OEM Programming Manual - Revision J.1

Danfoss Turbocor® **Twin-Turbine** Centrifugal Compressors

TTS/TGS/TTH/TGH Compressors

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Proprietary Notice

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Chapter 1.0 Introduction

This *Programming Manual* is intended for use by personnel responsible for configuration, control and monitoring the performance of Danfoss Turbocor, DTC, compressors. It describes how to physically establish and configure communication between the DTC compressor and a system controller using the Modbus protocol. The manual also describes the various functionality supported by the compressor software and contains a list of configurable parameters with detailed descriptions in "Chapter 16.0 Register Definitions" on page 7977.

1.1 Software Applicability

This manual is intended to be used with DTC Compressors which are using 2G (2nd Generation) Control Electronics software version 4.0.0; however, portions of this manual may be applicable to previous or future releases.

For more information about determining the software version, see Section "2.6 Software Version" on page 26 or the *Service Monitoring Tool Manual (M-SM-001)* for more information.

NOTE

If you are using Firmware 3.X.X, see Appendix A "3.1.X Functionality Definition" or Appendix B "3.0.X Functionality Definition" for more information about the specific functionality provided in BMCC Firmware 3.X.X.

Table - 1 Programming Manual Applicability

Manual	Release Date	BMCC Firmware Versions	Status
M-PR-001-XX Rev A	June 2011	2.3.1213 - 2.3.1219	Obsolete
M-PR-001-XX Rev B	October 2011	2.3.1213 - 2.3.1219	Obsolete
M-PR-001-XX Rev C	October 2013	3.0.0	Obsolete
M-PR-001-XX Rev D	November 2013	3.1.0 BETA	Obsolete
M-PR-001-XX Rev E	May 2014	3.0.0/3.1.0	Obsolete
M-PR-001-XX Rev F	March 2016	3.1.4	Obsolete
M-PR-001-XX Rev G	June 2016	4.0.0/3.X.X	Obsolete
M-PR-001-XX Rev H	June 2017	4.1.0/4.0.3/3.X.X*	Obsolete
M-PR-001-XX Rev I	April 2019	4.2.0/4.1.0/4.0.3/3.X.X*	Obsolete
M-PR-001-XX-Rev J	May 2019	4.2.0/4.1.0/4.0.3/3.X.X*	Active

*(See Appendices A & B for 3.X.X)

NOTE

Default parameters listed in this manual may be different between firmware versions. Registers added and/or removed between firmware versions have been indicated where applicable.

1.2 Organization of this Manual

The additional sections of the *Programming Manual* are:

"Chapter 2.0 Compressor Communication and System Configuration" on page 19 provides a basic description of the Modbus protocol, the access level strategy, the compressor communication set-up, and the Modbus functions implemented by DTC.

"Chapter 3.0 Compressor Control" on page 29 defines compressor control itself and its various phases: Start Up Phase, Mechanical Capacity Control Phase and Speed Capacity Control Phase. The parameters are organized by functional area.

"Chapter 4.0 Operation Modes" on page 33 describes the different modes in which the compressor will operate: Startup, Mechanical Capacity Control, Speed Capacity Control, and Fast Restart.

"Chapter 5.0 High Lift Operation" on page 45 describes operation of the compressor in the High Lift or high pressure ratio portion of the compressor operating envelope.

""Chapter 6.0 Low Lift Operation" on page 47 describes operation of the compressor in the Low Lift or low pressure ratio portion of the compressor operating envelope.

"Chapter 7.0 Inverter, Cavity and SCR Temperature Monitoring" on page 49 describes temperature monitoring of specific modules on the compressor and the module cooling that occurs as the module's temperature rises.

"Chapter 8.0 Recommended Control Strategy" on page 53 describes recommendations for controlling multiple compressors on a single refrigerant circuit.

"Chapter 9.0 Stepper Motor Control Mechanism" on page 57 describes the function of the stepper motor control as used with an expansion valve (EXV), staging valve or load balance valve.

"Chapter 10.0 Controlled Assist Shutdown" on page 61 describes the function of the Controlled Assist Shutdown and provides recommendations on its use.

"Chapter 11.0 Analog Output" on page 63 describes the use of the Analog Output on the I/O board and its programming.

"Chapter 12.0 Motor/Power Electronics Control" on page 65 defines the various parameters of Motor/Power Electronics Control.

"Chapter 13.0 Compressor Control Mode and Control Status" on page 69 describes the use and function of register 40029 Compressor Control Mode/Compressor Control Status.

"Chapter 14.0 Alarms and Faults Descriptions and Limits" on page 71 describes all of the alarms and faults that can be triggered by the compressor.

"Chapter 15.0 Lockout Fault" on page 77 describes the Lockout Faults that can occur, what causes them and how to clear them.

"Chapter 16.0 Register Definitions" on page 79 provides a description of each Modbus register organized numerically.

1.3 Document Conventions

The following conventions are used in this manual:

• **Procedures** - all user procedures (actions by user) are listed in numerical steps, unless it is a one-step procedure. A one step procedure is shown as a bullet. Options within a procedure are shown as bullets and sub-steps use alpha steps.

• **User Action Required (software)** - if a user is required to take action in a software procedure, the action will be shown in bold. Example: When the *Login* window opens, type in your **name** and **password**.

• **Window Names, Fields, Modes, and Phase names** - window and field names are displayed in italic. For example: *Compressor Connection Manager*. Phases are also displayed in italic, for example: *Start Up Phase.*

• **Italic text** - denotes a calculated value internal to the compressor, for example: *IGV Position.*

• **Parameter Names** - For parameter names, the following nomenclature is used:

Register number and bold text is used to denote a user accessible Modbus register; i.e. 42061 **IGV Start Position**.

• **External References** to other DTC manuals are in italic. Example: Refer to the *Installation and Operations Manual (M-IO-001)* for installation procedures.

NOTE: Indicates something to be noted by the reader.

NOTE

DANGER: Indicates an essential operating or maintenance procedure, practice, or condition, which, if not strictly observed, could result in serious injury to or death of personnel or long-term health hazards.

• • • DANGER • • •

CAUTION: Indicates an essential operating or maintenance procedure, practice, or condition which, if not strictly observed, could result in damage to equipment or potential problems in the outcome of the procedure being performed.

⚠ • • • CAUTION • • •

1.4 Related Documents

• *Service Monitoring Tools User Manual (M-SM-001)*

• *Service Manual (M-SV-001)*

• *Applications and Installation Manual (M-AP-001)*

1.5 Register Heading Descriptions

This section describes the headings for the Register Definition tables found in this guide:

• **Reg.# (Register Number):** The Modbus Holding Register address.

• **Register Name:** A unique name identifying the Modbus Register.

• **Range:** The range of possible register values which may be read and/or written. Registers which have a range of values which are negative must be interpreted as **Signed**. Registers which have a range of values which are greater than 32,767 must be interpreted as **Unsigned**.

• **Conv. (Conversion/Scaling):** The conversion formula or factor to be applied to the register value to convert it to physical units.

• **Type/Unit:** The physical unit or type of value that the register represents after its conversion formula or factor has been applied.

• **R/W Level (Read Only/Write Level):** The level required in 40425 Access Code Entry Current Level in order for the compressor to accept write commands. Registers marked 'R' are read only and will not accept write commands, regardless of the access level.

• **P/T (Persistent/Temporary):** Defines whether or not the register when written to supports saving the value to persistent memory (EEPROM) or only stores it in RAM. Values stored in RAM are lost after a power cycle.

• **Default:** The factory configured value of the register. Registers marked with a '-' imply that its value is dynamic, such as a sensor reading.

• **Detailed Description:** A description of the functionality provided by the register including how it relates to other registers, if at all.

1.6 Parameter Notes

The notes in "Table - 2 Parameter Notes" are applied to various registers where needed.

Table - 2 Parameter Notes

Note	Description
Note 1	40057 **Display Units** dependent. If *US Customary*, the register value is in Rankine. If *Metric*, the register value is in Kelvin.
Note 2	K or °R (see Note 1)
Note 3	**Liq Lev 1 or Liq Lev 2:** 1:1 **All other modes:** 1:10
Note 4	Pressure values are dependent on the selection for 40057 **Display Units** and all pressures are in absolute. Therefore, the register value will be either psia for US Customary or kPaa for Metric/SI.
Note 5	The register value is written in kPag but is displayed or read back in kPaa. There is an automatic conversion that takes place after writing the value. Ex. Write 200kpag and read back 301kpaa.
Note 6	Motor Current = (Register Value /32768) * 309
Note 7	Result = (Register Value/32767) *100
Note 8	The date and timestamp are always formatted in three 16-bit parameters with the following layout: Reg. 1 Minute & Second (00mmmmmm / 00ssssss) Reg. 2 Hour (00000000 / 000hhhhh) Reg. 3 Year, Day & Month (YYYYYYYD / DDDDMMMM) m = minutes, s = seconds, h = hours (24), Y = year, D = day, M = month
Note 9	MSB 0 - 255 seconds LSB Cooling Solenoid 0=No Cooling 1=Inverter 2=Motor 3=Motor & Inverter
Note 10	Reg. 1: MSB: MMMMmmmm M=Major, m=minor; LSB: unused Reg. 2: Revision Firmware Version=Major.minor.Revision
Note 11	Reg. 1 Serial Component 1 (SC1) Reg. 2 Serial Component 2 (SC2) Reg. 3 Serial Component 3 (SC3) Serial Number = "SC1-SC2-SC3" Ex. 3234-85741-0
Note 12	These registers are interpreted at 1:1 but are combined together to make a 32-bit integer.
Note 13	Ramp Up Increment = Register Value * 200 RPM 0 = disabled; 1 = ~200 rpm/s; 2 = ~400 rpm/s; 3 = ~600 rpm/s etc.
Note 14	Result = (Register Value/32768) * 41899 **DC Bus Current Scaling Factor**
Note 15	Result = (Register Value/32768) * 16
Note 16	Result = (Register Value/32768) * 1.65
Note 17	The Range, Conversion and Type/Unit of these registers depends on the specific register configured in the corresponding 42200 - 42299 Configurable Bulk Readout Addresses. See the definition of the register specified for conversion information.
Note 18	Result = (Register Value/32768) * 41898 **DC Bus Voltage Scaling Factor**

1.7 Units of Measure

The following units of measure are used in this manual:

Table - 3 Units of Measure

Abbreviation	Term
AC	Alternating Current.
A mA	Ampere/AMP (SI electric current) milliAmpere.
Baud	Baud Rate, The number of symbol changes (waveform changes or signaling events) made to the transmission medium per second using a digitally modulated signal or a line code. The rate is measured in baud (Bd) or symbols/second.
DC	Direct Current.
kg g	kilogram (SI, mass). gram.
K °R °C °F	Kelvin, K = (°F+459.67) 5/9 = °C+273.15 = °R*5/9 (SI thermodynamic temperature). Rankine, °R = K*9/5 = (°C+273.15)*9/5 = °F+459.67. Celsius, °C = K-273.15 = (F-32)*5/9. Fahrenheit, °F = (°C*9/5)+32 = K*9/5-459.67 = °R-459.67.
mH	millihenry: SI derived unit of electrical inductance.
Ohm	SI derived unit of electrical resistance.
Pa kPa kPag psi psig	Pascal (SI derived; pressure, stress.) kilo Pascal, kPa = (psig+14.69)*6.895. kilo Pascal gauge, kPag = kPa – 101. Pounds-force per square inch, psi=(kPag + 101)/6.895. Pounds-force per Square inch gauge (psig=psi-14.69).
RPM	Revolutions Per Minute.
s ms min hr	second (SI time). millisecond. minute. hour.
V	Volt (SI derived; voltage, electrical potential difference, electromotive force).
W kW	Watt (SI derived; power, radiant flux). kiloWatt.

1.8 Definitions

Table - 4 Definitions

Term	Definition
1:1, 1:10 etc.	1:1 indicates reading the value as presented. 1:10 indicates reading the value as value / 10. 1:100 indicates reading the value as value / 100 etc. 10:1 indicates reading the value as 10 * value. 100:1 indicates reading the value as 100 * value etc.
ADC	Analog Digital Converter.
AFT	Ascending Fault Triggering: See Section "14.1 Alarm/Fault Trigger Method" on page 71.
Alarm	A condition at the limit of the normal operating envelope. Alarms will still allow the compressor to run, but shaft speed is usually reduced to bring the alarm condition under the setpoint. **Note:** In this document, the terms alarm and warning are used interchangeably. See "Chapter 14.0 Alarms and Faults Descriptions and Limits" on page 71
AVC	Automatic Vibration Control; a part of the compressor magnetic bearing control system.
BMC	Bearing and Motor Control section of software held in BMCC.
BMCC	Bearing, Motor and Compressor Controller; Separate casing containing circuit board and software, installed in compressor service side. Controls all aspects of compressor, motor and bearings.
Boolean	A value of either 0 (FALSE/NO) or 1 (TRUE/YES).
Brownout	An intentional or unintentional drop in voltage in an electrical power supply system.
Cavity Sensor	PTC temperature sensor located behind the Backplane for the purpose of sensing the motor cooling vapor temperature. Provides overheat protection to rotor magnets.
CC	Compressor Controller: part of the BMCC.
Choke	Definitive points on the compressor map where the mass flow rate is at maximum for the compressor speed and lift conditions.
CIM / IO-board	Compressor Interface Module: the part of the compressor electronics where the user connects all field connection wiring such as RS-485, EXV and analog / digital wiring. Also known as the IO-board.
CMS	Compressor Model Specific.
CPU	Central Processing Unit: can be a dedicated type like a Digital Signal Processor (DSP) or a more general type like a Micro Controller Unit.
Configuration	A DTC predetermined set of parameters necessary to configure a compressor for a general or particular customer. It is also known as the parameter revision.
DC-DC converter	DC-DC converter supplies and electrically isolates high and low DC voltages that are required by the control circuits.
DFT	Descending Fault Triggering: see Section "14.1 Alarm/Fault Trigger Method" on page 71.
DTC	Danfoss Turbocor Compressors Inc.
DSP	Digital Signal Processor: a specific Central Processing Unit (CPU) dedicated for special applications like video handling or electric motor control.
EEPROM	Electrical Erasable Programmable Read Only Memory: A type of non-volatile memory used in computers and other electronic devices to store small amounts of data that must be saved when power is removed, e.g., calibration tables or device configuration. It has a limited write life – that is, the number of times it can be reprogrammed is limited. An EEPROM has an unlimited amount of reads.
EMF	Electromotive Force: the principle of electromagnetic induction states that a time-dependent magnetic field produces a circulating electric field. An EMF is induced in a coil or conductor whenever there is change in the flux linkages. Depending on the way in which the changes are brought about, there are two types: When the conductor is moved in a stationary magnetic field to procure a change in the flux linkage, the EMF is *statically induced*. The electromotive force generated by motion is often referred to as *motional emf*. When the change in flux linkage arises from a change in the magnetic field around the stationary conductor, the EMF is *dynamically induced*. The electromotive force generated by a time-varying magnetic field is often referred to as *Transformer EMF*.
EXV	Electronic Expansion Valve: Pressure-independent refrigerant metering device driven by electrical input.
Fault	An intolerable or unsafe condition that may result in equipment failure. Faults will cause the compressor controller to shut down the system. Depending on the type, the fault will either automatically reset or require a manual reset. See"Chapter 14.0 Alarms and Faults Descriptions and Limits" on page 71.
FLA	Full Load Ampere.

Table 4 - Definitions (Continued)

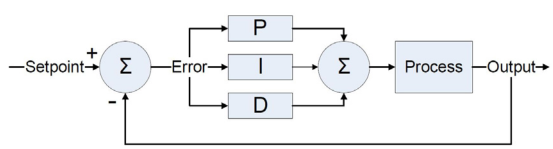
Term	Definition
FVS	Firmware Version Specific
FW	Flag Word/Bit Flag. One or more bits that are used to store a binary value or code that has an assigned meaning.
Generator Mode	A function of the compressor where the stator becomes a generator, providing power to the DC bus. This allows bearing power and control to be maintained during compressor spin down in the event of a power failure.
Hex	Hexadecimal number system.
Id	The part of the motor current generating torque.
Iq	The part of the motor current magnetizing the field.
IGV	Inlet Guide Vanes: The IGV assembly is a variable-angle guiding device that pre-rotates refrigerant flow at the compressor inlet. Its function is to assist in capacity control and surge mitigation. The IGV assembly consists of movable vanes and a step motor actuator.
Impeller	Rotating part of a centrifugal compressor that increases the pressure of refrigerant vapor from the evaporator pressure to the condenser pressure.
lsb / LSB	Least significant bit / byte.
Memory Page	A fixed-length continuous block of computer memory.
Modbus	www.modbus.org, Modbus is a serial communications protocol published by Modicon in 1979 for use with its programmable logic controllers (PLCs). It has become a de facto standard communications protocol in industry, and is a commonly available means of connecting industrial electronic devices.
Motor Back EMF	Back electromotive force is a voltage that occurs in electric motors where there is relative motion between the rotor of the motor and the external magnetic field. In relation to a DTC compressor, it is also a parameter used to evaluate the strength of the permanent magnets of the shaft.
msb / MSB	Most significant bit / byte.
NIST	National Institute of Standards and Technology, www.nist.gov.
NTC	Negative Temperature Coefficient: Refers to a thermistor characteristic. Decrease in temperature equating to an increase in resistance of the sensor.
OEM	Original Equipment Manufacturer.
PCB	Printed Circuit Board.
PDU	Protocol Data Unit. Information that is sent as a unit.
PID	Proportional / Integral / Derivative control.  The control is based on a control loop as shown above. If any of the proportional, integral or derivative gains are not to influence your control scheme set them to 0 (zero). The PID controller calculation (algorithm), sometimes called three-term control, involves three separate parameters: the proportional, the integral and derivative values, denoted *P, I,* and *D*. Heuristically, these values can be interpreted in terms of time: *P* depends on the *present* error, *I* on the accumulation of *past* errors, and *D* is a prediction of *future* errors, based on current rate of change.
PLC	Programmable Logic Controller.
PM	Permanent Magnet (motor).
Power Cycle	Switch off the 3-phase mains until the compressor capacitor bank is discharged – then turn the 3-phase mains on again.
Pressure Ratio	Is the ratio of discharge pressure/suction pressure in absolute terms.
PWM	Pulse Width Modulation.
RAM	Random Access Memory: All the memory that is lost when powering off a device with RAM,.
Register, reg.	A word designating a particular numbered 16 bit value handled by the Modbus RTU protocol. Not to be mistaken by a register inside a CPU.

Table 4 - Definitions (Continued)

Term	Definition
Reset of fault	Resetting non-critical faults can be completed using the Clear Faults command or by toggling demand. For more information, refer to Section "15.4 Resetting Non-Lockout Faults" on page 78.
RFT	Range Fault Triggering: see Section "14.1 Alarm/Fault Trigger Method" on page 71
RMS	Root Mean Square.
RPM	Revolutions Per Minute.
RTC	Real-Time Clock: A Real Time Clock is a digital clock that keeps track of the current time.
SCR	Silicon Controlled Rectifier: The SCR is a semi-controlled, solid-state device that controls current and converts AC to DC.
SDD	Software Design Document.
SH	Superheat: The sensible heat added to a refrigerant thus increasing its temperature following evaporation of all liquid vapor.
SI	System International: the International System of Units, http://www.bipm.org.
SMT	Service Monitor Tools: a PC program provided by DTC. A user friendly way of displaying compressor data to the user and offer adjustment of predetermined parameters. The user interface adjusts itself according to the active access level at the compressor.
Surge	The condition at which the compressor experiences reverse refrigerant flow through the impeller. This will result in increased noise level, rapid temperature increase of the impeller and decrease of absorbed power. This is an undesirable situation that should be avoided. A Stall can be classified as the compressor being unable to sustain refrigerant flow, but is still not a Surge.
TT	Twin Turbo: A type of compressor in which two turbine type impellers compress the intake gas.

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Chapter 2.0 Compressor Communication and System Configuration

The Bearing, Motor and Compressor Controller (BMCC) software is designed so that a user can configure system behavior, monitor system status and control system operations by sending standard Modbus register read and write operations over an RS-485 or RS-232 network.

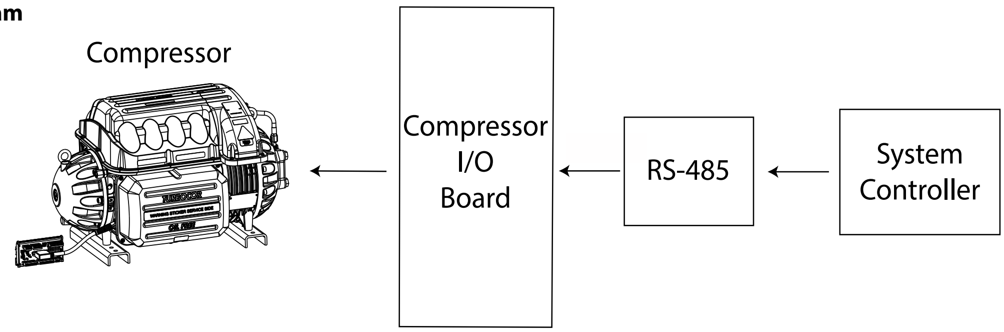
The complete list of available Modbus registers (configuration/status/control) is described in "Chapter 16.0 Register Definitions" on page 79. Throughout the document, registers associated with the specific section are shown.

This section specifies how the compressor can be interfaced with either a RS-485 or RS-232 network. System settings such as software version, Real-Time Clock (RTC) and configuration part numbers are also described in this section.

2.1 Compressor Communication

All controller communication to the compressor takes place through the I/O board. Configuration, status monitoring or control of the compressor requires a physical connection to the I/O board. It is recommended that the RS-485 connection be used for interfacing with the Chiller Controller and that the RS-232 port is only used for initial setup and service. The slave address must be set appropriately in register 40251 and applies to both the RS-232 and RS-485 connections.

Figure - 1 System Block Diagram



NOTE
DTC recommends having one master connected to a compressor at a time. More than one device writing to the compressor can create unpredictable behavior.

NOTE
Please refer to the *Applications and Installation Manual (M-AP-001)* for detailed information on making physical RS-232 or RS-485 connections to the compressor.

2.1.1 I/O Board RS-232 Communication

RS-232 is a point-to-point communication method. It is typically a connection between the I/O board and a PC, allowing connection of the Service Monitor Tools (SMT) software. It is not recommended for customer use as a Chiller Controller connection. The parameters in "Table - 5 RS-232 Communication Parameters" on page 20 are available for adjustment to fit the user application. Changes to any of these values will only become effective after a power cycle and will require that the interfacing tool changes accordingly so that both applications can continue to communicate.

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Unintended changes to these parameters could prevent successful communication with the BMCC.

NOTE
The 40251 **Modbus Slave Address** parameter takes effect immediately as this parameter is used dynamically. Once changed, the interfacing application must also change to the address set in order to continue communications with the compressor.

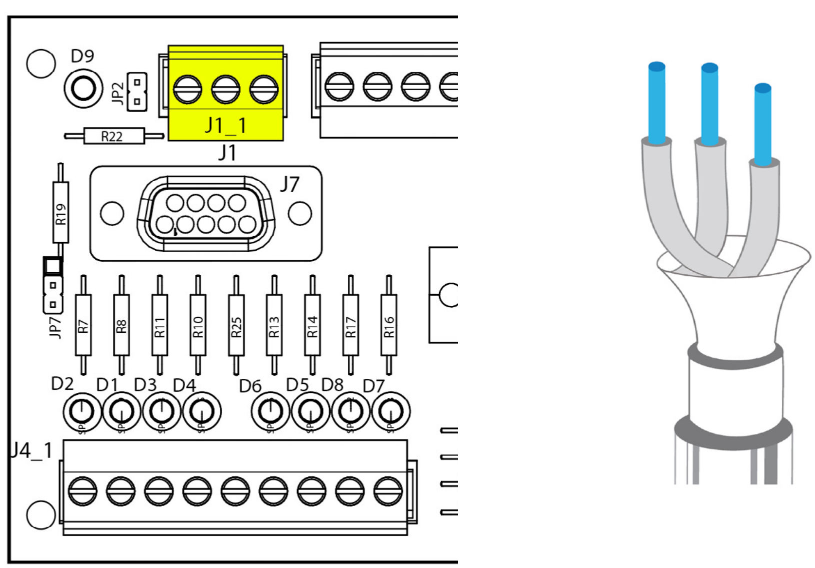
Table - 5 RS-232 Communication Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40251	Modbus Slave Address	[0…64]	1:1	-	2	P	1	A unique identifier for the compressor on the Modbus network.
40255	RS-232 Baud Rate	[9…10] 9 = 38400 bit/s 10 = 19200 bits/s	1:1	-	2	P	9	The RS-232 communication line transmission speed in bits transferred per second.
40256	RS-232 Parity	[0…4]	1:1	-	2	P	0	The Parity bit is added to ensure that the number of bits with the value 1 in a set of bits is even or odd. Parity bits are used as the simplest form of error detecting code. **0** = None
40257	RS-232 Stop Bits	[0…1] 0 = 1 Stop Bit 1 = 2 Stop Bits	1:1	-	2	P	0	The Stop Bit is actually a "stop period". the stop period of the transmitter may be arbitrarily long. It cannot be shorter than a specified amount, usually 1 to 2 bit times.

2.1.2 I/O Board RS-485 Communication

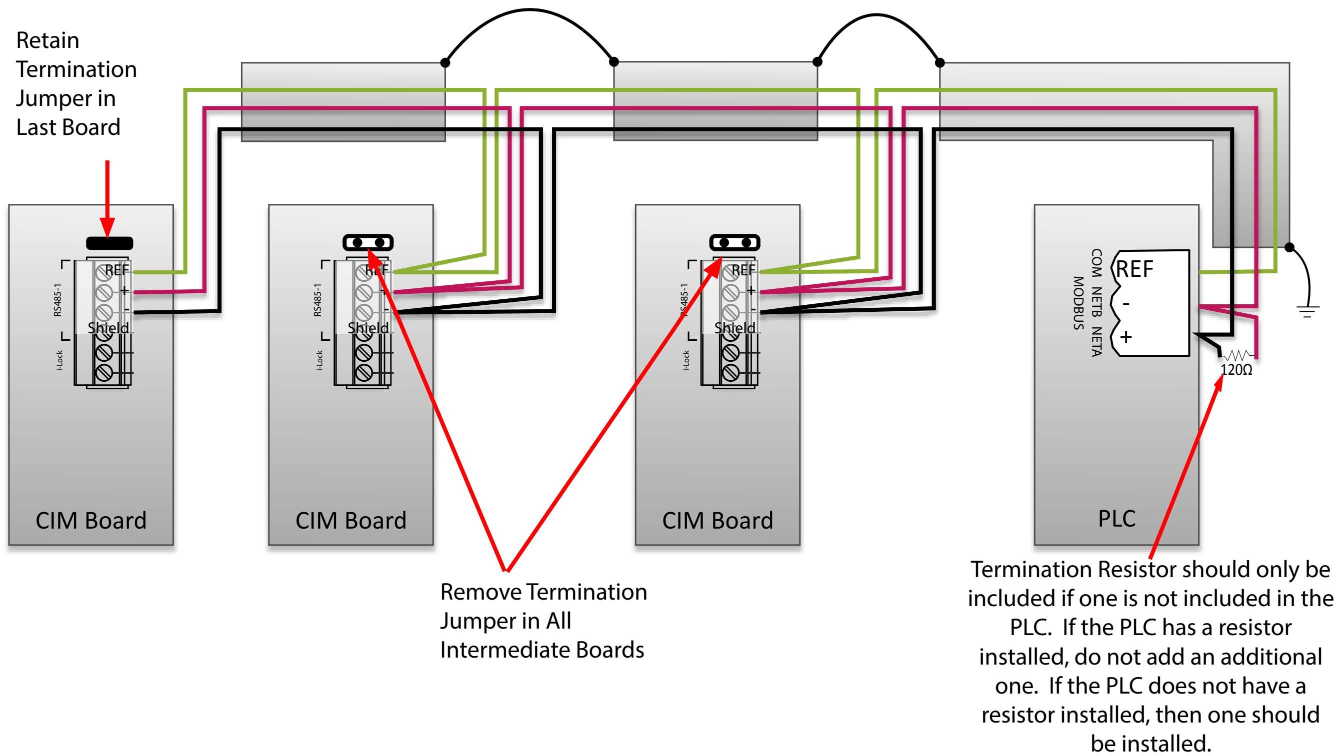
RS-485 is a multi-point master-slave communication method with the potential for many slaves, but only one master. The Programmable Logic Controller (PLC) must connect to the I/O board at J1 via RS485, using a single shielded twisted pair plus ground cable, as shown below. Wire that is at least AWG22 will ensure quality communication. Minimizing the length of all RS-485 cables will also ensure quality communication. The parameters in "Table - 6 RS-485 Communication Parameters" on page 21 may be configured to fit the user application. Changes to all of these values, except the Slave Address, will become effective after a power cycle and will require that the interfacing tool is adjusted accordingly so that both applications can continue to communicate.

Figure - 2 Connect Controller RS-485 ModBus at J1 using a single shielded twisted pair plus ground cable



In order to connect multiple compressors in a single ModBus network using a "Daisy-chain" technique, be sure to remove the termination jumpers on all but the last I/O boards. If the termination jumpers are not removed, then communication across the entire network will not be complete and communication interruptions are likely. Additionally, if the PLC does not include a termination resistor, then one should be included. If the PLC does include the termination resistor, then do not add an additional one.

Figure - 3 Connecting Multiple Compressors



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Unintended changes to these parameters could prevent successful communication with the BMCC

NOTE

The 40251 **Modbus Slave Address** parameter takes effect immediately as this parameter is used dynamically. Once changed, the interfacing application must also change to the address set in order to continue communications with the compressor.

Table - 6 RS-485 Communication Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40251	Modbus Slave Address	[0...64]	1:1	-	2	P	1	A unique identifier for the compressor on the Modbus network.
40252	RS-485 Baud Rate	[9…10] 9 = 38400 bit/s 10 = 19200 bits/s	1:1	-	2	P	9	The RS-485 communication line transmission speed in bits transferred per second.
40253	RS-485 Parity	[0…4]	1:1	-	2	P		The Parity bit is added to ensure that the number of bits with the value 1 in a set of bits is even or odd. Parity bits are used as the simplest form of error detecting code. **0** = None
40254	RS-485 Stop Bits	[0…1] 0 = 1 Stop Bit 1 = 2 Stop Bits	1:1	-	2	P	0	The Stop Bit is actually a "stop period". The stop period of the transmitter may be arbitrarily long. It cannot be shorter than a specified amount, usually 1 to 2 bit times.

2.1.3 Communication Blackout Period

Upon power up, a DTC compressor can take up to 70 seconds to be ready to accept commands on the RS-232 or RS-485 network. The RS-485 device used in DTC compressors creates a network blackout condition during the first 10-15 seconds of this configuration period. This applies to both a single compressor network and a multiple compressor network. Therefore, the user must account for this condition and avoid any communications on the network for at least this initialization period.

NOTE

Watch register 40039 **BMCC Temperature** for an indication of readiness. A value greater than 0 is an indication that the initialization period is complete and the compressor is at a ready state.

2.1.4 Communication Timing

Proper message spacing between reads and writes can ensure successful continuous communication between compressor and controller. In general, the firmware can handle up to 5 messages per second when reading approximately 100 registers per request. Therefore, spacing messages at a minimum of ~200 msec intervals should provide adequate time for the compressor to respond, depending on the size of the request. Additional time should also be included for the original read/write request from the controller. Testing is recommending to validate proper communication settings. Additionally, timeouts, which should only occur when the compressor is no longer communicating, should not be set too tightly. A timeout setting greater than 100 msec is recommended to ensure the compressor has had adequate time to respond.

2.2 Implemented Modbus Function Codes

This section defines the specific Modbus Protocol Function Codes which are supported by the compressor. Function Codes not listed here are not supported.

2.2.1 03 (0x03) Read Holding Registers

This function code is used to read the contents of a continuous block of holding registers in a remote device.

The register data in the response message is packed as two bytes per register with the binary contents right-justified within each byte. For each register, the first byte contains the high-order bits and the second byte contains the low-order bits.

2.2.2 06 (0x06) Write Single Register

This function code is used to write a single holding register in a remote device. The Protocol Data Unit (PDU) specifies the address of the register to be written.

2.2.3 Configurable Bulk Register Readout

To minimize the number of read commands, the Configurable Bulk Register Readout feature allows the user to read up to 100 noncontiguous registers. The valid register range to insert for read out is within registers 40021 – 42099.

- Registers 42200 - 42299 contain the register numbers the user wants to have read out.

- Registers 42100 - 42199 contain the register values to read.

There is no specific order or sequence of the readout registers. The setup is retained in RAM and is lost after a power cycle.

