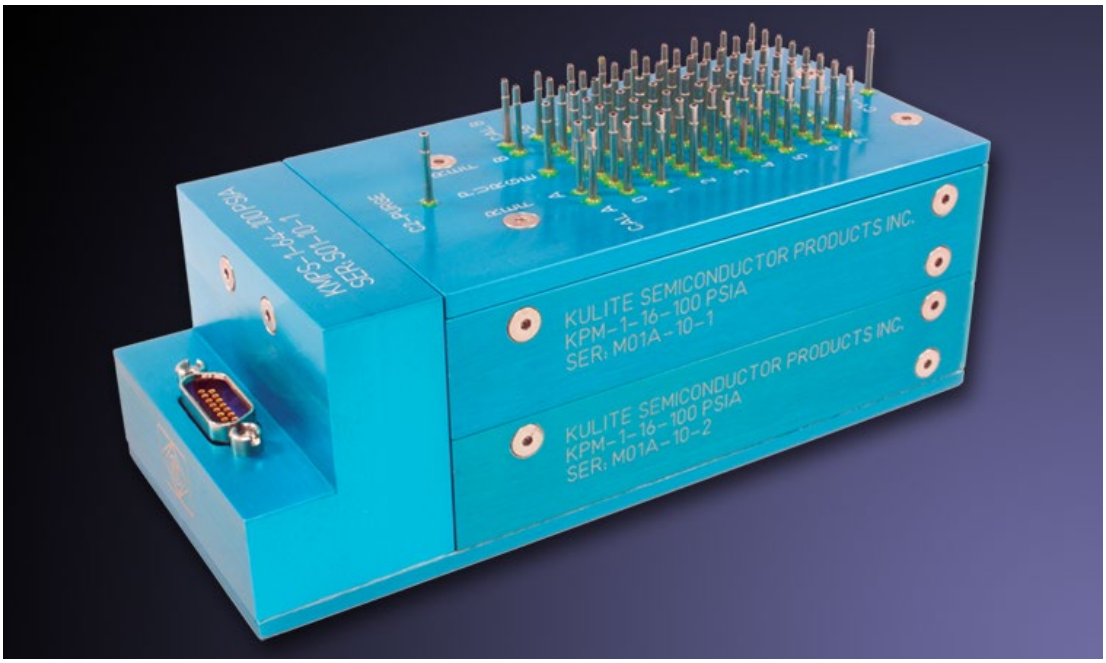
KMPS-1-64



Pressure Scanner
Instruction Manual
Version 2.6.2 and Higher

Contents

List of Tables

List of Figures

1 Specifications

SPECIFICATIONS	
Available Channels	64
Pressure range	1 – 250 PSIG 15 – 250 PSIA
Operating Temperature Range	-65°F to 255°F (-55°C to 120°C)
Compensated Temperature Range	-65°F to 255°F (-55°C to 120°C)
TEB over 12 months	< +/- 5 PSI TEB :± 0.20% FS. TYP > +/- 5 PSI TEB :± 0.10% FS. TYP
Dimensions	Width: 1.5” Length: 3.25” Height: 2.0”
Weight	1.1 kg
Reference pressure	30 PSIA
Sample Rate	275 samples/channel/sec
Connections	Electrical connector : **15 Pin subminiature D-shell** Pneumatic connector: 64 .040” Bulged tubulations
Excitation	8 - 32 VDC
Max Current	0.25 A
Resolution	24 Bit
Over Pressure	2X Rated Pressure
Burst Pressure	3X Rated Pressure
Multiplexer Inputs	3.3 Volt Inputs with 10 kOhm Pull-Up resistor To select pin pull to ground to unselect leave floating

Table 1: General Specification

1.1 Electrical Connector

Pin	Function
1	+28V
2	Ground
3	RS-485A
4	RS-485B
5	X
6	X
7	X
8	MUX1
9	MUX2
10	MUX3
11	MUX4
12	MUX5
13	MUX6
14	Trigger
15	Factory Use

Table 2 : Electrical Connector for RS485 KMPS-1-64-XX-R

Pin	Function
1	+28V
2	Ground
3	RX+
4	RX-
5	Tx+
6	Tx-
7	X
8	MUX1
9	MUX2
10	MUX3
11	MUX4
12	MUX5
13	MUX6
14	Trigger
15	Factory Use

Table 3 : Connections for Ethernet KMPS-1-64-XX-E

1.2 Part Numbers

The KMPS-1 part number is of the form:

KMPS-1-64-XX-Y

Where:

XX – Purge Option

AP – Air Purge - Pneumatically activated purge block installed

NP – No Purge

Y – Communication Option

E – Ethernet

R – RS-485

Inside each KMPS-1 up to four KPM-N-16-AA pressure modules can be installed.

Where:

N – Revision Number of KPM

AA – Pressure range of the 16 sensors on the KPM

Example:

KMPS-1-64-AP-E - Air Purge and Ethernet output
With
KPM-1-16-7BARA
KPM-1-16-20PSIA
KPM-1-16-5PSIG

Note that all modules do not have to have same unit type (PSI or Bar) or pressure mode (Absolute or gauge).

2 Theory of Operation

The KMPS-1-64 consists of 64 Silicon on Insulator(SOI) piezoresistive pressure sensors mounted onto plates of 16 sensors each. These sensors are then connected to individual pressure inputs via a manifold. The pressure sensors are grouped into 4 module which each contain 2 groups of 8 sensors. Each group is connected to a multiplexer. The output of the multiplexer is then routed through an analog amplifier which is then sent to the inputs of a 24 bit delta/sigma analog to digital converter (A/D).

Each of these eight A/Ds then sends the digital information to a single microprocessor (μP). By switching the inputs of the multiplexer it is possible for the A/Ds to measure both the pressure output of the transducer as well as the temperature of the transducer. In this way the μP can correct the pressure data for errors over both temperature and pressure.

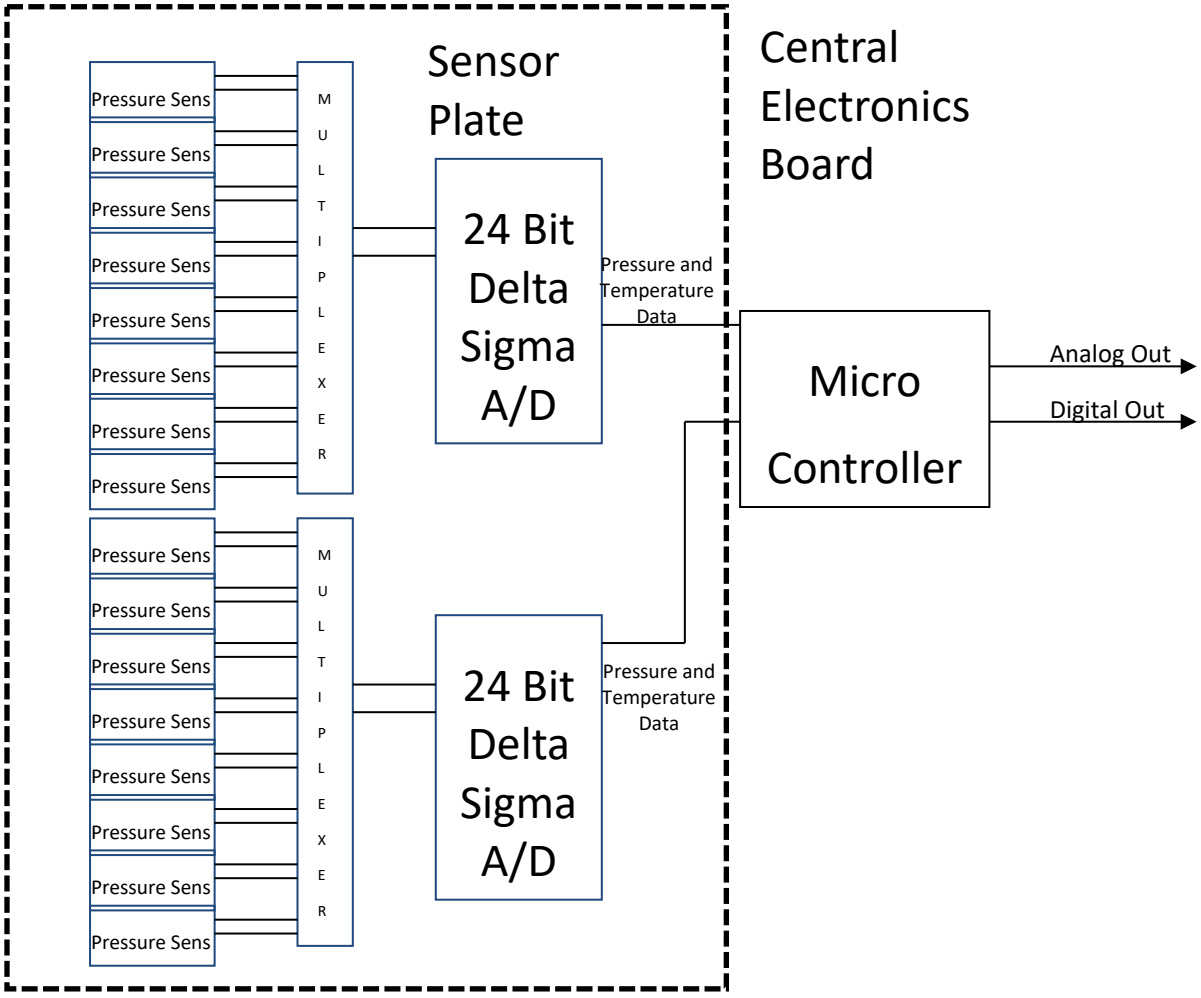


Figure 1: Block Diagram of Scanner Electronics

When all sixty-four sensors are being polled the maximum data rate is 275 samples/channel/sec. However because the sensors are arranged in groups of eight it is possible to increase the sampling rate by limiting the sensors that are scanned. For instance if only sensor 1, 9, 17, 25, 33, 41, 49, and 56 (one per A/D) are scanned the data rate would be 2000 samples/channel/sec. By selecting sensors from each of the eight different groups it is possible to customize the data rate and number of channels available.

