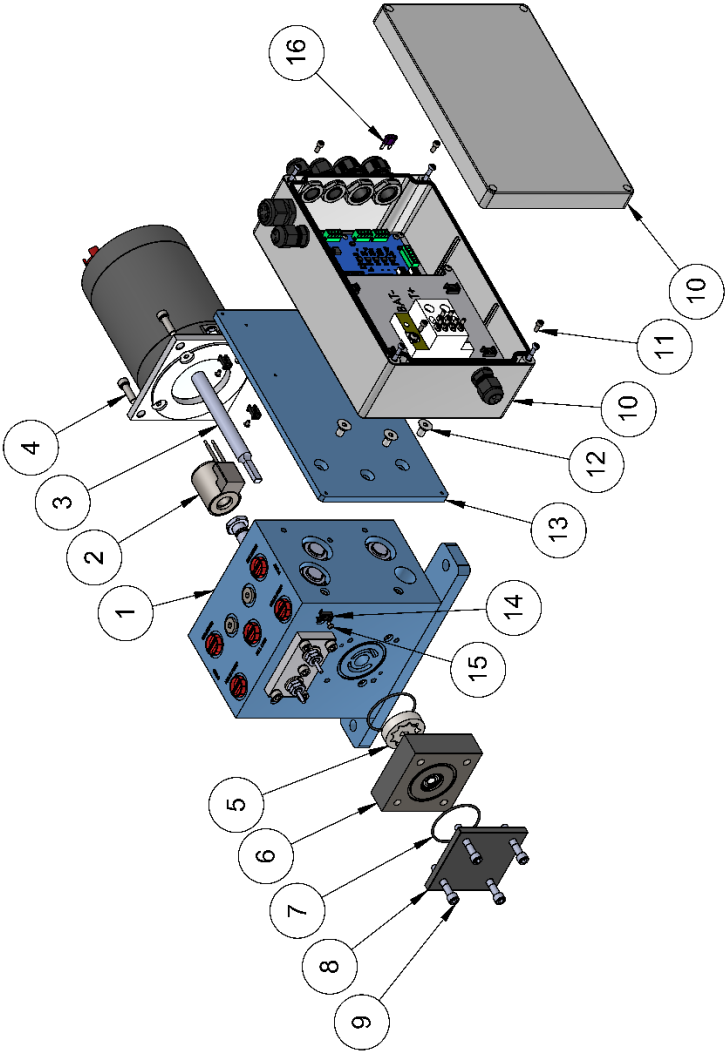


Figure 21: PA35 Parts Diagram

Table 15: PA35 Parts List

	Model No.:	PA35-12	PA35-24
	Part No.:	600-510	600-511
ITEM	**DESCRIPTION**		
1	MANIFOLD SUB- ASSEMBLY	502-650	
2	COIL	7024-0002	7024-0003
3	MOTOR SUB-ASSEMBLY	502-655	502-656
4	SOCKET HEAD CAPSCREW ¼-20 x 3/4	1002-1012-2	
5	GEROTOR	7250-0004	
6	PUMP HOUSING SUB ASSEMBLY	502-115	
7	O-RING (PA35 REPAIR KIT)	600-510-RK	
8	PUMP END COVER PLATE	7001-0042	
9	SOCKET HEAD CAPSCREW ¼-20 x 1 1/2	1002-1024	
10	ELECTRICAL ENCLOSURE	503-200	
11	SOCKET HEAD SCREW	1002-0605	
12	SOCKET HEAD CAPSCREW 6-32 x 5/16	1015-1008	
13	JUNCTION BOX MOUNTING PLATE	7057-0013	
14	CABLE MOUNT, M3 x 8MM	6009-7245	
15	SOCKET BUTTON HEAD CAPSCREW	1014-0403	
16	FUSE BLADE MINI	6009-8403	6009-8402