Figure - 4 Bulk Register Setup and Read-out

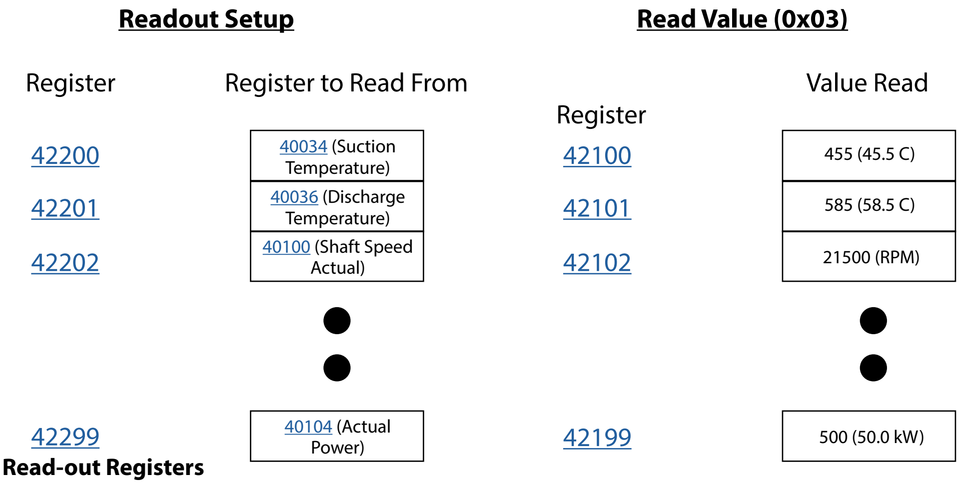


Table - 7 Bulk Register Setup and Read-out Registers

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
42100 - 42199	Configurable Bulk Readout Values	**Note 17**	**Note 17**	**Note 17**	R	-	-	The values of the corresponding Modbus register addresses configured in 42200 - 42299 **Configurable Bulk Readout Addresses**. See Section "2.2.3 Configurable Bulk Register Readout" on page 22 for more information.
42200 - 42299	Configurable Bulk Readout Addresses	[0...65535]	1:1	-	1	T	-	Section "2.2.3 Configurable Bulk Register Readout" Modbus register addresses that the user would like to read in the corresponding 42100 - 42199 **Configurable Bulk Readout Values**.

2.3 Configuring the Compressor

The user must customize the compressor settings to ensure adequate operation for the given application. This process is referred to as *Compressor Configuration*. During this process, the user provides a set of inputs (for example, amperage limits, pre-cooling time, operational mode, temperature limits for fault or alarms conditions, etc.) to the system so that it will operate efficiently under the specific environmental conditions and system demand. There are two possible approaches to achieve this goal: *Dynamic Configuration* or *Static Configuration*. The following sections provide a memory operation overview and a description of how both of these methods work.

⚠ • • • CAUTION • • •

To prevent unintended changes to the EEPROM, ensure that the "RAM Only" selection is made in the *Connection Manager* window of the SMT. If the intention is to make changes in EEPROM, then make sure that the "RAM & EEPROM" option is selected.

⚠ • • • CAUTION • • •

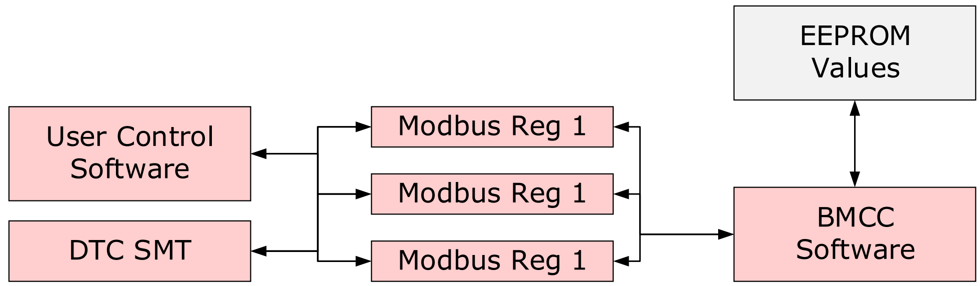
Making changes to RAM Only and switching to RAM & EEPROM in a single session without cycling power to the compressor first is NOT recommended. This could lead to values intended to be changed in RAM Only to be stored to EEPROM because the EEPROM save options work on a per page basis. The recommended method is to make RAM & EEPROM changes on a single session, followed by a power cycle. Then on a subsequent power up session, the user would make any RAM Only changes.

2.3.1 Memory Operation Overview

The EEPROM memory device holds persistent values for all configurable compressor parameters. During power up, the BMCC software loads EEPROM values into its corresponding Modbus register and uses those values to control operations.

Once the compressor is powered on and a connection is established with a valid access code, then configuration and control values can only be changed in RAM with any tool which implements Modbus write operations. The SMT must be used to make persistent changes to values stored in EEPROM. By default, the SMT takes every register update and commands the BMCC to store the value in EEPROM. However, the SMT also has a "RAM Only" feature which limits the Modbus writes to the corresponding Modbus register without changing the default value in EEPROM. The "RAM Only" feature is recommended when changes are made for testing different options without affecting the default settings. Please see the *Service Monitoring Tool User Manual (M-SM-001)* for more information on the use of the parameter saving feature.

Figure - 5 Memory Operation Diagram



NOTE

SMT version 3.1.0 or later should be used for BMCC Firmware 4.x.x and later.

The EEPROM chip has a limitation on the maximum amount of writes that it can support during its life. The BMCC tracks the number of write operations which have occurred in registers 40491/40492 **EEPROM** Writes which must be merged together to make a 60-bit integer. In addition, statistical data, which changes frequently, is written to EEPROM every sixty minutes and in the event of mains power loss to limit the number of writes over the life of the compressor.

2.3.2 Dynamic Configuration

The *Dynamic Configuration* approach requires loading configuration values each time after the compressor has achieved ready state. Using this approach, the compressor must be fully re-configured on every power cycle as these configuration settings are stored in volatile memory (RAM) and are lost once power is removed from the processor in the BMCC. The *Dynamic Configuration* is the only method of configuration that is available to the Chiller Controller or any external device which is not the SMT.

2.3.3 Static Configuration

The *Static Configuration* approach is to use the SMT to change the persistently stored configuration values so that each time the compressor powers up it is configured for its application.

• Using this approach, the compressor will return to the desired setup in the next power cycle as these configuration settings are stored in non-volatile memory (EEPROM). Statically configured data will persist through a power cycle.

Refer to the *Service Monitoring Tool Manual (M-SM-001)* for further information on using the SMT.

2.4 Access Control

The compressor implements Access Control to secure the use of various features and settings of the compressor from unauthorized users. The result is a variety of access levels which apply on a per register basis only on write operations. The compressor does not enforce access control on read operations. If the users access level is equal to or greater than the minimum required for a given register, the user is permitted write privileges.

The current access level can be determined by reading register 40425 **Access Code Entry Current Level** and can be modified by writing the appropriate access code to the same register.

NOTE

Starting with v4.0.0, access control is implemented independently on the RS-232 and RS-485 ports. Each port has its own access level and login. Register 40425 will show the current access level for the port that the device is connected to.

Table - 8 Access Control Registers

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40425	Access Code Entry/ Current Level	[0...65535] W [0...3] R	1:1	-	1	T	1	Displays the current access level and is the register used to input the compressor access code.

• • • CAUTION • • •

Invalid Access Code entry will set the compressor Access Level to 1 (Basic). Repeated Invalid Access Code entries will result in the compressor locking at Access Level 1 (Basic) and requires a power cycle to reset.

2.4.1 Access Level 1 (Basic) End User (Access Code = 1)

Access Level 1 is aimed at chiller control and service monitoring. At this access level, start up registers including Demand are writable to RAM.

2.4.2 Access Level 2 (Low) Service Technician

Access Level 2 is aimed at the service technician. The Control Mode can be changed, Bearing Calibration can be performed and Stepper Motor Control setup is allowed.

2.4.3 Access Level 3 (Medium) OEM

Access Level 3 is aimed at the Original Equipment Manufacturer, OEM. The necessary registers required for chiller/compressor commissioning are writable.

2.5 System Settings

The compressor uses the registers in "Table - 9 System Setting Parameters" on page 26 below to tailor readouts, provide system identification or configure how the product behaves as a whole.

Table - 9 System Setting Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40057	Display Units	[0…1] 0 = US Customary 1 = Metric	1:1	-	2	P	1	This setting affects all parameters which have **Note 1** or **Note 4** in the Type/Unit column. When in "Metric", the values read out/written to the compressor are interpreted as kPa, ºC and K. In "US Customary", they are interpreted as psi, ºF and ºR.
40177 40178 40179	Compressor Real Time Clock (RTC) Current Time	[0...65535]	**Note 8**	-	R	-	-	Current time of the internal Real Time Clock (RTC). The RTC is initialized from DTC before shipping with the current (UTC - 05:00) US Eastern Time. A small battery ensures that the RTC is running even though no mains voltage is applied to the compressor.
40404 40405 40406	BMCC Serial Number	[0...65535]	**Note 11**	-	R	-	BMCC Specific	Every BMCC has a unique fixed Serial Number.
40410 40411	Compressor Software (Configuration) Part Number	[0…65535]	**Note 12**	-	4	P	CMS	These registers identify the part number for the configuration parameters used inside the compressor. This information correlates to the part number of the compressor either directly (1-1) or indirectly in the case of adjustable amperage range models (1-many). The combination of this part number with the 40412 **Configuration Revision** determines the complete software configuration including which 42044 **Compressor Control (CC)** Version is downloaded.
40412	Configuration Revision	[0...65535]	1:1	-	4	P	-	An increasing consecutive number which identifies the revision of the compressor configuration. This is used in conjunction with the 40410 **Compressor Software (Configuration) Part Number** for configuration management traceability and tracking.

2.6 Software Version

The Software version of the compressor is determined by the BMCC installed on the compressor and can only be changed by replacing the BMCC. Using the software version to determine how to operate the compressor, increases the opportunity for bugs and potential for improper function of the compressor or chiller. The chiller controller should handle additional features and new functionality carefully with significant testing with all possible software versions to ensure the compressors and chiller operate smoothly and effectively.

The BMCC Software is versioned as follows:

• Compressor Controller Version – 4.1.0 (Registers 42044 **CC Version** and 42045 **CC Revision**).

The version number scheme is decomposed as follows:

• Major – Incremented to indicate customer interface changes such as feature functionality modification or removal, this may break backward compatibility.

• Minor – Incremented to indicate new features have been added, but not break backwards compatibility.

• Revision – Incremented to indicate defect fixes or optimizations that do not affect customer interface.

Figure - 6 Software Version Description

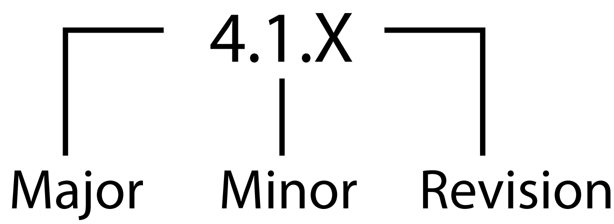


Table - 10 Software Version Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
42044 42045	Compressor Control (CC) Version	[0...65535]	**Note 10**	-	R	-	FVS	The current version of the compressor firmware.

2.7 Compressor Model and Refrigerant Configuration (Reg. 40413)

For the most part the compressor will be preconfigured; however, some registers may require adjustment based on the requirements of the OEM. Recall that in order to ensure these values are always configured and are permanently set in EEPROM, be sure to set them through the SMT. For more information, please refer to Section "2.3 Configuring the Compressor" on page 23.

The Compressor Model and Refrigerant configuration can be read from register 40413 as described by "Table - 11 Compressor Model and Refrigerant Configuration".

Also, the refrigerant is only configurable in Twin Turbo (TT) models between R134a and R513A. To select the refrigerant write a value of 1 for R134a or 8 for R513A to this register.

Table - 11 Compressor Model and Refrigerant Configuration

Type	Refrigerant		Reg. Value
TT300	R134a	1	8449
TT300-R22	R22	2	8706
TT350	R134a	1	17665
TT400	R134a	1	17153
TT700	R134a	1	26113
TG310	R1234ZE	3	18179
TG230	R1234ZE	3	10243
TG390	R1234ZE	3	18691
TG520	R1234ZE	3	27139
TT300	R513A*	8	8456
TT350	R513A*	8	17672
TT400	R513A*	8	17160
TT700	R513A*	8	26120

*Refrigerant R513A is only available in firmware version 4.1.0 or later.

2.7.1 Configured Voltage (Reg. 40330)

The specific voltage is provided through register 40330. This register is read only. The configured voltage register is only available in firmware version 4.1.0 or later.

2.7.2 Configurable Frequency (Reg. 41979)

With firmware version 4.2, the Compressor Mains Frequency will be selectable. Register 41979 will allow the Mains Frequency to be adjusted between 50 Hz and 60 Hz. While the frequency will likely be configured correctly for the given voltage, if frequency requires adjustment, it is the responsibility of the OEM to ensure that the frequency is correctly set during factory configuration or field commissioning.

2.7.3 Standard Lift / Low Lift Configuration (Reg. 40531)

The specific configuration related to where on the map the compressor is expected to operate can be selected by changing the value in register 40531. Standard Lift is 0 and is the default value. Low Lift can be selected by changing this value to 1. If the compressor is expected to operate in the Low Lift area of the compressor map, then a pump for the motor cooling line should be installed. Please see "Chapter 5.0 Low Lift Operation" on page 28 for more details. The Low Lift Configuration is only available in firmware version 4.1.0 or later.

Table - 12 Compressor Configuration

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40330	Configured Voltage	[0…65535]	1:1	-	R	P	CMS	The decimal value read is the actual voltage.
40413	Compressor Model and Refrigerant	[0…65535]	1:1	-	R	P	CMS	The Compressor Type and Refrigerant as configured by the Compressor Model selection. Refrigerant can be modified between R134a and R513A by writing a 1 for R134a or a 8 for R513A to this register.
40531	Enable Low Lift Configuration	[0…1]	1:1	-	3	P	0	0 = Standard Lift (Default) 1 = Low Lift

Chapter 3.0 Compressor Control

This section defines the components and mechanisms involved with controlling the compressor. This includes, but is not limited to compressor status, start up, mechanical capacity control, speed capacity control, Stepper Motor Control and other compressor functionality. It also describes the start up, part-vane and full-vane conditions of the compressor. User access points like analog, digital and stepper motor ports are described.

3.1 Compressor Status Parameters

The *Compressor Status* registers inform the user about the current operational status of the compressor.

Table - 13 Compressor Status Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40024	Shaft Levitation Status	[0...3]	1:1	-	R	-	-	Indicates the current operational status of the BMC control system: **0** *(Standby)*; **1** *(Levitate)*; **2** *(Drive)*; **3** *(Calibrate)*.
40026	Compressor Status Faults	[0…65535]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the compressor controller. The compressor control signals one or several faults at a time independently from bearing and motor control. See "Chapter 14.0 Alarms and Faults Descriptions and Limits" on page 71.
40027	Compressor Status Alarms	[0…65535]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the compressor controller. The compressor control signals one or several alarms at a time independently from the bearing and motor control. Alarms will generally cause the compressor to reduce speed. See "Chapter 14.0 Alarms and Faults Descriptions and Limits" on page 71.
40028	Demand	[0…1000]	1:10	%	1	T	-	The target cooling capacity the compressor is asked to provide.
40029	Compressor Control Mode	[0…16]	1:1	FW	2	P	8	The functional control mode of the compressor and how it is expected to interact with external chiller components. See "Chapter 13.0 Compressor Control Mode and Control Status" on page 69 for more information.
	Compressor Control State	[32…65520]	1:1	FW	R	-	-	Indicates the current operational state of the compressor controller. See "Chapter 13.0 Compressor Control Mode and Control Status" on page 69 for more information.
40031	Suction Pressure	[0…65535]	1:10	**Note 4**	R	-	-	The pressure measured at the compressor's suction port.
40033	Discharge Pressure	[0…65535]	1:10	**Note 4**	R	-	-	The pressure measured at the compressor's discharge port.
40034	Suction Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured at the compressor's suction port.
40035	SCR Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured on the Silicon Controlled Rectifiers (SCR).
40036	Discharge Temperature	[0…65535]	1:10	**Note 1**	R		-	The temperature measured at the compressor's discharge port.
40037	Cavity Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured in the motor cavity.
40038	Entering Fluid Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The externally measured entering fluid temperature ('ENTRY' on the I/O board).
40039	BMCC Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured on the BMCC.
40040	Backplane Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The temperature measured at the compressor's backplane.
40041	Motor Thermal Raw Value (MTRV)	[0…65535]	1:1	-	R	-	-	The readout from the motor winding thermistor.
40042	Liquid (LIQ) Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured by the external sensor, connected to the LIQDT input on the I/O board.
40043	DC/DC Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The temperature measured at the DC/DC
40044	PWM Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The temperature measured at the PWM.
40045	24 VDC Voltage	[0…65535]	1:10	VDC	R	-	-	The internally measured voltage of the 24V DC Bus.
40046	Leaving Fluid Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The externally measured fluid temperature ('LEAVE' on the I/O board).
40047	Compressor Interlock Status	[0…1] 0 = Open 1 = Closed	1:1	Boolean	R	-	-	The current status indicated by the interlock signal. It must be in the *closed* state for normal operation of the compressor and in the *open* state for service operations, such as bearing calibration, levitation, etc.

Table 13 - Compressor Status Parameters (Continued)

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40048	Spare Pressure	[0...65535]	1:10	**Note 4**	R	-	-	The indicated pressure as measured at the external pressure sensor ("SPARE P" on the I/O board).
40049	Spare Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The indicated temperature as measured at the external, application-specific thermistor ("SPARE T" on the I/O board).
40050	Chiller Demand Percentage	[0…1000]	1:10	%	R	-	-	The resulting value of (40104 **Actual Power**/40021 **Requested Power**) * 40028 **Demand** giving the compressor demand from the internal chiller controller.
40055	Surge Speed	[0…65535]	1:1	RPM	R	-	-	Estimated minimum speed, calculated by the compressor based on compressor model and operating conditions.
40056	Choke Speed	[0…65535]	1:1	RPM	R	-	-	Estimated maximum speed calculated by the compressor based on compressor model and operating conditions. The compressor will not exceed this speed.
40060	Suction Pressure Remaining Alarm Delay	[0...120]	1:1	Seconds	R	-	-	The amount of time remaining before a fault or alarm is indicated while under such conditions. This parameter only applies during start up.
40088	Cooling Mode	[0...3]	1:1	-	R	-	-	Indicates the current status of the cooling solenoid valves: 0 (No Cooling) 1 (Inverter Cooling only) 2 (Motor Cooling only) 3 (Motor & Inverter Cooling)
40196	Total Standby Hours	[0...65535]	1:1	Hours	1	-	-	Indicates the amount of compressor standby hours since last power reset. The sum of 40196 **Total Standby Hours**, 40197 **Total Standby Minutes**, 40212 **Total Running Hours** and 40213 **Total Running Minutes results** in the total ON time for the compressor since last reset.
40197	Total Standby Minutes	[0...65535]	1:1	Minutes	R	-	-	Indicates the amount of compressor standby minutes and seconds since the last power reset.
40212	Total Running Hours	[0...65535]	1:1	Hours	4	-	-	Indicates the amount of compressor running hours since last power reset. The sum of 40196 **Total Standby Hours**, 40197 **Total Standby Minutes**, 40212 **Total Running Hours** and 40213 **Total Running Minutes** results in the total ON time for the compressor since last power reset.
40213	Total Running Minutes	[0...65535]	1:1	Minutes	R	-	-	Indicates the amount of compressor running minutes and seconds since the last power reset.
40328	Liquid Level 1	[0…1000]	1:10	%	R	-	-	This register represents the percentage 0-100 of the liquid level 1 input (either 0-5v or 0-90Ohm) on the IO board.
40329	Liquid Level 2	[0…1000]	1:10	%	R	-	-	This register represents the percentage 0-100 of the liquid level 2 input (either 0-5v or 0-90Ohm) on the IO board.
40391	Suction Sat. Temperature (SST)	[0...65535]	1:10	**Note 1**	R	-	-	The calculated Saturated Suction Temperature (SST) using the reading from the Pressure Sensor at the compressors suction port.
40392	Discharge Sat. Temperature (SDT)	[0…65535]	1:10	**Note 1**	R	-	-	The calculated Saturated Discharge Temperature (SDT) using the reading from the Pressure Sensor at the compressors discharge port.
40393	Suction Superheat	[0…65535]	1:10	**Note 1**	R	-	-	The calculated Suction Superheat using the measured Suction Temperature minus the calculated Saturated Suction Temperature (SST).
40397	Pressure Ratio	[0…65535]	1:100	-	R	-	-	The pressure ratio value is the maximum of: (40033 **Discharge Pressure**/40031 **Suction Pressure**) or (40048 **Spare Pressure**/40031 **Suction Pressure**).
40499	Drive Enabled Count	[0…65535]	1:1	-	4	P	-	Indicates the total amount of compressor start ups. The trigger for counting a start up is a minimum of 10 RPM on the motor speed.

3.2 Inlet Guide Vane (IGV) Parameters

The Inlet Guide Vane (IGV) assembly consists of movable vanes and a stepper motor. The IGV is a variable-angle fluid flow guiding device that is used to control the capacity of the compressor at low-load conditions. As the compressor adapts to the current conditions to provide the requested 40028 **Demand**, the IGV position will vary between 42046 **Minimum IGV Steps** and 40233 **Maximum IGV Steps**.

Additionally, the IGV can now be initialized to fully open or fully closed. In this way, the reliability of the IGV vanes can be improved greatly by initializing to fully open. The IGV initialization will force the inlet guide vanes to fully open or fully closed based on the selection in register 40318 **Initialize IGV to Fully Open**. For backwards compatibility reasons, the default selection is to initialize to fully closed.

Table - 14 Inlet Guide Vane (IGV) Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40030	IGV Open Percentage	[0…1100]	1:10	%	3	T	0	The percentage of Inlet Guide Vane (IGV) opening which is a function of 40233 **Maximum IGV Steps**. 110% is equal to fully open; i.e. the compressor is operating in full vane.
40233	Maximum IGV Steps	[0...16000]	1:1	steps	R	P	CMS	The number of steps between the fully closed and fully open positions of the IGV.
41812	Skip IGV Initialization on Fault	[0…1] 0 = False 1 = True	1:1	Boolean	3	P	0	Enable this parameter to cause the compressor to skip initialization of the IGV the next time a fault occurs while the compressor is in operation.
41814	Open IGV to Start Position after Initialization	[0…1] 0 = False 1 = True	1:1	Boolean	3	P	0	Enable this parameter to cause the compressor to initialize the IGV to the start position after the reset sequence has completed.
42036	IGV Gain	[0…60000]	1:1	-	3	P	30000	The value used to determine the rate at which the IGV is adjusted. The larger the number, the smaller the adjustment increment.
42046	Minimum IGV Steps	[0...65535]	1:1	steps	3	P	0	The minimum number of steps from full close that the IGV must stay open. For example, a value of 0 indicates that the IGV can close completely while a value of 1000 indicates that the IGV must always stay open at least 1000 steps.
42061	IGV Start Position	[0...CMS]	1:1	steps	2	P	CMS	The 40030 **IGV Open Percentage**, in steps, to which the IGV will be set at motor start up.
40318	Initialize IGV to Fully Open	[0…1]	1:1	-	3	P	0	The IGV initializes the vanes upon compressor power up and after shutdown. This is performed to ensure the IGV stepper motor is always aligned with the software. Initialization is selectable to open to its full open position or close to its fully closed position. For reliability purposes, selecting the IGV to initialize to fully open is recommended. For backwards compatibility reasons, the default is 0, fully closed.

3.3 Interlock

The compressor requires closure of a hard wired contact on the interlock input on the I/O board before the compressor will operate in response to a Modbus demand signal. DTC recommends that the compressor be routinely started and stopped in response to the demand register value. Opening the interlock contact should be reserved for disabling the compressor for service or other extended time periods.

Setting demand on the compressor will have no effect with the interlock opened. Once the interlock is closed, then the compressor will respond to the demand setting.

• • • DANGER • • •

The interlock is intended to disable compressor operation, but it is not qualified as a safety device according to ANY codes or standards.

3.4 DC Bus Voltage Monitoring

DC bus voltage is constantly monitored and is stored in register 40025. If the voltage drops by more than indicated by the 42002 **Generator Mode Enabled Level** (default 15%) in less than 2 ms, then the Generator Mode Fault is triggered and the compressor enters Generator Mode. Alternatively, if the DC Bus slowly drops below the 41980 **DC Bus Under Voltage Fault Limit**, then the DC Bus Voltage Fault will be triggered.

Figure - 7 DC Bus Voltage Monitoring

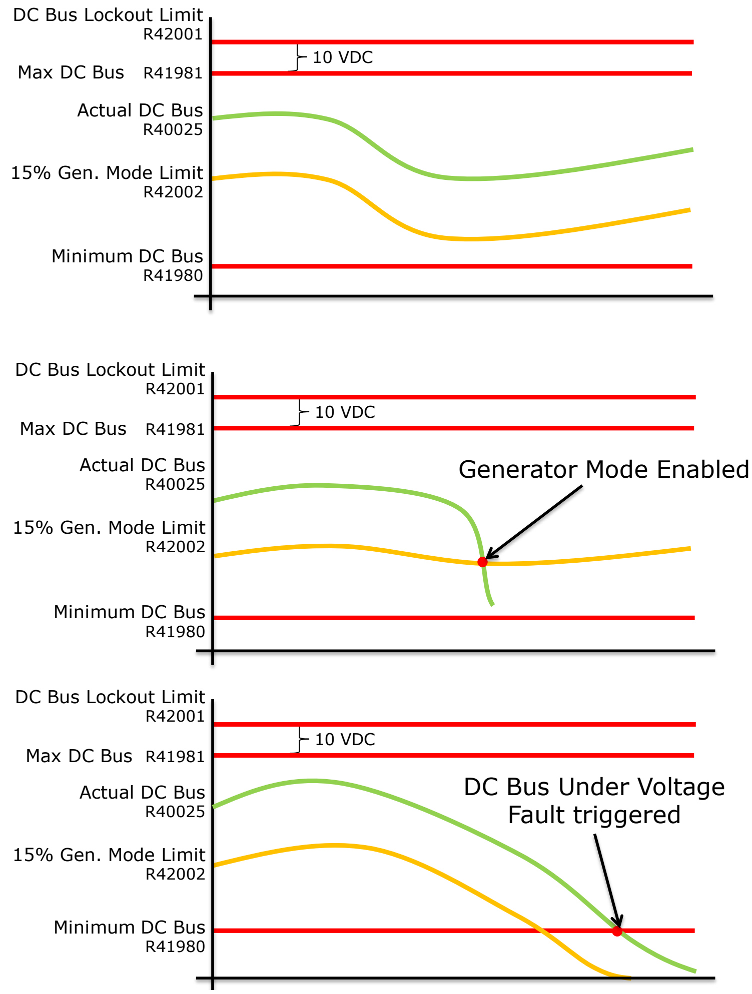


Table - 15 DC Bus Voltage Monitoring Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
41980	DC Bus Under Voltage Fault Limit	[-32768…32767]	**Note 18**	VDC	R	P	CMS	The minimum 40025 **DC Bus Voltage** below which the 40106 DC Bus Under/ Over Voltage Fault would be indicated and the motor is stopped or prevented from starting.
41981	DC Bus Over Voltage Fault Limit	[-32768…32767]	**Note 18**	VDC	4	P	CMS	The maximum 40025 **DC Bus Voltage** above which the 40106 DC Bus Overvoltage fault would be indicated and the motor is stopped or prevented from starting.
42001	Maximum DC Bus Voltage	[-32768…32767]	**Note 18**	VDC	4	P	CMS	The highest acceptable 40025 **DC Bus Voltage** above which the 40106 DC Bus Overvoltage Fault is indicated and the motor is stopped.
42002	Generator Mode Enabled Level	[-32768…32767]	**Note 7**	%	4	P	27851	Percentage of the filtered 40025 **DC Bus Voltage** below which Generator Mode Fault will be triggered
40025	DC Bus Voltage	[0...65535]	1:1	VDC	R	-	-	The DC bus voltage measured by the inverter drive module.

Chapter 4.0 Operation Modes

4.1 Start Up Mode

During Start Up, the compressor will power up and initialize the IGV. After initialization (unless set otherwise), the compressor will begin increasing speed as described below.

4.1.1 Power Up

At power on, the compressor will initialize or calibrate the IGV to fully-closed or fully-open depending on the selection of 40318 **Initialize IGV to Fully Open**. If the 41814 **Open IGV to Start Position After Initialization** is enabled, then the IGV will move to the 42061 **IGV Start Position.** Otherwise, the IGV will stop at the initialized location, until demand is given to the compressor.

However, if the compressor experienced a full power outage and entered generator mode and Fast Restart is enabled, then the compressor will restart using Fast Restart which is described later.

Setting the 40318 **IGV Initialization Selection** to fully open and setting the 42061 **IGV Start Position** to maximum IGV steps will allow the compressor to quickly ready itself to begin startup, whether or not the 41814 **Move IGV to Start Position After Reset** is enabled.

NOTE

The IGV can be initialized to fully open or fully closed by setting the 40318 **Initialize IGV to Fully Open.** Please refer to Section "3.2 Inlet Guide Vane (IGV) Parameters" on page 31 for more information.

4.1.2 Default Startup Sequence

With the IGV parameters set at their default values, the IGV will initialize to fully closed, then wait until demand is given to the compressor. After demand is applied and as long as no faults are present and the interlock is closed, then the IGV will move to the 42061 IGV Start Position. Once the IGV is about 50% open, then the speed will begin to increase and the compressor will begin the startup sequence.

Figure - 8 IGV Position During Power Up Using Default Parameters

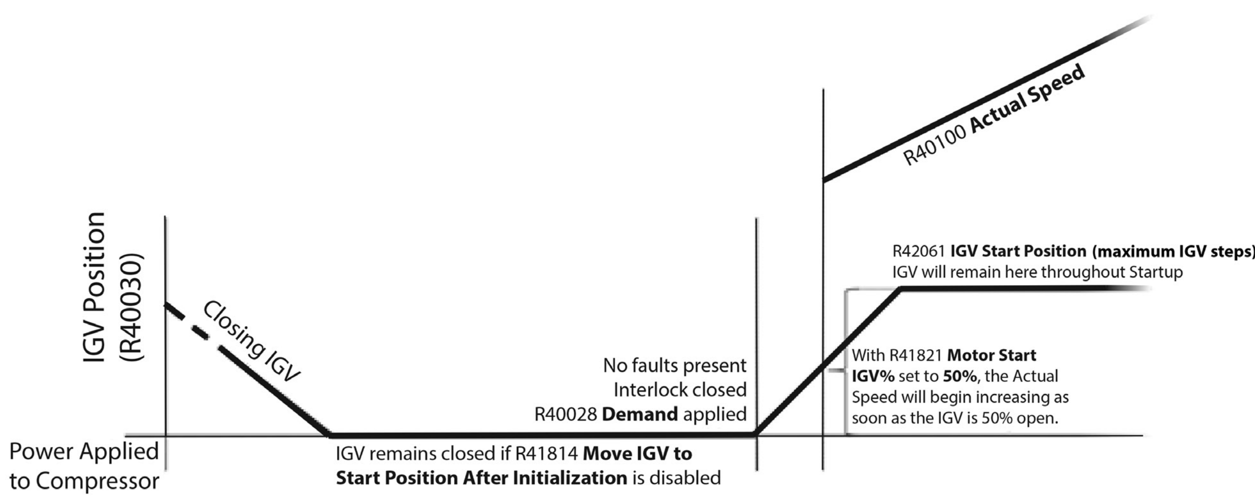


Chart not to scale.

4.1.3 Recommended Startup Sequence

Enabling the 40318 **Initialize IGV to Fully Open** and keeping the default setting for 42061 **IGV Start Position** at maximum IGV steps will allow the compressor to quickly ready itself to begin startup, whether or not the 41814 **Open IGV to Start Position After Initialization is enabled**.

