

ENGINEERING  
TOMORROW

*Danfoss*

OEM Programming Manual

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

TT & TG Series



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## Introduction

This *Programming Manual* is intended for use by personnel responsible for configuration, control and monitoring the performance of 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 Section "Register Definitions."

### 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 "Software Version" 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	4.1.0/4.0.0/3.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.

### Organization of this Manual

The additional sections of the *Programming Manual* are:

Section "Compressor Communication and System Configuration": Provides a basic description of the Modbus protocol, the access level strategy, the compressor communication set-up, and the Modbus functions implemented by DTC.

Section "Compressor Control": This section 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.

Section "Bearing Control": This section defines the various parameters of Bearing Control.

Section "Motor/Power Electronics Control": This section defines the various parameters of Motor/Power Electronics Control.

Section "Alarms, Faults and Status Descriptions": This section provides a description of the compressor alarms, faults, status words and their related registers.

Section "Register Definitions": This section provides a description of each Modbus register organized numerically.

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## Introduction

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### 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: *Minimum 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.

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**NOTE**

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**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.

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**... DANGER ...**

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**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.

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 **... CAUTION ...**

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## Introduction

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### Related Documents

- *Service Monitoring Tools User Manual (M-SM-001)*
  - *Service Manual (M-SV-001)*
  - *Application Manual (M-AP-001)*
  - *Installation and Operation Manual (M-IO-001)*
- 

### 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.

## Introduction

### Parameter Notes

The notes in Table 2 (Parameter Notes) are applied to various registers where needed.

**Table 2 - Parameter Notes**

Note	Description
Note 1	<a href="#">40057 Display Units</a> dependent. If <i>US Customary</i> , the register value is in Rankine. If <i>Metric</i> , the register value is in Kelvin.
Note 2	K or °R (see Note 1)
Note 3	<b>Liq Lev 1 or Liq Lev 2: 1:1</b> <b>All other modes: 1:10</b>
Note 4	Pressure values are dependent on the selection for <a href="#">40057 Display Units</a> and all pressures are in absolute. Therefore, the register value will be either psia for US Customary or kPaa for Metric/Sl.
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 301kpa.
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 / 00sssss) Reg. 2 Hour (00000000 / 00hhhhh) Reg. 3 Year, Day & Month (YYYYYYD / DDDMMMM) 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: MMMMmmm 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) * <a href="#">41899 DC Bus Current Scaling Factor</a>
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 <a href="#">42200 - 42299</a> Configurable Bulk Readout Addresses. See the definition of the register specified for conversion information.
Note 18	Result = (Register Value/32768) * <a href="#">41898 DC Bus Voltage Scaling Factor</a>

## Introduction

### Abbreviations

The following abbreviations are used in this manual:

**Table 3 - Abbreviations**

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.
CMS	Compressor Model Specific.
DC	Direct Current.
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.
kg g	kilogram (SI, mass). gram.
K °R °C °F	Kelvin, $K = (°F + 459.67) \cdot 5/9 = °C + 273.15 = °R \cdot 5/9$ (SI thermodynamic temperature). Rankine, $°R = K \cdot 9/5 = (°C + 273.15) \cdot 9/5 = °F + 459.67$ . Celsius, $°C = K - 273.15 = (F - 32) \cdot 5/9$ . Fahrenheit, $°F = (°C \cdot 9/5) + 32 = K \cdot 9/5 - 459.67 = °R - 459.67$ .
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, $kPa = (psig + 14.69) \cdot 6.895$ . 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.

### 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 "Alarm/Fault Trigger Method".
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. <b>Note:</b> In this document, the terms alarm and warning are used interchangeably. See Section "Alarms, Faults and Status Descriptions".
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.
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 "Alarm/Fault Trigger Method".
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 <i>statically induced</i> . The electromotive force generated by motion is often referred to as <i>motional emf</i> . When the change in flux linkage arises from a change in the magnetic field around the stationary conductor, the EMF is <i>dynamically induced</i> . The electromotive force generated by a time-varying magnetic field is often referred to as <i>Transformer EMF</i> .
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 Section "Alarms, Faults and Status Descriptions".
FLA	Full Load Ampere.

## Introduction

**Table 4 - Definitions  
(Continued)**

Term	Definition
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	<p>Proportional / Integral / Derivative control.</p> <p>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 <i>P</i>, <i>I</i>, and <i>D</i>. Heuristically, these values can be interpreted in terms of time: <i>P</i> depends on the <i>present</i> error, <i>I</i> on the accumulation of <i>past</i> errors, and <i>D</i> is a prediction of <i>future</i> errors, based on current rate of change.</p>
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.

