Analog output modules provide 4 to 20 mA current outputs for a maximum of eight user loads per module. The module's triplicated I/O Safetybus interface ensures that no Regent system failure will inadvertently affect the output signal, and that no failure in the module can affect the operation of the Regent system or other I/O modules in the system.

### Features
- Eight 4 to 20 mA output circuits.
- High resolution 12-bit D/A converter per output.
- Hot-replaceable.
- Automatic testing of triplicate I/O Safetybus circuits and many simplex logic circuits.
- Front panel indicators on each module show active/fault and shutdown status.
- 2500 volt minimum electrical isolation between field and logic circuits.
- TÜV certified, Risk Class 5, non-interfering.

### Module Operation
A block diagram of the analog output module is shown in Figure 1.

The processor modules send triplicated write data commands to the output module over the I/O Safetybus. The processors’ addressing data and data write commands are voted by the module (preventing I/O Safetybus failures upstream from the
module from affecting module operation). The voted result is then passed to the I/O bus interface logic.

The voted output data from the I/O bus interface logic is then used to drive individual digital-to-analog (D/A) converters per output channel. The field-side D/A output circuits are optically isolated from the I/O bus interface logic circuits and receive power from the external power supply.

Each D/A output circuit provides a 4 to 20 mA output current corresponding to analog output values ranging from 0 to 4095. The analog output circuits are capable of driving external load devices up to 500 Ohms.

**Figure 1. Block Diagram of Analog Output Module.**

### Testing and Diagnostics

Each module’s voter circuits are periodically tested by the processor modules. Discrepant data are sent through one of three legs of the I/O Safetybus to determine whether the module’s voter is able to outvote the incorrect data. A failure
Analog Output Modules

To return the correct majority-voted result to the processors produces an I/O module error indication at the processor modules and a module fault indication at the I/O module.

Each type of module has a unique identification code that is read by the controller. This code lets the controller know which type of module is installed in each I/O chassis slot and how to address that module and its points specifically. If a module is removed, or is replaced with a module of a different type, the processor modules will indicate an I/O module error.

Loopback logic tests periodically write data to the module and then read it back to determine whether the module’s I/O bus interface logic is functioning correctly.

Whenever a module fault is detected, there will be an I/O module fault indication at the controller, the controller's fault relay contacts are actuated, and fault indication will appear on the module.

Front Panel Indicators

The analog output module is shown in Figure 2. The front panel contains active, fault, and shutdown indicators.

Active and Fault Status Indicators

These green and red LEDs indicate the overall health of the module. During normal operation the green ACTIVE indicator flashes at the controller's scan rate. If a module fault occurs the red FAULT indicator turns on and the green ACTIVE indicator turns off.

Note: The module will indicate a FAULT if the field power is not applied.
Figure 2. Analog Output Module.
Shutdown Indicator
Upon loss of communications with the controller, output modules enter either a shutdown or hold fault mode. If the I/O unit is set to shutdown, the red SHUTDOWN indicator will turn on when communications with the controller are lost. If the I/O unit is set to hold, the SHUTDOWN indicator will always be off (see page 8, Fault Mode Jumper).

Note: When the module is installed in the I/O chassis or when logic power (from the I/O power supply modules) is first applied to the module, it will be in the shutdown mode until the first output scan, regardless of the fault mode jumper settings. Also, removing two I/O transceiver modules, two I/O power supply modules, or two power legs will cause the module to be in the shutdown mode.

Application

Simplex Configuration
Analog output modules provide a suitable interface to non-critical load devices. These non-critical devices typically include analog display meters, valve positioners and analog signal repeats to other electronic equipment. Although much of the circuitry of the analog output module is automatically tested, some of the logic circuits and the field-side D/A circuits are simplex and non-tested. This simplex configuration is shown in Figure 3.

Figure 3. Simplex Analog Output Configuration.
For high integrity applications requiring fail-safe or fault tolerant analog outputs, guarded analog outputs should be used.

**Field Wiring**

Field wiring terminal blocks on the I/O chassis are used to connect an external 24 VDC power source and analog loads to the module. The terminal blocks are located directly above and below the slot where the module is installed. Each terminal block consists of ten #6 wire clamp screw terminals capable of holding two 12 AWG wires. Figure 4 shows the proper field wiring connections for the analog output module.
Figure 4. Module Wiring.
Fault Mode Jumper

The fault mode jumper is located behind the ID switch cover in the lower left-hand corner of each I/O chassis. The position of the fault mode jumper determines the module's response to system level faults. The fault mode jumper’s position will cause all output modules in the I/O chassis to either shutdown (turn off all outputs) or to hold (hold the last state) after a system level failure occurs. An example of a system level failure is the failure of two processor modules.

Important! When the analog output module is in the shutdown mode, analog output signals are at 0 mA (not 4 mA).

Keying

The I/O chassis can be physically keyed to prevent accidental damage caused by inserting a module into a slot wired for a different module type. Figure 5 illustrates how the slot keys are installed on the I/O chassis slot field wiring connectors. The slot key positions for the analog output module are listed in Table 1.