The sensors are numbered starting at 0 and going up to 63.

2.1 Internal Connections

The KMPS-1-64 has an internal purge manifold which allows for the KMPS-1 to be placed either in measure mode or purge/calibration mode by supplying pressure either to the MSR input or PRG input on the two ends of the KMPS (see figure 2). The manifold is moved by a pair of pistons that are extended via the applied pressure. Under normal conditions 100 PSI is required to move the manifold but at temperatures below -40°F pressures as high as 200 PSI may be required.

In measure mode the front of each of the 64 sensors is connected directly to one of the bulged tubulations on the top of the KMPS. If the sensor is differential the back is connected to a reference manifold which is connected to one of the two reference tubes (REFA or REFB) depending on which side of the scanner the sensor is on.

When the manifold moves into purge/calibration mode the sensors become disconnected from the top tubulations. Instead all of the tubulations are connected to the purge input allowing for high pressure air to be blown out of the tubes clearing away moisture or obstructions. At the same time the front of all of the sensors are connected together and connected to one of the calibration tubes (CALA or CALB) allowing for an in place calibration of the scanner.

WHEN IN CAL MODE IT IS IMPORTANT NOT TO APPLY HIGHER PRESSURE THAN THE LOWEST RANGE SENSOR CAN HANDLE.

The backs of the sensors remain connected to the reference manifold which is still connected to the reference input. In this way it is possible to calibrate higher pressure absolute sensors by raising the pressure of both the CAL and REF1 inputs simultaneously so that no differential pressure is applied to low pressure differential sensors.

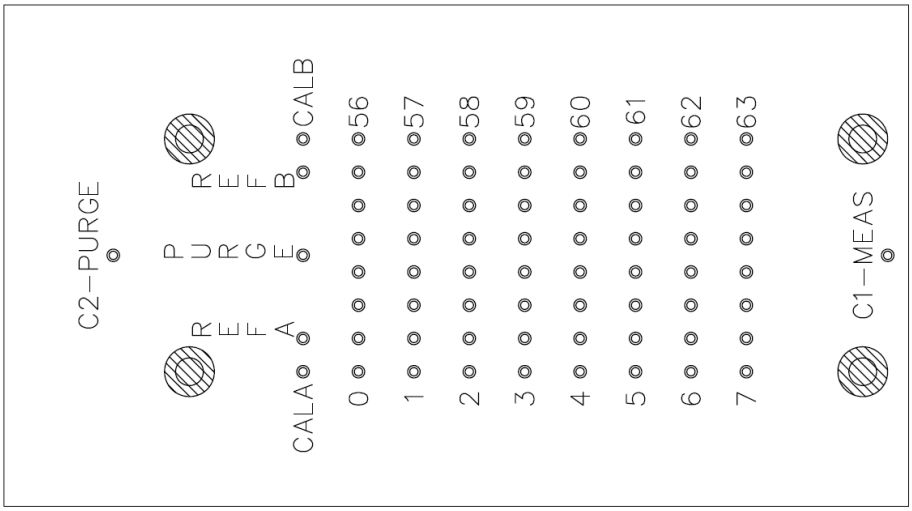


Figure 2: Drawing of top of KMPS-1

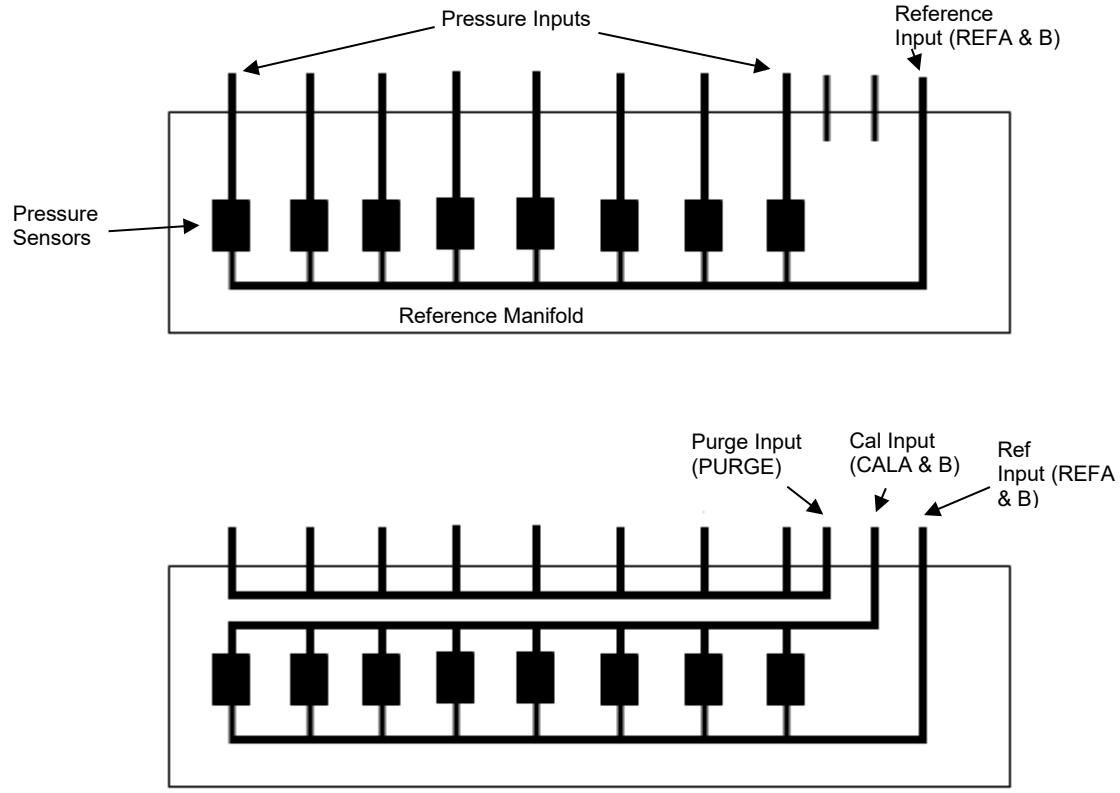


Figure 3: Schematic Diagram of internal Piping of KMPS-1

2.2 Temperature Compensation

Both the pressure and temperature output is compensated inside the microprocessor using coefficients programmed at the factory. All coefficients for these calculations are stored on an EEPROM in each of the four modules. In this way a module can be replaced without any programming. The user has access to the user gain (G_u) and offset (O_u) for each unit to allow for adjustment but does not have access to temperature correction coefficients which are programmed at the factory. The offset and gain can be changed using the SLope and OFfset command. The UNits command automatically adjusts the full scale value to reflect the difference between PSI and Bar (see section 4.6.

2.3 Pressure Output

The pressure sensors are compensated using a fourth order compensation in temperature and a third order compensation in pressure according to the formulae:

Offset = $O = O_0*T^4 + O_1*T^3 + O_2*T^2 + O_3*T + O_4$

Gain = $G = G_0*T^4 + G_1*T^3 + G_2*T^2 + G_3*T + G_4$

Linearity = $L = L_0*T^4 + L_1*T^3 + L_2*T^2 + L_3*T + L_4$

Third Order = $C = C_0*T^4 + C_1*T^3 + C_2*T^2 + C_3*T + C_4$

Pressure Out(% of Range) = $G_u* (C*P^3 + L*P^2 + G*P) + O + O_u$

Pressure Out (Engineering Units) = Pressure Out * Full Scale Reading

2.4 Temperature Output

The temperature is read off of each sensor and then the raw output is converted to temperature using a second order conversion

$T_{out} = A_2*T^2 + A_1*T + A_0$

This data is available for each sensor using the TEmperature command. The UNits command automatically switches the temperature between Fahrenheit and centigrade.

UNit PRessure *arg*	Sets or returns the pressure units. Valid values for *arg* are PSi or BAr. All pressure readings will be expressed in this unit.
UNit TEmperature *arg*	Sets or returns the temperature units. Valid values for *arg* are C or F. All temperature readings will be expressed in this unit.

Table 4 : Units Commands

2.5 Analog Output

The analog output is available in Analog Mode. The channel number to output is selected via the multiplexer pins. These pins are 3.3 volt tolerant and have a weak pull-up to 3.3 volts. A pin is selected by electrically grounding. For instance to select channel 3 pins 1 and 2 would be pulled to ground and 3, 4, 5, and 6 left to float.

The analog output is from 0.5 to 4.5 volts for any channel. For absolute channels 0.5 volts represents 0 PSIA and 4.5 volts represents the full scale of the channel. For differential channels 0.5 represents the negative full scale pressure and 4.5 volts represents positive full scale pressure.

2.6 Trigger

Triggered acquisition allows the user to simultaneously sample data from many scanners at the same time. The trigger can be activated by bringing the trigger pin low or by sending a trigger command. In standard trigger mode the data for all 64 channels is immediately output after acquisition. In the polled trigger mode the data is taken and stored until polled by the user (see section 4.6). This can be useful to avoid data collision on an RS-485 network.

3 Communication

The KMPS digital output can either be RS-485 or Ethernet output. The advantages of RS-485 are a simpler wiring scheme (2 vs 4 wires) and the ability to connect multiple units together along a single bus (daisy chaining). Ethernet output has the advantage of being more easily connected to existing networks.