Figure - 9 IGV Position During Power Up Using Recommended Parameters

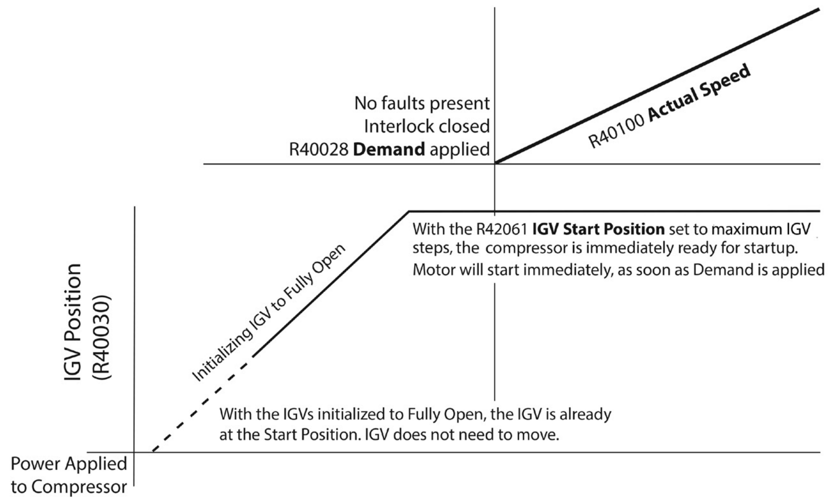


Table - 16 IGV Startup Parameters: Default Values versus Recommended Values

Register	Description	Default Value	Recommended Value
40318	Initialize IGV to Fully Open	0 (Fully Closed)	1 (Fully Open)
41814	Open IGV to Start Position After Initialization	1 (Enabled)	0 (Disabled)
42061	IGV Start Position	maximum IGV steps	maximum IGV steps

4.1.4 Ramp Up

The Motor will start when the IGV is open to greater than the 41821 **Motor Start IGV %**. If the IGV is already open to at least 42061 **IGV Start Position**, then the motor will start as soon as 40028 **Demand** is applied. As the compressor begins to ramp up, the IGV will remain at the 42061 **IGV Start Position** until the startup process is complete. Please note: if the IGV Start Position is less than the maximum of maximum IGV steps, and the 40318 **Initialize IGV to Fully Open** is enabled, then the IGV will begin to close after the initialization process is complete. The IGV will continue to close to the 42061 **IGV Start Position** and remain there until the startup process is complete.

Figure - 10 IGV Position During Start Up

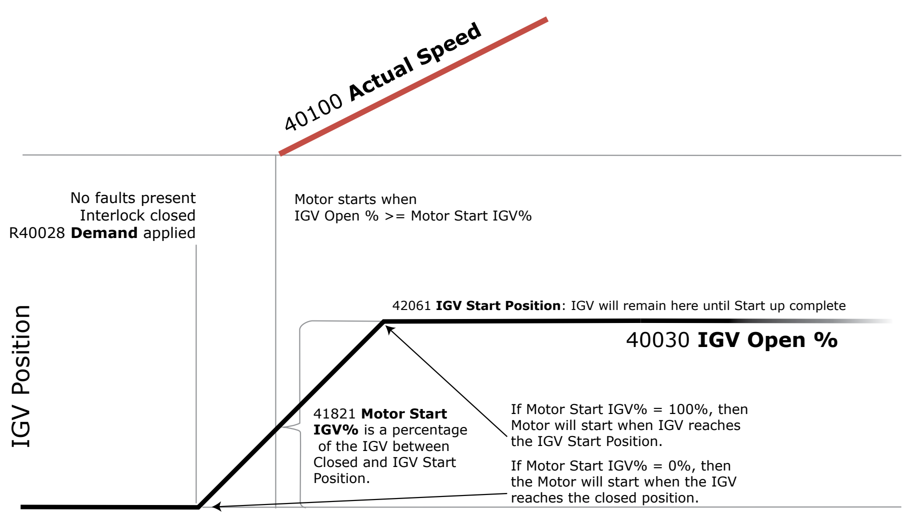


Chart not to scale. Chart is not representative of all situations.
Conditions and compressor settings vary significantly, which would alter the look of this chart.

4.1.5 Spare Pressure Input

Actual surge and choke conditions are difficult to measure until the compressor check valve is fully and consistently open. If required, an external discharge pressure sensor on the condenser side of the check valve connected to the 40048 **Spare Pressure** input on the I/O board will enable the compressor to determine the operating system surge and choke speeds whenever 40048 **Spare Pressure** is higher than 40033 **Discharge Pressure**.

4.1.6 Faults and Alarms During Start Up

During Start-up, any alarm is ignored. However, Faults are enabled with the exception of the High Suction Superheat and Suction Pressure Faults provided the 40422 **Suction Superheat Fault Delay Timer (Startup)** and the 40059 **Suction Pressure Alarm/Fault Delay** settings are configured and enabled.

4.1.7 High Suction Superheat Fault Delay

A delay of the Superheat fault prevents the fault from occurring after demand is given until the timer runs out. The timer begins when the compressor enters drive mode and begins ramping.

Table - 17 High Suction Superheat Fault Delay

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40422	Suction Superheat Fault Delay Timer (Startup)	[0…600]	1:1	Seconds	R	-	-	Shows remaining time until a **High Suction Superheat** fault will occur after startup. The timer starts when the 40100 Actual Speed has exceeded 50 RPM. After the 3 minute timer has elapsed, the temperature will be monitored. At this time, if the fault limit is exceeded the **Suction Superheat Fault** will be triggered immediately.

4.1.8 Suction Pressure Alarm/Fault Delay

The Suction Pressure Alarm/Fault Delay and Factor are used to alter when and how the faults and alarms will occur. The factor is applied to the absolute Suction Pressure. The timer begins when the compressor enters drive mode and begins ramping.

Table - 18 Suction Pressure Alarm/Fault Delay

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40058	Suction Pressure Alarm/ Fault Factor	[500...1000]	1:10	%	2	P	850	The factor used to reduce the Suction Pressure Alarm/ Fault operating points during compressor start up. Apply 40058 **Suction Pressure Alarm/Fault Factor** to absolute pressure.
40059	Suction Pressure Alarm/ Fault Delay	[0...600]	1:1	Seconds	2	P	0	The period of time during start up and operation when the 40058 **Suction Pressure Alarm/Fault Factor** will be used for temporarily adjusting the Suction Pressure Alarm/Fault Limits.

4.1.9 Start Up Complete

Start Up is complete when the following three criteria are met:

1. 40100 **Actual Speed** > 42039 **Motor Start Speed** + Minimum Start Speed Offset by Percentage, AND

2. 40100 **Actual Speed** > 40055 **Surge Speed** – 42034 **Surge Speed Offset**, AND

3. 40102 **Motor Current (Id)** > 41817 **Minimum Motor Current**.

Figure - 11 IGV Position and Compressor Speed at Completion of Start Up

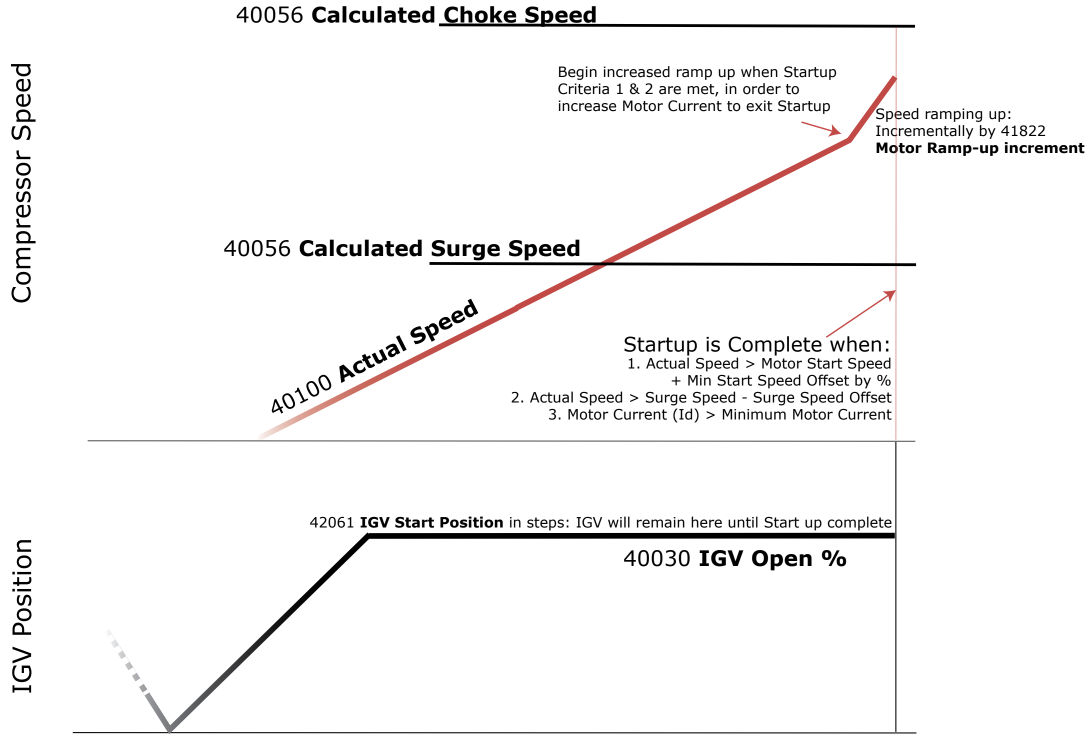


Chart not to scale. Chart is not representative of all situations.
Conditions and compressor settings vary significantly, which would alter the look of this chart.

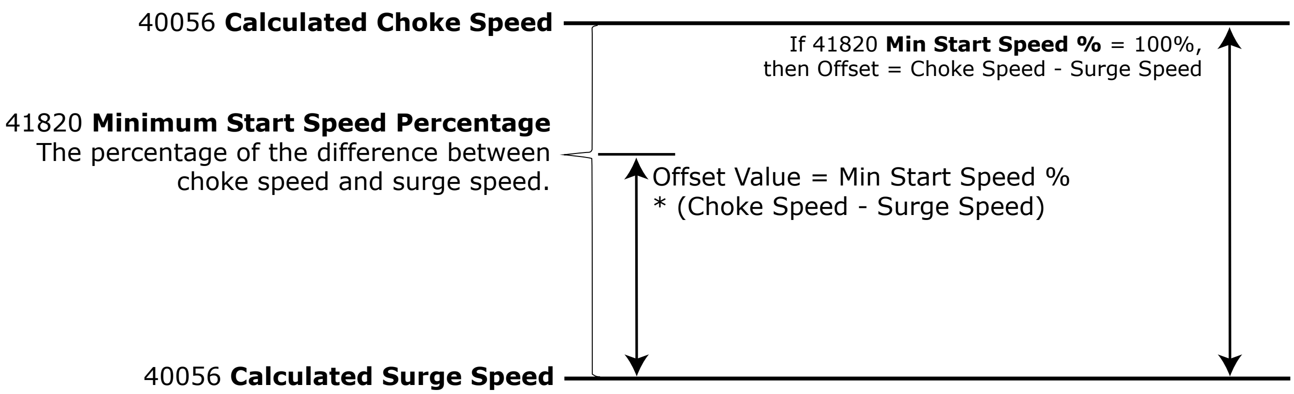
4.1.10 Start Speed Offset (Reg. 41818)

The Start Speed Offset is a direct speed value that is added to the 42039 **Motor Start Speed**. This value is used to calculate Desired Speed. DTC recommends this value not be adjusted. If adjustment is required, then significant testing should be performed to validate all potential and expected running conditions to ensure control strategy is valid and well-constructed.

4.1.11 Minimum Start Speed Offset by Percentage (Reg. 41820)

The Minimum Start Speed Offset by Percentage is the percentage of the difference between Choke Speed and Surge Speed. The percentage is set in register 41820 **Minimum Start Speed Percentage**. The offset value is then the percent of the difference between Choke Speed and Surge Speed as described in "Figure - 12 Minimum Start Speed Offset by Percentage Explained". Setting the percent to 0 will mean that the 41818 **Start Speed Offset** will be the only value added to 42039 **Motor Start Speed** to meet this criterion.

Figure - 12 Minimum Start Speed Offset by Percentage Explained



4.1.12 Compressor Start Up Parameters

During the Start Up Phase, there is a set of features available with the purpose of assisting system start up, particularly on multiple compressor installations. DTC default settings for start up are based on general requirements of a single compressor system. The Chiller Controller designer should decide the appropriate settings for their specific application. These settings should be validated by appropriate testing. There is no universal solution. These settings are application specific.

Table - 19 Compressor Start Up Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40032	Minimum Pressure Ratio	[0…10]	1:10	-	2	T	0	This register may be used to override the compressor actual operating pressure ratio (PR). By writing a value higher than the actual operating pressure ratio, the compressor will use the higher of the operating PR and the written PR as the basis to calculate the compressor operating envelope. This is useful for start up of a lag compressor on multi compressor systems and the following control regime or similar could be used. Read the highest pressure ratio of running compressors and write that value to register 40032 **Minimum Pressure Ratio** of the start up compressor. This register should be written back to 1 after startup is complete. **NOTE:** The feature will be disabled after the compressor exits the Start Up Mode.
40058	Suction Pressure Alarm/ Fault Factor	[500…1000]	1:10	%	2	P	850	The factor used to reduce the Suction Pressure Alarm/Fault operating points during compressor start up. To determine the actual operating point, convert the gauge pressure setting to absolute pressure, apply 40058 **Suction Pressure Alarm/Fault Factor**, then convert back to gauge pressure;. i.e. LP trip point with 65% factor and trip setting 20 psi gauge results in a Factor = (20 + 14.7) * .65 - 14.7.
40059	Suction Pressure Alarm/ Fault Factor Delay Timer Setting	[0…600]	1:1	Seconds	2	P	60	The period of time during start up and operation when the 40058 **Suction Pressure Alarm/Fault Factor** will be used for temporarily adjusting the Suction Pressure Alarm/Fault Limits.
40220	Start Up Pre-Cooling Configuration	[0…65283]	**Note 9**	-	2	P	0	The solenoids to open during the motor pre-cooling process and the number of seconds the solenoids should be open before the motor starts turning.
41814	Open IGV to Start Position after Initialization	[0…1] 0 = False 1 = True	1:1	Boolean	2	P	0	Enable this parameter to cause the compressor to initialize the IGV to the start position after the reset sequence has completed.
41817	Minimum Motor Current	[0…65535]	1:88	A	3	P	CMS	The minimum motor current that must be present to transition from the "Start Up Phase" to the "Mechanical Capacity Control Phase". The motor speed will keep increasing if this minimum motor current is not met.
41818	Start Speed Offset	[0…65535]	1:1	RPM	3	P	CMS	Value that is added to 42039 **Motor Start Speed** to determine the 40101 **Desired Speed** during the "Start Up Phase". This ensures that the controller does not undershoot and fail to reach the 42039 **Motor Start Speed**.
41820	Minimum Start Speed Percentage	[0…1000]	1:10	%	3	P	CMS	Minimum start speed in percentage between 40055 **Surge Speed** and 40056 **Choke Speed**. The register is used in this expression to calculate the *Minimum Start Up Speed* for the current operating conditions. **NOTE:** This is not the same as 42039 **Motor Start Speed**. *Minimum Start Up Speed* = 40055 **Surge Speed** + (41820 **Minimum Start Speed Percentage** / 1000) * (40056 **Choke Speed** - 40055 **Surge Speed)** + 41818 **Start Speed Offset**.
41821	Motor Start IGV Percentage	[0…1000]	1:10	%	3	P	0	IGV position in percentage of 42061 **IGV Start Position** when the motor will start spinning. 0% means the IGV and motor start at the same time. 100% means that the motor will first start spinning when the IGV has reached 42061 **IGV Start Position**.

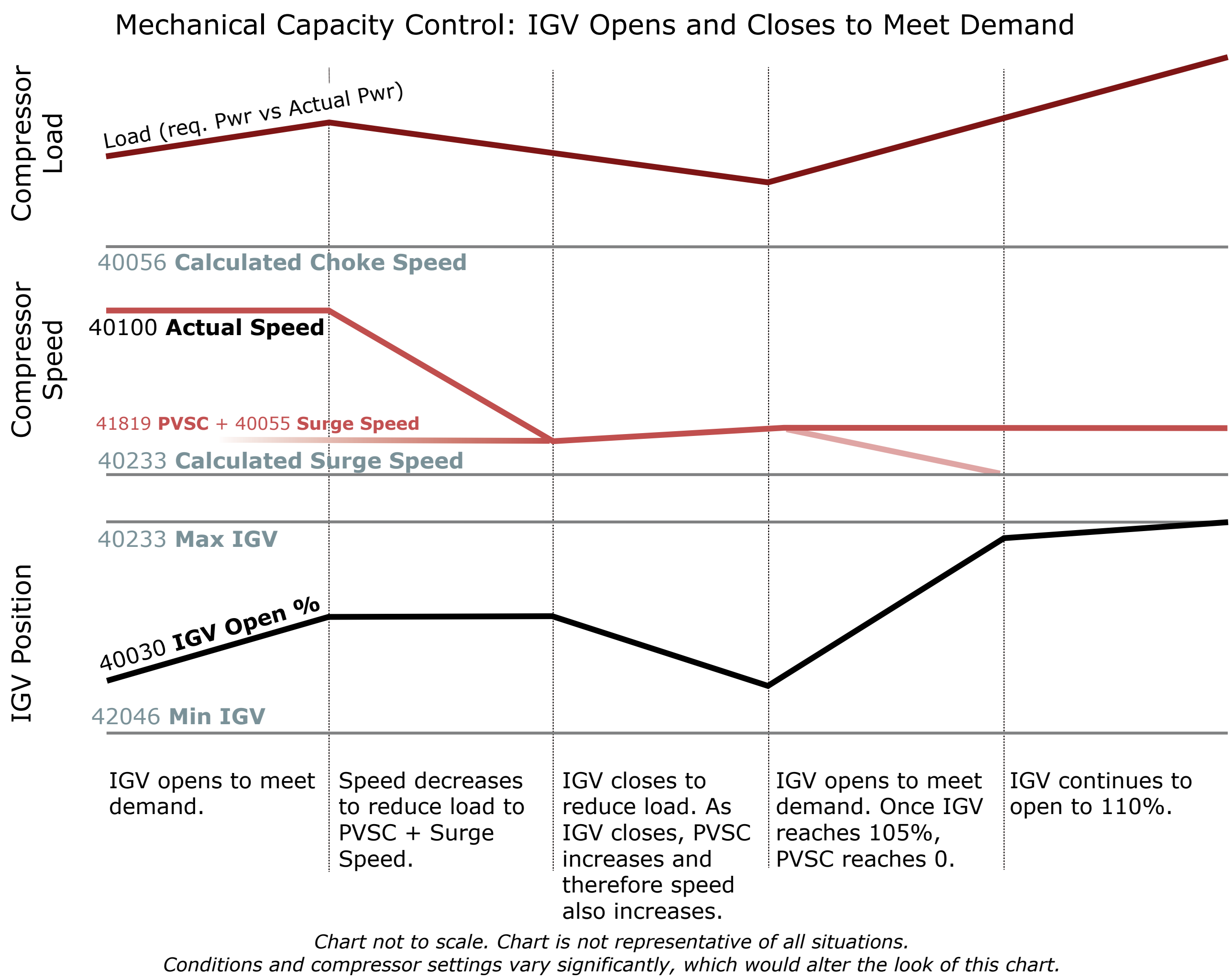
Table 19 - Compressor Start Up Parameters (Continued)

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
41822	Motor Speed Ramp-Up Increment	[0…65535]	**Note 13**	-	3	P	CMS	Speed increase in RPM's per compressor control loop iteration (~200Hz) during ramp-up acceleration in the very last period of start up after start speed is reached. The purpose of this is to ensure that the check valve is driven open and that 41817 **Minimum Motor Current** is achieved.
42039	Motor Start Speed	[0…65535]	1:1	RPM	2	P	CMS	The compressor will ramp up to this speed to exit the Start Up Phase.
42043	Max Drive Start Up Temperature	[0…65535]	1:1	°C	R	P	50	The maximum 40105 **Inverter Temperature** allowed at start up time. If this temperature is exceeded, the compressor will not start and the 40029 Above drive temperature limit - waiting to cool down status will be indicated.
42061	IGV Start Position	[0…R40233]	1:1	steps	2	P	CMS	The 40030 **IGV Open Percentage**, in steps, to which the IGV will be set at motor start up.

4.2 Mechanical Capacity Control Mode

Mechanical Capacity Control Mode is used to alter the IGV position to control the compressor as it ramps up and to keep it from entering surge. In this mode, speed and the IGV are controlled in a way that the IGV takes higher priority to meet loading demand and the speed takes higher priority to meet unloading demand. Once the IGV is fully-open, the compressor enters Speed Capacity Control Mode and is no longer in Mechanical Capacity Control Mode.

Figure - 13 Compressor Speed and IGV Position as a result of changes in Compressor Load



4.2.1 Part Vane Speed Compensation (PVSC)

41819 **Part Vane Speed Compensation (PVSC)** is inversely proportional to the IGV position (i.e. At IGV = 60%, the PVSC = 40% of Register Value) and is used to increase speed on the compressor to stay out of surge during part vane operation.

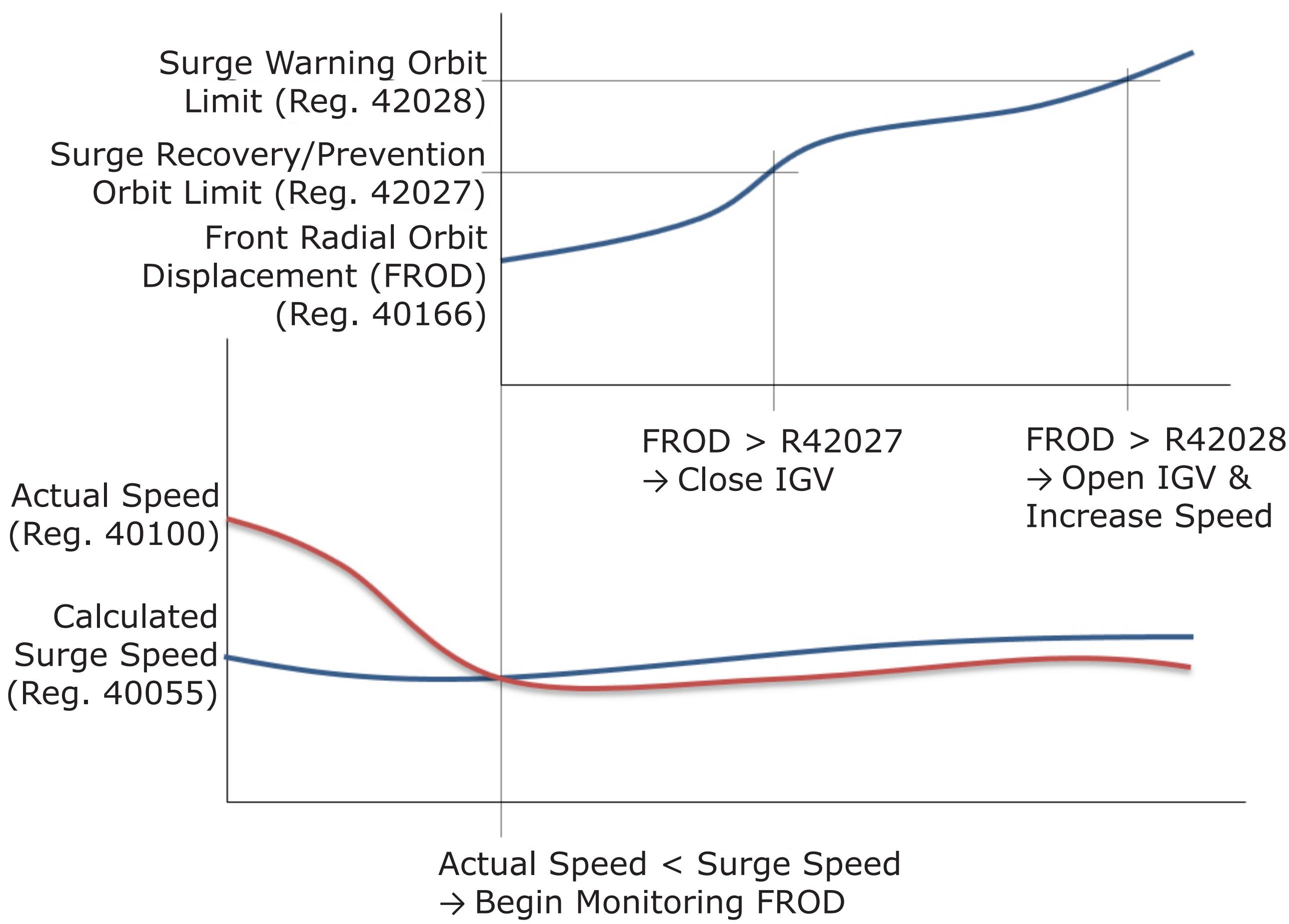
When 40021 **Requested Power** > 40104 **Actual Power**, IGV opens, 41819 **PVSC** reduces and speed does not change.

Note: Compressor loads when 40021 **Requested Power** > 40104 **Actual Power** and unloads when 40021 **Requested Power** < 40104 **Actual Power**.

4.3 Front Radial Orbit Displacement (FROD)

The compressor will attempt to avoid actual surge conditions by monitoring 40166 Front Radial Orbit Displacement (FROD) and adjusting the IGV and speed as shown in "Figure - 14 How FROD Relates to IGV". If the actual speed drops below the calculated surge speed, then the compressor will begin monitoring FROD. If the FROD increases above the 42027 Surge Recovery/Prevention Orbit Limit, then the IGV will close. If the FROD continues to intensify and eventually increases above the 42028 Surge Warning Orbit Limit, then the IGV will open and speed will increase. In this way, the compressor will attempt to avoid an actual surge condition. The compressor will speed up to a maximum of calculated choke speed until either the compressor successfully recovers or it trips on a bearing fault or a three-phase overcurrent fault.

Figure - 14 How FROD Relates to IGV



4.4 Speed Capacity Control Mode

Speed Capacity Control Mode is the normal operating mode of the compressor and is used to alter the speed to meet demand. As the demand increases and decreases, the compressor will speed up and slowdown in response. If the compressor attempts to slow to below to the 40055 **Calculated Surge Speed**, then Mechanical Capacity Control Mode will take over to recover from surge.

Figure - 15 Speed Capacity Control Mode and Mechanical Capacity Control Mode During Normal Operation

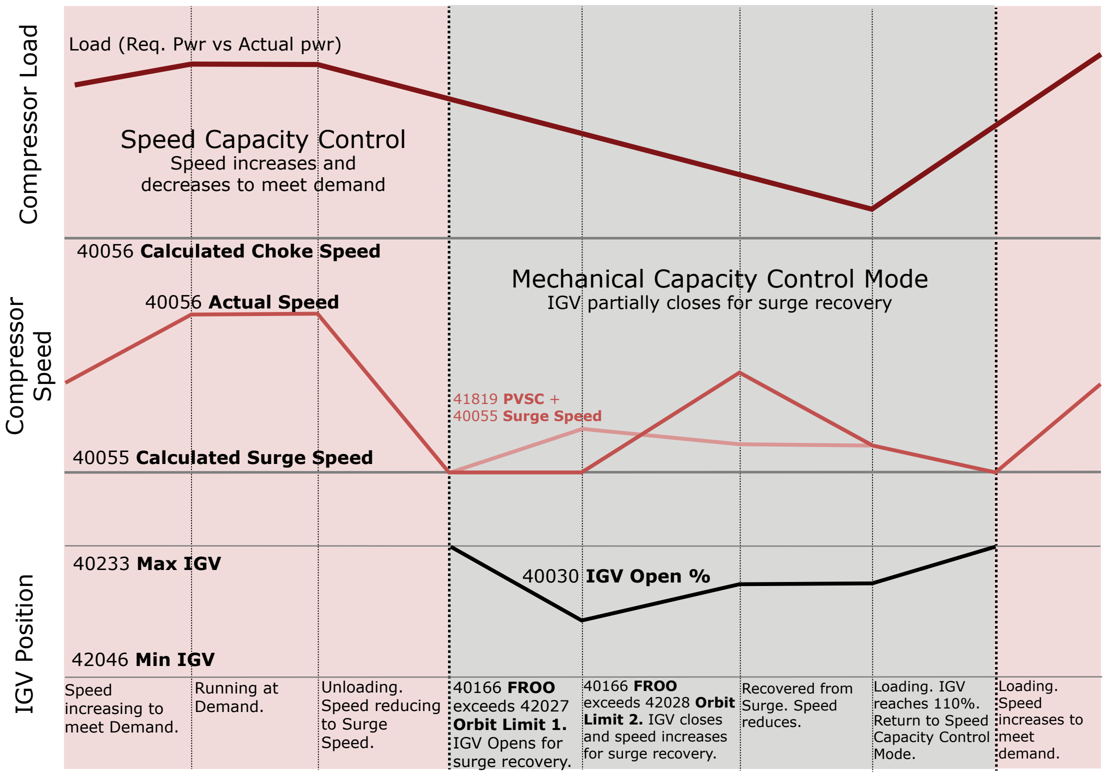


Chart not to scale. Chart is not representative of all situations.
Conditions and compressor settings vary significantly, which would alter the look of this chart.

4.4.1 Relationship Between Pressure Ratio and Loading

The 40021 **Requested Power (kW)** is calculated using the flange to flange pressure ratio and the 40028 **Demand** setting. Changes in 40028 **Demand** or pressure ratio will change the 40021 **Requested Power**. Changes in 40021 **Requested Power** will cause the 40100 **Actual Speed** and/or 40030 **IGV Open Percentage** to be changed to match 40104 **Actual Power** with 40021 **Requested Power**.

At certain points during operation, the demand may be lowered so that 40021 **Requested Power** is less than 40104 **Actual Power**, but the 40030 **IGV Open Percentage**, 40100 **Actual Speed** and kW input of the compressor will not decrease because it has reached the minimum unloading point for that pressure ratio. The only way to reduce the capacity from that point is to lower the pressure ratio. The compressor will maintain 42037 **Motor Minimum Speed** and Minimum IGV Position to prevent surge.

4.4.2 Minimum and Maximum Speed

The 42037 **Motor Minimum Speed** is the absolute minimum speed that the compressor will run. If 40055 **Calculated Surge Speed** is below 42037 **Motor Minimum Speed**, the compressor will still run at or above 42037 **Motor Minimum Speed**. The absolute maximum speed for a particular compressor model is 42037 **Motor Minimum Speed** + 42038 **Motor Speed Range**. The maximum speed of the compressor is always the lesser of the 40056 **Choke Speed** and this absolute maximum speed.

4.4.3 Calculated Surge and Choke Speed Vary

The minimum IGV Position, 40055 **Surge Speed** and 40056 **Choke Speed** are calculated values that are adjusted continuously during compressor operation according to the running conditions.

4.4.4 Low Suction Pressure Alarm/Fault Delay

To delay action on the 40026 **Suction Pressure** fault and 40027 **Suction Pressure** alarm during normal operation, the user must write a time greater than zero to 40326 **Low Suction Pressure Alarm/Fault Delay Timer Setting** before the fault limit is exceeded. Once the condition that triggers a 40026 **Suction Pressure** alarm/fault occurs, the BMCC will count down to zero from the value in register 40326 **Low Suction Pressure Alarm/Fault Delay Timer Setting**. The current count value can be read in register 40325 **Low Suction Pressure Alarm/Fault Delay Timer**. Once the register 40325 **Low Suction Pressure Alarm/Fault Delay Timer** reaches zero and the alarm/fault condition still exists, the appropriate alarm/fault action will occur. A value of zero in register 40326 **Low Suction Pressure Alarm/Fault Delay Timer Setting** disables the delay.

The countdown resets when the suction pressure rises above the alarm level. If the suction pressure exceeds the 40058 **Suction Pressure Alarm/Fault Factor**, the fault will be triggered and the compressor will shut down.

4.4.5 Compressor Capacity Control Parameters

This section defines the parameters which configure the Compressor Capacity Control algorithm.

Table - 20 Compressor Capacity Control Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40250	Demand Control Integral Gain	[0...32000]	1:100000	-	2	P	10	The gain of the integral component of the Demand Control loop.
41819	Part Vane Speed Compensation	[0...65535]	1:1	RPM	3	P	CMS	Surge speed compensation added at 0% IGV. The compensation is linear with maximum RPM added at 0% IGV and 0 RPM added at 105% IGV. From 105% to 110% IGV, 0 RPM is added.
42027	Surge Recovery/ Prevention Orbit Limit	[0...400]	1:1	-	3	P	CMS	The maximum amount of 40166 **Front Radial Orbit Displacement (FROD)** allowed before the compressor attempts to recover from or prevent surge by closing the IGV. See "Mechanical Capacity Control Phase" for more information. Default Values: TT300/TT350/TT400/TG230/TG310/ TG390: 50 TT700/TG520: 800
42028	Surge Warning Orbit Limit	[0...400]	1:1	-	3	P	CMS	The maximum amount of 40166 **Front Radial Orbit Displacement (FROD)** allowed before the compressor actively prevents surging by speeding up and opening the IGV. See "Mechanical Capacity Control Phase" for more information. Default Values: TT300/TT350/TT400/TG230/TG310/ TG390: 75 TT700/TG520: 1200
42033	Part-Vane Speed Gain	[0...65535]	1:1	-	3	P	CMS	The rate of acceleration is the inverse of the value set in this register (e.g. Value of 1 is 20 RPM/s per iteration; Value of 100 is 0.2 RPM/s per iteration.)
42034	Surge Speed Offset	[-5000… 5000]	1:1	RPM	3	P	1	The offset of the surge line used for compressor control.