## Introduction

**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 the Resetting Non-Lockout Faults.
RFT	Range Fault Triggering: see Section "Alarm/Fault Trigger Method."
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, <a href="http://www.bipm.org">http://www.bipm.org</a> .
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.



## Compressor Communication and System Configuration

The 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 Section "Register Definitions". Throughout the

document, registers associated with the specific section are shown.

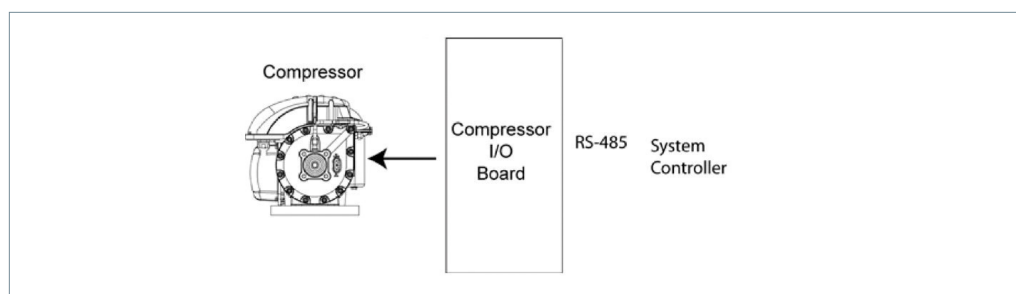
This section specifies how the compressor can be interfaced with either a RS-485 or RS-232 network. System settings such as software version, Real-Time Clock (RTC) and configuration part numbers are also described in this section.

### 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 Manual (M-AP-001)* for detailed information on making physical RS-232 or RS-485 connections to the compressor.

### 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 SMT software. It is not recommended for customer use as a Chiller Controller connection. The parameters in Table 5 (RS-232) 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.

#### ⚠ ... CAUTION ...

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

#### NOTE

The [40251 Modbus Slave ID](#) 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.

## Compressor Communication and System Configuration

**Table 5 - RS-232  
Communication Parameters**

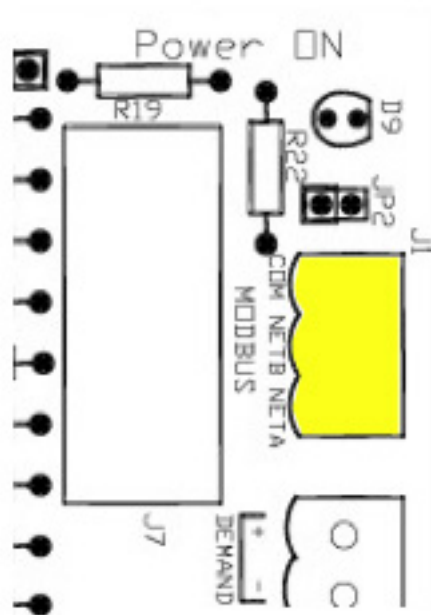
Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40251</a>	Modbus Slave ID	[0...64]	1:1	-	2	P	1	A unique identifier for the compressor on the Modbus network.
<a href="#">40255</a>	RS-232 Baud Rate	[9...10] 9 = 38400 bit/s 10 = 19200 bits/s	1:1	-	2	P	9	The RS-232 communication line transmission speed in bits transferred per second.
<a href="#">40256</a>	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. <b>0</b> = None; <b>1</b> = Odd; <b>2</b> = Even; <b>3</b> = Mark; <b>4</b> = Space
<a href="#">40257</a>	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.

### 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. It is the recommended connection between the I/O board and a Programmable Logic Controller (PLC) or other controller. The parameters in Table 6 (Communication Parameters) available for

adjustment 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 changes accordingly so that both applications can continue to communicate.

