



Operating Bulletin



MODBUS-RTU & MODBUS-TCP/IP

The Fastest Flow Controller Company in the World!

RECALIBRATION

Your Alicat instrument is a precision device and Alicat strongly recommends that you send it to us on a yearly basis for recalibration.

A yearly recalibration does a few things:

- ▶ It insures that your unit is functioning according to specification.
- ▶ Contamination may cause the instrument to measure flow improperly. Recalibration insures the instrument is clean and free from debris.
- ▶ Recalibration maintains your LIFETIME WARRANTY!

Sending your unit for recalibration is easy and inexpensive. Recalibrations are usually shipped within five days of receipt, so it's fast too.

Please keep the original box to return your Alicat instrument for recalibration.

ACCESSORIES

Now that you have your Alicat instrument are you sure you've got everything you need? Alicat accessories can make your job easier.

Many of our customers also order:

- ▶ Power Supplies — A universal wall power supply that makes it easy to power your Alicat unit just about anywhere in the world.
- ▶ BB9 — Alicat's multi-drop box that allows easy connection of up to nine Alicat instruments to a single USB, RS-232 or RS-485 port.
- ▶ MD8DB9 — An RS-232 to 8 pin Mini-DIN cable to connect your Alicat instrument to a computer. A variety of other cables are also available.
- ▶ Flow Vision™ SC — A GUI based Windows® program that allows easy computer access and control for one or multiple Alicat instruments.
- ▶ Fittings and filters — Keep your instrument properly connected to your process and free from harmful contamination.



ALICAT MODBUS OPERATING BULLETIN

Modbus is an application layer messaging protocol that formats data for communications among industrial devices. Alicat supports both Modbus-RTU and Modbus TCP/IP protocols depending on the device configuration.

Devices ordered with the Modbus-RTU application layer communicate over serial RS-232 or RS-485. Modbus data is transmitted through Alicat's default 8-pin mini-DIN connector, a 9-pin or 15-pin D-Sub connector or an RJ45 connector. Note: An RJ45 connector in a Modbus-RTU device does not indicate support of Ethernet communication or availability of the Modbus-TCP/IP protocol in this unit. In addition to Modbus-RTU support, your device supports standard Alicat serial commands. Please see your operating manual for a description of the supported commands.

Devices ordered with Modbus-TCP/IP support include a dual-RJ45 connector that supports standard 10BaseT & 100BaseT Ethernet communication. See section 3 for information on setting the device's network configuration.

1 Modbus Registers

Alicat's deployment of Modbus uses a Master/Slave structure that organizes data into 16-bit registers. Alicat supports Modbus function codes 03 "Read Holding Registers," 04 "Read Input Registers" and 16 "Write Multiple Registers."

Alicat devices use the Modbus PLC numbering convention such that all registers begin at index 1. The values seen in a Modbus Protocol Data Unit are zero based and would be one less than those specified below. If your master controller does not follow this convention, you may need to decrement register addresses by one.

All 32-bit values are handled in consecutive Modbus registers in big-endian format. This means bits 31:16 are in the lower numbered Modbus register and bits 15:0 are in the higher register. All floating-point values are IEEE 32-bit floats.

Parameter	Access	Register Number	Description
Command ID	RW	1000	See Section 1.1
Command Argument	RW	1001	
Setpoint	W	1010-1	See Section 1.2
Mixture Gas 1 Index	RW	1050	See Section 1.3
Mixture Gas 1 Pct	RW	1051	
Mixture Gas 2 Index	RW	1052	
Mixture Gas 2 Pct	RW	1053	
Mixture Gas 3 Index	RW	1054	
Mixture Gas 3 Pct	RW	1055	
Mixture Gas 4 Index	RW	1056	
Mixture Gas 4 Pct	RW	1057	
Mixture Gas 5 Index	RW	1058	
Mixture Gas 5 Pct	RW	1059	
Gas Number	R	1200	See your Alicat operating manual for a list of gas numbers
Device Status	R	1201-02	See Section 1.4
Device Statistic 1 Value	R	1203-04	
Device Statistic 2 Value	R	1205-06	
Device Statistic 3 Value	R	1207-08	
Device Statistic 20 Value	R	1241-42	

1.1 Device Commands

Commands can be issued to the Alicat device using Modbus register 1000. Commands are described in the table below. Some commands require a parameter to be passed in Command Argument register 1001 using the “Write Multiple Registers” Modbus function code. A write to only the Command ID register 1000 will be interpreted as having a value of 0 in the Command Argument. Commands take effect at the completion of a Modbus write command.