Most commands are available in RS-485, TCP, and UDP communication. Those that are only used in one type are listed separately under that protocol.

For RS485 commands are in the form of $AA X where AA is the address of the scanner and X is the command. Commands can either be sent as the full word or only the first two characters. There must be at least one space between the address and the command. Another space is used between the command and each option.

For Ethernet the $ and address can be used or left off. Kulite recommends using the $ and address is the user is using broadcast UDP with multiple scanners otherwise it is redundant with the IP address.

3.1 RS-485 Communication

RS-485 communication works over a two wire twisted pair bus. There can be up to 256 KMPSs on a single bus with one computer (or other controller) to interrogate them. Because all the devices are on a single bus it is necessary for each unit to have a unique two byte address. Each KMPS will only respond when it is polled. To allow for faster data acquisition a streaming data mode as well as a triggered data mode are available on the KMPS. By default the RS-485 bus is tied up continuously during streaming to increase the maximum data rate. The user can set the bus to be released between data bursts using the RS485 Release command, this will decrease the maximum speed at which the KMPS can stream. It is recommended that when either of any of these modes are going to be used only one KMPS per bus is used.

The only extra command needed for RS-485 communication is for setting the serial communication setting which the scanner uses. It is important to have a baud rate high enough that the data can be output at the data rate required.

RS485 BAud *x*	Sets or returns the baud rate used by the scanner 0-2400 1-9600 2-57600 3-115200 4-460800 5-512000 6-921600 Set in programming mode only. Must reset to take effect.
RS485 PArity *x*	Sets or returns the parity used by the scanner EVen/ODd/MArk/SPace Set in programming mode only. Must reset to take effect.
RS485 STop *x*	Sets or returns the number of stop bits used by the scanner 1 or 2 Set in programming mode only. Must reset to take effect.
RS485 REIease *ON/OFf*	Sets or returns whether the RS-485 Bus is released during streaming.

Table 5 : RS485 Commands

3.2 Ethernet Communication

The KMPS supports both TCP and UDP communication. TCP allows for a direct connection between the host computer and each scanner. A TCP connection requires both an IP address and port number for each scanner. UDP is a connectionless protocol and can be sent to only one or multiple scanners on a network (unicast vs multi/broadcast).

Because UDP is a connectionless protocol, it is recommended to use the time stamp when acquiring high speed data because packets may be transmitted out of order by the network.

The KMPS will respond to both UDP and TCP commands at all times, it is not necessary to set the form of communication. It is also possible to set the KMPS configuration via TCP and stream data out using UDP.

The KMPS comes from the factory set into DHCP/AUTO-IP mode with a receive port of 18008. In this mode the KMPS will find an IP address that is not being used on the network. The KMPS may be found by using broadcast UDP or via the included KMPS Config program. The KMPS will always respond to commands sent on to port 65001 with a both a broadcast and

unicast to the sender IP UDP packet on port 65002. This can be used to find the scanner when the configuration is unknown.

3.2.1 UDP vs TCP

Both UDP and TCP can be useful protocols for communicating with the KMPS. TCP allows for direct connection to each KMPS individually allowing for error checking as well as data arriving in the order received with no extra delay. Because each KMPS on a network will have its own unique IP address for TCP connections the address portion of the command is not useful and all KMPS can be set to the same 00 address or the address can be left off. TCP is the most straight forward and common type of connection and can be used in most applications where the extra functionality of UDP connections is not needed.

UDP broadcast datagrams are useful in instances where many scanners are being used simultaneously. In this case a single broadcast message can be sent to all the scanners simultaneously. If address FF or the address is left off then all of the scanners will respond no matter what their actual address is. The data received from all of the scanners can then be separated using the time and address stamps or IP address. At the same time each individual scanner can be polled separately using their unique addresses. Also because the UDP datagram is much less complex than a TCP datagram there is much less overhead for the network to handle.

Another method to separate individual scanners on a UDP network would be to make them all respond to different ports. In this way a single message could be sent to all units on the network but each one would respond to a separate part of a program listening on different ports.

The UDP format also allows a user to issue the Announce command on the network. Each unit will respond to this command with vital information allowing it to be identified. In this way a quick scan of the network can reveal all of the available pressure channels.

To stream data via TCP the IP Stream must be set to 0.0.0.0 and the Port Stream must be set to 0. Otherwise the streamed data will be sent via UDP. A useful configuration for many users will be to set the scanners on a network up via TCP and receive streaming data back via UDP on a separate port. This will create less network traffic.

3.2.2 Command List

Below is a list of Ethernet only commands. Italicized parts are required for setting but not for reading.

ANnounce	Returns the part number, serial number, IP address, subnet mask, default gateway, and MAC address of the transducer
BRoadcast REsponse ***ON/Off***	Sets or returns command response broadcasting ON or OFf Set in programming mode only.
BRoadcast STream ***ON/Off***	Sets or returns streaming broadcasting ON or OFf Set in programming mode only.

DYnamic *ON/OFf*	Sets or returns if dynamic IP acquisition is ON or Off. If on then the KMPS will first attempt DHCP and if that fails it will use AUTO-IP. If off it will use the IP address in memory. Set in programming mode only. Must reset to take effect.
GAteway *xxx.xxx.xxx.xxx*	Sets or returns the default gateway Set in programming mode only.
IP *xxx.xxx.xxx.xxx*	Sets or returns the IP address. If set will automatically switch the static IP. Set in programming mode only. Must reset to take effect.
IP STream *xxx.xxx.xxx.xxx*	Sets or returns the IP address to which the unit will send streaming data(i.e. the unit's streaming remote IP) Must be set to 0.0.0.0 for TCP streaming. Set in programming mode only. Must reset to take effect.
IP REsponse *xxx.xxx.xxx.xxx*	Sets the IP address to which the unit will send command responses to UDP commands (i.e. the unit's response remote IP). If set to 0.0.0.0 then the scanner will respond to the IP address of the sender. Set in programming mode only. Must reset to take effect.
MAc	Returns the MAC address
MAc STream	Sets or returns the MAC address to which the unit will send streaming data. This setting is only used if the IP Stream is set to a fixed value. In that case the unit will use a static MAC address rather than finding the MAC address using ARP packets. If the MAC address does not correspond to the correct IP address the packets may be misdirected by a network. MAC address is entered as six pairs of hexadecimal digits separated by a : or – (01:23:45:67:89:AB). Set to 00:00:00:00:00:00 for dynamic ARP (default). Set in programming mode only. Must reset to take effect.
POrt x	Sets or returns the KMPS local port on which the unit will listen for commands. Set in programming mode only. Must reset to take effect.
POrt REsp *x*	Sets or returns the port on which the unit will respond to commands (i.e. the unit's response remote port). If set to 0 then the unit will respond to commands on the same port is was sent from. In UDP broadcast this

	can not be the same as the receive port or 0 to avoid datagrams bouncing between scanners. Set in programming mode only. Must reset to take effect.
POrt STream *x*	Sets or returns the port on which the unit will send streaming data. In UDP broadcast this can not be the same as the receive port or 0 to avoid datagrams bouncing between scanners. Set in programming mode only. Must reset to take effect.
PTp *x*	Sets or returns the version of PTP (IEEE 1588) to use. Set in programming mode only. Must reset to take effect.
PTp SYnc	Sets or returns the sync interval for PTP v1. Allowed values are 0,1,3,4,6. Set in programming mode only. Must reset to take effect.
SUbnet *xxx.xxxx.xxx.xxx*	Sets or returns to subnet mask. Set in programming mode only.

Table 6 : Ethernet Commands

3.2.3 Wrong Subnet

When a KMPS with a static IP is placed on a different Subnet it is not possible to reach the scanner with either with unicast UDP or TCP packets. In this case it is necessary to reset the IP address either to DHCP or to an address on the new subnet. To do this broadcast UDP packets must be used. If multiple scanners with the same address are on the same Subnet this may reset all the addresses. To avoid this a command preceded by a % and the last three values of the MAC address can be used. Only the KMPS with that MAC address will respond

Example:

%AB 11 01 IP 100.100.1.1 will set the scanner with MAC address 9C:31:B6:AB:11:01 will set its IP address to 100.100.1.1.

3.3 PTP

Precision Time Protocol (IEEE-1588) is a standard that allows for synchronization of Ethernet enabled devices over a standard Ethernet network. The KMPS supports both v.1 and v.2 version of this protocol. The feature can be configured using the PTP command.

3.4 Command list

These commands are valid for both RS-485 and Ethernet enabled KMPSs. Neither the command or hexadecimal data sent is case sensitive. All commands can use either the full command or the first two letters. Commands must be followed by a carriage return. There must be at least one space between portions of commands. Portions in italics are optional, if omitted data is read and if they are present data is written. APPENDIX A contains sample outputs from each of these commands for reference. All returned values are followed by a carriage return.

ADdress *xx*	Sets or returns the address to xx where xx is any 2-digit hexadecimal number Set in programming mode only. Must reset to take effect.
CHannel a,b,c,…	Sets or returns the active channels for streaming where a,b,c... is a comma separated list of all the channels which are active. CHannel * resets the channel count to all channels. See section 4.5 for more details.
DAte *x m yy/yy/yy*	Sets or returns the MAnufacture, CAlibration, or DUe date for each module m. Manufacture date is not settable. See section 4.9 for more details.
EEprom xxxx *yyyy*	Set or returns the value *yyyy* to EEPROM address xxxx. See section 4.9 for more details.
FOrmat *arg*	Sets or returns the streaming format. See section 4.2 for more details. Set in programming mode only.
FUllscale *c*	Returns the full-scale pressure for channel c. If c is omitted returns value for all channels.
HEader *x*	Sets or returns the header settings. See section 4.3 for more details. Set in programming mode only.
IEna x	Sets or returns the IENA KEY, END, and STATUS used in IENA streaming format. See section 4.2.6 for more details
MOde *arg*	Sets or returns the mode. See section 4.1 for more details.
OFfset *c y*	Sets or returns the user offset of channel c. If c is omitted returns the offset of all channels. See section 4.10 for more details. Set in programming mode only.
PArt	Returns the unit part number.
PRessure *c*	Returns the pressure for channel c. If c is omitted returns pressure for all channels.
REset	Resets the KMPS.
SAmplerate *arg*	Sets or returns the pressure sampling rate. See section 4.6 for more details.