**Figure 2 - Connect Controller  
RS-485 ModBus at J1**

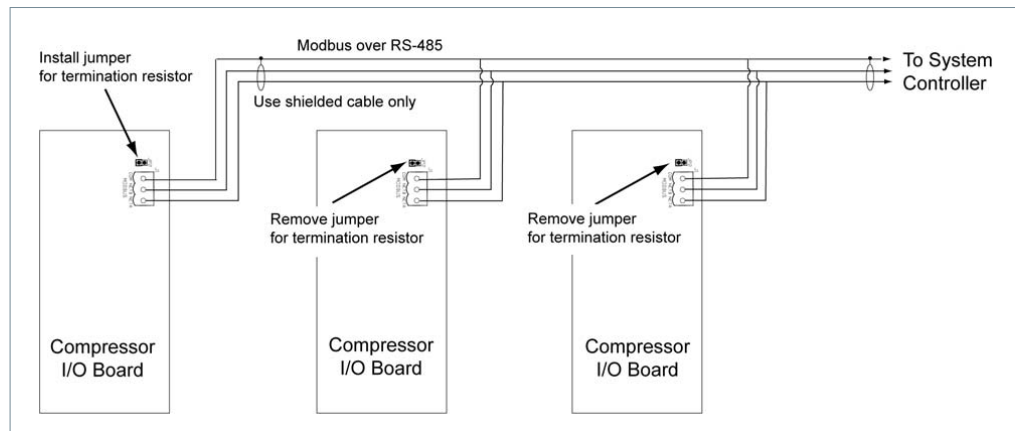


## Compressor Communication and System Configuration

**Figure 3 - Connecting Multiple Compressors**

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.



**CAUTION**

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

**NOTE**

The [40251 Modbus Slave ID](#) 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
<a href="#">40251</a>	Modbus Slave ID	[0...64]	1:1	-	2	P	1	A unique identifier for the compressor on the Modbus network.
<a href="#">40252</a>	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.
<a href="#">40253</a>	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. <b>0</b> = None; <b>1</b> = Odd; <b>2</b> = Even; <b>3</b> = Mark; <b>4</b> = Space
<a href="#">40254</a>	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.

**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.

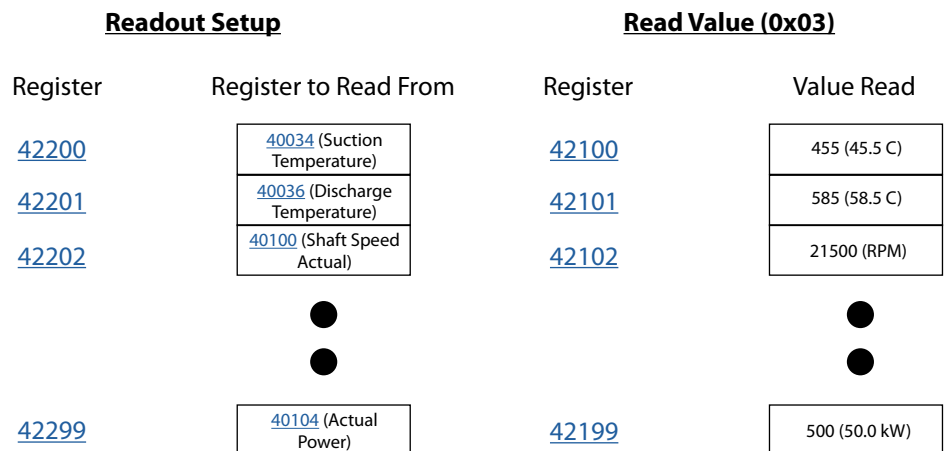
**NOTE**

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.

## Compressor Communication and System Configuration

<b>Communication Timing</b>	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.
<b>Implemented Modbus Function Codes</b>	This section defines the specific Modbus Protocol Function Codes which are supported by the	compressor. Function Codes not listed here are not supported.
<b>03 (0x03) Read Holding Registers</b>	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.
<b>06 (0x06) Write Single Register</b>	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.
<b>Configurable Bulk Register Readout</b>	<p>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 <a href="#">40021 – 42099</a>.</p> <ul style="list-style-type: none"> <li>Registers <a href="#">42200 - 42299</a> contain the register numbers the user wants to have read out.</li> </ul>	<ul style="list-style-type: none"> <li>Registers <a href="#">42100 - 42199</a> contain the register values to read.</li> </ul> <p>There is no specific order or sequence of the readout registers. The setup is retained in RAM and is lost after a power cycle.</p>