4.5 Fast Restart

The Fast Restart feature provides a method to reduce the time required by the compressor to return to an operational state due to a mains power failure while the compressor is running. A normal startup sequence may take up to two minutes. With the Fast Restart feature, the startup time can be reduced to less than 40 seconds.

NOTE

The compressor may require up to 30 seconds to delevitate the shaft and all writes to the compressor, including writes to demand and EXV control will be ignored. During this time, the compressor control status (reg. 40029) will show the IGV/EXV Reset Status flag enabled (0x0040). Once the compressor is ready for writes again, the compressor control status will show with Faults Detected and ready to be cleared (0x2000).

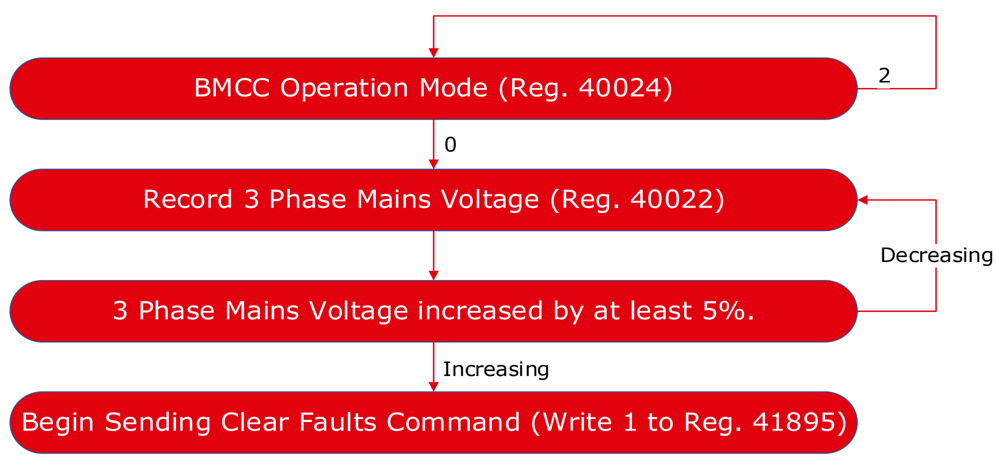
The Fast Restart is supported in Modbus Network Control Mode and Analog Mode. The Fast Restart feature is enabled by default but can be disabled by writing a value of 0 to register 41813 **Fast Restart Enabled**.

4.5.1 Stepper Fast Restart

With the 4.2 firmware release, the option has been added to allow the Stepper driver to follow the Fast Restart procedure as well. If the Fast Restart Electronic Expansion Valve (EXV) on Power Interrupt (reg. 40319) has been enabled, then the current Stepper positions for each driver will be stored to EEPROM during a power outage and then written back to the actual position once power is restored.

If a Generator Mode Fault or a DC Bus Under/Over Voltage Fault occurs[1], the chiller controller should check the 40024 **Shaft Levitation Status** to wait for the shaft to delevitate[2]. After the shaft is delevitated, then check every second for the 3 Phase Mains Voltage to increase by at least 5%.

Figure - 16 Control Strategy for Power Outages



4.5.2 Short Power Outage

During a Short Power Outage, less than approximately 30 seconds, the compressor BMCC never actually fully loses power. This can be witnessed by watching the lights on the backplane. If the lights never turn off, then the BMCC will not have lost full power. The compressor may require up to 30 seconds to delevitate the shaft and all writes to the compressor, including writes to demand and EXV control will be ignored. During this time, the compressor control status (reg. 40029) will show the IGV/EXV Reset Status flag enabled (0x0040). Once the shaft has delevitated, then the compressor control status will show the compressor is in Fault (0x2000) with the Generator Mode Fault enabled (reg. 40106 0x2000).

1 BMC Fault (Reg. 40106) indicates the current state of the Bearing and Motor Controller. If this register is greater than 0, then the 40026 Bearing/Motor Controller Fault is indicated. Generator Mode Fault is indicated by bit 13 (0x2000). DC Bus Under/Over Voltage Fault is indicated by bit 9 (0x0200).

2 Shaft Levitation Status (Reg. 40024) indicates the current operational status of the Bearing and Motor Controller system: 0 (Standby); 1 (Levitate); 2 (Drive); 3 (Calibrate). A value of 0 indicates the shaft is delevitated.

After the shaft has delevitated (BMC Operation Mode reg. 40106 shows value of 0) and DC Bus or 3 Phase Current has increased by more than 5%, the faults can then be cleared by sending a 1 to register 41985. At this point, the compressor will reset and demand can be set, the compressor will then begin ramping.

4.5.3 Extended Power Outage

If an extended power outage occurs while the compressor is running, then the Generator Mode Fault will be activated and the compressor will restart using the Fast Restart procedure. However, if the Generator Mode Fault is reset prior to the BMCC fully losing power, then the last known IGV position will not be stored and the compressor will follow a Normal Power On sequence when power is restored. The last known IGV position must be stored to register 40203 prior to the BMCC fully losing power, in order for the compressor to follow the Fast Restart procedure when power is restored.

4.5.4 Troubleshooting

If IGV moves at all prior to the compressor ramping up, then the Fast Restart procedure is not being followed. If this occurs, then verify that:

1. Fast Restart is enabled.

2. The Interlock was closed during the entire power outage.

3. Demand was not set to 0 during the entire power outage.

4. If a "Brown Out" or quick power drop occurs (approximately less than 30 seconds), then the Fast Restart algorithm will not actually be used. In this case, the 41812 Skip IGV Initialization on Fault must be enabled in order to ensure the IGVs do not reset.

5. To verify the Fast Restart procedure is working properly, monitor register 40203 Fast Restart IGV Position.

a. This register should not be set back to 0 until after voltage has been restored and the compressor begins its powering up sequence.

b. The controller should wait until the shaft is delevitated and the voltage has been restored before sending the "Clear Faults" command.

Table - 21 Fast Restart Related Registers

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40024	Shaft Levitation Status	[0...3]	1:1	-	R	-	-	Indicates the current operational status of the BMC control system: **0** *(Standby)*; **1** *(Levitate)*; **2** *(Drive)*; **3** *(Calibrate)*
40106	BMC System State	[0x0000… 0xFFFF]	1:1	FW	R	-	-	Indicates the current state of the Bearing and Motor Controller. If this register is greater than 0, then the 40026 **Bearing/Motor Controller Fault** is indicated. See "Table - 35 Compressor Cooling Parameters" on page 67 for more information on interpreting this register.
40203	Fast Restart IGV Position	[0...R40233]	1:1	Steps	R	P	0	Stores the actual position of the IGV when a power interruption occurs while the compressor is running.
40319	Fast Restart EXV on Power Interrupt	[0…1]	1:1	-	3	P	0	If this feature is enabled, then when there is a power outage, the BMCC will store the last known Stepper position of both Steppers and rewrite to the actual position once power has been restored.
40320	Fast Restart EXV 1 Stored Actual Position	[0... R40235]	1:1	Steps	R	P	0	Stores the actual position of the EXV 1 when a power interruption occurs while the compressor is running.
40321	Fast Restart EXV 2 Stored Actual Position	[0... R40237]	1:1	Steps	R	P	0	Stores the actual position of the EXV 2 when a power interruption occurs while the compressor is running.
41813	Fast Restart IGV on power interruption	[0…1] 0 = False 1 = True	1:1	Boolean	3	P	1	When there is a power failure and this feature is enabled, the BMCC will store the last known IGV position and restore on the next power up for a Fast Restart sequence.
41895	Clear Faults	[0…1]	1:1	FW	1	T	-	Once the condition(s) that caused fault(s) to be triggered has been cleared, then writing 1 to this register clears the faults.

Chapter 5.0 High Lift Operation

With the Danfoss Turbocor High Lift Compressor (TTH/TGH models), two additional parameters will be monitored: Interstage Temperature and Pressure. Additionally, the SCR temperature will not be monitored. Any relevant alarms and faults related to SCR temperature will be disabled.

Table - 22 High Lift Operation Status

Reg.#	Register Name	Detailed Description
40313	Interstage Temperature	Interstage temperature reading. Scaled the same as Suction or Discharge temperature. Applies only for High Lift Compressor Models.
40314	Interstage Pressure	Interstage pressure reading. Scaled the same as Suction or Discharge pressure. Applies only to High Lift Compressor Models.

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Chapter 6.0 Low Lift Operation

If the compressor is expected to operate in the Low Lift area of the compressor map, then a refrigerant pump should be installed in the subcooled liquid refrigerant motor/inverter cooling supply line to ensure adequate motor and drive cooling is supplied during low pressure ratio conditions. The OEM control system should run the pump whenever the pressure ratio is 1.5 or less. The Low Lift configuration is only available in firmware version 4.1.0 or later.

6.1 Configuring Compressor

The specific configuration related to where on the map the compressor is expected to operate can be selected by changing the value in register 40531. The default value is 0 or Standard Lift. To select Low Lift, enter 1 in this register. Recall that in order to ensure this value is always configured and is set to EEPROM, be sure to set this value through the SMT. Please refer to the *SMT Manual* for more information on how to properly configure the compressor.

6.2 Maximum Capacity

Maximum Capacity of the compressor will be determined by the configuration. If the compressor is configured to operate in the Low Lift portion of the compressor map, then the compressor's maximum capacity will be determined by the true choke limit. If the compressor is configured for Standard Lift and is, therefore, not configured for Low Lift, then the compressor will operate at the maximum Standard Lift operation to avoid overheating the motor or inverter.

6.3 Temperature Monitoring

The compressor will monitor all temperatures regardless of the configuration of the compressor. If the cavity, inverter or Silicon Controlled Rectifier (SCR) temperatures rise to an unacceptable level, the compressor will alarm and subsequently fault whether or not the compressor is configured as a Low Lift compressor. For more information on Temperature Monitoring, please see the next section.

Table - 23 Enable Low Lift Configuration

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40531	Enable Low Lift Configuration	[0…1]	1:1	Boolean	3	P	0	If value is "0", the compressor will be configured for Standard Lift (default). If value is "1", the compressor will be configured for Low Lift.

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Chapter 7.0 Inverter, Cavity and SCR Temperature Monitoring

Temperatures in the compressor are monitored from startup and throughout all runtime.

7.1 Cooling and Temperature Monitoring during Startup

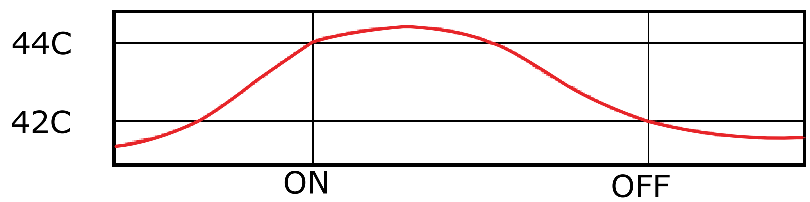
Passive Startup Cooling Mode (Default)

Passive Startup Cooling mode is continuous cooling of both the Motor and Inverter during startup, regardless of cavity or inverter temperature. This is the default standard cooling mode during startup.

Dynamic Startup Cooling Mode

Dynamic Startup Cooling mode is cooling on demand. This mode is the same cooling that is provided during normal operation. If the stator temperature or the inverter temperature rises above 44C, the cooling solenoid will open to provide cooling to that component. Once the temperature then lowers to below 42C, then the cooling solenoid will close. In this way, cooling is only provided when the temperature of the component requires extra cooling. This mode can be enabled during startup in firmware 4.2 by disabling the Passive Startup Cooling.

Figure - 17 Startup Cooling



Temperature Monitoring during Startup

Beginning with startup and continuing for 15 minutes, the alarm and fault limits are slightly higher than during normal operation. This 15-minute Startup Fault Timer is shown in the Example 1 graph in "Figure - 19 Operational Alarm and Fault Triggering" on page 51.

7.2 Cooling and Temperature Monitoring during Normal Operation

Cooling during Normal Operation

After the 15-minute Startup Fault Timer has expired, Dynamic Cooling Mode is used during normal operation, regardless of the cooling mode during startup.

Operational Temperature Monitoring

Once the 15-minute Startup Fault Timer has expired, Operational Temperature Monitoring of the Inverter, Cavity and SCR will begin. At this time, the fault and alarm limits will lower to the Operational Fault and Alarm Limits. If any of the component temperatures rise above the alarm, then the alarm will be immediately triggered. If the component temperature continues to rise above the fault, then the fault will be triggered. This temperature monitoring is described in "7.3 Example 1: Operational Temperature Monitoring" on page 51.

Cooling Control Temperature Monitoring

Additionally, a delay timer of 3 hours will begin at startup and control of cooling will be monitored once that timer has expired. This delay is referenced in the graph below as Motor/Inverter Cooling Control Monitoring Delay after Startup. If the monitored temperature rises above the Fault Limit, then a Fault Delay timer is started. This is shown in the Example 2 graph in "Figure - 20 Persistent Lack of Cooling" on page 52. The Alarm will be triggered 15 seconds after the temperature rises above the limit. The compressor will attempt to reduce the cavity and/or inverter temperature(s) by reducing motor speed while the alarm is flagged. If the temperature remains above the limit for the entire 15-minute timer, then the Fault will be triggered.

Monitoring for cooling control is not necessary for the SCR. The SCR temperature is only monitored during startup and normal operation.

Startup and Operational Temperature monitoring was implemented with 4.0.0. Monitoring for cooling control was implemented with 4.1.0. Refer to "Table - 24 Inverter, Cavity, and SCR Temperature Monitoring (registers added in 4.0.0 firmware)" and "Table - 25 Motor (Cavity)/Inverter Cooling Control Monitoring (registers added in 4.1.0 firmware)".

Figure - 18 Temperature Monitoring: Startup through Operation

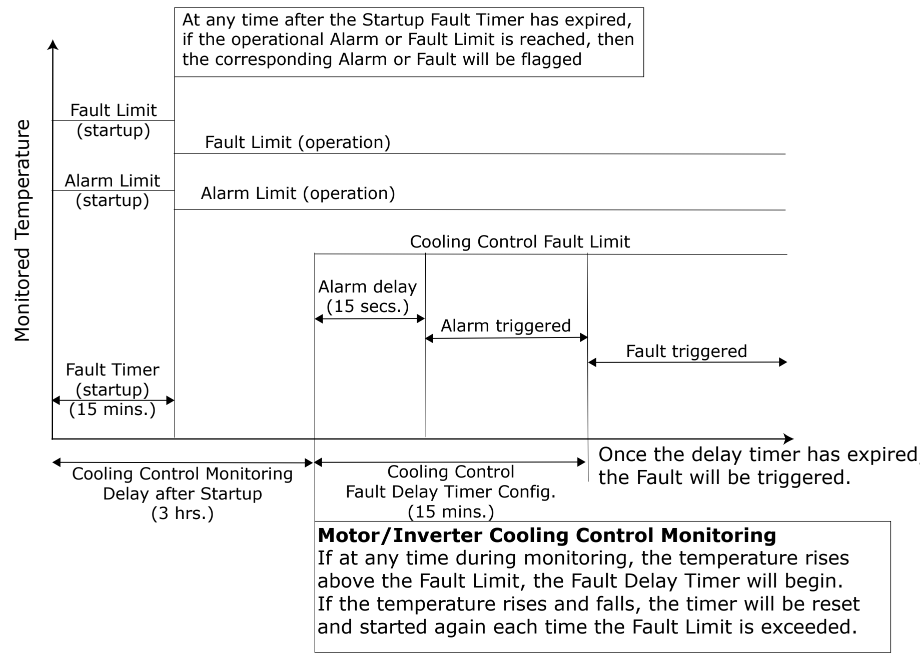


Table - 24 Inverter, Cavity, and SCR Temperature Monitoring (registers added in 4.0.0 firmware)

		Startup				Operational	
		Alarm Limit (C)	Fault Limit (C)	Fault Timer (mins) Config.	Fault Timer (mins) Remaining	Alarm Limit (C)	Fault Limit (C)
SCR	Register	R40435	R40434	R40432	R40433	R42041	R42042
	Default	70	75	15	-	65	70
Inverter	Register	R40439	R40438	R40436	R40437	R40224	R40242
	Default	70	75	15	-	65	70
Cavity	Register	R40443	R40442	R40440	R40441	R40227	R40245
	Default	80	85	15	-	75	80

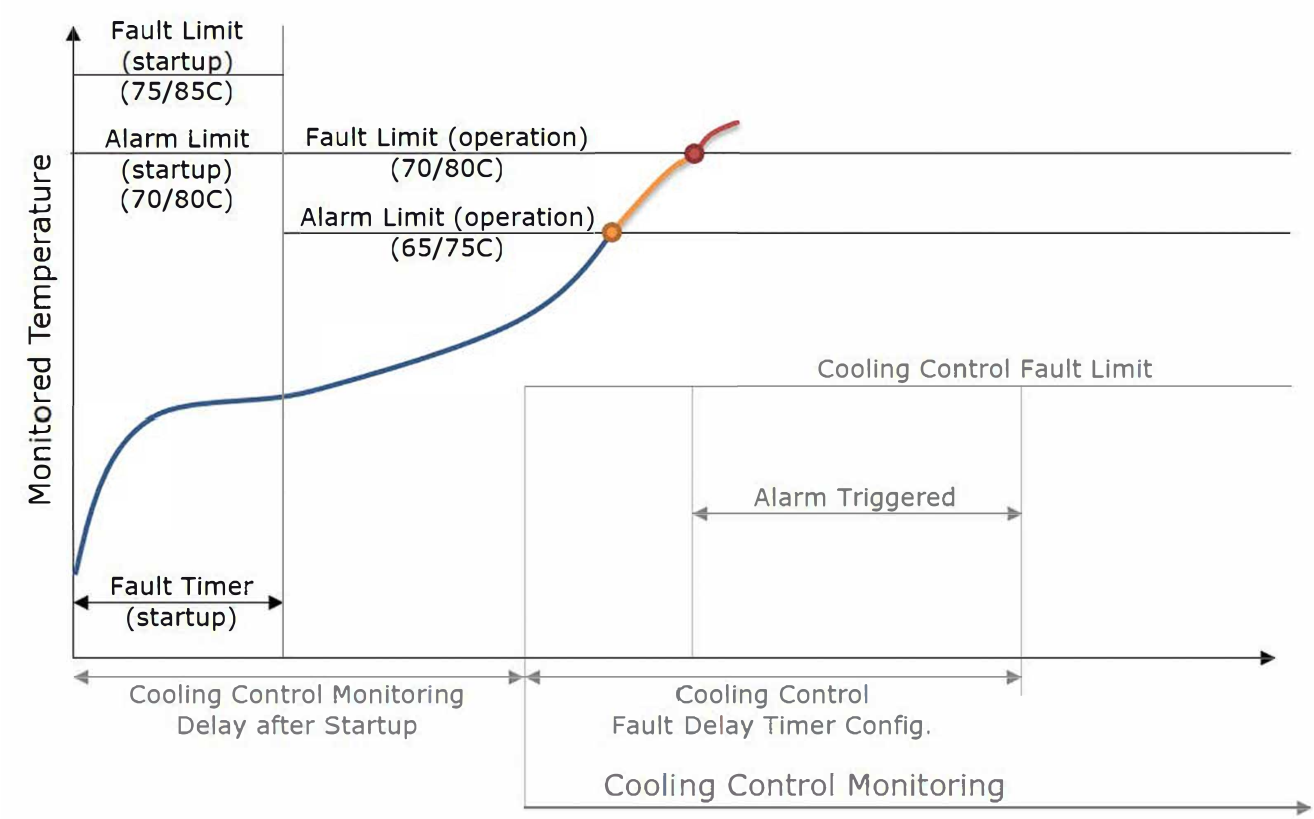
Table - 25 Motor (Cavity)/Inverter Cooling Control Monitoring (registers added in 4.1.0 firmware)

		Cooling Control					
		Monitoring Delay after Startup (mins)		Fault Delay Timer (mins)		Alarm Triggering Timer Config. (mins)	Fault Limit (C)
		Config.	Remaining	Config.	Remaining		
Inverter	Register	R40355	R40356	R40352	R40353	R40354	R40351
	Default	180	-	15	-	14 mins. 45 secs.	55
Motor Cavity	Register	R40349	R40350	R40346	R40347	R40348	R40345
	Default	180	-	15	-	14 mins. 45 secs.	55

7.3 Example 1: Operational Temperature Monitoring

After the Startup Fault Timer expires, the Operational Alarm and Fault Limits apply to Inverter, Cavity and SCR Temperature Monitoring. If any one of these temperatures rise above the corresponding alarm limit, then the alarm will trigger and the motor will slow down in order to attempt to reduce the temperature and avoid the fault. If the temperature continues to rise and reaches the Fault Limit, then the corresponding fault will trigger and the compressor will shut down.

Figure - 19 Operational Alarm and Fault Triggering



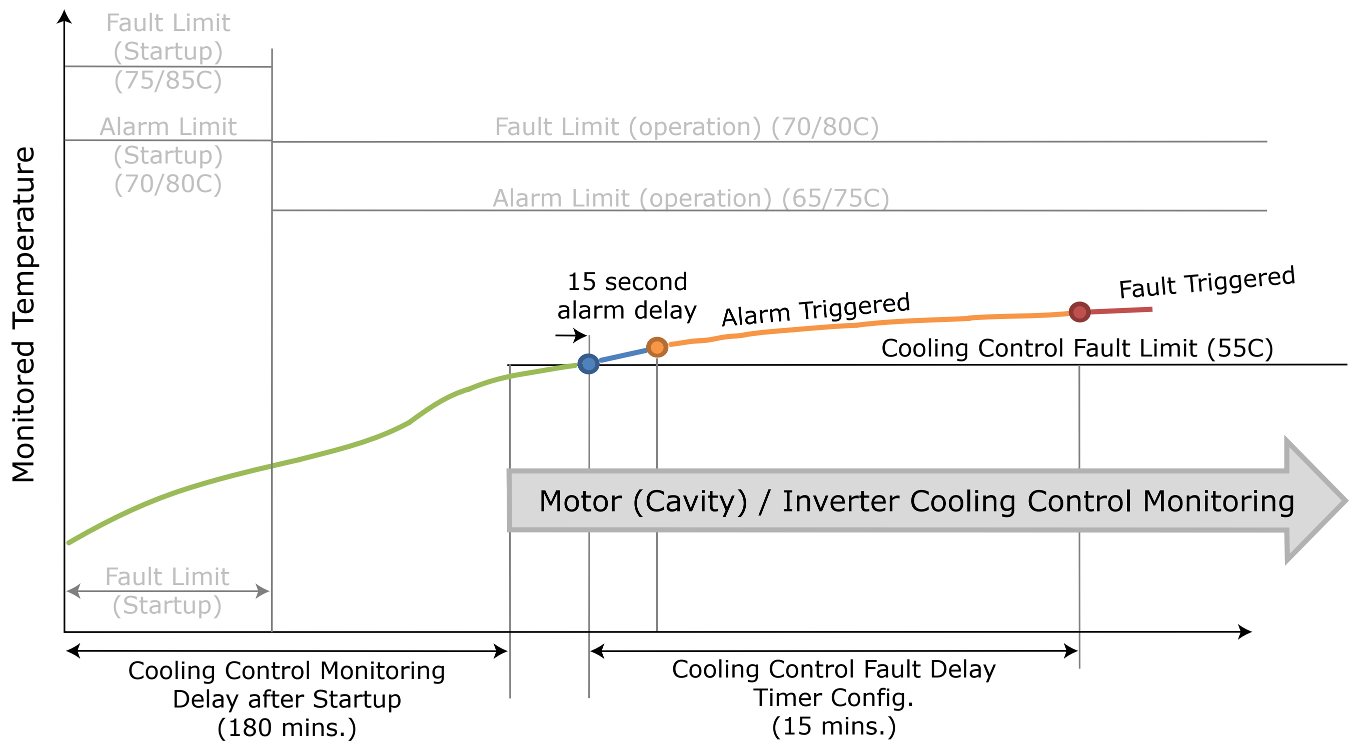
7.4 Example 2: Persistent Lack of Cooling

Once the Cooling Control Monitoring Delay after Startup timer expires, the Inverter and Cavity temperatures will be monitored for Cooling Control. If the Inverter or Cavity temperatures rise above the Cooling Control Fault Limit, then the Fault Delay Timer will begin.

The Alarm will be triggered 15 seconds after the temperature rises above the limit. Once the alarm is triggered, the motor will slow down in order to attempt to reduce the temperature and avoid the fault. If the temperature remains above the limit for the entire 15 minute timer, then the Fault will be triggered.

If at any time while the timer is counting down, the temperature lowers to under the Fault Limit, then timer will be reset. The timer will start over if the temperature rises back above the Fault Limit.

Figure - 20 Persistent Lack of Cooling



Chapter 8.0 Recommended Control Strategy

8.1 Compressor Startup

When staging a compressor, the sequence and timing must be properly coordinated to avoid surge and ensure a proper start. Surging will cause the check valve to flutter, which will cause undue stress on the shaft and may reduce the life expectancy of the compressor. Any control strategy must be well-tested in a controlled environment to ensure the timing and controls are correct for the given requirements. The following suggested startup algorithms should provide a starting point for any control strategy.

Figure - 21 How to Startup a Single/Lead or Lag Compressor

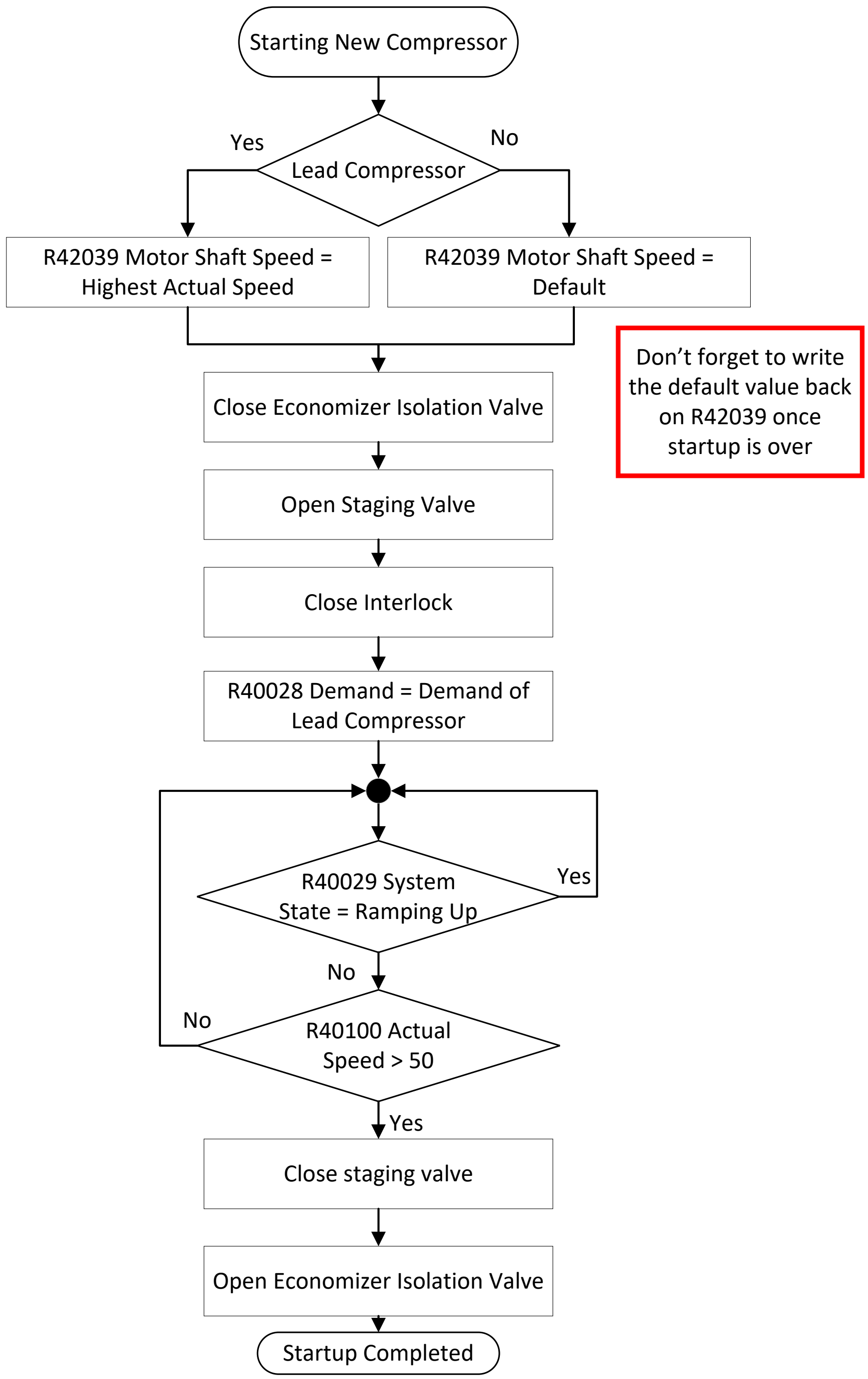


Figure - 22 When to Stage on the Next Compressor

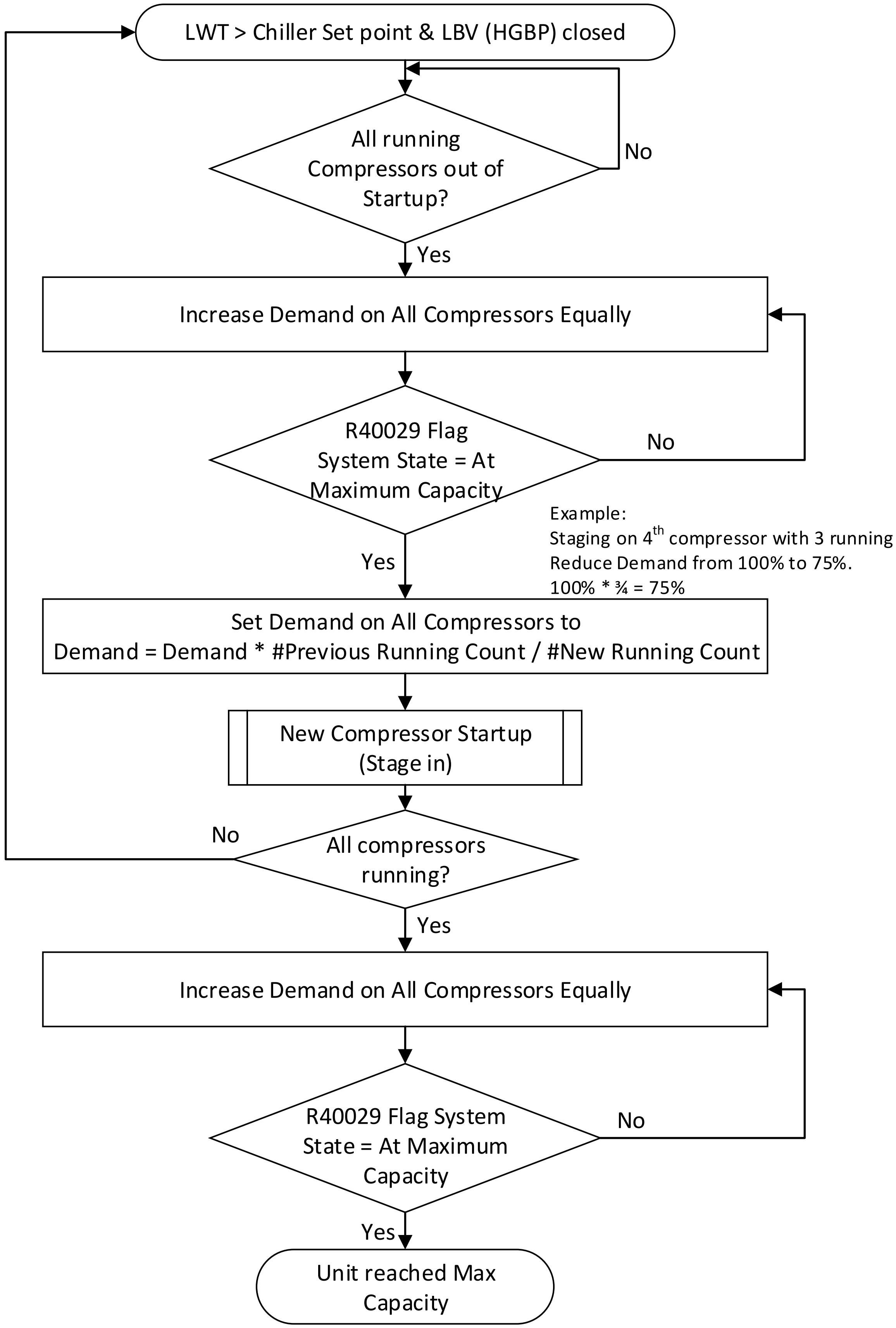
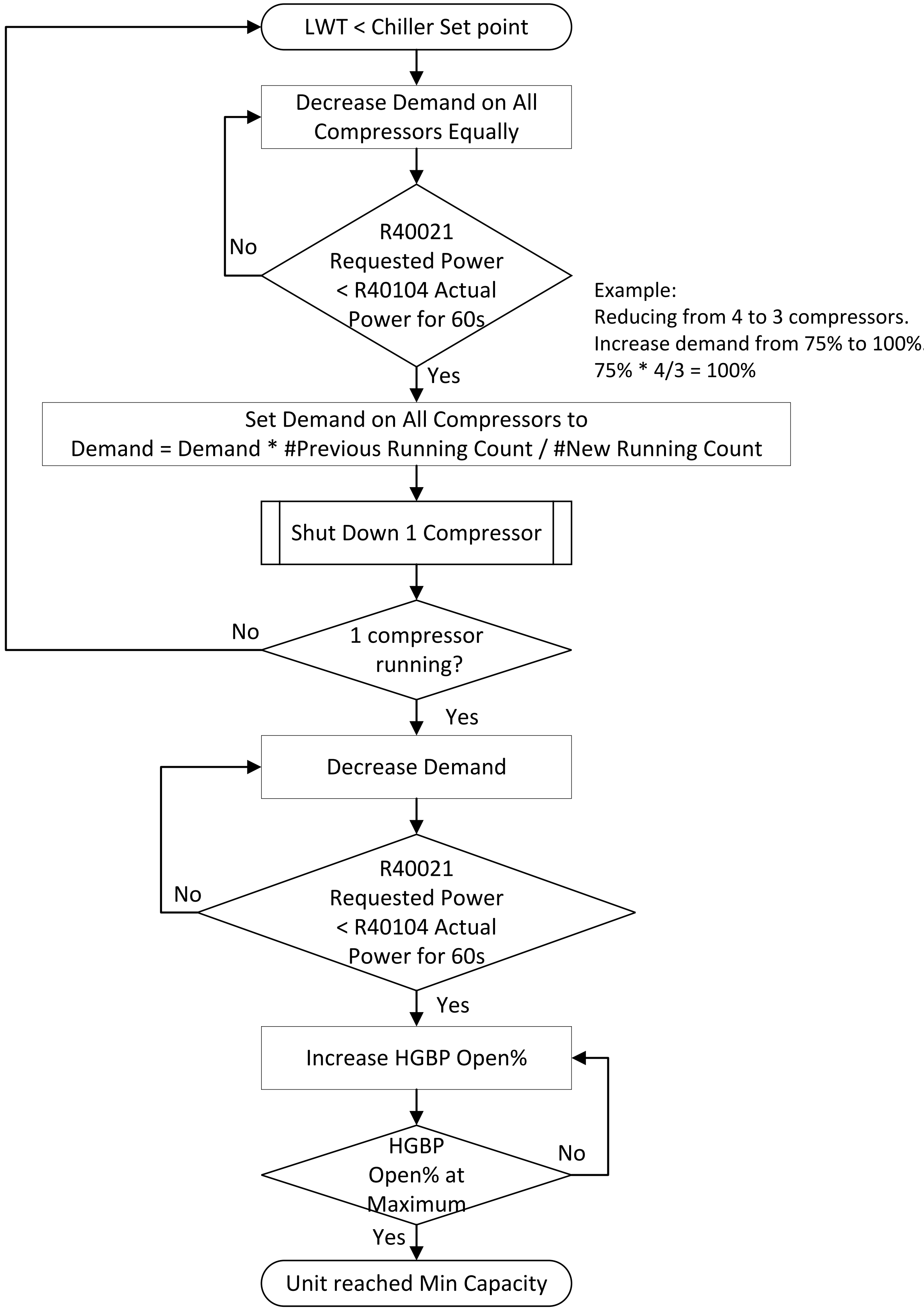