Command ID	Action	Argument
1	Change gas number	Gas Table Index
2	Mix gas	Gas mixture index (236-255) or 0 to use next available
3	Delete gas mixture	Gas mixture index
4	Tare	0 = Pressure 1 = Abs Pressure 2 = Volume
5	Totalizer reset	None
6	Valve setting Exhaust is only supported on dual-valve devices	0 = Cancel 1 = Hold close 2 = Hold current 3 = Exhaust
7	Display lock Only supported on devices with a display.	0 = Unlock 1 = Lock
8	Change P in PID Loop	0-65535
9	Change D in PID Loop	0-65535
10	Change I in PID Loop	0-65535
11	Change control loop variable.	0 – Mass Flow 1 – Volumetric Flow 2 – Diff Pressure 3 – Absolute Pressure 4 – Gauge Pressure
12	Save current set-point as power-up value.	None
13	Change control loop algorithm.	1 – PD 2 – PDDI
14	Read PID value	0 – PID P 1 – PID D 2 – PID I
32767	Change Modbus Slave ID – Modbus/RTU only.	New ID 1-247

Reads of the ID register 1000 will return the last executed command. Reads of the argument register 1001 will return the status of the last executed command (see next page).

Command status returns in register 1001 are as follows:

Status	Description
0	Success
236-255	Gas mix index that was created or updated (Mix gas command only)
0x8001	Invalid command ID
0x8002	Invalid setting
0x8003	Requested feature is unsupported
0x8004	Invalid gas mix index
0x8005	Invalid gas mix constituent
0x8006	Invalid gas mix percentage

1.2 Setpoint

The device setpoint should be sent as a 32-bit IEEE floating point value. Setpoint values must be sent together in a Write Multiple Registers command. Any writes to only one half of the setpoint value will cause an error. Setpoint is ignored on devices without a controller.

1.3 Gas Mixing

Gas mixing can be performed with 2-5 gases using the mix registers 1050-1059. The mix is a two-step process. First, the desired constituent gas indexes and percentages must be written to the mix registers followed by a write of the Mix Gas command (ID 2) into command register 1000 (with the command argument being optional).

Gas mix percentages are interpreted as integer hundredths of a percent and the total percentage must sum to 100%. For example, to specify a mix of 50%, a value of 5000 should be written into the gas percentage register. The mix will be performed with the first N gases that have a non-zero percentage. As an example, if you wish to mix 3 gases, you would write the index and percentage for those gases into registers 1050-1055 and write a value of zero into 1057-1059.

If the command argument passed to the mix command is 0 or is omitted, a new gas mix index will be allocated in the next empty gas mix index starting at 255 and working down to 236. If no user mix indices are unused, the command will not be successfully completed and an error will be returned in the command argument register.

If the command argument passed is between 236 and 255, the mixture with the specified index will be either created or updated to the new composition. If the specified index is not valid (the command argument is neither 0 nor 236-255), an error will be returned.

Upon completion of mixing, the command argument register will be updated with the mix result. If the mix was valid, the index of the mixed gas will be returned. If one of the requested mix gas constituents did not exist or the percentage does not add to 100%, an error value will be returned and the mix will not be created.



Note: Gas mixing is only available over the Modbus serial interface and cannot be performed from the front panel display.

All gas mixtures are accessible via Gas Select on the front panel, but mixtures may not be created or deleted via the front panel.

1.4 Device Status

This register specifies status conditions in the device. The value in parenthesis is the front-panel display of the corresponding condition.

Bit	Description
0	Temperature Overflow (TOV)
1	Temperature Underflow (TOV)
2	Volumetric Overflow (VOV)
3	Volumetric Underflow (VOV)
4	Mass Overflow (MOV)
5	Mass Underflow (MOV)
6	Pressure Overflow (POV)
7	Totalizer Overflow (OVR)
8	PID Loop in Hold (HLD)
9	ADC Error (ADC)
10	PID Exhaust (EXH)
11	Over pressure limit (OPL)
12	Flow overflow during totalize (TMF)
13	Measurement was aborted

1.5 Device Statistics

Your Alicat device can output 20 different configurable data statistics. The default statistics for each device type are specified in the sections below.