SAmplerate TEmperature *arg*	Sets or returns the temperature sampling rate. See section 4.6 for more details.
Serial	Returns the unit serial number.
SErial MOdules m	Returns the serial number of module m.
SLope *c y*	Sets or returns the user gain of channel c. See section 4.10 for more details. Set in programming mode only.
SPan *m A/B*	Sets or returns the full scale pressure for the currently selected range of the module m. If m is omitted returns the ranges for all modules and if A or B is omitted returns available ranges. See Section 4.4 for more details. Set in programming mode only.
STream *s*	Stream pressure for s seconds in format selected by Format command. If s is omitted the scanner will stream continuously (Ethernet only). If s is 0 then Ethernet scanner will stop streaming.
STream SAmple	Sends out a single streaming packet for test purposes.
TEmperature *c*	Returns the temperature for channel c. If c is omitted returns temperature for all channels.
TEmperature CHannel *C*	Sets or returns the channel used for temperature comparisons in the status word. See Section 4.3 for more details.
TEmperature COmpensated HIgh/LOw *M*	Sets or returns the high or low compensated temperature of module M. This value is used for the status word. Set in programming mode only. See Section 4.3 for more details.
TEmperature OPerating	Returns the maximum operating temperature of the KMPS. This value is used for the status word. See Section 4.3 for more details.
TYpe *c*	Returns if a sensor channel if absolute, differential, gauge, or sealed gauge. If c is omitted returns value for all channels.
UNit x *arg*	Sets or returns the pressure and temperature units. Valid values for *arg* are PSi or Bar for pressure and C or F for temperature. All readings will be expressed in this unit. See section 2.3 and 2.4 for more details.
USer m x *y*	Sets or returns one of the user strings to modules m. x is the string number and y is the string to be saved. See section 4.9 for more details.

VErsion	Returns the firmware version.
ZEro	Auto-zero differential sensors. See section 4.10.1 for more details. Programming mode only.

Table 7 : General Commands

3.5 MODBUS

Ethernet versions of the KMPS support MODBUS/TCP. BY sending the correct packets to port 502 it is possible to read all the available pressure data as well as read and write all of the set-up registers. See APPENDIX D for a memory map of all available registers. Some registers may not have meaning for the KMPS.

4 Using the KMPS

The KMPS was designed to meet the needs of many different users. It is easy to set up and use quickly by connecting it to an RS-485 bus, Ethernet network or analog data acquisition system. However it also has the capability to stream high speed data as well as perform triggered data acquisition to allow for data correlation with other sensors.

4.1 Modes

The KMPS has seven different modes to allow access to its various features. To switch between modes the MOde command is used. The scanner will default to analog mode upon startup. However if the MOde command is followed by a DEfault (ie MO DE PR) then this mode becomes the default for future start-up.

ANalog – Analog output mode. Digital data may be polled using P or I commands. Analog output is controlled using the multiplexer pins

NOrmal- Digital output mode. No analog output. Digital data may be polled or streamed out using the STream command.

TRigger – Trigger mode with automatic output. No analog output. Digital data is immediately output upon a trigger input. Data is output in same format as streamed data.

POlled – Trigger mode with polled output. No analog output. Digital data is only updated upon a trigger input and must be polled.

STream – Streaming Output. No analog output. Digital data is automatically output upon startup for Ethernet KMPS. There is no streaming mode for RS-485 to avoid tying up the bus permanently.

DElay – Delayed streaming Output. No analog output. Digital data is automatically output 30 seconds after startup. Delayed streaming mode may only be set as the default (MOde DEfault DElay)

PRogramming - User programming mode. Allows limited access to programming registers for data rate, gain, offset, etc.

4.2 Data Output Format

Depending on the speed at which the KMPS is acquiring data there are several different output formats that can be selected using the FOrmat command. If the data is polled using the PRessure command then the data is sent out using a full ASCII format in engineering units

with the channel number indicated by the first two digits. The measurement unit this data represents is controlled by the full scale parameter for each channel. If that parameter is set in Bar then this number will be in Bar, etc.

Example:

01: 0003.4567

In streaming mode then the data can be output either as ASCII text or as binary data. For data rates below 40 samples/second/channel any of these formats can be used but for higher data rates the KMPS will only be able to keep up using binary output. To select a format use the FOrmat command followed by the name of the format. See section 4.3 on header information for all formats.

In streaming mode data is acquired eight channels at a time (see section 2.0 for more details). For an RS-485 scanner this data is then immediately sent over the bus. For an Ethernet scanner the data for all of the selected channels is accumulated and sent in a single packet. In UDP mode the packet structure is preserved so that parsing is fairly straight forward. In RS-485 and TCP mode it is recommended to use the synchronization stamp in order to avoid losing your place.

4.2.1 TExt format

Data is output in engineering units based on the selected pressure unit. A two digit channel is output followed by a colon and then an 8 character number with the decimal location dependent on the full scale of each channel. A carriage return ends each line.

Maximum data rate for Ethernet Text format is 125 samples/second. Maximum data rates for RS-485 depend on baud rate.

Example:

00: 123.456
08:-00.1234

4.2.2 TExt PErcentage format

Data is output as a percentage of full scale pressure. All spaces and decimal points are omitted to save characters. The two digit channel is followed by a five digit number which is percentage of full scale output times 100. The data can be converted to engineering units in post processing by multiplying by the full scale setting for each channel (read using the FUllscale command)

Example:

0000234
0802567
1610134

This partial data set represents Channel 0 being at 2.34% of FS, Channel 8 being at 25.67% of FS, and Channel 2 being at 101.34% of FS. Note the data can go above 100% of full scale however this data may not meet the accuracy standards of the data within the range and will eventually saturate. Negative numbers represent differential pressures in the opposite direction. For outputs below 100% of fullscale a 9 is used to avoid changing length. Eg 0390123 means that channel 3 is at -101.23% of full scale.

Maximum data rate for Ethernet Text Percentage format is 125 samples/second. Maximum data rates for RS-485 depend on baud rate.

4.2.3 BInary format

Data is output in engineering units as IEEE-754 32-bit floating point numbers. A 1 byte integer for the channel number is followed by the 32-bit channel data.

Example: (in hexadecimal)

(0x00)(0x3F)(0xA0)(0x75)(0xF7)
(0x08)(0x3C)(0xA3)(0xD7)(0x0A)

This data represents Channel 0 at 1.2536 PSI and channel 8 at 0.02 PSI.

4.2.4 BInary TEmperature format

The same as the BInary format but the temperature data is also output. Each time the temperature data is read it is output as a 32-bit floating point number. The channel numbers for the temperature are 128 higher than the actual channel number

Example: (in hexadecimal)

(0x80)(0x3F)(0xA0)(0x75)(0xF7)
(0x88)(0x3C)(0xA3)(0xD7)(0x0A)

This data represents Channel 0 at

4.2.5 BInary PErcentage format

As with Text Percentage the data is output as a percentage of fullscale but this time as a binary 32-bit integer. The percentage full scale is given as a 4 byte number in two's compliment with the maximum value being 800 and the minimum -800.

Example: (in hexadecimal)

(0x00)(0x00)(0x5F)(0xD8)(0xAE)
(0x08)(0XF8)(0XB1)(0x5B)(0x57)
The easiest way to convert these 4 bytes into a single decimal number. If this number is equal to or smaller than 2147483647(0x7FFFFFFFh) than it is positive. Divide the number by 2147483647 and multiply by 800. If it is larger than this than divide by the same number and multiply by 800, then subtract 1600 from this number. Two examples are given below:

(0x00)(0x00)(0x5F)(0xD8)(0xAE) => 0 = 6281390 => 0 = 9.38

(0x08)(0xF8h)(0xB1)(0x5B)(0x57) => 8 = 4172372823 => 8 = 1554.33 => -45.67

Of course many programs can handle two's compliment numbers automatically and can do this conversion process.

4.2.6 IENA

4.2.6.1 IENA 8

Data is output 8 channels at a time inside of IENA packet structure. Pressure data is in engineering units as 32-bit floating point numbers. See APPENDIX B for full packet structure.

Note: Because of high overhead on the IENA 8 packet, data rates of 125 samples/second or less must be used for Ethernet output.

4.2.6.2 IENA 64

Data is output 64 channels at a time inside of IENA packet structure. Pressure data is in engineering units as 32-bit floating point numbers. See APPENDIX B for full packet structure.

IEna HEader KEy	Sets or returns the IENA keyword used in IENA streaming format.
IEna HEader STatus	Sets or returns the IENA Status word used in IENA streaming format.
IEna FOoter STatus	Sets or returns the KMPS status words. Can be OFf, ON A, ON B, TOggle A B. See APPENDIX B for more details. ON A is default setting.
IEna FOoter ENd	Sets or returns the IENA end marker used in IENA streaming format.