Figure - 23 When to Shut Down a Compressor



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Chapter 9.0 Stepper Motor Control Mechanism

The compressor has the ability to independently modulate up to two external Bipolar Stepper motors for Expansion Valve (EXV), Load Balance Valve (LBV) or Staging Valve (SV) control. This section describes the implementation, configuration and use of this functionality. The **Stepper Max Steps** (register 40235 or 40237) sets the effective operational range. The **Stepper Position Command** (40063 or 40072) is a percentage of the **Stepper Max Steps** (register 40235 or 40237). Therefore, 0% should be fully closed and 100% should be fully open. The number of steps from fully closed to fully open is the **Stepper Max Steps** (register 40235 or 40237)

NOTE

For LBV and SV setup, please refer to the section on Control Logic Guidelines for Multiple Compressors in the *Applications and Installation Manual.*

9.1 Stepper Selection and Timing

Please refer to the *Applications and Installation Manual* for more information on voltage and current requirements to select the proper valve. Selecting a valve that does not conform to these requirements can cause the valve to skip steps and not properly reset fully. With firmware 4.0, the stepper controls were adjusted slightly to allow for faster resetting of the IGVs. With this change two new registers were added to indicate the speed at which the steppers will be driven. Register 40259 is the Stepper Speed during Normal Operation. This is a high-level register with default of 81 (or 89 Hz) and should not require any adjustment. Register 40240 is the Stepper Speed during Reset. With the 4.2 firmware release, this will be an OEM adjustable register. The register values and corresponding speed are shown in "Table - 26 Stepper Speed".

Table - 26 Stepper Speed

Frequency	Current Consumption	Register Value
~89 Hz	~190 mA	81
~178 Hz	~ 110 mA	36
~243 Hz	~ 70 mA	24

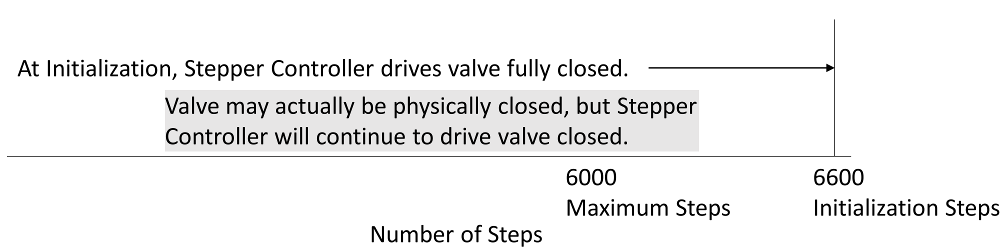
• • • CAUTION • • •

Adjustment to this register will adjust the speed of all steppers, including the IGV, during all reset sequences.

9.2 Initialization

The stepper motor must be initialized to ensure correct open/close percent is known. The **Stepper Initialization Steps** (register 40236 or 40238) must be set to a value greater than the maximum number of steps, preferably approximately 10% greater than the maximum steps. During initialization, the Stepper Controller drives the valve the number of Initialization Steps indicated. This will ensure the valve is fully closed. Initialization occurs during every reset, including when power is applied and when a fault occurs.

Figure - 24 Stepper Control Initialization Procedure

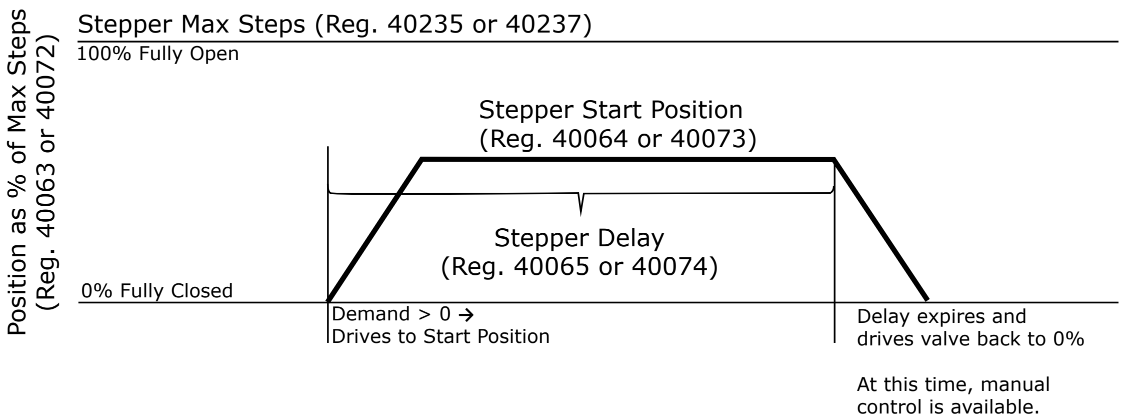


9.3 Operation using Stepper Delay Control

The Stepper Delay is intended for use with a Staging Valve. Once initialization is complete, the Stepper Controller maintains the 0% position until 40028 **Demand** is applied. When the compressor is given a demand, the stepper controller will move the stepper to the **Stepper Start Position** (40064 or 40073). The Stepper Controller will hold the start position for the number of seconds specified by **Stepper Delay** (40065 or 40074). Once the delay time is exceeded the Stepper Controller will drive the valve closed. Once the delay timer has expired, then the Stepper Controller is entirely under manual control and **Stepper Position Command** (40063 or 40072) can be set to drive the valve to a new position.

Note: If the delay time is less than the time it takes to reach the start position the stepper driver will not reach the full start position and it will start to close once the time delay expires.

Figure - 25 Stepper Delay Control



9.4 Operation using Only Manual Control

If either the **Stepper Delay** (40065 or 40074) or the **Stepper Start Position** (40064 or 40073) is set to a value of 0, then the Stepper Delay will not be used. In this case, the Stepper Controller is entirely under manual control. Once initialization is complete, the Stepper Controller will drive the valve to the open position indicated by the **Stepper Position Command** (40063 or 40072). The position is a percentage of the **Stepper Max Steps** (register 40235 or 40237). Therefore, 0% should be fully closed and 100% should be fully open. The number of steps from fully closed to fully open is the **Stepper Max Steps** (register 40235 or 40237).

Table - 27 Stepper Control Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40063	Stepper 1 Position Command	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of Stepper Maximum Steps.
40064	Stepper 1 Start Position	[0...1000]	1:10	%	2	P	0	If desired, the valve can be set to open to a pre-start value for a given time at compressor start up. This value represents the percentage of maximum steps made by the stepper motor when the shaft starts to rotate. The stepper motor will hold at this position until the 40065 **Stepper 1 Stepper Start Delay Time** has expired.
40065	Stepper 1 Stepper Delay	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the 40064 **Stepper 1 Start Position** is in held. The Stepper Start Delay Timer starts to count down when drive is enabled.
40072	Stepper 2 Position Command	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of Stepper Maximum Steps.
40073	Stepper 2 Start Position	[0...1000]	1:10	%	2	P	0	If desired, the valve can be set to open to a pre-start value for a given time at compressor start up. This value represents the percentage of maximum steps made by the motor when the shaft starts to rotate. The stepper motor will hold at this position until the 40074 **Stepper 2 Stepper Start Delay Time** has expired.
40074	Stepper 2 Stepper Delay	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the 40073 **Stepper 2 Start Position** is in held. The 40074 **Stepper 2 Stepper Start Delay Time** starts to count down when drive is enabled.
40235	Stepper 1 Maximum Steps	[0…32767]	1:1	steps	2	P	6000	The number of steps between the fully closed and fully open positions for Stepper 1.
40236	Stepper 1 Initialization Steps	[0…32767]	1:1	steps	2	P	6600	The number of steps required to ensure initialization of Stepper1 to the fully closed position. This value must be larger than or equal to 40235 **Stepper 1 Maximum Steps** for the initialization feature to function as expected.
40237	Stepper 2 Maximum Steps	[0…32767]	1:1	steps	2	P	6000	The number of steps between the fully closed and fully open positions for Stepper 2.
40238	Stepper 2 Initialization Steps	[0…32767]	1:1	steps	2	P	6600	The number of steps required to ensure initialization of Stepper2 to the fully closed position. This value must be larger than or equal to 40237 **Stepper 2 Maximum Steps** for the initialization feature to function as expected.
40240	Stepper Speed during Reset	[24...81]	1:1	-	3	P	24	The number of control cycles to delay between steps to the steppers during stepper initialization or reset. Note: Drop-down selection in SMT shows frequency of the stepper. Refer to "Table - 26 Stepper Speed" on page 57 for the register value that corresponds to the frequency required.
40301	Stepper Control Mode	[0...1]	1:1	-	R	P	0	Mode to define the Stepper Control Type. **0**: Control as described above; **1**: Control as described in Appendix B 3.0.X Functionality Definition.

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Chapter 10.0 Controlled Assist Shutdown

10.1 Reducing Pressure Ratio at Shutdown

Reducing the pressure ratio prior to shutdown will ensure the compressor does not enter a fault mode. A combined strategy of using the Controlled Assist Shutdown described below and externally reducing pressure ratio will allow the compressor to shutdown properly. The pressure ratio can be reduced by any and/or all of the following:

- Opening staging valves
- Opening load balance valves
- Continuing to cool the condenser throughout shutdown

Staging Valves MUST be installed in ALL multiple compressor, single refrigerant circuit systems, (especially air cooled systems) OR on any single compressor system that is expected to shutdown at Pressure Ratio > 2.5. Installation of these valves is mandatory to ensure proper startup of multi compressor systems and orderly shutdown at high Pressure Ratios. The staging valve should be fully open prior to shutting down the compressor.

An economizer vapor isolation valve should also be installed on the economizer line and closed during startup and shutdown. It should also stay closed while the compressor is idle. If the compressor is ever shut down due to a fault or other unplanned action, then the economizer isolation valve should be closed at that time as well. Please refer to "Chapter 8.0 Recommended Control Strategy" on page 53 for additional information on recommended control algorithms.

10.2 Controlled Assist

The Controlled Assist Shutdown, which reduces the speed of the compressor prior to shutting down to 0 RPM, should always be used in combination with a properly sized Staging Valve. When properly configured, the compressor will reduce speed when given a shutdown request (when 40028 **Demand** is set to 0). The compressor speed will be reduced to the target 40398 **Shutdown Speed** until a configurable 40399 **Shutdown Timer Setting** has expired. If the timer has not expired once the compressor reaches the target speed then the compressor will hold at that speed until the timer has expired. Since the Controlled Assist Shutdown procedure should not be used unless a properly sized Staging Valve is opened prior to shutdown, then register 40416 Controlled Assist Shutdown on Interlock Open should also be disabled.

NOTE
The default values for 40416 Controlled Assist Shutdown on Interlock Open and 40399 Shutdown Timer Setting vary between firmware versions.

The recommended settings for Shutdown Speed and Shutdown Timer Setting by compressor model are shown in "Table - 28 Recommended Controlled Assist Settings When Used in Combination with Properly Sized Staging Valve". However when faults occur, the compressor will shut down immediately regardless of the controlled assist settings.

If a staging valve is not installed and fully open 5 - 20 seconds prior to setting the demand to 0, then the Controlled Assist Shutdown should NOT be used. By default, 40399 Shutdown Timer Setting will be set to 0 seconds, effectively disabling the Controlled Assist Shutdown. If a properly sized staging valve is installed and opened prior to shutdown, then Controlled Assist Shutdown can be enabled by changing the 40399 Shutdown Timer Setting.

Table - 28 Recommended Controlled Assist Settings When Used in Combination with Properly Sized Staging Valve

Parameter	TT300/TG230	TT350/TG310	TT400/TG390	TT700/TG520
40398 Shutdown Speed (RPM)	22,200	10,800	10,800	10,800
40399 Shutdown Timer Setting (secs)	20	20	20	20

Figure - 26 Controlled Assist Shutdown

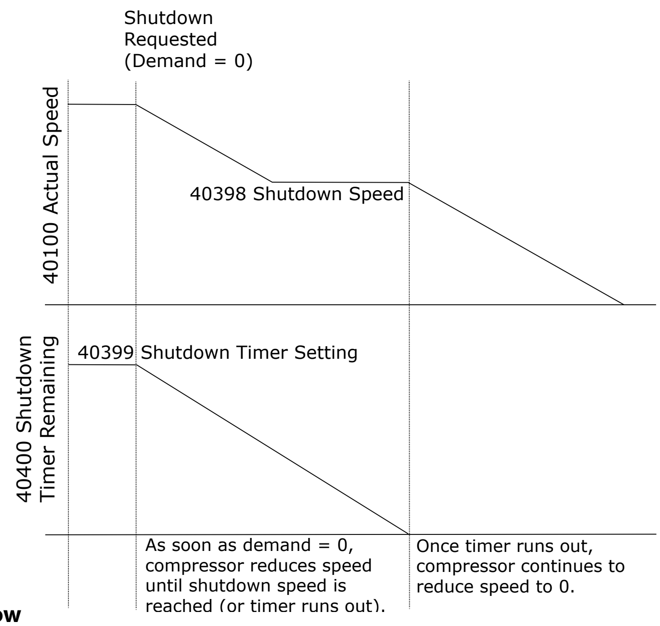

Figure - 27 Controlled Assist Shutdown Logic Flow

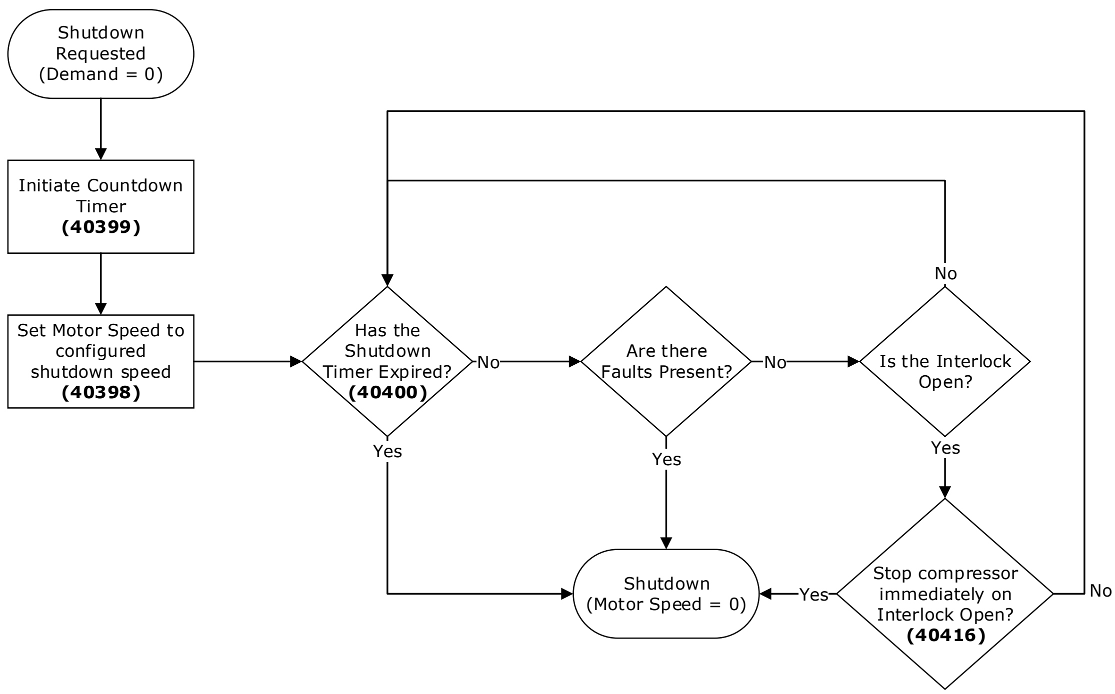

Table - 29 Controlled Assist Shutdown Parameters

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
40398	Shutdown Speed	[0…R42003]	1:1	RPM	3	P	CMS	The speed that the compressor will slow down to when the shutdown sequence is started.
40399	Shutdown Timer Setting	[0…R40414]	1:1	s	3	P	20	The length of time the compressor will remain in the shutdown sequence before stopping the motor completely.
40400	Shutdown Timer Remaining	[0…65535]	1:1	s	R	T	-	The amount of time remaining before the shutdown sequence expires.
40414	Shutdown Timer Setting Max Value	[0…65535]	1:1	s	3	P	30	The maximum value which can be set in register 40399.
40416	Controlled Assist Shutdown on Interlock Open	[0-1]	1:1	Boolean	3	P	1	Whether to use Controlled Assist Shutdown when the Interlock is opened. 0 = Shut down immediately when Interlock is opened. 1 = Use Controlled Assist Shutdown when Interlock is Opened.

Chapter 11.0 Analog Output

The analog output can only be used to manually control a 0-5VDC or 0-10VDC output on the I/O board. The output is used by writing the setpoint to 40081 **Analog Output Control/Status** as a percentage of the total range or by allowing changes in the Discharge Pressure Reading to regulate the output voltage. See "Table - 30 Analog Output Example" for more information. The 40080 Analog Output Mode will determine how the output is controlled.

Table - 30 Analog Output Example

Register Value	Discharge Pressure Reading (kPaa)* **	Analog Output Voltage Percentage	Analog Output Voltage based on Jumper Setting** 0-5 V	0-10 V
0	0	0	0V	0V
500	1000	0.5	2.5V	5V
1000	2000	1	5V	10V

* In Discharge Pressure Mode, the Analog Output will change based on the Discharge Pressure Reading.

** Values are approximate and should be validated with testing.

For example, with 40080 Analog Output Mode set to 0, writing a value of 500 to register 40081 **Analog Output Control/Status** will specify a setpoint of 50.0% of the total voltage. If JP1 is set to the 5V setting, the resulting voltage on the I/O board will be 2.5VDC. If JP1 is set to the 10V setting, the resulting voltage on the I/O board will be 5.0VDC. If the 40080 Analog Output Mode is set to 1 (Discharge Pressure Control Mode), then a Discharge Pressure of approximately 1000 kPa will result in an output voltage of 50% of the total voltage, which would be approximately 2.5V if JP1 is set to the 5V setting or 5V if JP1 is set to the 10V setting.

Table - 31 Analog Output Registers

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40080	Analog Output Mode	[0…1]	1:1	-	2	P	0	The state of this register determines how the Analog Output from the IO board is derived for Register 40081 **Analog Output Control/Status**. **0** = Manual Control Mode **1** = Discharge Pressure Control Mode
40081	Analog Output Control/Status	[0...1000]	1:10	%	1	T	0	The Analog Output voltage controlled as described in "Table - 30 Analog Output Example", based on the 40080 **Analog Output Mode**.

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Chapter 12.0 Motor/Power Electronics Control

The Motor/Power Electronics Control implements a closed system able to spin the shaft at a certain speed. This allows the mounted impeller to carry out the compression task.

12.1 Motor Control and Status

During motor control, a set of parameters is used to tune the motor control and read out the status of the task.

Table - 32 Motor Control and Status Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40249	Run Status Indication Speed	[0....50000]	1:1	RPM	2	P	1000	The motor speed above which the external run signal is active.
40100	Actual Speed	[0...65535]	1:1	RPM	R	-	-	Calculated shaft speed in revolutions per minute.
40101	Desired Speed	[0...65535]	1:1	RPM	2	T	-	Indicates the requested shaft speed being supplied to the Motor Controller. This parameter is write-enabled when 40029 **Compressor Control Mode** is set to Manual Control.
40102	Motor Current (Id)	[0...65535]	**Note 14**	A	R	-	-	The Id part of the motor drive current.
40106	BMC System State	[0x0000…0xFFFF]	1:1	FW	R	-	-	Indicates the current state of the Bearing and Motor Controller. If this register is greater than 0, then the 40026 Bearing/Motor Controller Fault is indicated. See "Table - 37 Compressor Alarm and Fault Registers" on page 72 for more information on interpreting this register.

12.2 Power Configuration and Status

"Table - 33 Power Configuration and Status Parameters" contains parameters associated with configuring or viewing power configuration settings.

Table - 33 Power Configuration and Status Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40021	Requested Power	[0...65535]	1:10	kW	R	-	-	The maximum power currently demanded by the compressor controller. This is a calculated value based on 40028 **Demand** and other parameters.
40022	3-Phase Mains Voltage	[0...65535]	1:1	VAC	R	-	-	The 3-phase AC mains input voltage calculated from the DC bus voltage.
40023	3-Phase Mains Current	[0...65535]	1:1	A	R	-	-	The 3-phase mains input current calculated from the DC bus voltage and motor current.
40025	DC Bus Voltage	[0...65535]	1:1	VDC	R	-	-	The DC bus voltage measured by the inverter drive module.
40104	Actual Power	[0...65535]	1:10	kW	R	-	-	The actual power consumption of the compressor as calculated by the Motor Controller.
41898	DC Bus Voltage Scaling Factor	[0...65535]	1:1	VDC	4	P	1000	The scaling factor to be applied to the voltage reading from the inverter.
41899	DC Bus Current Scaling Factor	[0...65535]	1:1	A	4	P	CMS	The scaling factor to be applied to the current reading from the inverter.
41979	SCR Mains Frequency	50 or 60	1:1	Hz	3	P	CMS	Indicates the SCR Mains Input Frequency which is typically 50Hz or 60Hz.
42001	Maximum DC Bus Voltage	[-32768…32767]	**Note 18**	VDC	4	P	CMS	The highest acceptable 40025 **DC Bus Voltage** above which the 40106 DC Bus Overvoltage is indicated and the motor is stopped.

12.3 Compressor Current Limit and Operating Range Settings

The compressor is designed to allow a user to configure the current setting based on the intended application. The compressor defines the Full Load Amperage and Locked Rotor Amperage as a range on the nameplate. The values are adjustable to register 40401 **3-Phase Current Maximum Adjustable Limit** using the SMT or customer controller applications using the registers shown in "Table - 34 Compressor Current Limit and Operating Range Settings".

Table - 34 Compressor Current Limit and Operating Range Settings

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40230	3-Phase Overcurrent Alarm Limit (FLA)	[0...R40248]	1:1	A	2	P	CMS	The highest acceptable 40023 **3-Phase Mains Current** at which point the 40027 3-Phase Overcurrent alarm is indicated and the compressor motor is slowed down to overcome the alarm condition.
40248	3-Phase Overcurrent Fault Limit (LRA)	[0... R40401]	1:1	A	3	P	CMS	The highest acceptable 40023 **3-Phase Mains Current** at which point the 40026 3-Phase Overcurrent fault is indicated and the motor is stopped. Temporary fluctuations above this limit are allowed but cannot be sustained for more than ~2 seconds.
40401	3-Phase Current Maximum Adjustable Limit	[0…400]	1:1	A	4	P	CMS	The upper limit that the 40248 **3-Phase Overcurrent Fault Limit (LRA)** can be set.

* The max value of Register 40230 3-Phase Overcurrent Alarm Limit (Full Load Ampere, FLA) is the value in register 40248 3-Phase Overcurrent Fault Limit (LRA). The max value of Register 40248 3-Phase Overcurrent Fault Limit (LRA) is the value in register 40401 3-Phase Current Maximum Adjustable Limit.

NOTE

The alarm limit in register 40230 **3-Phase Overcurrent Alarm Limit (FLA)** cannot be set higher than the fault limit in 40248 **3-Phase Overcurrent Fault Limit (LRA)**. The maximum allowable limit that the compressor can operate is defined in register 40401 **3-Phase Current Maximum Adjustable Limit** and neither the FLA nor the LRA can exceed this value.

⚠ • • • CAUTION • • •

Failure to adjust the 3-Phase Over Current alarm and fault limits from the DTC factory settings to the appropriate amperage rating for the application could result in a limitation of the compressor performance.

The default setting for these values can vary by model. However, the typical setting is at the lowest rated operating point for a given compressor model and electrical supply configuration. Recommended settings can be found in the *Applications and Installation Manual (M-AP-001).*

⚠ • • • CAUTION • • •

Adjustment to the 3-Phase Over Current alarm and fault limits cannot exceed the electrical rating for the disconnect, fuses, or wire size. Power configuration must be in accordance with applicable local, national, and international building codes (such as NEC/CEC).

12.4 Cooling of the Compressor

Compressor temperatures indicate the status of components and alarms will be activated if temperatures exceed the expected values. See "Chapter 14.0 Alarms and Faults Descriptions and Limits" on page 71 for the maximum and minimum values for each.

Also, refer to "Chapter 7.0 Inverter, Cavity and SCR Temperature Monitoring" on page 49 for more information on how the compressor monitors and handles rising temperatures.

Table - 35 Compressor Cooling Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40035	SCR Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured on the Silicon Controlled Rectifiers (SCR).
40037	Cavity Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured in the motor cavity.
40041	Motor Raw Thermal Value (MTRV)	[0…65535]	1:1	-	R	-	-	The readout from the motor winding thermistor.
40088	Cooling Mode	[0...3]	1:1	-	R	-	-	Indicates the current status of the cooling solenoid valves: **0** (No Cooling) **1** ('Cool L') **2** ('Cool H') **3** ('Cool L' & 'Cool H') **Note:** When in split cooling configuration, 'Cool L' active implies Inverter or SCR Cooling and 'Cool H' active implies Cavity or MTRV cooling.
40105	Inverter Temperature	[0…65535]	1:10	**Note 1**	R	-	-	Temperature of the IGBT heat sink measured by the IGBT and relayed to the Motor Controller. This temperature is used in the monitoring of the alarm/fault reaction control and when delaying motor start up (42043 **Max Drive Start Up Temperature**).
42064	Cavity Temperature Cooling Setpoint	[0…65535]	1:1	°C	4	P	CMS	The maximum 40037 **Cavity Temperature** at or above which the Cavity Cooling Solenoid will be opened.
42065	Drive Temperature Cooling Setpoint	[0…65535]	1:1	°C	4	P	44	The maximum 40035 **SCR Temperature** or 40105 **Inverter Temperature** at or above which the Drive Cooling Solenoid will be opened.

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Chapter 13.0 Compressor Control Mode and Control Status

This section represents a detailed breakdown of the FW's, Flag words/Bit Flags, for register 40029 **Compressor Control Mode/Compressor Control Status**. Bits 0-4 represent the control mode, while bits 5-15 represent the system status. The value shown in "Figure - 28 Compressor Control Mode/ Control Status Register Interpretation" would be read as 1544 from the register and would indicate the compressor is in Modbus Network Mode, and in normal operation running at maximum capacity.