For Modbus-RTU devices, the actual statistic and units output on your device can be determined by issuing the Alicat data frame query command (*??D*).

For Modbus-TCP/IP, the available statistics are viewable from the device's embedded webserver. To access, point your web browser to the device's IP address and select the Data I/O tab.

If you wish to customize the output of your device please speak to an Alicat applications engineer.

Unless specified below, all output values are in 32-bit IEEE floating point. If an unused device statistic slot is read on Modbus-RTU, the value 0xFFFFFFFF will be returned. On Modbus-TCP/IP devices unused slots will return an invalid register address error.

The value returned for a pressure reading can be absolute pressure, gauge pressure or differential pressure depending on your device's configuration.

1.5.1 Mass Flow Controller

Register Number	Statistic
1203-04	Pressure
1205-06	Flow Temperature
1207-08	Volumetric Flow
1209-10	Mass Flow
1211-12	Mass Flow Setpoint
1213-14	Mass Total*

* Mass Total is only available on units with the Totalizer option.

1.5.2 Mass Flow Meter

Register Number	Statistic
1203-04	Pressure
1205-06	Flow Temperature
1207-08	Volumetric Flow
1209-10	Mass Flow
1211-12	Mass Total*

* Mass Total is only available on units with the Totalizer option.

1.5.3 Pressure Gauge

Register Number	Statistic
1203-04	Pressure

1.5.4 Pressure Controller

Register Number	Statistic
1203-04	Pressure
1205-06	Pressure Setpoint

2 Legacy Registers

For backwards compatibility, the following legacy registers are supported on the Modbus-RTU protocol. These registers are not available on Modbus-TCP/IP devices. Unlisted registers are not configurable via Modbus. Please consult Alicat for assistance if additional configuration is required.

2.1 User-Accessible Configuration Registers

For new deployments, Alicat recommends using the Device Command Registers above to set these values.

Parameter	Access	Register Number	Description
PID control loop P	RW	21	16-bit integer
PID control loop D	RW	22	16-bit integer
PID control loop I	RW	23	16-bit integer
Setpoint	RW	24	0-65535 with 64000 equal to 100% of full scale range.
Gas Selection	RW	46	16-bit integer
Modbus device ID	RW	65	1-247

2.2 Device Data Registers

Alicat uses read-only Modbus registers 2,041-2,059 to hold the values of the instrument data as follows:

Query	Register Number	Data Type
Pressure	2041-2042	32-bit float*
Temperature	2043-2044	32-bit float*
Volumetric Flow Rate	2045-2046	32-bit float*
Mass Flow Rate	2047-2048	32-bit float*
Setpoint	2049-2050	32-bit float*
Totalized Mass Flow	2051-2052	32-bit float*
Modbus Device ID	2053	16-bit integer
Gas Number	2054	16-bit integer
Vol. Flow Overage (VOV)	2055	0=ok, 1=error exists
Mass Flow Overage (MOV)	2056	0=ok, 1=error exists
Pressure Overage (POV)	2057	0=ok, 1=error exists
Temp. Overage (TOV)	2058	0=ok, 1=error exists
Totalizer Rollover (OVR)	2059	0=ok, 1=error exists

3 Modbus-TCP/IP Configuration

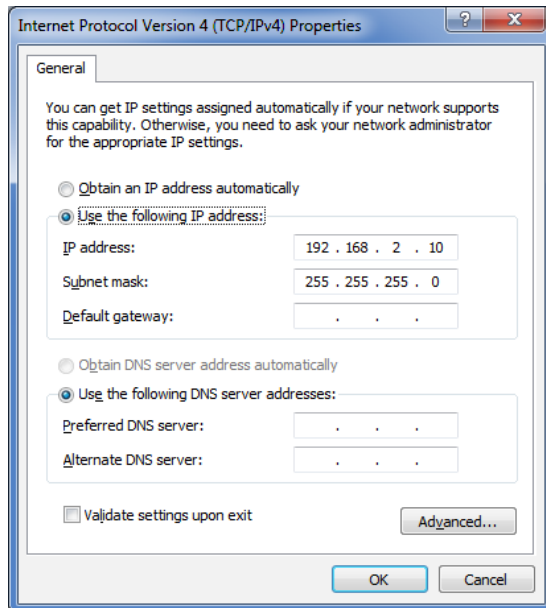
Alicat Modbus-TCP/IP devices have two 10/100Mbps Ethernet ports with an embedded switch. Either port can be used to communicate with the device. In addition, the embedded switch supports packet forwarding allowing daisy-chaining devices in a linear or ring topology.