Table 8 : IENA Commands

4.3 Header Information

Data is acquired eight sensors at a time and is streamed out as it is acquired. Before each set of eight channels is output a header is sent out with user selectable data. The user can use the HEader command plus the sub commands below to change the included information (e.g. HEader STatus ON). The order of the data is Synchronization, Status, Address, Time.

SYnchronization ON/OFf

This allows for the user to synchronize to the streaming data if your place is lost or some of the data is corrupted in transmission. In text mode before the first set of channels is transmitted the string AxxPK01 is transmitted where xx is the address and before the fourth set AxxPK02 is transmitted. So for every 64 channels of data there is one AxxPK01 and one AxxPK02. In binary mode before the first set of data (0xFFh)(0xFFh)(0xFFh)(0xFFh)(0xFFh) is transmitted. This only happens once per 64 channels.

STatus ON/OFf A/B/AB

There are two status words (two bytes each) that show various status parameters for the KMPS. This can only be used in the binary modes. See Table 12 and Table 13 for more details. The status is output once for every 64 channels. Header status can be: off, on A, on B, on A B, Toggle A B (where in one packet contains status A and the next contains B).

ADdress ON/OFf

Puts the two character address of the scanner before each set of 8 channels. In test mode this is followed by a carriage return

Time PTp/IEna/OFf

Every set of 8 channels is acquired at the same time and has a unique time stamp. This time starts when the KMPS is turned on unless it is on a PTP network in which case it is set to the correct PTP time (see section 3.2.2). Time is sent before every group of eight channels. In text mode the IENA time (microsecond since January 1st) is sent as a text integer on its own line. The PTP time is sent as two integers (seconds and nanosecond since 1970) with a comma separating them on a single line.

In binary mode the IENA time is sent as a 6 byte integer and the PTP time is sent as two four byte integers.

Example:

Text header
A000PK01
00
1245,345678

Binary Header
(0xFF)(0xFF)(0xFF)(0xFF)(0xFF)(0x00)(0x00)(0x30)(0x30)(0x00)(0x00)(0x04)(0xDD)(0x00)
(0x05)(0x46)(0x4E)

4.4 Multi-Range Modules

The KPM-1-16 pressure modules can be compensated over two distinct ranges. This can either be two pressure ranges (e.g. 5 PSID and 25 PSID) or two different temperature ranges (e.g. 20ºF to 255ºF and 80ºF to 180ºF) to increase total accuracy. To switch between ranges the SPan command is used (e.g. to switch to the A range send the command “SPan X A”, where X is the module that you want to set). Each module can be set individually and the set range is stored on the module EEPROM so if the module is moved to a different scanner it retains that setting. The available ranges can be read by sending the SPan command by itself. The module can also be polled using “TEmperature COmpensated X”, where X is the module number, to see what temperature range it is compensated over.

4.5 Channel Selection

As discussed in section 2.0 not all channels must be selected when acquiring data. Using the CHannels command the list of acquired channels can be changed. When a comma separated list is entered the KMPS automatically parses this list and separates the channel numbers into the correct A/D. For example if the user entered 0,5,1,31,14,14,24,63 the KMPS would separate this into the second column in Table 9. Because every A/D must acquire from the same number of channels, the KMPS would automatically pad any A/D with fewer than three to give the list in the third column of Table 9. Note that channels do not have to be in numerical order and a channel can be selected more than once to increase the sampling rate of that channel. A maximum of eight channels can be selected per A/D. The channels that the A/Ds are padded with are based on the previous channel selection. The CHannels command followed by a * resets the KMPS to all channels in numerical order.

A/D #	Channels Selected	Channels Used
0	0,5,1	0,5,1
1	14,14	14,14,9
2	24	24,17,18
3	31	31,25,26
4		32,33,34
5		40,41,42
6		48,49,50
7	63	63,57,58

Table 9 : Channel Parsing Example

4.6 Pressure Data Rate

The data rate of the KMPS acquisition is set using the SAmplerate commands. In general the lowest data rate possible should be used as any pressure fluctuations due to tubing will be eliminated in this way. When higher data rates are needed the use of streaming data is necessary as the polling speed of the KMPS is only a few cycles per second. For RS-485 scanners it is also necessary to use a baud rate high enough to support the output rate desired. If the baud rate is too slow it will pause the acquisitions while the data is output. Use of the time stamp can help test whether the baud rate is sufficient.

The data rates available are:

0 – 275 samples/second/channel
1 – 200 samples/second/channel
2 – 125 samples/second/channel
3 – 80 samples/second/channel
4 – 40 samples/second/channel
5 – 25 samples/second/channel

These sample rates are given assuming all 64 channels are sampled. If fewer channels are selected than higher data rates can be achieved. For example if half of the channels are selected the data rate will be twice as high.

SAmple	Sets or returns the sample rate. Set in programming mode only.
SAmple TRue	Sets or returns the actual sampling rate taking into effect temperature sampling rate and other effects. Set in programming mode only.
SAmple LIst	Returns available sampling rates. Can be used with TRue to show actual sampling rates.
SAmple LOw/HIgh	Sets the KMPS-4 to low speed sampling mode allowing for cable lengths longer than 2 meters. Can be used with the True switch to see new sampling rates. Set in programming mode only. The KMPS must be reset to take effect.

Table 10 : Sample rate commands

4.7 Temperature Data Rate

The temperature of the pressure transducers is measured to do thermal compensation. These temperatures are not measured continuously in order to devote more time to pressure acquisition. The user can select how often the temperature is measured. Every time the temperature is measured there will be a pause, in the pressure sampling, equivalent to approximately two cycles. For example if the sample rate is set to 40 samples/channel/second for that second the user will only see 38 samples. If the KMPS is in a relatively stable thermal environment then this setting can be high. The rate is set by the SAmplerate TEmperature command.

The sampling rates available are:

0 – Every 15 Seconds
1 – Every 30 Seconds
2 – Every 1 Minute
3 – Every 2 Minutes

4 – Every 5 Minutes
5 – Every 10 Minutes
6 – Every Second
7 – Every sample (this will drastically reduce sampling rate)

4.8 Default Mode

If Multiplex Pin 6 is held low when the KMPS is started or reset it will enter default mode. In this mode the address is always set to 00 and the baud rate is 9600 for RS-485 scanners. For Ethernet scanners it will default to DHCP mode with a port number of 18008. It also defaults to the lowest scan rate available with streaming turned off. This is useful if a parameter was set incorrectly and communication is no longer possible. It is important that in normal use the Multiplex Pin 6 is not held low during startup. The trigger pin can also not be held low during startup as the scanner then enters a factory programming mode used for updating the firmware.

4.9 User Data Storage

There is a limited amount of space in which users can store data both in the main scanner EEPROM and in each module's EEPROM. Data is stored in the main KMPS memory using the EEprom command. Data is stored two bytes at a time in hexadecimal format. There is 0x1000h space available for user data. Each module has a built in command for storing the calibration date and calibration due date using the Date command followed by either CAlibration or DUe. Dates are entered in the MM/DD/YYYY format. There are also 4 strings of 28 characters each where users can enter zany other information using the USer command followed by the string number (0-3) and the string they wish to save. For example USer 0 CAL -65 to 255F will store the string "CAL -65 to 255F".

4.10 Calibration

While all temperature compensation is done at the factory the user does have the ability to adjust the gain and offset of each channel to correct for small drifts over times. This is done using the OFfset and SLope commands. Each channel starts with a user offset of 0 and a user slope of 1. See APPENDIX C for detailed instructions on calculating correction coefficients.

4.10.1 Auto-Zero

The SOI piezoresistive sensors used on the KMPS are extremely stable and have very low drift rates over time. However, after a long period of use or after the KMPS has seen extremes of temperature or pressure the offset may drift out of specification. The KMPS has the ability to automatically adjust the User Zero for differential sensors to correct for any offset drift with time. When there is known to be zero differential pressure between the front and reference port of all the active sensors the user can issue a ZEro command. The KMPS will then take a reading of all the active channels and adjust the User Zero to make the output exactly 0. It is important to make sure there is no applied pressure at the time of a zero command. The user can manually reset the offset using the OFfset command if a channel was incorrectly zeroed.

5 Maintenance

The KMPS has been designed with several user serviceable parts. Proper maintenance will allow the KMPS to function for long periods of time. The four modules are designed for easy removal and replacement allowing for customization for different tests environments.

There is a risk of electrical shock if the KMPS is powered during maintenance. It is important to remove power before any maintenance operation.

Spare parts such as new top plates or screws can be ordered directly from Kulite using the parts list found in APPENDIX E. For all maintenance steps there are part numbers listed. These numbers refer to line number in the appendix. Numbers in brackets {} are replacements for a high pressure H model.

5.1 O-Ring Maintenance

In order to seal properly the O-rings on the KMPS must be properly maintained. Kulite recommends replacement of the O-rings every year but life time depends on operating conditions and number of purge cycles. APPENDIX E lists the proper O-ring for various pressure ranges/models of KMPS. It is important that the user select the proper O-ring for the operating condition as the wrong O-ring may fail causing a leak in the system.

Before installation it is important to lubricate the O-rings with a small amount an appropriate grease. Kulite typically uses a Krytox® GPL203 high temperature grease but there are many other to select from. To lubricate the O-rings a small amount of grease can be applied to a gloved hand and then the O-ring can be gently rolled either in the fingers or palm of the hand.

For reference, please note the order of the KPM modules, with “A” and “B” on the right, and “C” and “D” facing the left of the KMPS-1 from the connector end (see Figure 4).