11 APPENDIX C: MANIFOLD ASSEMBLY PARTS

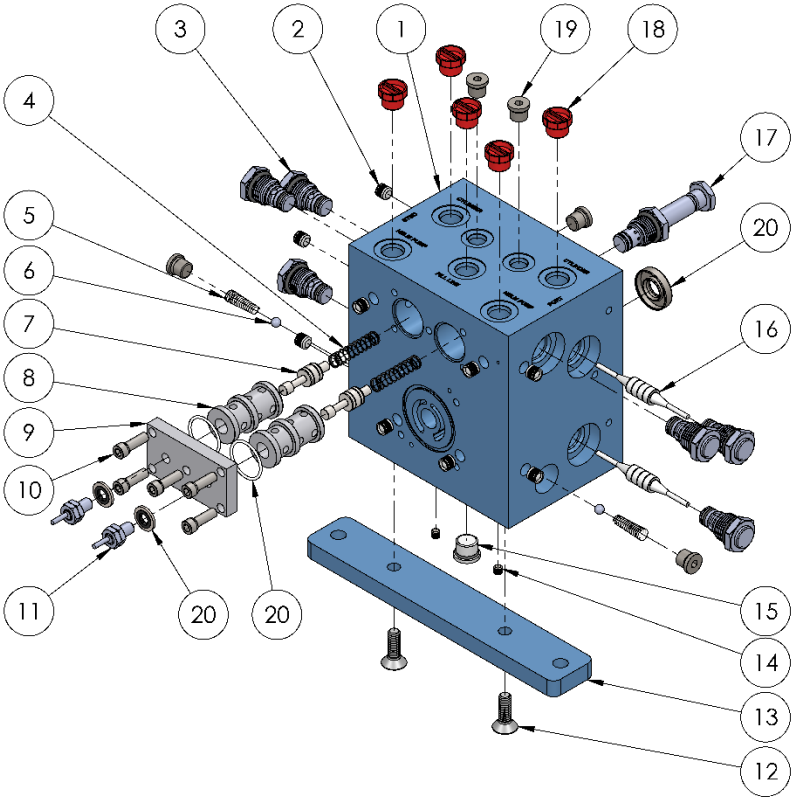


Figure 22: PA35 502-650 Manifold Parts Diagram

Table 16: PA35 502-650 Manifold Parts Table

		Part No.:	502-650
ITEM	**QTY**	**DESCRIPTION**	
1	1	PA MANIFOLD BLOCK	7001-0047
2	9	EXPANSION PLUG CV173-343S	7039-3056
3	6	CHECK VALVE	7049-0018
4	2	SPRING	1201-0266
5	2	SPRING	1201-0261
6	2	BALL CHECK	1301-0108
7	2	SENSOR PISTON	7006-0008
8	2	SENSOR CYLINDER	7006-0007
9	1	SENSOR COVER	7001-0048
10	5	SCREW, CAP, SKT HD, 1/4UNC X3/4, GR 18-8	1002-1012-2
11	2	SENSOR IND PROX M8X20MM 1.5MM NPN NC	6011-0009
12	2	FLAT HEAD SOCKET CS: 5/16-18 x 1 SS	1015-1116
13	1	HPU FOOT MOUNT PLATE	7057-0011
14	2	EXPANSION PLUG CV173-218S	7039-3054
15	1	PLUG, HEX SKT, -06 ORB, PLATED STEEL	7039-0662
16	2	PA LOCK VALVE SPOOL	7006-0006
17	1	SOL. VALVE 2 WAY N.C.	7048-0013
18	5	PLASTIC PLUG, -06	7039-3155
19	5	PLUG, HEX SKT, -04 ORB, PLATED STEEL	7039-0661
20	1	PA35 REPAIR KIT (12 VDC/ 24 VDC)	600-510-RK