<table>
<thead>
<tr>
<th>Module</th>
<th>Upper Connector</th>
<th>Lower Connector</th>
</tr>
</thead>
<tbody>
<tr>
<td>T3470A</td>
<td>9</td>
<td>2</td>
</tr>
</tbody>
</table>
Analog Output Modules

**Figure 5. Installing Slot Keys.**

**Configuration**

Each output module is configured using the WINTERPRET I/O Configuration Editor. In the editor you will perform the three steps described below to configure the output module.
1) Set the Module Type:

Position the cursor on the module slot you wish to define. Choose Set Module Type from the Edit Menu and select the appropriate analog output module from the list.

2) Edit the Module Definition:

Choose Edit Module Definition from the Edit Menu. A dialog box will open where you can define the analog output point definitions.

3) Edit each point:

Choose Edit from the Module Definition dialog box to define a name and description for each output point. In the Analog Output Point dialog, enter names and values for the configuration fields as described below.
Figure 7. Defining an Analog Output Point.

Name
Also called the tag name, this is the name used in the application program to reference the output point. The name can be up to 12 characters long.

Description
This 40-character field provides a place to describe the output point definition. The description is used to help document your system (it does not affect application program operation).

Comm Protect
Marking the Comm Protect check box protects the point from changes by communications functions such as data write, forcing, and load initial value when Comm Protect is enabled.

Initial Value
The initial value for the output is loaded to the Regent when you load the I/O configuration and also when you load the application program that controls the output.

Final Value
The final value for the output is loaded to the Regent when the application program that controls the output is deleted. Unless special circumstances exist, you should always enter zero, so that the output is turned off when you delete the application program that controls it.
Programming

Outputs are controlled by writing application programs that solve for output values. For example, placing an output tag name in the result field of a math element in ladder logic will set the analog output to the value calculated by the math element. Note that the data range for analog outputs is 0 to 4095 corresponding to the output current range of 4 to 20 mA.

Often you may choose to write analog control logic using an engineering unit number range other than 0 to 4095 to simplify the creation and interpretation of the control logic. If you do so you should use the analog scaling function block to “unscale” your calculated value to the 0 to 4095 range required for the analog output. An example of an analog scaling entry for analog outputs is shown in Figure 8.

![Figure 8. Unscaling an Analog Output.](image)

This example implies that some other control logic solves a value for the shared register “AO1_ENG_VAL” which ranges from 0 to 10,000 (the low and high values). The analog scaling entry shown in the example then converts the engineering unit value to the analog output range of 0 to 4095, storing the converted value in the analog output “AO1”. By using an engineering unit range of 0 to 10,000 for your
control logic, you maintain the full resolution of the analog output (1 part in 4096) and have a convenient engineering range that represents 0.00 to 100.00% (the two decimal places are implied).

**Maintenance**

There are no user replaceable parts inside the analog output module. Re-calibration is recommended once per year, in order to maintain the rated accuracy of the analog output signals over an extended period of time. The following procedure describes the equipment and steps necessary to calibrate the analog output module.

**Calibration Procedure**

**Equipment Required**
- A 5½-digit voltmeter.
- Eight 250 ohm, 0.005%, 5 ppm/°C resistors to convert the eight output signals from a current to a voltage.
- Potentiometer adjustment tool.
- Phillips screwdriver
- I/O module extender, catalog number T3322.
- PC running the WINTERPRET software, used to force the analog output channels to the specific values for calibration.

**Calibration Preparation**

The module must be calibrated while connected to an I/O chassis of an operational Regent system.

**Important!** During calibration, the analog output module will be disconnected from the actual controlled field devices. Appropriate precautions should be taken to ensure that the disconnection of the control signals does not pose a safety risk to plant personnel or process equipment.

There are Offset and Gain potentiometers for each analog output channel. These potentiometers are located on a circuit board inside the module's protective clamshell housing (see...
Figure 9). During the calibration steps you will remove the printed circuit board from the housing in order to access these potentiometers for adjustment.

**Figure 9. Analog Output Module Calibration Potentiometer Locations.**

The I/O extender module has jumper posts that allow you to connect or disconnect the I/O slot field wiring on the I/O chassis to the printed circuit board plugged into the I/O extender. During the calibration steps you will remove any jumpers installed on these posts in order to connect the
precision load resistors to the analog outputs. Figure 10 shows the jumper posts to which you should connect the precision resistors for each analog output channel.

**Figure 10. I/O Extender Connections for Analog Output Calibration.**

**Important!** Within each pair of jumper posts, make sure that you connect the resistors to the jumper posts nearest the front of the I/O extender. Do not make any connections to the jumper posts nearest the I/O chassis backplane — these connect to the actual field wiring attached to the I/O slot terminals on the I/O chassis.

**Calibration Steps**

1. Remove the module to be calibrated from the I/O chassis.
2. Install the I/O extender module into the slot from which the module was removed.