3.1 IP Address Configuration

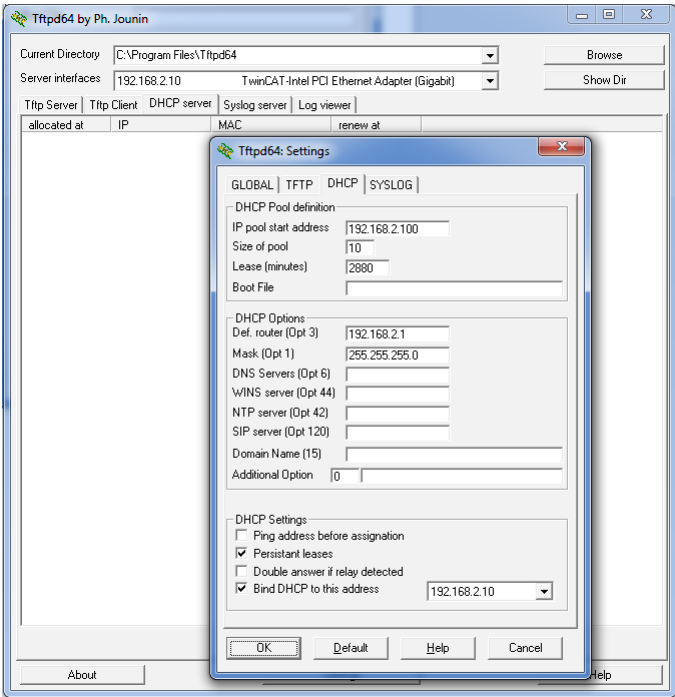
The out-of-the-box configuration of your device is to use DHCP to obtain an IP address. There is an embedded web server in the device which supports assigning a static IP address to the device. To do so, you must first assign an address using DHCP.

The following shows an example of configuring the address using Microsoft Windows:

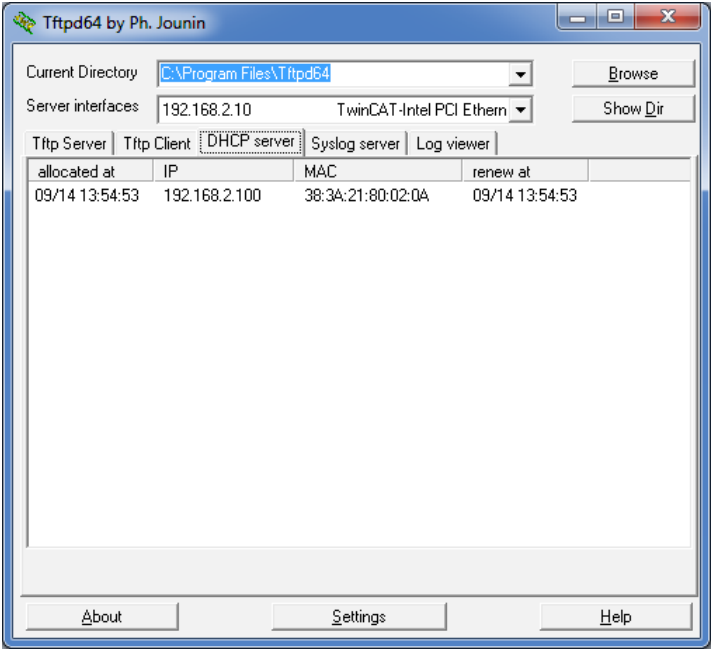
First, assign a static IP to an unused network interface:



Second, configure a DHCP server to give a known IP address to your device on the static network. This example uses the open source Tftpd64 tool (<http://tftpd32.jounin.net>):



After connecting your Alicat device directly to the static port and supplying power to the device, you should see an address allocated to the device by the DHCP server:



The network configuration can then be changed using the device’s embedded webserver. Navigate to the Network Config tab, uncheck the “Use DHCP” box, and enter the desired static IP address into the form.