12 APPENDIX D: TYPICAL SYSTEM ARRANGEMENT

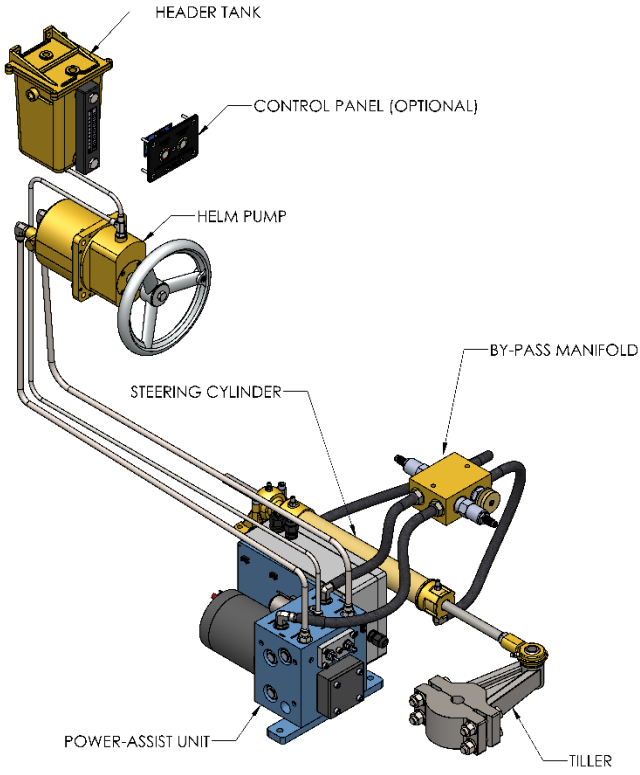


Figure 23: Typical System Arrangement

13 APPENDIX E: SHAFT SEAL REPLACEMENT

Steps for Replacement of Motor Shaft Seal:

1. Clean both the Bore and Seal thoroughly with Methyl Hydrate or Similar Degreaser
2. Apply thin film of Loctite 567 (Liquid Teflon) to the Bore and Seal
3. Using moderate force, drive Seal into bottom of Bore using seating tool.

Note: Installation force is often provided solely by hand-operated arbor presses or soft-faced mallets (used in conjunction with strike plates).

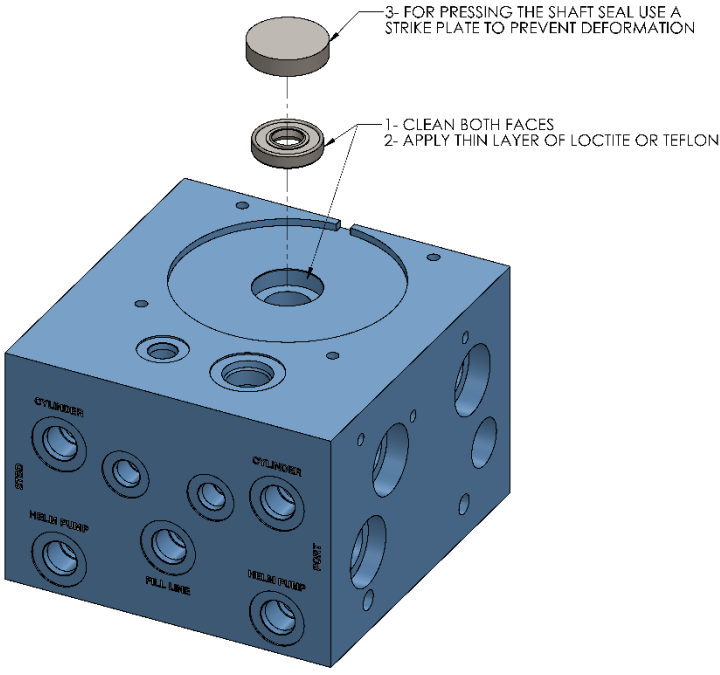


Figure 24: Motor Shaft Seal Diagram

14 APPENDIX F: FACTORY ELECTRICAL CONNECTIONS

Connectors shown in Figure 5 that are installed at the factory are provided here for reference only. There is no need to modify or remove these connections.

Table 17: Power Connector

POWER			
Pin #	**Pin Name**	**Pin Type**	**Function**
1	VMC	Power	Motor Controller Power
2	GND	Power	Ground
3	VIN	Power	DC Supply, 12/24VDC

Table 18: Bypass Connector

BYPASS			
Pin #	**Pin Name**	**Pin Type**	**Function**
1	SVA	Output	Bypass Solenoid Connection, Open-drain Output
2	SVB	Power	Bypass Solenoid Connection, DC Supply Output

Table 19: Helm Sensor Connector

HELM SENSORS			
Pin #	**Pin Name**	**Pin Type**	**Function**
1	VDC	Power	DC Supply Output for Helm Sensors
2	PORT	Input	Helm Sensor Port
3	GND	Power	Ground
4	VDC	Power	DC Supply Output for Helm Sensors
5	STBD	Input	Helm Sensor Starboard
6	GND	Power	Ground