Figure - 28 Compressor Control Mode/Control Status Register Interpretation

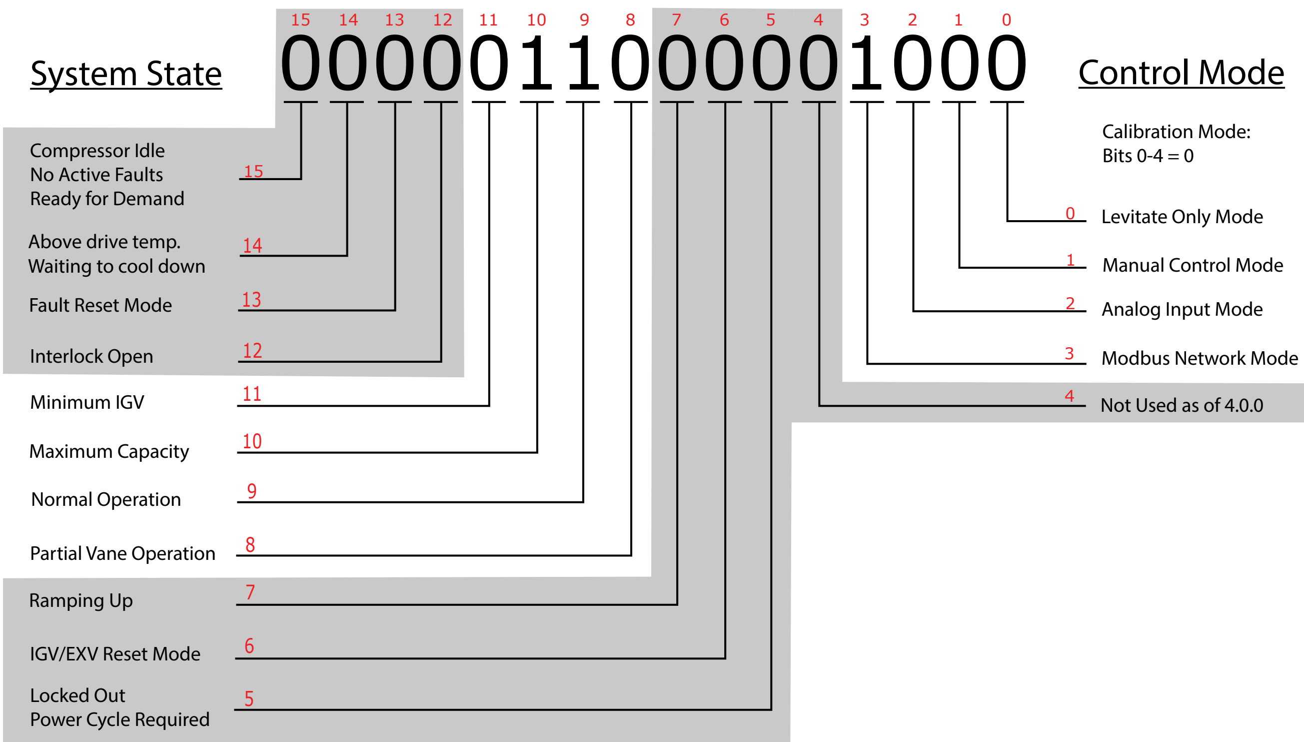


Table - 36 Compressor Control Mode/Control Status Descriptions

Bit #	40029 Control Mode/Status	Hex Value	Description
–	Calibration Mode	0x0000	In order to perform a Bearing Calibration, the control mode must be set to Calibration Mode. This ensures the compressor will not react to 40028 **Demand**.
0	Levitate Only Mode	0x0001	Levitate Only Mode is a service or test mode which only allows the user to command the compressor to levitate the shaft. The compressor will not react to 40028 **Demand**.
1	Manual Control Mode	0x0002	Manual Control mode, like Levitate Only mode, is a service or test mode which allows the user to command the compressor to drive the shaft to a specific RPM, set the IGV position, etc. The compressor will not react to 40028 **Demand**.
2	Analog Input Mode	0x0004	Similar to Modbus Network Mode except Analog Input Mode only reacts to the demand signal given via the 0-10VDC Demand input on the I/O board instead of 40028 **Demand**.
3	Modbus Network Mode	0x0008	Modbus Network control mode allows the user to write 40028 **Demand** requests via the RS-232 or RS-485 Modbus interfaces.
5	Locked out - cycle power to restart	0x0020	The compressor is currently locked out due to a Lockout and requires a Power Cycle to reset.
6	IGV/EXV Reset Mode; System in Reset state	0x0040	The compressor is currently resetting the IGV and EXV's to their initial start conditions. This occurs after a value of 0 is written to 40028 **Demand** or a 40026 **Compressor Status Faults (critical)** occurs.
7	Ramping up	0x0080	The compressor is currently accelerating the shaft to meet the requested 40028 **Demand**.
8	Partial Vane operation	0x0100	The compressor is currently operating in "Mechanical Capacity Control Phase" with the IGV partially open.
9	Normal Operation	0x0200	The compressor is currently operating in "Speed Capacity Control Phase" with the IGV fully open.
10	At maximum capacity	0x0400	The compressor has achieved its maximum rated capacity for the current operating conditions.
11	At Minimum IGV Position	0x0800	The compressor has closed the IGV to its minimum calculated position for the current operating conditions.
12	Interlock Open	0x1000	The compressor has been given 40028 **Demand** and is waiting for the Interlock to close before levitating and starting the motor.
13	Fault Rest Mode; Awaiting Clear Faults Command	0x2000	The compressor is currently in fault and is awaiting the appropriate 41895 **Clear Faults** command or 40028 **Demand** toggle (see Section "15.4 Resetting Non-Lockout Faults" on page 78) before it clears the fault.
14	Above drive temperature limit - waiting to cool down	0x4000	The IGBT/Inverter is currently above the 42043 **Max Drive Start Up Temperature** and must cool down before it can react to 40028 **Demand**.
15	The compressor is idle and ready to accept demand	0x8000	The compressor is currently delevitated, with no faults active and is ready to react to 40028 **Demand**.

Chapter 14.0 Alarms and Faults Descriptions and Limits

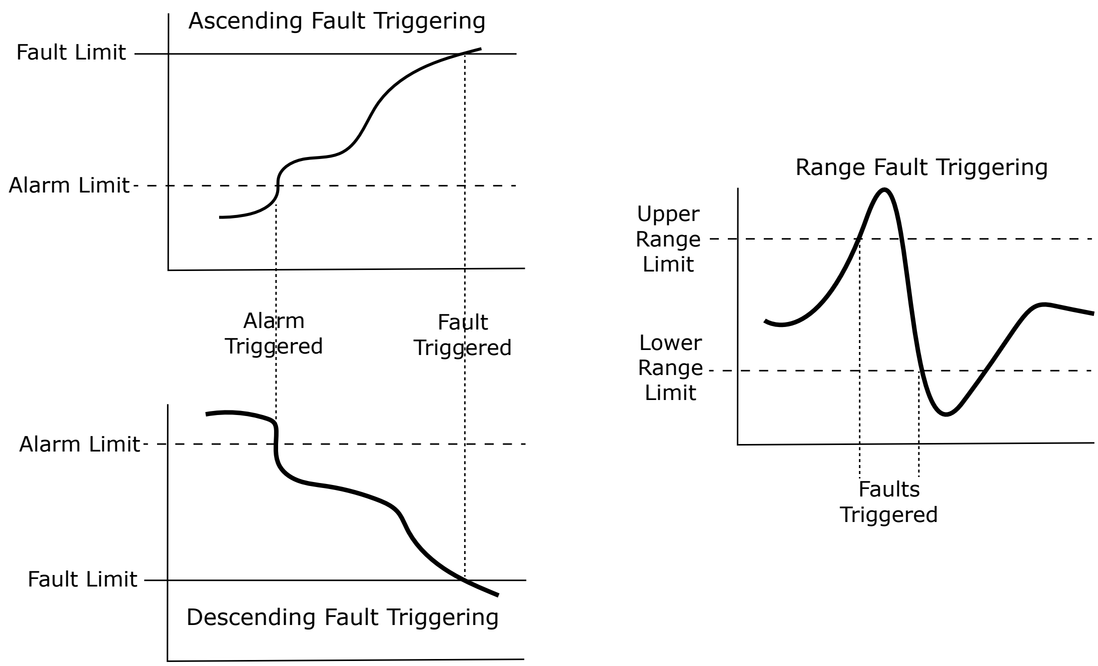
Alarm conditions are usually a sign to the compressor control firmware to take action to move away from the undesired operation condition. Chiller control software must take these limits into account and operate the compressor within normal compressor limits. Forcing the compressor to repeatedly operate beyond alarm levels is inadvisable, may lead to compressor or system damage and may void the warranty. Faults and alarms are indicated through certain parameter values. For definitions of the terms fault and alarm, refer to Section "1.8 Definitions" on page 15.

14.1 Alarm/Fault Trigger Method

The reason for indicating a fault or an alarm is explained in detail, especially the limits that are surpassed, triggering the compressor to either protect itself (the electronic and mechanical hardware) or the application.

In general, the following principle is applied when having both a fault and/or an alarm limit as triggers. In the following explanations for faults and alarms, the trigger method terminology is used: Ascending Fault Triggering (AFT), Descending Fault Triggering (DFT) and Range Fault Triggering (RFT).

Figure - 29 Alarm and Fault Triggering Methods



14.2 Compressor Alarms and Faults

This section contains a detailed definition of the word composition for various FW's used throughout the compressor control software. This includes but is not limited to Compressor Alarms and Faults, Bearing Alarms and Faults, as well as various status messages. For alarms and faults, this section will also define its corresponding Trigger Method (see Section "14.1 Alarm/Fault Trigger Method") so it is clear under what conditions the alarm or fault will be triggered.

Table - 37 Compressor Alarm and Fault Registers

Reg. #	Reg. Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def.	Detailed Description
40026	Compressor Status Faults	[0…65535]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the compressor controller. The compressor control signals one or several faults at a time independently from bearing and motor control.
40027	Compressor Status Alarms	[0…65535]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the compressor controller. The compressor control signals one or several alarms at a time independently from the bearing and motor control. Alarms will generally cause the compressor to reduce speed.
40098	Bearing Faults	[0...65535]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the Bearing controller.
40099	Bearing Alarms	[0...65535]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the Bearing controller.
40106	Bearing/Motor Controller Fault	[0...65535]	1:1	FW	R	-	-	Indicates the current state of the Bearing and Motor Controller. If this register is greater than 0, then the 40026 **Bearing/Motor Controller Fault** is indicated.
40288	Compressor Faults Word 2	[0…65535]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the compressor controller. The compressor control signals one or several faults at a time independently from the bearing and motor control. Alarms will generally cause the compressor to reduce speed.
40290	Compressor Alarms Word 2	[0…65535]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the compressor controller. The compressor control signals one or several alarms at a time independently from the bearing and motor control. Alarms will generally cause the compressor to reduce speed.

Table - 38 Compressor Alarms and Faults

Type & Regs.	Alarm/Fault Name	Bit	Hex	Dec.	Alarm or Fault?	Trigger Method[1]	Register of			Additional Notes
							Actual Value	Alarm Limit	Fault Limit	
Compressor Status Alarm 40027 Fault 40026	Inverter Temperature	0	0x0001	1	Both	Ascending	40105	40224	40242	If the 40105 Inverter Temperature exceeds 42043 Max Drive Startup Temperature, then the compressor will not start and 40029 Above Drive Temperature Limit - Waiting to cool down status will be indicated.
	Discharge Temperature	1	0x0002	2	Fault	Ascending	40036		40243	
	Suction Pressure	2	0x0004	4	Both	Descending	40031	40226	40244	
	Discharge Pressure	3	0x0008	8	Both	Ascending	40033	40223	40241	
	3-Phase Overcurrent	4	0x0010	16	Both	Ascending	40023	40230	40248	
	Cavity Temperature	5	0x0020	32	Both	Ascending	40037	40227	40245	
		6	0x0040	64						
	Pressure Ratio	7	0x0080	128	Both	Ascending	40397	40229	40247	
	Bearing/Motor Controller Fault	8	0x0100	256	Fault		40106			40106 BMC Fault triggered.
	Sensor Fault	9	0x0200	512	Fault	Range	Various			
	SCR Temperature[2]	10	0x0400	1024	Both	Ascending	40035	42041	42042	
	Lock Out	11	0x0800	2048	Fault					See "Chapter 15.0 Lockout Fault" on page 77
	Motor Winding Temperature	12	0x1000	4096	Fault	Ascending	40041		41892	
	High Suction Superheat	13	0x2000	8192	Fault	Ascending	40393		42062	
	Earth Leakage	14	0x4000	16384	Fault	Ascending	41858		40444	
	Soft Start Temperature	15	0x8000	32768	Fault	Ascending	41894		40304	
Bearing Alarm 40099 Fault 40098		0	0x0001	1						
		1	0x0002	2						
		2	0x0004	4						
		3	0x0008	8						
	Calibration Failed	4	0x0010	16	Fault	-				
	Bearing Self Test Failed	5	0x0020	32	Fault	-				If the minimum 40025 DC Bus Voltage is below 41982 DC Bus Voltage Bearing Self-Test Enabled Limit, then the Bearing Self-Test will not occur and this Fault will be flagged.
	Axial Displacement	6	0x0040	64	Fault	Ascending				
	Axial Static Load	7	0x0080	128	Both	Ascending				
	Front Radial Displacement X	8	0x0100	256	Fault	Ascending				
	Front Radial Displacement Y	9	0x0200	512	Fault	Ascending				
	Front Radial Static Load X	10	0x0400	1024	Both	Ascending				
	Front Radial Static Load Y	11	0x0800	2048	Both	Ascending				
	Rear Radial Displacement X	12	0x1000	4096	Fault	Ascending				
	Rear Radial Displacement Y	13	0x2000	8192	Fault	Ascending				

1 Refer to "Figure - 29 Alarm and Fault Triggering Methods" on page 71 for explanation.

2 SCR Temperature Alarm is flagged as bit #8 (0x0100) in Compressor Status Alarms (Reg. 40027)

Table 38- Compressor Alarms and Faults (Continued)

Type & Regs.	Alarm/Fault Name	Bit	Hex	Dec.	Alarm or Fault?	Trigger Method[1]	Register of			Additional Notes
							Actual Value	Alarm Limit	Fault Limit	
Bearing Alarm 40099 Fault 40098	Rear Radial Static Load X	14	0x4000	16384	Both	Ascending				
	Rear Radial Static Load Y	15	0x8000	32768	Both	Ascending				
BMC Fault: 40106	Motor Single Phase Overcurrent	0	0x0001	1	Fault	Ascending			42006	
	DC Bus Overvoltage	1	0x0002	2	Fault	Ascending	40025		42001	
	Motor High Current Warning	2	0x0004	4	Fault	Ascending				
	Motor High Current Fault	3	0x0008	8	Fault	Ascending				
	Inverter Error Signal Active[2]	4	0x0010	16	Fault					
	Rotor May Be Locked	5	0x0020	32	Fault	Ascending				Triggered if the motor current's phase does not align as expected.
	Bearing Fault	6	0x0040	64	Fault	-				
	Bearing Warning	7	0x0080	128	Fault	-				
	Motor Voltage Generates No Current	8	0x0100	256	Fault	Ascending	40104		42015	
	DC Bus Under/Over Voltage Fault	9	0x0200	512	Fault	Range	40025		41980 / 41981	
	24 VDC Out of Range	10	0x0400	1024	Fault	Range				
	Low Motor Back EMF	11	0x0800	2048	Fault	Descending	42032			
	EEPROM Checksum Error	12	0x1000	4096	Fault	-				When the compressor is booting up, it reads the contents of EEPROM to ensure that all required data is present and has not been corrupted. If any of these checksums fail (AVC, Calibration, etc.) than this error is indicated.
	Generator Mode Status	13	0x2000	8192	Fault	Descending	40025		42002	When Generator Mode is active, the compressor is no longer responding to demand requests and is using the rotational energy of the shaft to supply power to the DC Bus. This is essential so the compressor can maintain constant control of the levitated shaft until its speed has slowed to a stop. At that point the compressor will safely delevitate the shaft and remain in a faulted state until power is restored.
	SCR Phase Loss	14	0x4000	16384	Fault	Descending				
	Compressor is Booting Up	15	0x8000	32768	Fault	-				
Compressor /Sensor Alarm 40290 Fault 40288	Inverter Temperature Sensor Error	0	0x0001	1	Fault		40105			Sensor errors occur when the temperature sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or functional problem with the sensor.
	Cavity Temperature Sensor Error	1	0x0002	2	Fault		40037			

1 Refer to "Figure - 29 Alarm and Fault Triggering Methods" on page 71 for explanation.

2 These Faults are instantaneous Lock Out Faults and will immediately cause the compressor to stop running and lock itself out. In order to reset the fault and the compressor, a power cycle will be required.

Table 38 - Compressor Alarms and Faults (Continued)

Type & Regs.	Alarm/Fault Name	Bit	Hex	Dec.	Alarm or Fault?	Trigger Method[1]	Register of			Additional Notes
							Actual Value	Alarm Limit	Fault Limit	
Compressor /Sensor Alarms: R40290 Faults: R40288	Suction Temperature Sensor Error	2	0x0004	4	Fault		40034			Sensor errors occur when the temperature sensor is providing a reading that is outside the normal readable temperature range and therefore must have an error in the reading or a functional problem with the sensor.
	Discharge Temperature Sensor Error	3	0x0008	8	Fault		40036			
	Suction Pressure Sensor Error	4	0x0010	16	Fault		40031			
	Discharge Pressure Sensor Error	5	0x0020	32	Fault		40033			
	Invalid Bearing Calibration	6	0x0040	64	Fault					
	Inverter Cooling Control	7	0x0080	128	Both					
	Motor Cooling Control	8	0x0100	256	Both					
	Soft Start Temperature Sensor Error	9	0x0200	512	Fault		41894			
		10	0x0400	1024						
		11	0x0800	2048						
		12	0x1000	4096						
		13	0x2000	8192						
		14	0x4000	16384						
		15	0x8000	32768						

1 Refer to "Figure - 29 Alarm and Fault Triggering Methods" on page 71 for explanation.

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Chapter 15.0 Lockout Fault

Lockout faults are a specialized type of faults that once triggered the compressor requires a power cycle to clear the fault before returning to a ready to run state. The reason for the lockout is that if the specified number of faults occurs within a specified period of time then it is assumed that a potentially serious problem with the system is occurring which may lead to compressor or system damage. The compressor controller enters into the Lockout state to make sure that an automated clear command from a controller does not continuously attempt to run the system under these conditions. It is expected that qualified personnel will then rectify the source of the problem, power cycle the compressor and return the system to the operational state.

If any combination of the faults listed below occurs more than the number of times allowed by 40262 **Lockout Fault Count Limit** in the time period configured in 40263 **Lockout Fault Accumulate Time Period**, a lockout fault occurs.

- Discharge Pressure
- Three-Phase Overcurrent
- Inverter Temperature
- SCR Temperature
- Motor High Current
- Rotor May Be Locked
- Low Motor Back EMF

Lowering the counter for the number of lockout faults allowed (40262 **Lockout Fault Count Limit**) and/or increasing the active time period for this counter (40263 **Lockout Fault Accumulate Time Period**) will lockout the compressor with fewer faults in the given period making the compressor more sensitive to the Lockout mechanism. Lockout Faults require a power cycle to reset. The current lockout count can be determined by reading register 40261 **Lockout Fault Count**.

15.1 Lockout Fault Configurable Slots

Three configurable lockout slots are available. Each slot has its own fault count, count limit, time limit and fault type selections. Slots 2 and 3 are fully configurable and provide the ability to impose tighter control over what faults are indicative of issues which may require qualified personnel to visit a facility to rectify system issues.

To define what faults to include, configure Fault Word 1 (Reg. 40274 or 40278) with a combination of faults as defined in "Table - 37 Compressor Alarm and Fault Registers" on page 72. The value entered for the Fault Word register should be the sum of the decimal values of the faults to include. Fault Word 2 indicates which sensor faults to include (See Register 40288). Also, BMC Status Fault Selection (reg. 40276 or 40280) can be included using the BMC Faults described for reg 40106 in "Table - 37 Compressor Alarm and Fault Registers". Finally, Bearing Faults (reg. 40277 or 40281) can be included using the Bearing Faults as described for reg. 40098 in "Table - 37 Compressor Alarm and Fault Registers".

Note: if Sensor Fault Bit or BMC Fault Bit are included in Fault Word 1, then any single fault will be indicated in the Fault Word 1 and the compressor may lock out due to that single fault. Ideally, these should not be included in Fault Word 1. Similarly, if Bearing Fault is included in the BMC Fault Selection, then any single Bearing Fault will turn on the Bearing Fault bit in the BMC Fault Selection, potentially locking out the compressor in an undesired way. Therefore, use the Bearing Fault Selection to indicate the Bearing Faults, not the single bit in the BMC Fault Selection.

Table - 39 Lockout Fault Configurable Slot Registers

	Register Number for each Slot		
Lockout Setting	Slot 1	Slot 2	Slot 3
Lockout Fault Count	40261	40264	40267
Lockout Fault Count Limit	40262	40265	40268
Lockout Fault Accumulate Time Period	40263	40266	40269
Lockout Compressor Fault Word 1	*	40274	40278
Lockout Compressor Fault Word 2	*	40275	40279
Lockout BMC Status Fault Selection	*	40276	40280
Lockout Bearing Fault Selection	*	40277	40281

* Not Configurable

15.2 Instantaneous Lockout Faults

A lockout fault occurs immediately when any of the following faults occur, whether or not the 40262 **Lockout Fault Count Limit** has been reached.

The only instantaneous lockout fault is Inverter Error Signal Active.

15.3 Resetting Lockout Faults

To reset lockout faults, a power cycle is required. The 3-phase mains power must remain off long enough for 24VDC power to the backplane to be discharged (approximately 30 seconds). The cause of the fault must be investigated and rectified prior to the power cycle or the fault will remain active.

NOTE

The assumption is that the cause of the fault has been investigated and rectified. If the fault condition has not been rectified, the fault will remain active regardless of attempts to reset the fault.

15.4 Resetting Non-Lockout Faults

Write 1 to register 41895 **Clear Faults** in order to indicate to the compressor to attempt to clear the faults directly. During this process, the compressor will complete a full reset, including IGV initialization. This full reset will begin when the compressor enters fault mode. If the faults clear properly and once the compressor has reset completely, the compressor will be ready to accept demand or if demand has already been applied, it will attempt to meet it.

Table - 40 Clear Faults Register

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
41895	Clear Faults	0…1	1:1	-	2	T	0	Attempt to reset any faults.

Chapter 16.0 Register Definitions

Table - 41 Register Descriptions

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40021	Requested Power	[0...65535]	1:10	kW	R	-	-	The maximum power currently demanded by the compressor controller. This is a calculated value based on 40028 **Demand** and other parameters.
40022	3-Phase Mains Voltage	[0...65535]	1:1	VAC	R	-	-	The 3-phase AC mains input voltage calculated from the DC bus voltage.
40023	3-Phase Mains Current	[0...65535]	1:1	A	R	-	-	The 3-phase mains input current calculated from the DC bus voltage and motor current.
40024	BMC Operation Mode	[0...3]	1:1	-	R	-	-	Indicates the current operational status of the BMC control system: **0** *(Standby)*; **1** *(Levitate)*; **2** *(Drive)*; **3** *(Calibrate)*
40025	DC Bus Voltage	[0...65535]	1:1	VDC	R	-	-	The DC bus voltage measured by the inverter drive module.
40026	Compressor Status Faults	[0...65535]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the compressor controller. The compressor control signals one or several faults at a time independently from bearing and motor control. "Table - 37 Compressor Alarm and Fault Registers" on page 72.
40027	Compressor Status Alarms	[0...65535]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the compressor controller. The compressor control signals one or several alarms at a time independently from the bearing and motor control. Alarms will generally cause the compressor to reduce speed. "Table - 37 Compressor Alarm and Fault Registers" on page 72.
40028	Demand	[0…1000]	1:10	%	1	T	-	The target cooling capacity the compressor is asked to provide.
40029 (Lower 4 bits)	Compressor Control Mode	[0…16]	1:1	FW	2	P	8	The functional control mode of the compressor and how it is expected to interact with external chiller components. See "Chapter 13.0 Compressor Control Mode and Control Status" on page 69.
40029 (Upper 12 bits)	Compressor Control Status	[32…65520]	1:1	FW	R	-	-	Indicates the current operational state of the compressor controller. See "Chapter 13.0 Compressor Control Mode and Control Status" on page 69.
40030	IGV Open Percentage	[0…1100]	1:10	%	3	T	0	The percentage of Inlet Guide Vane (IGV) opening which is a function of 40233 **Maximum IGV Steps**. 110% is equal to fully open; i.e. the compressor is operating in full vane.
40031	Suction Pressure	[0…65535]	1:10	**Note 4**	R	-	-	The pressure measured at the compressor's suction port.
40032	Minimum Pressure Ratio	[0...10]	1:10	-	1	T	0	This register may be used to override the compressor actual operating pressure ratio (PR). By writing a value higher than the actual operating pressure ratio, the compressor will use the higher of the operating PR and the written PR as the basis to calculate the compressor operating envelope. This is useful for start up of a lag compressor on multi compressor systems and the following control regime or similar could be used. Read the highest pressure ratio of running compressors and write that value to this register **(Minimum Pressure Ratio)** of the start up compressor. This register should be written back to 1 after startup is complete. **NOTE:** The feature will be disabled after the compressor exits the "Ramping Up" Start Up Phase.
40033	Discharge Pressure	[0…65535]	1:10	**Note 4**	R	-	-	The pressure measured at the compressor's discharge port.
40034	Suction Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured at the compressor's suction port.
40035	SCR Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured on the Silicon Controlled Rectifiers (SCR).
40036	Discharge Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured at the compressor's discharge port.
40037	Cavity Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured in the motor cavity.
40038	Entering Fluid Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The externally measured entering fluid temperature ('ENTRY' on the I/O board).
40039	BMCC Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured on the BMCC.
40040	Backplane Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The temperature measured at the compressor's backplane.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40041	Motor Thermal Raw Value (MTRV)	[0…65535]	1:1	-	R	-	-	The readout from the motor winding thermistor.
40042	Liquid (LIQ) Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The temperature measured by the external sensor, connected to the LIQDT input on the I/O board.
40043	DC/DC Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The temperature measured on the DC/DC.
40044	PWM Temperature	[0...65535]	1:10	**Note 1**	R	-	-	The temperature measured on the PWM.
40045	24 VDC Voltage	[0…65535]	1:10	VDC	R	-	-	The internally measured voltage of the 24V DC Bus.
40046	Leaving Fluid Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The externally measured fluid temperature ('LEAVE' on the I/O board). **Note:** If there is not a sensor connected to this point, jumper 'Leave' must be installed to permit compressor operation.
40047	Compressor Interlock Status	[0…1] 0 = Open 1 = Closed	1:1	Boolean	R	-	-	The current status indicated by the interlock signal. It must be in the *closed* state for normal operation of the compressor and in the *open* state for service operations, such as bearing calibration, levitation, etc.
40048	Spare Pressure	[0…65535]	1:10	**Note 4**	R	-	-	The indicated pressure as measured at the external pressure sensor ("SPARE P" on the I/O board).
40049	Spare Temperature	[0…65535]	1:10	**Note 1**	R	-	-	The indicated temperature as measured at the external, application-specific thermistor ("SPARE T" on the I/O board).
40050	Chiller Demand Percentage	[0…1000]	1:10	%	R	-	-	The resulting value of (40104 **Actual Power**/40021 **Requested Power**) * 40028 **Demand** giving the compressor demand from the internal chiller controller.
40055	Surge Speed	[0…65535]	1:1	RPM	R	-	-	Estimated minimum speed, calculated by the compressor based on compressor model and operating conditions, at which point the compressor starts monitoring the 40166 **Front Radial Orbit Displacement (FROD)** value for indication of Surge. See Section "4.2 Mechanical Capacity Control Mode" on page 38 for more information.
40056	Choke Speed	[0…65535]	1:1	RPM	R	-	-	Estimated maximum speed calculated by the compressor based on compressor model and operating conditions. The compressor will not exceed this speed.
40057	Display Units	[0…1] 0 = US Customary 1 = Metric	1:1	-	2	P	1	This setting affects all parameters which have **Note 1** or **Note 4** in the Type/Unit column. When in "Metric", the values read out/ written to the compressor are interpreted as kPa, ºC and K. In "US Customary", they are interpreted as psi, ºF and ºR.
40058	Suction Pressure Alarm/Fault Factor	[500...1000]	1:10	%	2	P	850	The factor used to reduce the Suction Pressure Alarm/Fault operating points during compressor start up. To determine the actual operating point, convert the gauge pressure setting to absolute pressure, apply 40058 **Suction Pressure Alarm/Fault Factor**, then convert back to gauge pressure;. i.e. LP trip point with 65% factor and trip setting 20 psi gauge results in a Factor = (20 + 14.7) * .65 - 14.7.
40059	Suction Pressure Alarm/Fault Factor Delay Timer Setting	[0...600]	1:1	Seconds	2	P	60	The period of time during start up and operation when the 40058 **Suction Pressure Alarm/Fault Factor** will be used for temporarily adjusting the Suction Pressure Alarm/Fault Limits.
40060	Suction Pressure Alarm/ Fault Factor Delay Timer	[0...120]	1:1	Seconds	R	-	-	The amount of time remaining before a fault or alarm is indicated while under such conditions. This parameter only applies during start up.
40063	Stepper 1 Position	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of EXV Maximum Steps.
40064	Stepper1 Start Position	[0...1000]	1:10	%	2	P	0	If desired, the valve can be set to open to a pre-start value for a given time at compressor start up. This value represents the percentage of maximum steps made by the stepper motor when the shaft starts to rotate. The stepper motor will hold at this position until the 40065 **EXV 1 Stepper Start Delay Time** has expired.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40065	Stepper 1 Stepper Start Delay Time	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the 40064 **EXV 1 Start Position** is in held. The Stepper Start Delay Timer starts to count down when drive is enabled.
40072	Stepper 2 Position	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of EXV Maximum Steps.
40073	Stepper 2 Start Position	[0...1000]	1:10	%	2	P	0	If desired, the valve can be set to open to a pre-start value for a given time at compressor start up. This value represents the percentage of maximum steps made by the motor when the shaft starts to rotate. The stepper motor will hold at this position until the 40074 **EXV 2 Stepper Start Delay Time** has expired.
40074	Stepper 2 Stepper Start Delay Time	[0…600]	1:1	Seconds	2	P	90	Represents the time in seconds that the 40073 **EXV 2 Start Position** is in held. The 40074 **EXV 2 Stepper Start Delay Time** starts to count down when drive is enabled.
40080	Analog Output Mode	[0…1]	1:1	-	2	P	0	The state of this register determines how the Analog Output from the IO board is derived for Register 40081 **Analog Output Control/Status.** **0** = Manual Control Mode **1** = Discharge Pressure Control Mode
40081	Analog Output Control/ Status	[0...1000]	1:10	%	1	T	0	The analog output voltage controlled as described in the table below, based on the Analog Output Mode.

Register Value	Discharge Pressure Reading (kPaa)* **	Analog Output Voltage Percentage	Analog Output Voltage based on Jumper Setting** 0-5 V	0-10 V
0	0	0	0V	0V
500	1000	0.5	2.5V	5V
1000	2000	1	5V	10V

* In Discharge Pressure Mode, the Analog Output will change based on the Discharge Pressure Reading.
** Values are approximate and should be validated with testing.