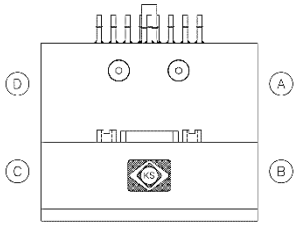


Figure 4: Orientation of KPM Modules

5.1.1 Module O-rings

To replace O-rings on the modules or to install a new module the following steps need to be followed:

Step 1: Remove three screws (PN# 1) using appropriate Hex driver on each module to be serviced (see Figure 5). It may be easier to remove the modules if the top plate screws are loosened slightly

Step 2: Using 2 Hex Drivers, gently remove modules by levering them out. (See Figure 5).

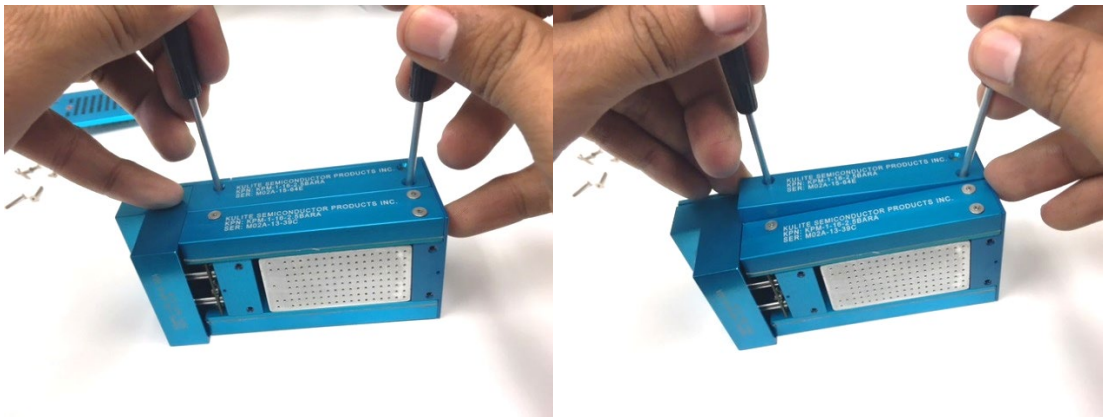


Figure 5: Removing Modules

Step 3: Replace all O-rings using appropriate O-ring (PN# 2,3) that has been properly lubricated. It is important to install O-ring in the reference port even if an absolute unit is being used to avoid moisture collecting in internal cavity (See Figure 6).

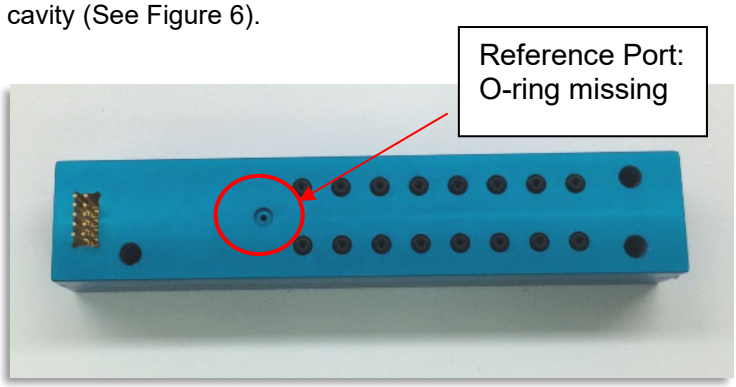


Figure 6: Module with O-rings

Step 4: Replace module in KMPS body making sure **to align electrical connector with connector on interface board. Do not force connector, if it does not enter smoothly then realign and try again.** Replace module screws (tighten to between 20 and 30 in-ozs).

5.1.2 Top Plate O-rings

To replace O-rings on the top plate (tubulation plate) the following steps need to be followed:

Step 1: Remove four screws (PN #4) using appropriate Hex driver on top plate (see Figure 7).

Figure 7: Removing Top Plate Screws

Step 2: Remove top plate and replace all O-rings using appropriate O-ring that has been properly lubricated (See Figure 8). It is very important no O-rings fall into KMPS-1 body.

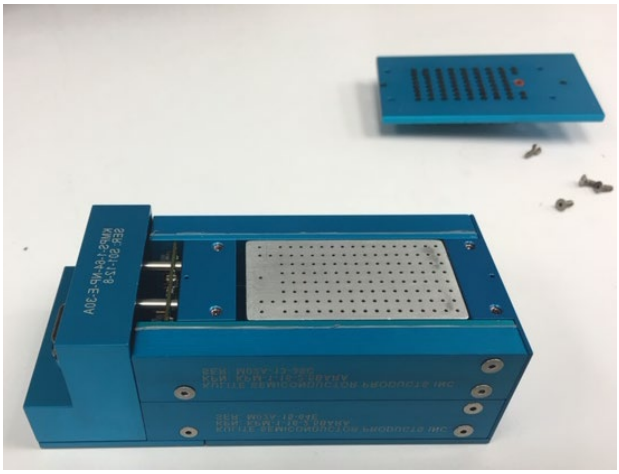


Figure 8: Replacing O-rings

Step 3: Replace top plate and reinstall screws. **To ensure proper function, make sure no O-rings fall into the unit body.**

5.2 Other Maintenance

5.2.1 Lubricate Purge Block

To lubricate purge block for proper purge actuation the following steps need to be followed:

Step 1: Remove the modules and top plate (or bottom plate if top plate is not easily accessible) as per the sections 5.1.1 and 5.1.2.

Figure 9: Purge Block In Scanner

Step 2: Remove purge block with gloved hand. Clean block with propanol or similar cleaner. If any holes in the block appear to be clogged they can be cleaned out with either an ultrasonic cleaner or very fine wire. After cleaning allow block to dry thoroughly.

Step 3: Spray sides and top with silicone lubricant. Allow lubricant to dry.

Step 4: Replace block in scanner in correct orientation (See Figure 9). Replace top plate and modules as in sections 5.1.1 and 5.1.2.

5.3 Training

Please contact your sales representative if further training for maintenance personnel is desired. Kulite offers training on replacing various scanner components and tubing.

APPENDIX A

This appendix contains a variety of sample commands to a KMPS-1 and the response from the KMPS-1. Please note that other responses and error messages are possible depending on the state of the KMPS-1 at the time of the communication (ie Mode).
Commands to the KMPS-1 are in **bold,** responses are normal formatting.

ANNOUNCE
Part number: KMPS-2-64-MP-E
Serial number S01-12-123
Local IP address:172.16.0.233
Netmask:255.255.0.0
Default gateway:172.16.0.1
Local port:18008
MAC address:9c:31:b6:00:00:01
Firmware version:2.0.0 xSR1

BROADCAST RESPONSE OFF
Broadcast Off

BROADCAST STREAM OFF
Broadcast Off

DYNAMIC ON
Dynamic IP

GATEWAY
172.16.0.1

IP
172.16.0.233

IP STREAM 172.16.0.120
172.16.0.120

IP RESPONSE
0.0.0.0

MAC
9c:31:b6:00:00:01

PORT
18008

PORT RESPONSE
0

PORT STREAM
18009

PTP
V 2

SUBNET
255.255.0.0

ADDRESS
00

CHANNEL 0,1,5,18,20,32

A2D0:00,01,05
A2D1:08,09,10
A2D2:18,20,18
A2D3:24,25,26
A2D4:32,33,34
A2D5:40,41,42
A2D6:48,49,50
A2D7:56,57,58

CHANNEL *
A2D0:00,01,02,03,04,05,06,07
A2D1:08,09,10,11,12,13,14,15
A2D2:16,17,18,19,20,21,22,23
A2D3:24,25,26,27,28,29,30,31
A2D4:32,33,34,35,36,37,38,39
A2D5:40,41,42,43,44,45,46,47
A2D6:48,49,50,51,52,53,54,55
A2D7:56,57,58,59,60,61,62,63

EEPROM 0000 1234
1234

EEPROM 0000
1234

FORMAT
IENA streaming format

FULLSCALE
00: 3.4473
01: 3.4473
…
63: 3.4473

HEADER
Sync Off
Address Off
Time PTP
HEADER SYNC ON
Sync On

MODE
Programming mode

MODE NORMAL
Normal mode

OFFSET 0
0.000000000

PART
KMPS-2-64-MP-E

PRESSURE 0
0000.0000

PRESSURE
00: 0000.0000
01: 0000.0344
…
63: 0002.1718

RESET
Reset

MODE PR
Programming mode

SAMPLERATE 2
125 samples/s

SERIAL
S01-12-123

SLOPE 0
1.00000

STREAM 1
A00PK01
1342013818,701557725
00: 0.0000
08: 0.2757
16: 0.5515
24: 0.8273
32: 1.1031
40: 1.3789
48: 1.6547
56: 1.9305

TEMPERATURE
00: 023.8
01: 023.8
02: 023.8
…
62: 023.8
63: 023.8

TEMPERATURE 0
023.8

UNIT PRESSURE
Bar

UNIT PRESSURE BAR
Bar

UNIT TEMPERATURE C
C

VERSION
2.0.0 xSR1

ZERO
Auto-zeroed

APPENDIX B

IENA 8 packet structure

All packets utilize UDP and therefore include the standard Ethernet, IP, and UDP layer header.
The UDP packet payload implements the IENA format as follows:

Channels 0,8,16,24,32,40,48,56

Word	Value	Comment
0	Key	Key-Set by IEna KEy command
1	0x001B	Size in 16-bit words (decimal 27)
2	Time - Bytes 5&4	Time in us from 1 Jan 00:00:00
3	Time - Bytes 3&2	
4	Time - Bytes 1&0	
5	0x0000	Status-Set by IEna STatus command
6	Sequence	Rolling 16 bit counter
7	Ch 0 pressure - Bytes 3&2	32-bit IEEE-754 floating point
8	Ch 0 pressure - Bytes 1&0	
9	Ch 8 pressure - Bytes 3&2	32-bit IEEE-754 floating point
10	Ch 8 pressure - Bytes 1&0	
11	Ch 16 pressure - Bytes 3&2	32-bit IEEE-754 floating point
12	Ch 16 pressure - Bytes 1&0	
13	Ch 24 pressure - Bytes 3&2	32-bit IEEE-754 floating point
14	Ch 24 pressure - Bytes 1&0	
15	Ch 32 pressure - Bytes 3&2	32-bit IEEE-754 floating point
16	Ch 32 pressure - Bytes 1&0	
17	Ch 40 pressure - Bytes 3&2	32-bit IEEE-754 floating point
18	Ch 40 pressure - Bytes 1&0	
19	Ch 48 pressure - Bytes 3&2	32-bit IEEE-754 floating point
20	Ch 48 pressure - Bytes 1&0	
21	Ch 56 pressure - Bytes 3&2	32-bit IEEE-754 floating point
22	Ch 56 pressure - Bytes 1&0	
23	Temperature - Bytes 3&2	32-bit IEEE-754 floating point
24	Temperature - Bytes 1&0	
25	KMPS Status	See Table 12 and Table 13 Below
26	0xDEAD	End marker -Set by IEna ENd command

Notes:

Each KMPS will be provided a unique Key value by the customer.
The value of Key field in the IENA packet will be different for each set of channels and will be determined by the customer supplied Key as follows:

KEY	Channels
Key	0,8,16,24,32,40,48,56
Key + 1	1,9,17,25,33,41,49,57
Key + 2	2,10,18,26,34,42,50,58
…	
Key + 7	7,15,23,31,39,47,55,63

IENA 64 packet structure

Word	Value	Comment
0	Key	Customer supplied
1	0x0093	Size in 16-bit words (decimal 147)
2	Time - Bytes 5&4	Time in µs from 1 Jan 00:00:00
3	Time - Bytes 3&2	
4	Time - Bytes 1&0	
5	Status	Customer supplied (defaults to 0x0000)
6	Sequence	Rolling 16 bit counter
7	Time Offset 0	Offset in µs for channels 0,8,16,24,32,40,48,56
8	Ch 0 pressure - Bytes 3&2	32-bit IEEE-754 floating point
9	Ch 0 pressure - Bytes 1&0	
10	Ch 8 pressure - Bytes 3&2	32-bit IEEE-754 floating point
11	Ch 8 pressure - Bytes 1&0	
12	Ch 16 pressure - Bytes 3&2	32-bit IEEE-754 floating point
13	Ch 16 pressure - Bytes 1&0	
14	Ch 24 pressure - Bytes 3&2	32-bit IEEE-754 floating point
15	Ch 24 pressure - Bytes 1&0	
16	Ch 32 pressure - Bytes 3&2	32-bit IEEE-754 floating point
17	Ch 32 pressure - Bytes 1&0	
18	Ch 40 pressure - Bytes 3&2	32-bit IEEE-754 floating point
19	Ch 40 pressure - Bytes 1&0	
20	Ch 48 pressure - Bytes 3&2	32-bit IEEE-754 floating point
21	Ch 48 pressure - Bytes 1&0	
22	Ch 56 pressure - Bytes 3&2	32-bit IEEE-754 floating point
23	Ch 56 pressure - Bytes 1&0	
24	Time Offset 1	Offset in µs for channels 1,9,17,25,33,41,49,57
25-40	Ch 1,9,17,25,33,41,49,57 pressure	32-bit IEEE-754 floating point
41	Time Offset 2	Offset in µs for channels 2,10,18,26,34,42,50,58
42-57	Ch 2,10,18,26,34,42,50,58 pressures	32-bit IEEE-754 floating point
58	Time Offset 3	Offset in µs for channels 3,11,19,27,35,43,51,59
59-74	Ch 3,11,19,27,35,43,51,59 pressures	32-bit IEEE-754 floating point
75	Time Offset 4	Offset in µs for channels 4,12,20,28,36,44,52,60
76-91	Ch 4,12,20,28,36,44,52,60 pressures	32-bit IEEE-754 floating point
92	Time Offset 5	Offset in µs for channels 5,13,21,29,37,45,53,61
93-108	Ch 5,13,21,29,37,45,53,61 pressures	32-bit IEEE-754 floating point
109	Time Offset 6	Offset in µs for channels 6,14,22,30,38,46,54,62
110-125	Ch 6,14,22,30,38,46,54,62 pressures	32-bit IEEE-754 floating point
126	Time Offset 7	Offset in µs for channels 7,15,23,31,39,47,55,63
127-142	Ch 7,15,23,31,39,47,55,63 pressures	32-bit IEEE-754 floating point
143	Temperature - Bytes 3&2	32-bit IEEE-754 floating point
144	Temperature - Bytes 1&0	
145	KMPS Status	See Table 12 and Table 13 below
146	0xDEAD	End marker (user settable)

Table 11: IENA 64 Packet Format

Bit(s)	Field	Value	Description
15	Status A	0	Signifies Status Word A
14-10	Reserved	1111	Reserved
9	Module error	0 1	All modules are operating normally Communication error with one or more modules
8	Thermostat	0 1	Scanner is below the thermostat temperature Scanner is at or above the thermostat temperature NOTE: This bit is always 0 on scanners without a heater
7	Module D compensation range	0 1	Module D temperature is within the compensated range Module D temperature is outside the compensated range
6	Module C compensation range	0 1	Module C temperature is within the compensated range Module C temperature is outside the compensated range
5	Module B compensation range	0 1	Module B temperature is within the compensated range Module B temperature is outside the compensated range
4	Module A compensation range	0 1	Module A temperature is within the compensated range Module A temperature is outside the compensated range
3	Scanner operating range	0 1	Scanner is at or below the maximum allowed operating temperature Scanner is above the maximum allowed operating temperature
2	Purge State	0 1	Purge motor is operating normally Purge motor is stuck NOTE: This bit is always 0 on units without a motorized purge
1-0	Purge Position	00 01 10 11	Purge is fully closed Purge is fully opened Purge is closing Purge is opening NOTE: These bits are always 00 on units without a motorized purge NOTE: These bits are undefined if the purge is stuck

Table 12: KMPS Status Word A

Bit(s)	Field	Value	Description
15	Status B	1	Signifies Status Word B
14-2	Reserved	0	Reserved
1-0	Bake Cycle	00 01 10 11	Bake cycle has not been performed Bake cycle is currently being performed Reserved Bake cycle is complete NOTE: This bit is always 0 on scanners without a heater

Table 13: KMPS Status Word B

APPENDIX C

KMPS-1-64 User Calibration

The user has the ability to adjust to offset and gain for each of the 64 channels on the KMPS-1-64. To adjust the coefficients the user must enter programming mode using the MOde command.

The user then must read both the pressure output at both zero and full scale pressure. Pressure is read using the PRessure command (e.g. $00PE 0 will read the pressure from channel 0).

The user then must read the user gain and user offset coefficients for the channel of interest using the OFfset and SLope commands (e.g. $00SL 12 will read the gain coefficient for channel 12).

Output pressure is calculated using the formula:

$$P_{out} = O_U + G_U F(T, P_{raw}) + O(T)$$

Where O_U is the user offset, G_U is the user gain, and F(T, P_{raw}) and O(T) are functions of temperature and pressure used to correct for thermal and pressure non-linearity errors.

To determine the new fixed gain coefficient the user must use the formula:

$$G_U = \frac{\Delta P_{New}}{\Delta P_{Old}} * G_{old}$$

Where ΔP is the difference between the full scale and the zero reading. As an example if the user originally measured a full scale of 99 PSI and a zero of 1 PSI with a full scale of 100 PSI and a user gain reading of 1.001 and wanted a new delta of 100 PSI then they would use:

G_{old} = 1.001
ΔP_{old} = (99 – 1) = 98
ΔP_{new} = 100 = 100
G_u = 100/98 * 1.001 = 1.02143

To determine the new offset coefficient the user must take another reading at any pressure with the new gain setting and use the formula:

$$O_u = P_{new} - P_{old} + O_{old}$$

Continuing from the above example if the user measured 0.95 PSIA at 1 PSIA after adjusting the gain they would use:

P_{old} = 0.95
P_{new} = 1
O_{old} = 0.1
O_{new} = 1 – 0.95 + 0.1 = -0.15
If the gain is already correct then it is possible to just adjust only the zero with the above formula, but any change in gain will affect the offset.

These new coefficients can be uploaded into the onboard module EEPROM using the SLope and OFfset commands (e.g. SL 0 1.02143) will upload a new gain of 1.02143 for channel 0). The changes to the values take place immediately. If an incorrect value is mistakenly entered the default values of 0 for offset and 1 for gain can be entered and then new values can be calculated from new readings.