15 APPENDIX G: CONTROL PANEL DIMENSIONS

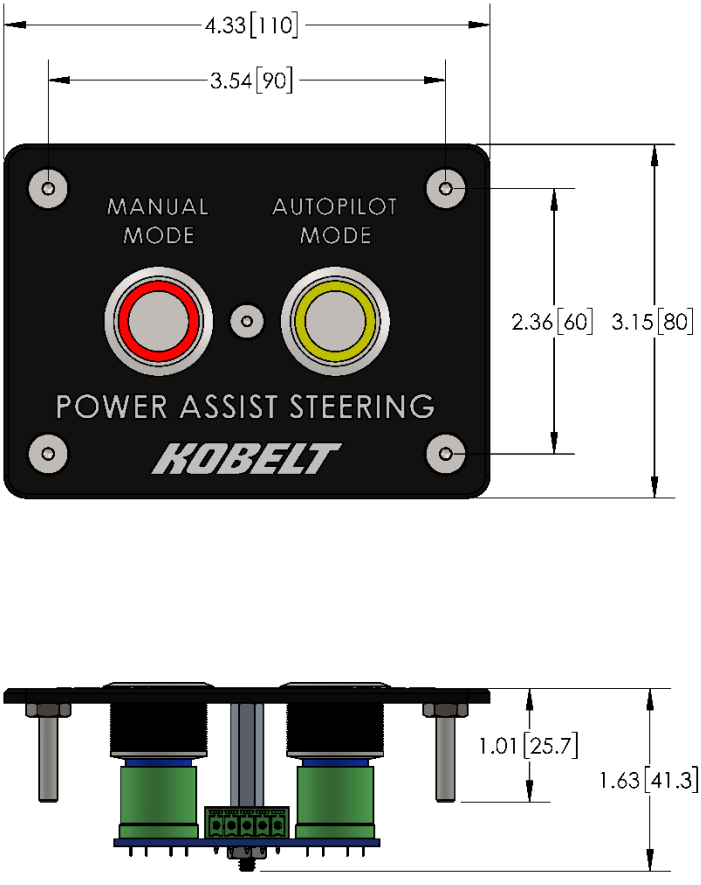


Figure 25: PA35 Control Panel Product Dimensions

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16 APPENDIX H: CONTROL PANEL CUT-OUT TEMPLATE

NOTICE	Scale may not be exactly 1:1 due to PDF and printer scaling. Verify primary dimension with a ruler after printing and before using to cut.

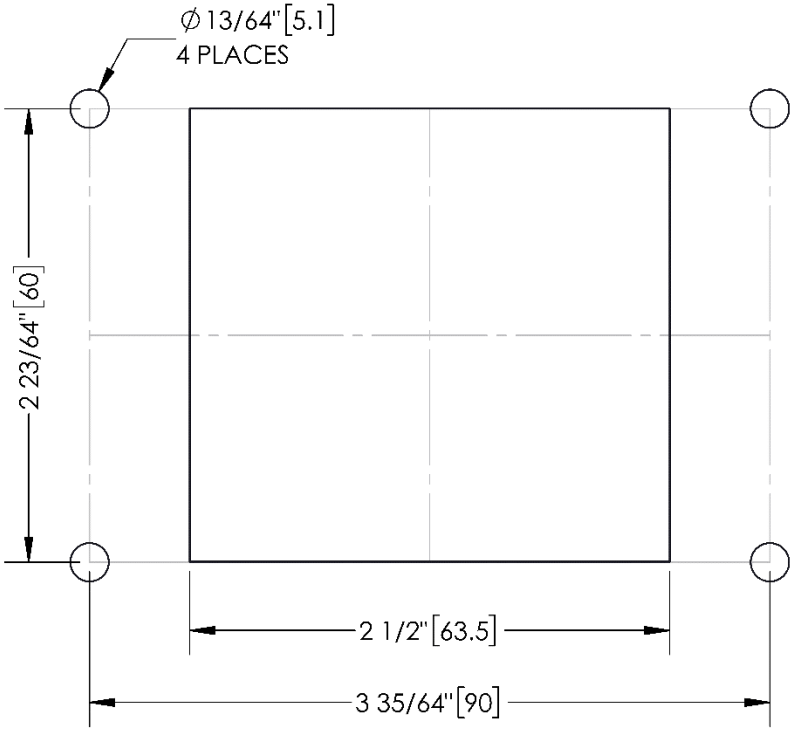

Figure 26: PA35 Control Panel Installation Cut-out Template

Kobelt Manufacturing Co. Ltd.
8238 129th Street
Surrey, British Columbia,
Canada, V3W 0A6

Sales Tel: +1-604-572-3935
Fax: +1-604-590-8313
Email: sales@kobelt.com
Website: www.kobelt.com

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