**Figure 4 - Bulk Register Setup and Read-out**



## Compressor Communication and System Configuration

**Table 7 - Bulk Register Setup and Read-out Registers**

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

### 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.

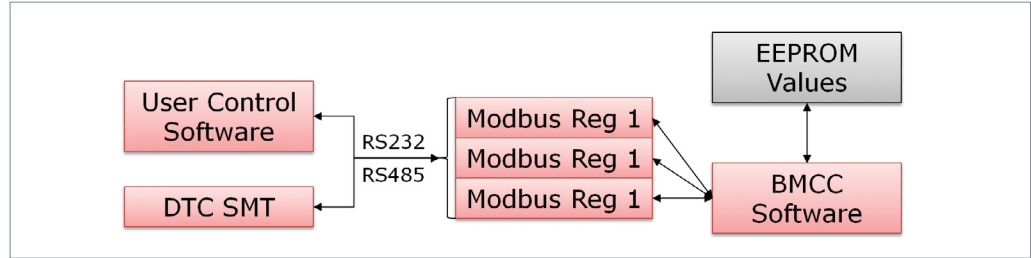
### Memory Operation Overview

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 32-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.

**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.

**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.

## Compressor Communication and System Configuration

### 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
<a href="#">40425</a>	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.

### 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.

### 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.

### Access Level 3 (Medium) OEM

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

### System Settings

The compressor uses the registers in Table 9 (System Setting Parameters) below to tailor

readouts, provide system identification or configure how the product behaves as a whole.

## Compressor Communication and System Configuration

**Table 9 - System Setting Parameters**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40057</a>	Display Units	[0...1] 0 = US Customary 1 = Metric	1:1	-	2	P	1	This setting affects all parameters which have <b>Note 1</b> or <b>Note 4</b> in the Type/Unit column. When in "Metric", the values read out/written to the compressor are interpreted as kPa, °C and K. In "US Customary", they are interpreted as psi, °F and R°.
<a href="#">40177</a> <a href="#">40178</a> <a href="#">40179</a>	Compressor Real Time Clock (RTC) Current Time	[0...65535]	<b>Note 8</b>	-	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.
<a href="#">40404</a> <a href="#">40405</a> <a href="#">40406</a>	BMCC Serial Number	[0...65535]	<b>Note 11</b>	-	R	-	BMCC Specific	Every BMCC has a unique fixed Serial Number.
<a href="#">40410</a> <a href="#">40411</a>	Compressor Software (Configuration) Part Number	[0...65535]	<b>Note 12</b>	-	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 <a href="#">40412 Configuration Revision</a> determines the complete software configuration including which <a href="#">42044 Compressor Control (CC) Version</a> is downloaded.
<a href="#">40412</a>	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 <a href="#">40410 Compressor Software (Configuration) Part Number</a> for configuration management traceability and tracking.

### Software Version

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:

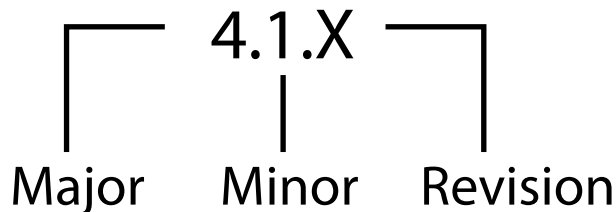
- Major – Incremented to indicate customer interface changes such as feature functionality

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
<a href="#">42044</a> <a href="#">42045</a>	Compressor Control (CC) Version	[0...65535]	<b>Note 10</b>	-	R	-	FVS	The current version of the compressor firmware.



## Compressor Configuration

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 Configuring the Compressor section earlier in this manual.

### Compressor Model and Refrigerant Configuration (Reg. 40413)

The Compressor Model and Refrigerant configuration can be read from register [40413](#) as described by the following table.

Also, only the refrigerant is configurable and can be modified by writing a "1" for R134a or an "8" for R513A to this register.

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	R153A*	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.

### Voltage Configuration (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.

### 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 the Low Lift Operation section for more details. The Low Lift Configuration is only available in firmware version 4.1.0 or later.

**Table 11 - Compressor Configuration**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40330</a>	Voltage Configuration	[0...65535]	1:1	-	R	P	CMS	The decimal value read is the actual voltage.
<a href="#">40413</a>	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.
<a href="#">40531</a>	Low Lift Selector	[0...1]	1:1	-	3	P	0	0 = Standard Lift (Default) 1 = Low Lift