APPENDIX D

MODBUS/TCP

Ref [Dec]	Address [Hex]	Description	Length(words)	Format	Range/Comments
40001	0000	Offset - channel 0	2	IEEE-754 (big endian)	Returns NaN if module missing
40003	0002	Offset - channel 1	2	IEEE-754 (big endian)	Returns NaN if module missing
40005	0004	Offset - channel 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
40123	007A	Offset - channel 61	2	IEEE-754 (big endian)	Returns NaN if module missing
40125	007C	Offset - channel 62	2	IEEE-754 (big endian)	Returns NaN if module missing
40127	007E	Offset - channel 63	2	IEEE-754 (big endian)	Returns NaN if module missing
40129	0080	Slope- channel 0	2	IEEE-754 (big endian)	Returns NaN if module missing
40131	0082	Slope- channel 1	2	IEEE-754 (big endian)	Returns NaN if module missing
40133	0084	Slope- channel 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
40251	00FA	Slope- channel 61	2	IEEE-754 (big endian)	Returns NaN if module missing
40253	00FC	Slope- channel 62	2	IEEE-754 (big endian)	Returns NaN if module missing
40255	00FE	Slope- channel 63	2	IEEE-754 (big endian)	Returns NaN if module missing
40257	0100	Pressure sample rate	1	uint16	0 - 275 sample/s 1 - 200 samples/s 2 - 125 samples/s 3 - 80 samples/s 4 - 40 samples/s 5 - 25 samples/s
40258	0101	Temperature sampling time	1	uint16	0 - Every 15 seconds 1 - Every 30 seconds 2 - Every 1 minute 3 - Every 5 minutes 4 - Every 10 minutes 5 - Every 1 second 6 - Every pressure sample
40259	0102	Pressure unit	1	uint16	0 - psi 1 - bar
40260	0103	Temperature unit	1	uint16	0 - °F 1 - °C
40261	0104	Thermostat channel	1	uint16	0-63
40262	0105	Thermostat temperature	1	int16	[In units without a heater, reads always return 0 and writes are ignored]
40263	0106	Actuate KMPS-6A solenoids	1	uint16	0 - Purge mode 1 - Measure mode 2 - Line purge mode 3 - Enclosure purge mode 4 - Calibration mode [In units other than KMPS-6A, reads always return 0 and writes are ignored]
40264	0107	Actuate motorized purge	1	uint16	0 - Open purge 1 - Close purge [In units without a motorized purge reads always return 0 and writes are ignored]
40265	0108	Purge pin	1	uint16	0 - Purge pin is off 1 - Purge pin is on [In units without a motorized purge

					reads always return 0 and writes are ignored]
Intentional break to allow alignment of Pressure Data to even hex address					
40513	0200	Pressure - channel 0	2	IEEE-754 (big endian)	Returns NaN if module missing
40515	0202	Pressure - channel 1	2	IEEE-754 (big endian)	Returns NaN if module missing
40517	0204	Pressure - channel 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
40635	027A	Pressure - channel 61	2	IEEE-754 (big endian)	Returns NaN if module missing
40637	027C	Pressure - channel 62	2	IEEE-754 (big endian)	Returns NaN if module missing
40639	027E	Pressure - channel 63	2	IEEE-754 (big endian)	Returns NaN if module missing
40641	0280	Temperature -channel 0	2	IEEE-754 (big endian)	Returns NaN if module missing
40643	0282	Temperature -channel 1	2	IEEE-754 (big endian)	Returns NaN if module missing
40645	0284	Temperature -channel 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
40763	02FA	Temperature - channel 61	2	IEEE-754 (big endian)	Returns NaN if module missing
40765	02FC	Temperature - channel 62	2	IEEE-754 (big endian)	Returns NaN if module missing
40767	02FE	Temperature - channel 63	2	IEEE-754 (big endian)	Returns NaN if module missing
40769	0300	Full-scale pressure - chan 0	2	IEEE-754 (big endian)	Returns NaN if module missing
40771	0302	Full-scale pressure - chan 1	2	IEEE-754 (big endian)	Returns NaN if module missing
40773	0304	Full-scale pressure - chan 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
40891	037A	Full-scale pressure - chan 61	2	IEEE-754 (big endian)	Returns NaN if module missing
40893	037C	Full-scale pressure – chan 62	2	IEEE-754 (big endian)	Returns NaN if module missing
40895	037E	Full-scale pressure - chan 63	2	IEEE-754 (big endian)	Returns NaN if module missing
40897	0380	Pressure type - channel 0	1	uint16	1 - Absolute 2 - Gauge
40898	0381	Pressure type - channel 1	1	uint16	1 - Absolute 2 - Gauge
40899	0382	Pressure type - channel 2	1	uint16	1 - Absolute 2 - Gauge
	. . .				
40958	03BD	Pressure Type - channel 61	1	uint16	1 - Absolute 2 - Gauge
40959	03BE	Pressure Type - channel 62	1	uint16	1 - Absolute 2 - Gauge
40960	03BF	Pressure Type - channel 63	1	uint16	1 - Absolute 2 - Gauge
40961	03C0	Min compensated temperature - module A	1	int16	Returns 0 if module missing
40962	03C1	Min compensated temperature - module B	1	int16	Returns 0 if module missing
40963	03C2	Min compensated temperature - module C	1	int16	Returns 0 if module missing
40964	03C3	Min compensated temperature - module D	1	int16	Returns 0 if module missing
40965	03C4	Max compensated temperature - module A	1	int16	Returns 0 if module missing

40966	03C5	Max compensated temperature - module B	1	int16	Returns 0 if module missing
40967	03C6	Max compensated temperature - module C	1	int16	Returns 0 if module missing
40968	03C7	Max compensated temperature - module D	1	int16	Returns 0 if module missing
40969	03C8	Max operating temperature	1	int16	
40970	03C9	Purge position	1	uint16	0-100 0 indicates fully open 100 indicates fully closed [In unitswithout a purge, reads always return 0]
40971	03CA	KMPS reference temperature	1	int16	Temperature of reference channel used for thermal control
40972	03CB	KMPS Status A	1	unit16	See Table 12
40973	03CC	KMPS Status B	1	uint16	See Table 13

Table 14 MODBUS/TCP Holding Registers

Ref [Dec]	Address [Hex]	Description	Length(words)	Format	Range/Comments
30001	0000	Pressure - channel 0	2	IEEE-754 (big endian)	Returns NaN if module missing
30003	0002	Pressure - channel 1	2	IEEE-754 (big endian)	Returns NaN if module missing
30005	0004	Pressure - channel 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
30123	007A	Pressure - channel 61	2	IEEE-754 (big endian)	Returns NaN if module missing
30125	007C	Pressure - channel 62	2	IEEE-754 (big endian)	Returns NaN if module missing
30127	007E	Pressure - channel 63	2	IEEE-754 (big endian)	Returns NaN if module missing
30129	0080	Temperature -channel 0	2	IEEE-754 (big endian)	Returns NaN if module missing
30131	0082	Temperature -channel 1	2	IEEE-754 (big endian)	Returns NaN if module missing
30133	0084	Temperature -channel 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
30251	00FA	Temperature - channel 61	2	IEEE-754 (big endian)	Returns NaN if module missing
30253	00FC	Temperature - channel 62	2	IEEE-754 (big endian)	Returns NaN if module missing
30255	00FE	Temperature - channel 63	2	IEEE-754 (big endian)	Returns NaN if module missing
30257	0100	Full-scale pressure - chan 0	2	IEEE-754 (big endian)	Returns NaN if module missing
30259	0102	Full-scale pressure - chan 1	2	IEEE-754 (big endian)	Returns NaN if module missing
30261	0104	Full-scale pressure - chan 2	2	IEEE-754 (big endian)	Returns NaN if module missing
	. . .				
30379	017A	Full-scale pressure - chan 61	2	IEEE-754 (big endian)	Returns NaN if module missing
30381	017C	Full-scale pressure - chan 62	2	IEEE-754 (big endian)	Returns NaN if module missing
30383	017E	Full-scale pressure - chan 63	2	IEEE-754 (big endian)	Returns NaN if module missing
30385	0180	Pressure type - channel 0	1	uint16	1 - Absolute 2 - Gauge

30386	0181	Pressure type - channel 1	1	uint16	1 - Absolute 2 - Gauge
30387	0182	Pressure type - channel 2	1	uint16	1 - Absolute 2 - Gauge
	. . .				
30446	01BD	Pressure Type - channel 61	1	uint16	1 - Absolute 2 - Gauge
30447	01BE	Pressure Type - channel 62	1	uint16	1 - Absolute 2 - Gauge
30448	01BF	Pressure Type - channel 63	1	uint16	1 - Absolute 2 - Gauge
30449	01C0	Min compensated temperature - module A	1	int16	Returns 0 if module missing
30450	01C1	Min compensated temperature - module B	1	int16	Returns 0 if module missing
30451	01C2	Min compensated temperature - module C	1	int16	Returns 0 if module missing
30452	01C3	Min compensated temperature - module D	1	int16	Returns 0 if module missing
30453	01C4	Max compensated temperature - module A	1	int16	Returns 0 if module missing
30454	01C5	Max compensated temperature - module B	1	int16	Returns 0 if module missing
30455	01C6	Max compensated temperature - module C	1	int16	Returns 0 if module missing
30456	01C7	Max compensated temperature - module D	1	int16	Returns 0 if module missing
30457	01C8	Max operating temperature	1	int16	
30458	01C9	Purge position	1	uint16	0-100 0 indicates fully open 100 indicates fully closed [In units without a purge, reads always return 0]
30459	01CA	KMPS reference temperature	1	int16	Temperature of reference channel used for thermal control
30460	01CB	KMPS Status A	1	unit16	See Table 12
30461	01CC	KMPS Status B	1	uint16	See Table 13

Table 15 MODBUS/TCP Input Registers

APPENDIX E

	KMPS-1	KMPS-1H	
Item	**Part Number**	**Part Number**	**Description**
1	904-A-78858		#2-56 x 9/16" Flat Socket Head Screw
		904-A-78854	#2-56 x 5/8" Socket Head Screw
2	900-A-82874		O-Ring (0.17” ID x 0.040” CS) HNBR (For > 300 PSI)
3	900-A-80764		O-Ring (0.17” ID x 0.040” CS) Viton (For <=300 PSI)
4	904-A-74687		#2-56 x 1/4” flat head cap screw
		904-A-81178	#2-56 x 5/16” socket head cap screw