3. Remove the jumpers (if installed) labeled CH1 through CH16 from the I/O extender module.

4. Connect the eight precision resistors to the I/O extender jumper posts as shown in Figure 10. Use test clips as required to make the connections.

5. Remove the four screws on one side of the module and remove the printed circuit board from the module clamshell housing.

6. Install the printed circuit board into the I/O extender module. Allow the board to warm up for approximately one minute.

7. Using the forcing functions of WINTERPRET, force all of the eight analog outputs to zero. Refer to the Regent User’s Guide for more details about the forcing functions. Wait approximately one minute after forcing the outputs to allow them to stabilize.

8. Adjust the eight Offset potentiometers to read +1.0000 V (± 0.0002 V) across each of the precision resistors. Connect the voltmeter across the resistor leads to measure the voltage.

9. Force all eight of the outputs to 4095. Wait approximately one minute after forcing the outputs to allow them to stabilize.

10. Adjust the eight Gain potentiometers to read +4.9990 V (± 0.0002 V) across each of the precision resistors.

11. Repeat steps 7 through 10 and readjust the Offset and Gain potentiometers if necessary until the Offset and Gain voltages are within the stated limits.

12. Force all eight of the outputs to 2048. Wait approximately one minute after forcing the outputs to allow them to stabilize.

13. Verify that the output voltages read +3.0000 V (± 0.0020 V) across each of the precision resistors. If the Offset and Gain adjustments are within the limits stated in steps 8 and 10 above, but this midvalue point is not, return the
analog output module to the factory for repair or replacement.

14. Calibration is complete. Unplug the printed circuit board from the I/O extender module and replace it in its clamshell housing. Remove all forcing of the analog outputs from the force table using WINTERPRET. Remove the I/O extender module from the I/O chassis and reinstall the calibrated module in the I/O chassis.

The module’s red Fault indicator will be on until you perform a voted reset by pressing the Reset buttons on two of the Regent processor modules. After the voted reset is complete, the module’s green Active indicator should turn on.

Safety Considerations

The analog output module is TÜV certified as non-interfering, and can be used in a safety system for simplex non-safety critical outputs.

Specifications

<table>
<thead>
<tr>
<th>Safetybus Power</th>
<th>0.5 load units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Outputs</td>
<td>Eight</td>
</tr>
<tr>
<td>External Power</td>
<td></td>
</tr>
<tr>
<td>Voltage:</td>
<td>24 VDC ±5%</td>
</tr>
<tr>
<td>Current:</td>
<td>0.5 amps, maximum</td>
</tr>
<tr>
<td>Output Range</td>
<td>4 to 20 mA</td>
</tr>
<tr>
<td>Data Range</td>
<td>0 to 4095</td>
</tr>
<tr>
<td>Resolution</td>
<td>12-bit (1 in 4096)</td>
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<tr>
<td>Accuracy</td>
<td>0.1% of full scale @ 25°C</td>
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<tr>
<td>Drift</td>
<td>±50 ppm/°C</td>
</tr>
<tr>
<td>Load Resistance</td>
<td>0 to 500 ohms</td>
</tr>
<tr>
<td>Isolation</td>
<td>2500 volts minimum (field wiring to control logic)</td>
</tr>
</tbody>
</table>
**Analog Output Modules (T3470A)**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Heat Dissipation</strong></td>
<td>10 Watts, 33 BTUs/hour</td>
</tr>
<tr>
<td><strong>Operating Temperature</strong></td>
<td>0° to 60° C (32° to 140° F)</td>
</tr>
<tr>
<td><strong>Storage Temperature</strong></td>
<td>-40° to 85° C (-40° to 185° F)</td>
</tr>
<tr>
<td><strong>Operating Humidity</strong></td>
<td>0 to 95% relative humidity, non-condensing</td>
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<tr>
<td><strong>Vibration</strong></td>
<td>10 to 55 Hz: ±0.15mm</td>
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<tr>
<td><strong>Shock</strong></td>
<td>Operating: 15 g, ½ sine wave, 11 msec</td>
</tr>
<tr>
<td><strong>Electromagnetic Interference</strong></td>
<td>Level 3: Contact discharge of 6 kV</td>
</tr>
<tr>
<td></td>
<td>Level 3: 10 V/M, 27 MHz · 500 MHz</td>
</tr>
<tr>
<td><strong>Safety</strong></td>
<td>Certified to DIN V VDE 0801 (non-interfering) and designed to meet UL 508 and CSA 22.2, No. 142-M1981</td>
</tr>
<tr>
<td><strong>Dimensions</strong></td>
<td>Height: 12.6&quot; (320 mm)</td>
</tr>
<tr>
<td></td>
<td>Width: 1.27&quot; (32 mm)</td>
</tr>
<tr>
<td></td>
<td>Depth: 10.12&quot; (257 mm)</td>
</tr>
<tr>
<td><strong>Weight</strong></td>
<td>3.5 lbs (1.6 kg)</td>
</tr>
</tbody>
</table>