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40088	Cooling Mode	[0...3]	1:1	-	R	-	-	Indicates the current status of the cooling solenoid valves: **0** (No Cooling) **1** ('Cool L') **2** ('Cool H') **3** ('Cool L' & 'Cool H') **Note:** When in split cooling configuration, 'Cool L' active implies Inverter or SCR Cooling and 'Cool H' active implies Cavity or MTRV cooling.
40089	Shaft Levitation Control/Status	[0…1] 0 = Delevitated 1 = Levitated	1:1	-	2	T	-	Indicates the current shaft levitation status and allows for manual control of shaft levitation/ delevitation when 40029 **Compressor Control Mode** is set to Levitate Only.
40098	Bearing Faults	[0x0001...0xFFFF]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the Bearing controller. See "Table - 35 Compressor Cooling Parameters" on page 67 for more information.
40099	Bearing Alarms	[0x0001...0xFFFF]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the Bearing controller. See "Table - 35 Compressor Cooling Parameters" on page 67 for more information.
40100	Actual Speed	[0...65535]	1:1	RPM	R	-	-	Calculated shaft speed in revolutions per minute.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40101	Desired Speed	[0...65535]	1:1	RPM	2	T	-	Indicates the requested shaft speed being supplied to the Motor Controller. This parameter is write-enabled when 40029 **Compressor Control Mode** is set to Manual Control.
40102	Motor Current (Id)	[0...65535]	**Note 14**	A	R	-	-	The Id part of the motor drive current.
40104	Actual Power	[0...65535]	1:10	kW	R	-	-	The actual power consumption of the compressor as calculated by the Motor Controller.
40105	Inverter Temperature	[0...65535]	1:10	**Note 1**	R	-	-	Temperature of the IGBT heat sink measured by the IGBT and relayed to the Motor Controller. This temperature is used in the monitoring of the alarm/fault reaction control and when delaying motor start up (42043 **Max Drive Start Up Temperature**).
40106	BMC System State	[0x0000…0xFFFF]	1:1	FW	R	-	-	Indicates the current state of the Bearing and Motor Controller. If this register is greater than 0, then the 40026 **Bearing/Motor Controller Fault** is indicated. See "Table - 35 Compressor Cooling Parameters" on page 67 for more information on interpreting this register.
40166	Front Radial Orbit Displacement (FROD)	[0...65535]	1:1	-	R	-	-	The sum of the squares of the X and Y orbit offsets of the Front Radial Bearing. This is a numeric representation of the fluid noise in the system which is most often caused by exceeding the boundaries of the compressor map.
40177 40178 40179	Compressor Real Time Clock (RTC) Current Time	[0...65535]	**Note 8**	-	R	-	-	Current time of the internal Real Time Clock (RTC). The RTC is initialized from DTC before shipping with the current (UTC-05:00) US Eastern Time. A small battery ensures that the RTC is running even though no mains voltage is applied to the compressor.
40196	Total Standby Hours	[0...65535]	1:1	Hours	2	-	-	Indicates the amount of compressor standby hours since last power reset. The sum of 40196 **Total Standby Hours**, 40197 **Total Standby Minutes**, 40212 **Total Running Hours** and 40213 **Total Running Minutes** results in the total ON time for the compressor since last reset.
40197	Total Standby Minutes	[0…65535]	1:1	Minutes	2	-	-	Indicates the amount of compressor standby minutes and seconds since the last power reset.
40203	Fast Restart IGV Position	[0...R40233]	1:1	Steps	R	P	0	Provides feedback to compressor where the IGV's were located prior to a power outage
40212	Total Running Hours	[0...65535]	1:1	Hours	2	-	-	Indicates the amount of compressor running hours since last power reset. The sum of 40196 **Total Standby Hours**, 40197 **Total Standby Minutes**, 40212 **Total Running Hours** and 40213 **Total Running Minutes** results in the total ON time for the compressor since last power reset.
40213	Total Running Minutes	[0...65535]	1:1	Minutes	2	-	-	Indicates the amount of compressor running minutes.
40220	Start Up Pre-Cooling Configuration	[0…65283]	**Note 9**	-	3	P	0	The solenoids to open during the motor pre-cooling process and the number of seconds the solenoids should be open before the motor starts turning.
40221	Event Log Wraparound Count	[0...65535]	1:1	-	R	-	-	A counter which tracks how many times the Event Log has been completely filled and has wrapped around.
40222	Fault Log Wraparound Count	[0...65535]	1:1	-	R	-	-	A counter which tracks how many times the Fault Log has been completely filled and has wrapped around.
40223	Discharge Pressure Alarm Limit	[0…R40241]	1:1	**Note 5**	2	P	CMS	The highest acceptable 40033 **Discharge Pressure** at which point the 40027 **Discharge Pressure alarm** is indicated and the compressor motor is slowed down to overcome the alarm condition.
40224	Inverter Temperature Alarm Limit Operation	[0…R40242]	1:1	°C	2	P	65	The highest acceptable 40105 **Inverter Temperature** at which point the 40027 **Inverter Temperature** alarm is indicated and the compressor motor is slowed down to overcome the alarm condition.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40226	Suction Pressure Alarm Limit	[R40244…499]	1:1	**Note 5**	2	P	CMS	The lowest acceptable 40031 **Suction Pressure** at which point the 40027 **Suction Pressure alarm** is indicated and the compressor motor is slowed down to overcome the alarm condition.
40227	Cavity Temperature Alarm Limit Operation	[0…80]	1:1	°C	2	P	75	The highest acceptable 40037 **Cavity Temperature** at which point the 40027 **Cavity Temperature alarm** is indicated and the compressor motor is slowed down to overcome the alarm condition.
40229	Pressure Ratio Alarm Limit	[0…R40247]	1:10	-	2	P	CMS	The highest acceptable 40397 **Pressure Ratio** at which point the 40027 **Pressure Ratio alarm** is indicated and the compressor motor is slowed down to overcome the alarm condition.
40230	3-Phase Overcurrent Alarm Limit (FLA)	[0...R40248]	1:1	A	2	P	CMS	The highest acceptable 40023 **3-Phase Mains Current** at which point the 40027 **3-Phase Overcurrent alarm** is indicated and the compressor motor is slowed down to overcome the alarm condition.
40233	Maximum IGV Steps	[0...32767]	1:1	steps	R	P	CMS	The number of steps between the fully closed and fully open positions of the IGV.
40235	Stepper 1 Maximum Steps	[0...32767]	1:1	steps	2	P	6000	The number of steps between the fully closed and fully open positions for Stepper 1.
40236	Stepper 1 Initialization Steps	[0...32767]	1:1	steps	2	P	6600	The number of steps required to ensure initialization of Stepper 1 to the fully closed position. This value must be larger than or equal to 40235 **Stepper 1 Maximum Steps** for the initialization feature to function as expected.
40237	Stepper 2 Maximum Steps	[0...32767]	1:1	steps	2	P	6000	The number of steps between the fully closed and fully open positions for Stepper 2.
40238	Stepper 2 Initialization Steps	[0...32767]	1:1	steps	2	P	6600	The number of steps required to ensure initialization of Stepper 2 to the fully closed position. This value must be larger than or equal to 40237 **Stepper 2 Maximum Steps** for the initialization feature to function as expected.
40241	Discharge Pressure Fault Limit	[0…R40402]	1:1	**Note 5**	3	P	CMS	The highest acceptable 40033 **Discharge Pressure** at which point the 40026 **Discharge Pressure fault** is indicated and the compressor motor is stopped.
40242	Inverter Temperature Fault Limit Operation	[0…90]	1:1	°C	R	P	70	The highest acceptable 40105 **Inverter Temperature** at which point the 40026 **Inverter Temperature fault** is indicated and the compressor motor is stopped.
40243	Discharge Temperature Fault Limit	[0...150]	1:1	°C	R	P	CMS	The highest acceptable 40036 **Discharge Temperature** at which point the 40026 **Discharge Temperature fault** is indicated and the compressor motor is stopped.
40244	Suction Pressure Fault Limit	[R40403…499]	1:1	**Note 5**	3	P	CMS	The lowest acceptable 40031 **Suction Pressure** at which point the 40026 **Suction Pressure fault** is indicated and the compressor motor is stopped.
40245	Cavity Temperature Fault Limit Operation	[0…100]	1:1	°C	R	P	80	The highest acceptable 40037 **Cavity Temperature** at which point the 40027 **Cavity Temperature alarm** is indicated and the compressor motor is slowed down to overcome the alarm condition.
40247	Pressure Ratio Fault Limit	[0...100]	1:10	-	R	P	CMS	The highest acceptable 40397 **Pressure Ratio** at which point the 40026 **Pressure Ratio fault** is indicated and the compressor is stopped.
40248	3-Phase Overcurrent Fault Limit (LRA)	[0... R40401]	1:1	A	3	P	CMS	The highest acceptable 40023 **3-Phase Mains Current** at which point the 40026 **3-Phase Overcurrent fault** is indicated and the motor is stopped. Temporary fluctuations above this limit are allowed but cannot be sustained for more than ~2 seconds.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def **	Detailed Description
40249	Run Status Indication Speed	[0....50000]	1:1	RPM	2	P	1000	The motor speed above which the external run signal is active.
40250	Demand Control Integral Gain	[0...32000]	1:100000	-	2	P	10	The gain of the integral component of the Demand Control loop.
40251	Modbus Slave Address	[0...64]	1:1	-	2	P	1	A unique identifier for the compressor on the Modbus network.
40252	RS-485 Baud Rate	[9…10] 9 = 38400 bit/s 10 = 19200 bits/s	1:1	-	2	P	9	The RS-485 communication line transmission speed in bits transferred per second.
40253	RS-485 Parity	[0…4]	1:1	-	2	P	0	The Parity bit is added to ensure that the number of bits with the value 1 in a set of bits is even or odd. Parity bits are used as the simplest form of error detecting code. **0** = None
40254	RS-485 Stop Bits	[0…1] 0 = 1 Stop Bit 1 = 2 Stop Bits	1:1	-	2	P	0	The Stop Bit is actually a "stop period"; the stop period of the transmitter may be arbitrarily long. It cannot be shorter than a specified amount, usually 1 to 2 bit times.
40255	RS-232 Baud Rate	[9…10] 9 = 38400 bit/s 10 = 19200 bits/s	1:1	-	2	P	9	The RS-232 communication line transmission speed in bits transferred per second.
40256	RS-232 Parity	[0…4]	1:1	-	2	P	0	The Parity bit is added to ensure that the number of bits with the value 1 in a set of bits is even or odd. Parity bits are used as the simplest form of error detecting code. **0** = None
40257	RS-232 Stop Bits	[0…1] 0 = 1 Stop Bit 1 = 2 Stop Bits	1:1	-	2	P	0	The Stop Bit is actually a "stop period"; the stop period of the transmitter may be arbitrarily long. It cannot be shorter than a specified amount, usually 1 to 2 bit times.
40261	Lockout Fault Count Slot 1	[0…3]	1:1	-	R	-	-	Indicates the number of faults that have occurred which have been configured to increment this counter. When this number exceeds 40262 **Lockout Fault Count Limit**, a Lockout fault is triggered.
40262	Lockout Fault Count Limit Slot 1	[1...3]	1:1	-	3	P	3	Set the number of fault trips to be used in Lockout fault.
40263	Lockout Fault Accumulate Time Period Slot 1	[180...32767]	10:1	Seconds	3	P	200	The time period within which alarms/faults may accumulate, potentially causing a Lockout fault if the 40261 **Lockout Fault Count** exceeds the 40262 **Lockout Fault Count Limit**.
40264	Lockout Fault Count Slot 2	[0…3]	1:1	-	R	-	-	Indicates the number of faults that have occurred which have been configured to increment this Slot 2 counter. When this number exceeds 40265 **Lockout Fault Count Limit Slot 2**, a Lockout fault is triggered.
40265	Lockout Fault Count Limit Slot 2	[1…3]	1:1	-	3	P	3	Set the number of fault trips to be used in Lockout fault for Slot 2.
40266	Lockout Fault Accumulate Time Period Slot 2	[180…32767]	1:1	Seconds	3	P	200	The time period within which alarms/faults may accumulate for Slot 2, potentially causing a Lockout fault if the 40264 **Lockout Fault Count Slot 2** exceeds the 40265 **Lockout Fault Count Limit Slot 2**.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40267	Lockout Fault Count Slot 3	[0…3]	1:1	-	R	-	-	Indicates the number of faults that have occurred which have been configured to increment this Slot 3 counter. When this number exceeds 40268 **Lockout Fault Count Limit Slot 3**, a Lockout fault is triggered.
40268	Lockout Fault Count Limit Slot 3	[1…3]	1:1	-	3	P	3	Set the number of fault trips to be used in Lockout fault for Slot 3.
40269	Lockout Fault Accumulate Time Period Slot 3	[180…32767]	1:1	Seconds	3	P	200	The time period within which alarms/faults may accumulate for Slot 3, potentially causing a Lockout fault if the 40267 **Lockout Fault Count Slot 3** exceeds the 40268 **Lockout Fault Count Limit Slot 3**.
40274	Lockout Compressor Fault Word 1 Selection Slot 2	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 2. Fault bits are as defined in register 40026.
40275	Lockout Compressor Fault Word 2 Selection Slot 2	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 2. Fault bits are as defined in register 40288.
40276	Lockout BMC Status Fault Selection Slot 2	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 2. Fault bits are as defined in register 40106.
40277	Lockout Bearing Fault Selection Slot 2	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 2. Fault bits are as defined in register 40098.
40278	Lockout Compressor Fault Word 1 Selection Slot 3	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 3. Fault bits are as defined in register 40026.
40279	Lockout Compressor Fault Word 2 Selection Slot 3	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 3. Fault bits are as defined in register 40288.
40280	Lockout BMC Status Fault Selection Slot 3	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 3. Fault bits are as defined in register 40106.
40281	Lockout Bearing Fault Selection Slot 3	[0…65535]	1:1	FW	3	P	0	The selected faults in this register are monitored and will trigger a lockout fault for slot 3. Fault bits are as defined in register 40098.
40288	Compressor Faults 2	[0…65535]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the compressor controller. The compressor control signals one or several faults at a time independently from the bearing and motor control. Alarms will generally cause the compressor to reduce speed.
40290*	Compressor Alarms Word 2	[0…65535]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the compressor controller. The compressor control signals one or several alarms at a time independently from the bearing and motor control. Alarms will generally cause the compressor to reduce speed.
40292	Earth Leakage Current (Filtered)	[0…65535]	1:100	Amps	R	-	-	This value represents the calculated amount of motor current (A) to ground.
40296	Request Interface ID	[1…2]	1:1	-	R	-	-	This value identifies the interface in which a modbus request was received. If the user reads this value they can verify to which port they are connected. **1** = RS-485 **2** = RS-232

* Registers added with 4.1.0 firmware.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40297	Privilege Source	[0…2]	1:1	-	2	P	0	This register allows the user to restrict changes to 40028 **Demand** and 40029 **Control Mode** to the communication port set in this register. **0** = This feature is disable and both ports can write to these registers (behavior in builds prior to 4.0.0). **1** = RS-485 is set as the privilege source and write operations to these registers will only be accepted from this port. **2** = RS-232 is set as the privilege source and write operations to these registers will only be accepted from this port.
40301	Stepper Control Mode	[0…1]	1:1	-	R	P	0	Mode to define the Stepper Control Type. **0**: Control as described above; **1**: Control as described in Appendix B 3.0.X Functionality Definition.
40304	Soft Start Temperature Fault Limit	[0…65535]	1:1	K	R	-	75	The highest acceptable 41894 **Soft Start Temperature** at which point the 40026 **Soft Start Temperature Fault** bit is indicated and the compressor motor is stopped.
40306	Shutdown Sequence Trigger Offset	[0…R40398]	1:1	RPM	3	P	2000	This register allows the user to give an offset from shutdown speed used to determine when is safe to stop the motor (i.e. set RPM to 0) during the shutdown sequence.
40307	RS-232 Current Access Level	[1…3]	1:1	-	R	-	-	Current Access Level of the RS-232 port. Refer to Section "Access Control" on page 101 for details.
40308	RS-485 Current Access Level	[1…3]	1:1	-	R	-	-	Current Access Level of the RS-485 port. Refer to Section "Access Control" on page 101 for details.
40313	Interstage Temperature	[0…65535]	1:10	**Note 1**	R	-	-	Interstage temperature reading. Scaled the same as Suction or Discharge temperature. Applies only for High Lift Compressor Models.
40314	Interstage Pressure	[0…65535]	1:10	**Note 1**	R	-	-	Interstage pressure reading. Scaled the same as Suction or Discharge pressure. Applies only to High Lift Compressor Models.
40318*	Initialize IGV to Fully Open	[0...1]	1:1	-	3	P	0	The IGV initializes the vanes upon compressor power up and after shutdown. This is performed to ensure the IGV stepper motor is always aligned with the software. Initialization is selectable to open to its full open position or close to its fully closed position. For reliability purposes, selecting the IGV to initialize to fully open (1) is recommended. For backwards compatibility reasons, the default is fully closed (0).
40325	Low Suction Pressure Alarm/Fault Delay Timer	[0….600]	1:1	Seconds	R	-	-	Shows remaining time until a Suction Pressure alarm/fault will occur. The timer restarts when the 40031 **Suction Pressure** exceeds the 40226 **Suction Pressure Alarm Limit** or 40244 **Suction Pressure Fault Limit**.
40326	Low Suction Pressure Alarm/Fault Delay Timer Setting	[0….600]	1:1	Seconds	3	P	0	The starting count for the 40325 **Low Suction Pressure Alarm/Fault Delay Timer** which is the amount of time that the Suction Pressure alarm/fault will be delayed.
40328	Liquid Level 1	[0…1000]	1:10	%	R	-	-	This register represents the percentage 0-100 of the liquid level 1 input (either 0-5v or 0-90Ohm) on the IO board.
40329	Liquid Level 2	[0…1000]	1:10	%	R	-	-	This register represents the percentage 0-100 of the liquid level 2 input (either 0-5v or 0-90Ohm) on the IO board.
40330	Configured Voltage	[0…65535]	1:1	V	R	P	CMS	The decimal value read is the actual voltage.
40345*	Motor Cooling Control Fault Limit	[0...65535]	1:1	V	R	P	55	The decimal value read is the actual voltage.
40346*	Motor Cooling Control Fault Delay Timer (Config)	[0…65535]	1:1	secs	R	P	900	The number of seconds that the Cavity Temperature may remain above the Motor Cooling Control Fault Limit prior to triggering the Motor Cooling Control Fault.
40347*	Motor Cooling Control Fault Delay Timer (Remaining)	[0…65535]	1:1	secs	R	-	-	The remaining number of seconds that the Cavity Temperature may remain above the Motor Cooling Control Fault Limit before the Motor Cooling Control Fault will be triggered.
40348*	Motor Cooling Control Alarm Trigger Timer (Config)	[0…65535]	1:1	secs	3	P	885	The number of seconds prior to the Motor Cooling Control Fault will be triggered that the Motor Cooling Control Alarm will be triggered.
40349*	Motor Cooling Control Monitoring Delay Timer (Config)	[0…65535]	1:1	secs	R	P	10800	The number of seconds after startup that Monitoring of the Motor Cooling Control will be delayed.

* Registers added with 4.1.0 firmware.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40350*	Motor Cooling Control Monitoring Delay Timer (Remaining)	[0…65535]	1:1	secs	R	-	-	The remaining number of seconds that Monitoring of the Motor Cooling Control will be delayed.
40351*	Inverter Cooling Control Fault Limit	[0…65535]	1:1	C	R	P	55	The limit at which the Inverter Temperature will be monitored for Inverter Cooling Control.
40352*	Inverter Cooling Control Fault Delay Timer (Config)	[0…65535]	1:1	secs	R	P	900	The number of seconds that the Inverter Temperature may remain above the Inverter Cooling Control Fault Limit prior to triggering the Inverter Cooling Control Fault.
40353*	Inverter Cooling Control Fault Delay Timer (Remaining)	[0…65535]	1:1	secs	R	-	-	The remaining number of seconds that the Inverter Temperature may remain above the Inverter Cooling Control Fault Limit before the Inverter Cooling Control Fault will be triggered.
40354*	Inverter Cooling Control Alarm Trigger Timer (Config)	[0…65535]	1:1	secs	3	P	885	The number of seconds prior to the Inverter Cooling Control Fault will be triggered that the Inverter Cooling Control Alarm will be triggered.
40355*	Inverter Cooling Control Monitoring Delay Timer (Config)	[0…65535]	1:1	secs	R	P	10800	The number of seconds after startup that Monitoring of the Inverter Cooling Control will be delayed.
40356*	Inverter Cooling Control Monitoring Delay Timer (Remaining)	[0…65535]	1:1	secs	R	-	-	The remaining number of seconds that Monitoring of the Inverter Cooling Control will be delayed.
40391	Suction Sat. Temperature (SST)	[0…65535]	1:10	**Note 1**	R	-	-	The calculated Saturated Suction Temperature (SST) using the reading from the Pressure Sensor at the compressors suction port.
40392	Discharge Sat. Temperature (SDT)	[0…65535]	1:10	**Note 1**	R	-	-	The calculated Saturated Discharge Temperature (SDT) using the reading from the Pressure Sensor at the compressors discharge port.
40393	Suction Superheat	[0…65535]	1:10	**Note 1**	R	-	-	The calculated Suction Superheat using the measured Suction Temperature minus the calculated Saturated Suction Temperature (SST).
40397	Pressure Ratio	[0…65535]	1:100	-	R	-	-	The pressure ratio value is the maximum of: (40033 **Discharge Pressure**/40031 **Suction Pressure**) or (40048 **Spare Pressure**/40031 **Suction Pressure**).
40398	Shutdown Speed	[0...CMS]	1:1	RPM	3	P	CMS	The speed that the compressor will slow down to when the shutdown sequence is started. Default values: TT300 - 22200; TT350 - 10800; TT400 - 10800; TT700 - 10800.
40399	Shutdown Timer Setting	[0...30]	1:1	Seconds	3	P	20	The length of time the compressor will remain in the shutdown sequence before stopping the motor completely.
40400	Shutdown Timer Remaining	[0...65535]	1:1	Seconds	R	T	-	The amount of time remaining before the shutdown sequence expires.
40401	3-Phase Current Maximum Adjustable Limit	[0…400]	1:1	A	R	P	CMS	The upper limit that the 40248 **3-Phase Overcurrent Fault Limit (LRA)** can be set.
40402	Discharge Pressure Maximum Adjustable Limit	[0…2399]	1:1	kPa	R	P	CMS	The upper limit that the 40241 **Discharge Pressure Fault Limit** can be set.
40403	Suction Pressure Maximum Adjustable Limit	[0…32666]	1:1	kPa	R	P	CMS	The lower limit that the 40244 **Suction Pressure Fault Limit** can be set.

* Registers added with 4.1.0 firmware.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40404 40405 40406	BMCC Serial Number	[0...65535]	**Note 11**	-	R	-	-	Every BMCC has a unique fixed Serial Number.
40410 40411	Compressor Software (Configuration) Part Number	[0...65535]	**Note 12**	-	R	P	CMS	These registers identify the part number for the configuration parameters used inside the compressor. This information correlates to the part number of the compressor either directly (1-1) or indirectly in the case of adjustable amperage range models (1-many). The combination of this part number with the 40412 **Configuration Revision** determines the complete software configuration including which 42044 **Compressor Control (CC) Version** is downloaded.
40412	Configuration Revision	[0...65535]	1:1	-	R	P	-	An increasing consecutive number which identifies the revision of the compressor configuration. This is used in conjunction with the 40410 **Compressor Software (Configuration) Part Number** for configuration management traceability and tracking.
40413	Compressor Model and Refrigerant Selection	[0...65535]	1:1	FW	3	P	CMS	The Compressor Type and Refrigerant as configured by the Compressor Model selection. Refrigerant can be modified between R134a and R513A by writing a 1 for R134a or a 8 for R513A to this register. The value read is determined by the table below.

Type	Refrigerant		Reg. Value
TR300/TT300	R134a	1	8449
TT300-R22	R22	2	8706
TT350	R134a	1	17665
TT400	R134a	1	17153
TT700	R134a	1	26113
TG310	R1234ZE	3	18179
TG230	R1234ZE	3	10243
TG390	R1234ZE	3	18691
TG520	R1234ZE	3	27139
TT300	R513A*	8	8456
TT350	R513A*	8	17672
TT400	R513A*	8	17160
TT700	R513A*	8	26120

* Refrigerant R513A is only available in firmware version 4.1.0 and later.

40414	Shutdown Timer Setting Max Value	[0...65535]	1:1	Seconds	R	P	30	The maximum value which can be set in register 40399 **Shutdown Timer Setting**.
40416	Controlled Assist Shutdown on Interlock Open	[0-1]	1:1	Boolean	3	P	1	Whether to use Controlled Assist Shutdown when the Interlock is opened. 0 = Shut down immediately when Interlock is opened. 1 = Use Controlled Assist Shutdown when Interlock is Opened.
40422	Suction Superheat Fault Delay Timer (Startup)	[0…600]	1:1	Seconds	R	-	-	Shows remaining time until a **High Suction Superheat** fault will occur after startup. The timer starts when the 40100 **Actual Speed** has exceeded 50 RPM. After the 3 minute timer has elapsed, the temperature will be monitored. At this time, if the fault limit is exceeded the **Suction Superheat Fault** will be triggered immediately.
40425	Access Code Entry Current Level	[0...65535] W [1...3] R	1:1	-	1	T	1	Displays the current access level and is the register used to input the compressor access code.
40431	Motor Thermal Limit	[0…65535]	1:1	-	R	-	-	Motor Thermal Limit is an indication that the stator requires cooling.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40432	SCR Temperature Fault Timer (Startup)	[0…65535]	1:1	secs	R	P	900	The number of seconds from startup that the Startup Faults and Alarms limits are active, after which the Operational Faults and Alams will be active.
40433	SCR Temperature Fault Timer (Startup) Remaining	[0…65535]	1:1	secs	R	-	-	The remaining number of seconds from startup that the Startup Faults and Alarms limits will be active. After this timer has expired, the Operational Faults and Alams will be active.
40434	SCR Temperature Fault (Startup)	[0…65535]	1:1	C	R	P	75	SCR temperature fault limit for start-up.
40435	SCR Temperature Alarm (Startup)	[0…65535]	1:1	C	2	P	70	SCR temperature warning limit for start-up.
40436	Inverter Temperature Fault Timer (Startup)	[0…65535]	1:1	secs	R	P	900	The number of seconds from startup that the Startup Faults and Alarms limits are active, after which the Operational Faults and Alams will be active.
40437	Inverter Temperature Fault Timer (Startup) Remaining	[0…65535]	1:1	secs	R	-	-	The remaining number of seconds from startup that the Startup Faults and Alarms limits will be active. After this timer has expired, the Operational Faults and Alams will be active.
40438	Inverter Temperature Fault (Startup)	[0…65535]	1:1	C	2	P	75	Inverter temperature fault limit for start-up.
40439	Inverter Temperature Alarm (Startup)	[0…65535]	1:1	C	2	P	70	Inverter temperature alarm limit for start-up
40440	Cavity Temperaure Fault Timer (Startup)	[0…65535]	1:1	secs	R	P	900	The number of seconds from startup that the Startup Faults and Alarms limits are active, after which the Operational Faults and Alams will be active.
40441	Cavity Temperaure Fault Timer (Startup) Remaining	[0…65535]	1:1	secs	R	-	-	The remaining number of seconds from startup that the Startup Faults and Alarms limits will be active. After this timer has expired, the Operational Faults and Alams will be active.
40442	Cavity Temperature Fault (Startup)	[0…65535]	1:1	C	R	P	85	Cavity temperature fault limit for start-up.
40443	Cavity Temperature Alarm (Startup)	[0…65535]	1:1	C	2	P	80	Temperature alarm limit used during startup.
40444	Earth Leakage Fault Limit	[0...65535]	1:1	A	R	P	500	If the Earth Leakage Current goes above this limit, then the 40026 Earth Leakage Fault will be triggered.
40465	IO Board Spare Pressure Coeff Selector	[0…1]	1:1	FW	2	P	0	This switch identifies which type of pressure is connected to the spare pressure input of the IO board. Setting this switch to the proper value allows the firmware to use the proper coefficients to compute pressure. **0** = Suction Pressure **1** = Discharge Pressure
40491 40492	EEPROM Writes	[0...65535]	**Note 12**	-	R	P	-	Tracks the total number of occurrences that Modbus registers are written to EEPROM. This does not include internal writes to EEPROM. See Section "2.3.1 Memory Operation Overview" on page 23 for more information.
40499	Drive Enabled Count	[0...65535]	1:1	-	2	P	-	Indicates the total amount of compressor start ups. The trigger for counting a start up is when the compressor changes modes from levitate to drive.
40516	Control Algorithm in Startup or Full Vane Count	[0…65535]	1:1	-	R	-	-	This is a counter indicating the number of times the control algorithm has been in startup or fullvane logic path since the last time it was read. Registers 40516-40519 should be read at the same time to provide an indication that the system is executing inside of a given logic path.
40517	Control Algorithm in Part Vane Count	[0…65535]	1:1	-	R	-	-	This is a counter indicating the number of times the control algorithm has been in part vane logic path since the last time it was read. Registers 40516-40519 should be read at the same time to provide an indication that the system is executing inside of a given logic path.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
40518	Control Algorithm in Part Vane Orbit 1 Count	[0…65535]	1:1	-	R	-	-	This is a counter indicating the number of times the control algorithm has been in part vane Orbit 1 path since the last time it was read. Registers 40516-40519 should be read at the same time to provide an indication that the system is executing inside of a given logic path.
40519	Control Algorithm in Part Vane Orbit 2 Count	[0…65535]	1:1	-	R	-	-	This is a counter indicating the number of times the control algorithm has been in part vane Orbit 2 path since the last time it was read. Registers 40516-40519 should be read at the same time to provide an indication that the system is executing inside of a given logic path.
40531*	Enable Low Lift Configuration	[0…1]	1:1	FW	3	P	0	If value is 0, the compressor will be configured for Standard Lift (default). If value is 1, the compressor will be configured for Low Lift.
41812	Skip IGV Initialization on Fault	[0…1] 0 = False 1 = True	1:1	Boolean	3	P	0	Enable this parameter to cause the compressor to skip initialization of the IGV the next time a fault occurs while the compressor is in operation.
41813	Fast Restart Enabled	[0…1] 0 = False 1 = True	1:1	Boolean	3	P	1	When there is a power failure and this feature is enabled, the BMCC will store the last known IGV position and restore on the next power up for a Fast Restart sequence.
41814	Open IGV to Start Position after Initialization	[0…1] 0 = False 1 = True	1:1	Boolean	3	P	0	Enable this parameter to cause the compressor to initialize the IGV to the start position after the reset sequence has completed.
41817	Minimum Motor Current	[0...65535]	1:88	A	3	P	CMS	The minimum motor current that must be present to transition from the "Start Up Phase" to the "Mechanical Capacity Control Phase". The motor speed will keep increasing if this minimum motor current is not met.
41818	Start Speed Offset	[0...65535]	1:1	RPM	3	P	CMS	Value that is added to 42039 **Motor Start Speed** to determine the 40101 **Desired Speed** during the "Start Up Phase". This ensures that the controller does not undershoot and fail to reach the 42039 **Motor Start Speed**.
41819	Part Vane Speed Compensation	[0...65535]	1:1	RPM	3	P	CMS	Surge speed compensation added at 0% IGV. The compensation is linear with maximum RPM added at 0% IGV and 0 RPM added at 105% IGV. From 105% to 110% IGV, 0 RPM is added.
41820	Minimum Start Speed Percentage	[0...1000]	1:10	%	3	P	CMS	Minimum start speed in percentage between 40055 **Surge Speed** and 40056 **Choke Speed**. The register is used in this expression to calculate the *Minimum Start Up Speed* for the current operating conditions. **NOTE:** This is not the same as 42039 **Motor Start Speed**. *Minimum Start Up Speed* = 40055 **Surge Speed** + (41820 **Minimum Start Speed Percentage** / 1000) * (40056 **Choke Speed** - 40055 **Surge Speed**) + 41818 **Start Speed Offset.**
41821	Motor Start IGV Percentage	[0...1000]	1:10	%	3	P	500	IGV position in percentage of 42061 **IGV Start Position** when the motor will start spinning. 0% means the IGV and motor start at the same time. 100% means that the motor will first start spinning when the IGV has reached 42061 **IGV Start Position**.
41822	Motor Speed Ramp-Up Increment	[0…65535]	**Note 13**	-	3	P	CMS	Speed increase in RPM's per compressor control loop iteration (~200Hz) during ramp-up acceleration in the very last period of start up after start speed is reached. The purpose of this is to ensure that the check valve is driven open and that 41817 **Minimum Motor Current** is achieved.
41858	Earth Leakage Current Actual Value	[0...65535]	1:1	A	R	T	-	Actual value of Earth Leakage at the time of a fault.
41892	MTRV Fault Limit	[0…65535]	1:1	-	R	P	3000	The limit at which point and MTRV Fault will be indicated.
41894	Soft Start Temperature	[0…65535]	1:10	K	R	-	-	A Soft Start Temperature reading less than -35 deg. C or greater than 100 deg. C will indicate an error with the sensor and will flag the Soft Start Temperature Fault (reg. 40288 bit 9).