Home

Data IO

Network Config

Device Config

Alicat Industrial Protocol Communications Adapter

Network Config

Use DHCP: ☒

IP Address: 192.168.2.100

Subnet Mask: 255.255.255.0

Gateway: 192.168.2.1

Update

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If you would like additional information regarding the use of this product, please contact:

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Alicat Scientific, Inc. warrants to the original purchaser (hereinafter referred to as "Buyer") that instruments manufactured by Alicat Scientific (hereinafter referred to as "Product") shall be free from defects in materials and workmanship for the life of the Products.

Under this warranty, the Products will be repaired or replaced at manufacturer's option, without charge for parts or labor when the Product is carried or shipped prepaid to the factory together with proof of purchase.

The foregoing shall constitute the exclusive and sole remedy in lieu of other remedies of the Buyer for any breach by Alicat Scientific of this warranty to the maximum extent permitted by law.

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This Warranty is in lieu of all other relevant warranties, expressed or implied, including the implied warranty of merchantability and the implied warranty of fitness for a particular purpose, and any warranty against infringement of any patent.

Continued use or possession of Products after expiration of the applicable warranty period stated above shall be conclusive evidence that the warranty is fulfilled to the full satisfaction of Buyer.

Alicat makes no warranty as to experimental, non-standard or developmental Products.

Accessories purchased from Alicat are not covered by this warranty.

Conformity / Supplemental Information:

The product complies with the requirements of the Low Voltage Directive 2006/95/EC and the EMC Directive 2004/108/EC and carries the CE Marking accordingly. Contact the manufacturer for more information.

Gas Viscosity, Density and Compressibility:

#	Gas	Absolute Viscosity* 25°C	Density ** 25°C	Compressibility 25°C
0	Air	184.918	1.1840	0.9997
1	Argon	225.593	1.6339	0.9994
2	Methane	111.852	0.6569	0.9982
3	Carbon Monoxide	176.473	1.1453	0.9997
4	Carbon Dioxide	149.332	1.8080	0.9949
5	Ethane	93.540	1.2385	0.9924
6	Hydrogen	89.153	0.08235	1.0006
7	Helium	198.457	0.16353	1.0005
8	Nitrogen	178.120	1.1453	0.9998
9	Nitrous Oxide	148.456	1.8088	0.9946
10	Neon	311.149	0.8246	1.0005
11	Oxygen	204.591	1.3088	0.9994
12	Propane	81.458	1.8316	0.9841
13	normal-Butane	74.052	2.4494	0.9699
14	Acetylene	104.448	1.0720	0.9928
15	Ethylene	103.177	1.1533	0.9943
16	iso-Butane	74.988	2.4403	0.9728
17	Krypton	251.342	3.4274	0.9994
18	Xenon	229.785	5.3954	0.9947
19	Sulfur Hexafluoride	153.532	6.0380	0.9887

Flow Conversions:

SCFM	1.00 = 28.3160	SLPM	SLPM	100.00 = 3.5316	SCFM
SCFH	1.00 = 0.4719	SLPM	SLPM	100.00 = 211.9093	SCFH
SCIM	100.00 = 1.6390	SLPM	SLPM	1.00 = 61.0128	SCIM
SCIH	1000.00 = 0.2732	SLPM	SLPM	1.00 = 3660.7668	SCIH

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#	Gas	Absolute Viscosity* 25°C	Density ** 25°C	Compressibility 25°C
20	75%Ar / 25% CO2	C-25 205.615	1.6766	0.9987
21	90%Ar / 10% CO2	C-10 217.529	1.6509	0.9991
22	92% Ar / 8% CO2	C-8 219.134	1.6475	0.9992
23	98% Ar / 2% CO2	C-2 223.973	1.6373	0.9993
24	75% CO2 / 25% Ar	C-75 167.451	1.7634	0.9966
25	75% Ar / 25% He	HE-75 230.998	1.2660	0.9997
26	75% He / 25% Ar	HE-25 234.306	0.5306	1.0002
27	90% He / 7.5% Ar / 2.5% CO2 Hellstar® A1025	A1025 214.840	0.3146	1.0003
28	90% Ar / 8% CO2 / 2% O2 Stargon® CS	Star29 218.817	1.6410	0.9992
29	95% Ar / 5% CH4	P-5 223.483	1.5850	0.9993

*In micropoise (1 Poise = gram / (cm) (sec)) **Grams/Liter
Reference: NIST REFPROP 7 Database



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