* Registers added with 4.1.0 firmware.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
41895	Clear Faults	[0…1]	1:1	FW	1	T	-	Once the condition(s) that caused fault(s) to be triggered has been cleared, then writing 1 to this register clears the faults.
41898	DC Bus Voltage Scaling Factor	[0…65535]	1:1	VDC	R	P	1000	The scaling factor to be applied to the voltage reading from the inverter.
41899	DC Bus Current Scaling Factor	[0…65535]	1:1	A	R	P	CMS	The scaling factor to be applied to the current reading from the inverter.
41979	SCR Mains Frequency	50 or 60	1:1	Hz	R	P	CMS	Indicates the SCR Mains Input Frequency which is typically 50Hz or 60Hz.
41980	DC Bus Under Voltage Fault Limit	[-32768…32767]	**Note 18**	VDC	R	P	CMS	The minimum 40025 **DC Bus Voltage** below which the 40106 DC Bus Under/Over Voltage Fault would be indicated and the motor is stopped or prevented from starting. **NOTE:** This limit was originally intended to be enforced at the Softstart but instead applies to the DC Bus.
41981	DC Bus Over Voltage Fault Limit	[-32768…32767]	**Note 18**	VDC	R	P	CMS	The maximum 40025 **DC Bus Voltage** above which the 40106 DC Bus Overvoltage fault would be indicated and the motor is stopped or prevented from starting. **NOTE:** This limit was originally intended to be enforced at the Softstart but instead applies to the DC Bus.
41982	DC Bus Voltage Bearing Self-Test Enabled Limit	[-32768...32767]	**Note 7**	VDC	R	P	CMS	The minimum 40025 **DC Bus Voltage** below which the "Bearing Self-Test (Startup Check)" will not occur.
42001	Maximum DC Bus Voltage	[-32768…32767]	**Note 18**	VDC	R	P	CMS	The highest acceptable 40025 **DC Bus Voltage** above which the 40106 DC Bus Overvoltage is indicated and the motor is stopped.
42002	Generator Mode Enabled Level	[-32768…32767]	**Note 7**	%	R	P	27851	Percentage of the filtered 40025 **DC Bus Voltage** below which Generator Mode Active fault will occur.
42006	Maximum Single Phase Motor Current	[-32768…32767]	**Note 14**	A	R	P	CMS	The highest acceptable Single-Phase Motor Current (Ia, Ib or Ic) at which point the 40106 Motor Single Phase Overcurrent fault is set and the motor is stopped.
42015	Motor Minimum Magnetized Power Fault Limit	[-32768…32767]	1:64	kW	R	P	2	The lowest acceptable 40104 **Actual Power** (before accounting for 2.5% Inverter losses) at which point the 40106 **Motor Voltage Generates No Current fault** is indicated and the motor is stopped.
42027	Surge Recovery/ Prevention Orbit Limit	[0...R42028]	1:1	-	3	P	CMS	The maximum amount of 40166 **Front Radial Orbit Displacement (FROD)** allowed before the compressor attempts to recover from or prevent surge by closing the IGV. Default Values: TT300/TT350/TT400/TG230/ TG310/TG390: 50 TT700/TG520: 800 See "Mechanical Capacity Control Phase" for more information.
42028	Surge Warning Orbit Limit	[0...R42029]	1:1	-	3	P	CMS	The maximum amount of 40166 **Front Radial Orbit Displacement (FROD)** allowed before the compressor actively prevents surging by speeding up and opening the IGV. Default Values: TT300/TT350/TT400/TG230/ TG310/TG390: 75 TT700/TG520: 1200 See "Mechanical Capacity Control Phase" for more information.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
42029	Orbit Limit Max	[0...65535]	1:1	-	R	P	CMS	The maximum value which can be set in register 42028 **Surge Warning Orbit Limit**. Default Values: TT300/TT350/TT400/TG230/ TG310/TG390: 400 TT700/TG520: 1200
42032	Motor Back EMF	[0...65535]	**Note 15**	-	R	T	-	The calculated Motor Back EMF feedback.
42033	Part-Vane Speed Gain	[0...65535]	1:1	-	3	P	CMS	The reciprocal rate of speed change while operating in "Mechanical Capacity Control Phase". The rate of acceleration is inverse to the value set. That is a setting of 1 = 20 RPM/s per iteration and a setting of 100 = 0.2 RPM/s per iteration.
42034	Surge Speed Offset	[-5000 to 5000]	1:1	RPM	3	P	1	The offset of the surge line used for compressor control.
42036	IGV Gain	[0...60000]	1:1	-	3	P	30000	The value used to determine the rate at which the IGV is adjusted. The larger the number, the smaller the adjustment increment.
42037	Motor Minimum Speed	[0...65535]	1:1	RPM	R	P	CMS	The minimum shaft speed that the capacity control algorithm will attempt to operate the compressor.
42038	Motor Speed Range	[0...65535]	1:1	RPM	R	P	CMS	The range of speeds beyond 42037 **Motor Minimum Speed** that the compressor can operate. 42038 **Motor Speed Range** + 42037 **Motor Minimum Speed** denotes the absolute maximum speed the compressor can obtain.
42039	Motor Start Speed	[0…65535]	1:1	RPM	2	P	CMS	The compressor will ramp up to this speed to exit the Start Up Phase.
42041	SCR Temperature Alarm Limit Operation	[0...65535]	1:10	**Note 1**	2	P	65	The highest acceptable 40035 **SCR Temperature** at which point the 40027 **SCR Temperature alarm** is indicated and the compressor motor is slowed down to overcome the alarm condition.
42042	SCR Temperature Fault Limit Operation	[0...65535]	1:10	**Note 1**	R	P	70	The highest acceptable 40035 **SCR Temperature** at which point the 40026 **SCR Temperature fault** is indicated and the compressor motor is stopped.
42043	Max Drive Start Up Temperature	[0...65535]	1:1	°C	R	P	50	The maximum 40105 **Inverter Temperature** allowed at start up time. If this temperature is exceeded, the compressor will not start and the 40029 **Above drive temperature limit - waiting to cool down status** will be indicated.
42044 42045	Compressor Control (CC) Version	[0...65535]	**Note 10**	-	R	-	FVS	The current version of the compressor firmware.
42046	Minimum IGV Steps	[0...65535]	1:1	Steps	3	P	0	The minimum number of steps from full close that the IGV must stay open. For example, a value of 0 indicates that the IGV can close completely while a value of 1000 indicates that the IGV must always stay open at least 1000 steps.
42060	Serial Driver Temperature	[0...65535]	1:1	**Note 1**	R	T	-	Actual recorded temperature of Serial Driver.
42061	IGV Start Position	[0...R40233]	1:1	Steps	2	P	CMS	The 40030 **IGV Open Percentage**, in steps, to which the IGV will be set at motor start up.
42062	Suction Superheat Fault Limit	[0...65535]	1:1	K	R	P	38	The maximum acceptable 40393 **Suction Superheat** at which the 40026 High Suction Superheat fault is indicated and the compressor motor is stopped.
42064	Cavity Cooling Max Temperature	[0...65535]	1:1	°C	R	P	CMS	The maximum 40037 **Cavity Temperature** at or above which the Cavity Cooling Solenoid will be opened.

Table 41 - Register Descriptions (Continued)

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
42065	Inverter Cooling Max Temperature	[0...65535]	1:1	°C	R	P	44	The maximum 40035 **SCR Temperature** or 40105 **Inverter Temperature** at or above which the Drive Cooling Solenoid will be opened.
42100 - 42199	Configurable Bulk Readout Values	**Note 17**	**Note 17**	**Note 17**	R	-	-	The values of the corresponding Modbus register addresses configured in 42200 - 42299 **Configurable Bulk Readout Addresses**. See Section "2.2.3 Configurable Bulk Register Readout" on page 22 for more information.
42200 - 42299	Configurable Bulk Readout Addresses	[0...65535]	1:1	-	1	T	-	Section "2.2.3 Configurable Bulk Register Readout" on page 22Modbus register addresses that the user would like to read in the corresponding 42100 - 42199 **Configurable Bulk Readout Values**.

* The min or max value of R4XXXX indicates the value is held by the register number (e.g. Register 40223 **Discharge Pressure Alarm Limit** has a range of [0…R40241] indicating the maximum of the range is the value in register 40241 **Discharge Pressure Fault Limit**).

** CMS = Compressor Model Specific / FVS = Firmware Version Specific.

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Appendix A: 3.1.X Functionality Definition

This appendix is dedicated to providing the detail that was removed from the software and likewise, the manual, for 4.X.X software.

• • • CAUTION • • •

The compressor will not accept **Demand** writes to register 40028 Demand at Access Level 1. The compressor must be at Access Level 2 or higher to accept Demand writes to register 40028 **Demand**. By default, the compressor starts up at access level 2 in 3.1.X.

Chiller Control Mode

Figure A-1 Using the Compressor as Chiller Controller

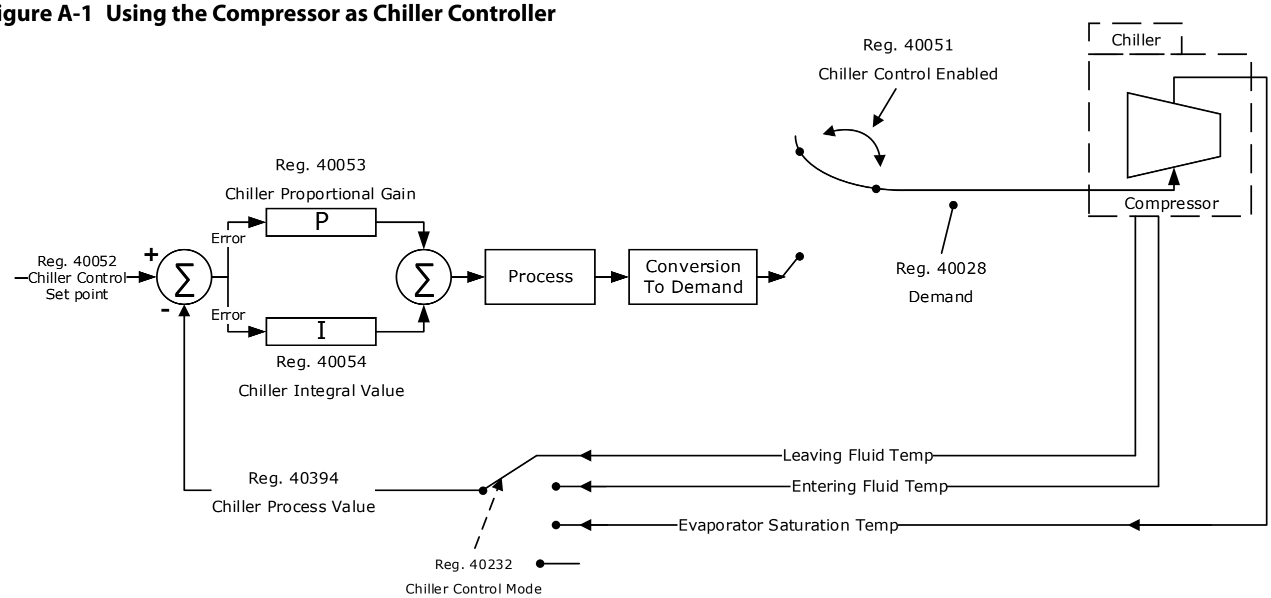


Table A-1 Chiller Control Mode Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40051	Chiller Control Mode Controller Enabled	[0...1]	1:1	Boolean	2	P	0	Indicates whether or not the Chiller Control Mode Controller is enabled. See Section "Chiller Control Mode" for more information.
40052	Chiller Control Mode Controller Set Point	[2530...3030]	1:10	K	2	P	2801	Represents the operational target for the Chiller Control Mode Controller.
40053	Chiller Control Mode Controller Proportional Gain	[0...1000]	1:1	-	2	P	30	Represents the proportional gain for the Chiller Control Mode Controller. The higher the proportional gain, the more severe the reaction to a given instantaneous deviation from the set point will be.
40054	Chiller Control Mode Controller Integral Gain	[0...1000]	1:1	-	2	P	3	Represents the integral gain for the Chiller Control Mode Controller. The higher the integral gain, the more severe the reaction to an accumulated deviation from the set point will be over time.
40232	Chiller Control Mode Controller Process Value Parameter	[0...2]	1:1	-	2	P	2	The parameter that the Chiller Control Mode Controller should use as its process value: **0** (Leaving Fluid Temperature) **1** (Entering Fluid Temperature) **2** (Evaporator Saturation Temperature)
40394	Chiller Control Mode Controller Process Value	[0…65535]	1:10	**Note 1**	R	-	-	The process value used by the compressor in Chiller Control mode. This value is dependent on the 40232 **Chiller Control Mode Controller Process Value Parameter**.

EXV Control Algorithm

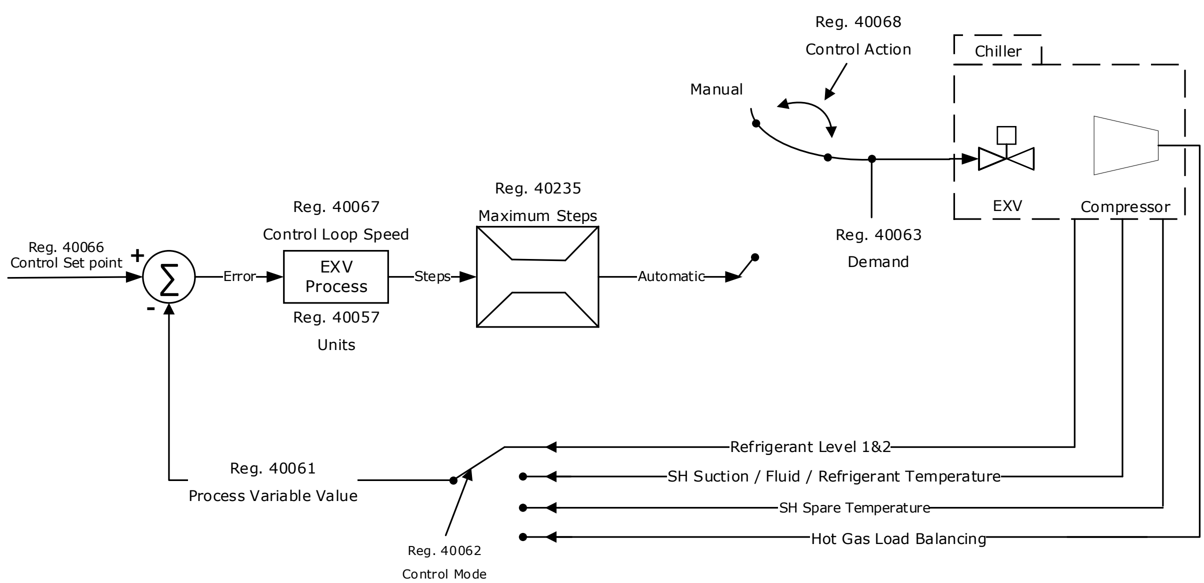
Expansion Valve (EXV), Load Balance Valve (LBV) and Staging Valve (SV) Control

The "Figure A-2 EXV Control Diagram" describes the EXV control loop and the parameters involved in setting up/controlling the EXV output. An important note is that 42062 **EXV 1 Control Mode**, together with 40057 **Display Units**, depicts the process variable used in the control loop, and therefore, the 40066 **EXV 1 Control Set Point** or 40075 **EXV 2 Control Set Point** is to be interpreted that way too. The process variable is reflected in 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** as a read-only register. The EXV rate of change is governed using the 40067 **EXV 1 Control Loop Speed** rather than using a PID control scheme.

NOTE

The functionality described here differs from BMCC Firmware release 3.0.x. See Appendix B "3.0.x Functionality Definition" for more information if you are using Firmware 3.0.x.

Figure A-2 EXV Control Diagram



The EXV position in "Figure A-2 EXV Control Diagram" illustrates the EXV configuration parameters and shows the position within these limits. The EXV output to the stepper motor will be due to 40067 **EXV 1 Control Loop Speed** approaching the setpoint over time, but never surpassing it. The illustration below indicates that the process value was fluctuating, thereby resembling a curved appearance instead of a rising straight line.

"Table A-2 Control Modes" on page 97 explains in more detail what, when and how to choose a control mode, depending on the kind of sensor and/or sensor signal the customer has for the EXV stepper motor control.

Table A-2 Control Modes

Control Mode	Detailed Description
Superheat	The calculation of superheat is based on the temperature and pressure measurements from one of the following sources: • Superheat control using the compressor flange temperature and pressure (this mode is not recommended as the temperature at the compressor flange is influenced by external factors). • Superheat control, using the compressor flange pressure and a thermistor that is connected to the terminals labeled "ENTRY" on the IO-Board. • Superheat control using the compressor flange pressure and a thermistor that is connected to the terminals labeled "LIQDT" on the IO-Board. • Superheat control using an external temperature and pressure sensor connected to the terminals labeled "Spare T" and "Spare P" on the I/O board. When this mode is selected, the register 42048 **EXV2 Minimum Steps** will use a 0-5 VDC output for a 0-1034 kPA (0-150 psi) range which assumes the pressure sensor has been connected to the suction line. Any other EXV control mode will result in the 42048 **EXV2 Minimum Steps** using a 0-5 VDC output for a 0-3447 kPa (0-500 psi) range when a sensor is connected. **NOTE:** Thermistors must be an NTC type 10k @ 25° C, curve type F
Liquid Level	Liquid level can be measured from one of the following sources: • Liquid Level 1 control using a level sensor connected to the terminals on the Compressor IO-Board labeled "LIQ LEV1". • Liquid Level 2 control using a level sensor connected to the terminals on the Compressor IO-Board labeled "LIQ LEV2". For liquid level sensing, two types of level sensors can be used: a level sensor with a supply of 15VDC and an output of 0- 5VDC, or a resistive-type level sensor, 0-90 Ohm. Refer to vendor documentation for wiring these types of sensors to the compressor I/O board.
Load Balance	The Load Balance control mode uses the compressor's own internal control algorithm to determine the best mix of speed control, IGV opening and load balance valve opening. Use this mode only if a load balancing valve is installed in the system. Since the load balancing valve is connected to the compressor's capacity control algorithm, selecting this mode without a valve installed will add a delay to the loading/ unloading process, i.e.: the compressor will try to open and close the valve for two minutes rather than close the vane or change the speed.

The compressor offers two EXV output ports on the I/O board for either pure OEM control or control by certain compressor parameters. Both EXVs are independently adjustable by the following parameters.

Table A-3 Chiller Control Mode Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40061	EXV 1 Process Variable Value	[0…65535]	**Note 3**	**Note 2**	R	-	-	The EXV's process value by which the EXV position is controlled. The value depends on EXV Control Mode and 40057 **Display Units**. **NOTE:** Value in register does not change when unit type is changed between Metric and US Customary.
40062	EXV 1 Control Mode	[0...7]	1:1	-	2	P	2	The methodology used to control the EXV output. The options available are suction superheat, liquid level or compressor load balance. **0** = No Function **1** = SH Suction Temp/Pressure **2** = SH Entering Fluid Temp/Suction Pressure **3** = SH Liquid Refrigerant Temp/Suction Pressure **4** = SH Spare Temp/Spare Pressure **5** = Liquid Level 1 **6** = Liquid Level 2 **7** = Hot Gas Load Balancing
40063	EXV 1	[0…65535]	**Note 3**	**Note 2**	R	-	-	The EXV's process value by which the EXV position is controlled. The value depends on EXV Control Mode and 40057 **Display Units**. **NOTE:** Value in register does not change when unit type is changed between Metric and US Customary.

Table A-3 Chiller Control Mode Parameters (Continued)

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40064	EXV 1 Start Position	[0...1000]	1:10	%	2	P	500	If desired, the valve can be set to open to a pre-start value for a given time at compressor start up. This value represents the percentage of maximum steps made by the stepper motor when the shaft starts to rotate. The stepper motor will hold at this position until the 40065 EXV 1 Stepper Start Delay Time has expired.
40065	EXV 1 Stepper Start Delay Time	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the 40064 EXV 1 Start Position is in held. The Stepper Start Delay Timer starts to count down when drive is enabled.
40066	EXV 1 Control Set Point	[0...1000]	1:10	%	2	P	10	Suction Superheat or Liquid Level percentage in accordance with the selected Control Mode. Not applicable to Hot Gas Load Balancing mode because the compressor will calculate the best position.
40067	EXV 1 Control Loop Speed	[0…50]	2:1	%	2	P	5	Represents the reaction time of the control loop to process error. 1 (2%) is slow and 50 (100%) is fast.
40068	EXV 1 Control Action	[0…1] 0 = Manual 1 = Automatic	1:1	-	2	P	1	**Manual:** Write directly to 40063 EXV 1 Position to make the EXV open or close. **Automatic:** See 40062 EXV 1 Control Mode for available EXV Control Modes.
40070	EXV 2 Process Variable Value	[0…65535]	**Note 3**	**Note 2**	R	-	-	The process value of the EXV by which the EXV position is controlled. The value depends on 40071 EXV 2 Control Mode and register 40057 Display Units. **NOTE:** Value in register does not change when unit type is changed between Metric and US Customary.
40071	EXV 2 Control Mode	[0...7]	1:1	-	2	P	2	The methodology used to control the EXV output. The options available are suction superheat, liquid level or compressor load balance. **0** = No Function **1** = SH Suction Temp/Pressure **2** = SH Entering Fluid Temp/Suction Pressure **3** = SH Liquid Refrigerant Temp/Suction Pressure **4** = SH Spare Temp/Spare Pressure **5** = Liquid Level 1 **6** = Liquid Level 2 **7** = Hot Gas Load Balancing
40072	EXV 2 Position	[0...1000]	1:10	%	R	-	-	The current valve position as a percentage of EXV Maximum Steps.
40073	EXV 2 Start Position	[0...1000]	1:10	%	2	P	500	If desired, the valve can be set to open to a pre-start value for a given time at compressor start up. This value represents the percentage of maximum steps made by the motor when the shaft starts to rotate. The stepper motor will hold at this position until the 40074 EXV 2 Stepper Start Delay Time has expired.
40074	EXV 2 Stepper Start Delay Time	[0…600]	1:1	Seconds	2	P	90	Represents the time in seconds that the 40073 **EXV 2 Start Position** is in held. The 40074 **EXV 2 Stepper Start Delay Time** starts to count down when drive is enabled.
40075	EXV 2 Control Set Point	[0...1000]	1:10	%	2	P	10	Suction Superheat or Liquid Level percentage in accordance with the selected control mode. Not applicable to Hot Gas Load Balancing mode because the compressor will calculate the best position.
40076	EXV 2 Control Loop Speed	[0…50]	2:1	%	2	P	5	Represents the reaction time of the control loop to a process error. **1** (2%) is slow and **50** (100%) is fast.
40077	EXV 2 Control Action	[0…1] 0 = Manual 1 = Automatic	1:1	-	2	P	1	**Manual:** Write directly to register 40072 **EXV 2 Position** to make the EXV open or close. **Automatic:** See register 40071 **EXV 2 Control Mode** for EXV position control.

Table A-3 Chiller Control Mode Parameters (Continued)

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40235	EXV 1 Maximum Steps	[0...7200]	1:1	steps	2	P	6000	The number of steps between the fully closed and fully open positions for EXV 1.
40236	EXV 1 Initialization Steps	[0...7200]	1:1	steps	2	P	6000	The number of steps required to ensure initialization of EXV1 to the fully closed position. This value must be larger than or equal to 40235 **EXV 1 Maximum Steps** for the initialization feature to function as expected.
40237	EXV 2 Maximum Steps	[0...7200]	1:1	steps	2	P	6000	The number of steps between the fully closed and fully open positions for EXV 2.
40238	EXV 2 Initialization Steps	[0...7200]	1:1	steps	2	P	6000	The number of steps required to ensure initialization of EXV2 to the fully closed position. This value must be larger than or equal to 40237 **EXV 2 Maximum Steps** for the initialization feature to function as expected.
42035	Hot Gas Bypass / Load Balance Valve Control Gain	[0...60000]	1:1	-	3	P	30000	The denominator used to calculate the rate at which the Load Balance Valves are adjusted;. i.e. the larger the number, the smaller the adjustment increments. This parameter is only in effect when 40062 **EXV 1 Control Mode** and/or 40071 **EXV 2 Control Mode** are set equal to 7 (Hot Gas Load Balancing).
42047	EXV 1 Minimum Steps	[0...65535]	1:1	steps	3	P	0	The minimum number of steps from full close that EXV 1 must stay open. For example, a value of 0 indicates that the EXV 1 can close completely while a value of 1000 indicates that EXV 1 must always stay open at least 1000 steps.
42048	EXV 2 Minimum Steps	[0...65535]	1:1	steps	3	P	0	The minimum number of steps from full close that EXV 2 must stay open. For example, a value of 0 indicates that EXV 2 can close completely while a value of 1000 indicates that EXV 2 must always stay open at least 1000 steps.

Fast Restart

The Bearing self-test with software prior to 4.X.X is significantly longer, but can be disabled up to a maximum of 10 times. See below and "Table A-4 Fast Restart Registers" on page 100 for more information on skipping the Bearing Self-Test. Fast Restart is enabled by writing a value of 1 to register 41813 **Fast Restart Enabled**.

NOTE

The Fast Restart feature is supported only in Modbus Network Control mode. Any specified pre-cooling time set in 40220 **Start Up Pre-Cooling Configuration** will be processed prior to compressor ramping up.

NOTE

The Fast Restart feature is saved in "RAM Only" and is off by default. The user must enable Fast Restart after every power cycle for the feature to remain active.

⚠ • • • CAUTION • • •

If the Interlock is opened before a generator mode fault occurs, the Fast Restart feature will be disabled, the compressor will stop and the IGV will reset.

Fast Restart - Skip Bearing Self-Test

The BMCC software is designed such that on every power-up a Bearing Self-Test (also known as Start Up Check or Bearing Check) is performed to account for possible cavity or magnetic bearing changes that may impact the control algorithms.

This feature has been added so that the user may reduce the Fast Restart time by skipping the Start Up Bearing Self-Test. This *Fast Restart - Skip Bearing Self-Test* sequence can be executed up to a maximum of 10 times (as defined in register 40210 **Fast Restart Bearing Self-Test Skipped Max Limit**, set to 0 by default) before it will force a Bearing Self-Test on start up and reset the running counter. The compressor will then return to skipping the Bearing Self-Test on the next power up sequence.

NOTE

If a normal power up (with Bearing Self-Test) takes place, the compressor will reset the 40211 Fast Start Up Bearing **Self-Test Skipped Counter** to 0.

Table A-4 Fast Restart Registers

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40210	Fast Restart Bearing Self-Test Skipped Max Limit	[0….10]	1:1	-	3	P	0	The maximum number of sequential Fast Restart - Skip Bearing Self Tests allowed before the Bearing Self Test sequence is performed by the compressor at next power on. See "Fast Restart - Skip Bearing Self Test".
40211	Fast Start Up Bearing Self-Test Skipped Counter	[0….10]	1:1	-	R	-	-	The counter for the number of sequential Fast Restarts since the last Bearing Self Test has been completed. When the counter equals the 40210 **Fast Restart Bearing Self Test Skipped Max** Limit a Bearing Self Test will be performed and the counter will be reset to 0.
41813	Fast Restart Enabled	[0…1] 0 = False 1 = True	1:1	Boolean	3	T	0	When there is a power failure and this feature is enabled, the BMCC will store the last known IGV position and restore on the next power up for a Fast Restart sequence.

Other Non-Specific Changes

Access Level 0 (None) (Access Code = 0)

Access Level 0 only allows input of access code to gain higher level access. All registers are readable at this level.

⚠ • • • CAUTION • • •

The compressor will not accept Demand writes to register 40028 **Demand** at Access Level 0 or 1. The compressor must be at Access Level 2 or higher to accept Demand writes to register 40028 **Demand.** By default the compressor starts up at access level 2 in 3.1.x.

Table A-5 Compressor Alarm and Fault Limit Registers Removed From 4.X.X Software

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40225	Discharge Temperature Alarm Limit	[0…R40243]	1:1	°C	2	P	CMS	The highest acceptable 40036 **Discharge Temperature** at which point the 40027 Discharge Temperature alarm is indicated and the compressor motor is slowed down to overcome the alarm condition.
40228	Leaving Fluid Temperature Alarm Limit	[40246…65535]	1:10	°K	2	P	2761	The lowest acceptable 40046 Leaving Fluid Temperature at which point the 40027 Leaving Fluid Temperature alarm is indicated and the compressor motor is slowed down to overcome the alarm condition.
40246	Leaving Fluid Temperature Fault Limit	[0…65535]	1:1	°K	R	P	2741	The lowest acceptable 40046 Leaving Fluid Temperature at which point the 40026 Leaving Fluid Temperature fault is indicated and the compressor motor is stopped.

Analog Output

The analog output is only available in manual mode, which means that it can only be used to manually control a 0-5VDC or 0-10VDC output on the I/O board. The output is used by writing the setpoint to 40081 **Analog Output Percentage** as a percentage of the total range.

For example, writing a value of 253 to register 40081 **Analog Output Percentage** will specify a setpoint of 25.3% of the total voltage. If JP1 is set to the 5V setting, the resulting voltage on the I/O board will be 1.265VDC. If JP1 is set to the 10V setting, the resulting voltage on the I/O board will be 2.53VDC.

Appendix B: 3.0.x Functionality Definition

This section contains specific excerpts from *Programming Manual Rev. C*. These excerpts: EXV – External Expansion Valve Manual Control and Analog Output, define the functionality of these features as of BMCC Firmware 3.0.x. The content of Section "Access Control", Section "Expansion Valve (EXV), Load Balance Valve (LBV) and Staging Valve (SV) Control" and Section "Analog Output" only apply to BMCC Firmware 3.1.x. The information in these sections constitutes the only feature difference between Firmware 3.0.x and 3.1.x. Please reference the appropriate *Software Release Notice (B-SR-xxx)* for more information.

Access Control

The compressor implements Access Control to secure the use of various features and settings of the compressor from unauthorized users. The result is a variety of access levels which apply on a per register basis only on write operations. The compressor does not enforce access control on read operations. If the users access level is equal to or greater than the minimum required for a given register, the user is permitted write privileges.

The current access level can be determined by reading register 40425 **Access Code Entry Current Level** and can be modified by writing the appropriate access code to the same register.

NOTE

When submitting the access code to the BMCC using register 40425 **Access Code Entry Current Level,** the compressor will not return the access code. It will return the access level (0-5). This may cause some Modbus implementations to return an error.

Table B-1 Access Control Register

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40425	Access Code Entry/ Current Level	[0...65535] W [0...5] R	1:1	-	0	T	0	Displays the current access level and is the register used to input the compressor access code.

⚠ • • • CAUTION • • •

The compressor will not accept Demand writes to register 40028 **Demand** at an Access Level which is less than Access Level 2. The compressor must be at Access Level 2 or higher to accept Demand. By default, the compressor starts up at access level 0 in 3.0.x.

⚠ • • • CAUTION • • •

Invalid Access Code entry will set the compressor Access Level to 1 (Basic). Repeated Invalid Access Code entries will result in the compressor locking at Access Level 1 (Basic) and requires a power cycle to reset.

EXV – External Expansion Valve Manual Control

The EXV feature provides control for two independent stepper motors. The OEM must send a command to a given register (40063 **EXV 1 Position** or 40072 **EXV 2 Position**) which corresponds to a given direction and number of steps. The feature also provides a feedback on the current step in reference to the last command register (40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value**).

Notice that the BMCC is unaware of the starting valve position, or the number of steps required to reach a fully open/closed position, or whether a positive/negative command means clockwise/counterclockwise rotation. These details are specific to the OEM selected motors, valves and their specific installation. The OEM is responsible to determine through testing the number of steps and command direction needed to fully close/open their selected valves. In addition, the OEM is responsible to properly manage commanding sequences to eliminate the potential of damage to the motors or valves due to over driving the controller beyond physical limits.

NOTE

Only the registers listed in "Table B-1 Access Control Register" on page 101 are utilized by the EXV control algorithm for Firmware 3.0.x. All other parameters have no effect even though they may appear configurable and may contain default values.

DTC development and testing was done using a step motor/gear combination which requires 360 steps to complete a full 360 degree rotation. This test information is used to provide a couple of examples to illustrate proper use of the feature.

For these examples we will assume the following:

• Step motor/gear with 360 steps for a full rotation.

• A positive command is a counterclockwise or open valve direction.

• The valve requires 1 full rotation to reach fully closed/open position.

• The valve starting position is fully closed.

Example 1: Command to fully open, followed by command to fully close

• The OEM will write 90 to 40063 **EXV 1 Position** or 40072 **EXV 2 Position** to fully open the valve.

• The OEM can monitor motor movement progress by inspecting the current step register.

— The 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** will start to increase from 0 to 360 (90x 4).

— Once register 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** reads 0, the motor has reached the commanded steps.

NOTE: Depending on the read rate of 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value**, the value reaching the target may not be observed. However, when the value reads 0 the motor has reached the its commanded position.

• The OEM will write -90 to the (40063 **EXV 1 Position** or 40072 **EXV 2 Position** to fully close the valve.

• The OEM can monitor motor movement progress by inspecting the 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value**.

— 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** will start to decrease from 0 to -360 (90x 4).

— Once 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** reads 0, the motor has reached the commanded steps.

Example 2: Command to half open, followed by command to ¼ open

• The OEM will write 45 to the 40063 **EXV 1 Position** or 40072 **EXV 2 Position** to half open the valve.

• The OEM can monitor motor movement progress by inspecting the 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value.**

— The 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** will start to increase from 0 to 180 (45 x 4).

— Once 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** reads 0, the motor has reached the commanded steps.

NOTE: Depending on the read rate of 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value**, the value reaching the target may not be observed. However, when the current steps reads 0 the motor has reached the its commanded position.

• The OEM will write -22 or -23 to 40063 EXV 1 Position or 40072 EXV 2 Position to close the valve back to only ¼ open.

• The OEM can monitor motor movement progress by inspecting 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value.**

— 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** will start to decrease from 0 to -88 or -92 (-22 x 4 or -23 x 4).

— Once the 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** reads 0, the motor has reached the commanded steps.

• 40063 **EXV 1 Position** or 40072 **EXV 2 Position** have a maximum range of -8192 to 8191. Due to computer representations of positive/negative integers, numbers beyond the range will be interpreted in the opposite direction.

For example, a value of 8192 will theoretically wrap back to the most negative number possible (-8192) and will rotate the motor in the opposite direction. The OEM must ensure to issue only commands within the specified ranges.

• A command of 0 makes the motor controller stop at the current step location. For example, if the OEM issues a command of 1000, it will take time for the motor to reach that number of steps, the OEM may send a command of 0 to immediately stop movement. Please note that the BMCC does not keep track of current position and will reset the current steps register to 0 immediately. This is not a recommended way of operating the controller. The recommended method will be to issue a command and wait until the BMCC reports 0 in the 40061 **EXV 1 Process Variable Value** or 40070 **EXV 2 Process Variable Value** indicating that it has reached the commanded position.

Table B-2 EXV Operation Parameters

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
40061	EXV 1 Process Variable Value	[-32768...32767]	1:1	Steps	R	-	-	The current position of the stepper motor on EXV1.
40063	EXV 1 Position	[-32768...32767]	4:1	Steps	2	-	-	The desired position of the stepper motor on EXV1.
40070	EXV 2 Process Variable Value	[-32768...32767]	1:1	Steps	R	-	-	The current position of the stepper motor on EXV2.
40072	EXV 2 Position	[-32768...32767]	4:1	Steps	2	-	-	The desired position of the stepper motor on EXV2.

Analog Output

The compressor can be configured as 0-5 or 0-10 VDC by jumper JP1 on the I/O board. In reference to this range, the output voltage is now only a function of 40033 **Discharge Pressure**.

Given the 0-5 VDC range, 0 volts equates to 0 kpag, and 5 volts equates to 2000 kpag.

Given the 0-10 VDC range, 0 volts equates to 0 kpag, and 10 volts equates to 2000 kpag.

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