## 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.

### Compressor Status Parameters

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

**Table 12 - Compressor Status Parameters**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40024</a>	BMC Operation Mode	[0...3]	1:1	-	R	-	-	Indicates the current operational status of the BMC control system: <b>0</b> ( <i>Standby</i> ); <b>1</b> ( <i>Levitate</i> ); <b>2</b> ( <i>Drive</i> ); <b>3</b> ( <i>Calibrate</i> ).
<a href="#">40026</a>	Compressor 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 Alarms and Faults Descriptions and Limits section.
<a href="#">40027</a>	Compressor 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 the Alarms and Faults Descriptions and Limits section.
<a href="#">40028</a>	Demand	[0...1000]	1:10	%	1	T	-	The target cooling capacity the compressor is asked to provide.
<a href="#">40029</a>	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 Compressor Control Mode and System State section for more information.
<a href="#">40029</a>	Compressor System State	[32...65520]	1:1	FW	R	-	-	Indicates the current operational state of the compressor controller. See Compressor Control Mode and System State section for more information.
<a href="#">40031</a>	Suction Pressure	[0...65535]	1:10	<b>Note 4</b>	R	-	-	The pressure measured at the compressor's suction port.
<a href="#">40033</a>	Discharge Pressure	[0...65535]	1:10	<b>Note 4</b>	R	-	-	The pressure measured at the compressor's discharge port.
<a href="#">40034</a>	Suction Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured at the compressor's suction port.
<a href="#">40035</a>	SCR Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured on the Silicon Controlled Rectifiers (SCR).
<a href="#">40036</a>	Discharge Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured at the compressor's discharge port.
<a href="#">40037</a>	Cavity Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured in the motor cavity.
<a href="#">40038</a>	Entering Fluid Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The externally measured entering fluid temperature ('ENTRY' on the I/O board).
<a href="#">40039</a>	BMCC Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured on the BMCC.
<a href="#">40040</a>	Back Plane Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured at the compressor's backplane.
<a href="#">40041</a>	Motor Thermal Raw Value (MTRV)	[0...65535]	1:1	-	R	-	-	The readout from the motor winding thermistor.
<a href="#">40042</a>	Liquid (LIQ) Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured by the external sensor, connected to the LIQDT input on the I/O board.
<a href="#">40043</a>	DC/DC Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured at the DC/DC
<a href="#">40044</a>	PWM Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured at the PWM.
<a href="#">40045</a>	24 VDC Voltage	[0...65535]	1:10	VDC	R	-	-	The internally measured voltage of the 24V DC Bus.
<a href="#">40046</a>	Leaving Fluid Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The externally measured fluid temperature ('LEAVE' on the I/O board).
<a href="#">40047</a>	Interlock Closed	[0...1] 0 = Open 1 = Closed	1:1	Boolean	R	-	-	The current status indicated by the interlock signal. It must be in the <i>closed</i> state for normal operation of the compressor and in the <i>open</i> state for service operations, such as bearing calibration, levitation, etc.

## Compressor Control

**Table 12 - Compressor Status Parameters (Continued)**

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40048</a>	Spare Pressure	[0...65535]	1:10	<b>Note 4</b>	R	-	-	The indicated pressure as measured at the external pressure sensor ("SPARE P" on the I/O board).
<a href="#">40049</a>	Spare Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The indicated temperature as measured at the external, application-specific thermistor ("SPARE T" on the I/O board).
<a href="#">40050</a>	Chiller Demand Percentage	[0...1000]	1:10	%	R	-	-	The resulting value of <a href="#">(40104 Actual Power/40021 Requested Power) * 40028 Demand</a> giving the compressor demand from the internal chiller controller.
<a href="#">40055</a>	Surge Detection Speed	[0...65535]	1:1	RPM	R	-	-	Estimated minimum speed, calculated by the compressor based on compressor model and operating conditions.
<a href="#">40056</a>	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.
<a href="#">40060</a>	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.
<a href="#">40088</a>	Cooling Status	[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)
<a href="#">40196</a>	Total Standby Hours	[0...65535]	1:1	Hours	1	-	-	Indicates the amount of compressor standby hours since last power reset. The sum of <a href="#">40196 Total Standby Hours</a> , <a href="#">40197 Total Standby Minutes</a> , <a href="#">40212 Total Running Hours</a> and <a href="#">40213 Total Running Minutes</a> results in the total ON time for the compressor since last reset.
<a href="#">40197</a>	Total Standby Minutes	[0...65535]	1:1	Minutes	R	-	-	Indicates the amount of compressor standby minutes and seconds since the last power reset.
<a href="#">40212</a>	Total Running Hours	[0...65535]	1:1	Hours	4	-	-	Indicates the amount of compressor running hours since last power reset. The sum of <a href="#">40196 Total Standby Hours</a> , <a href="#">40197 Total Standby Minutes</a> , <a href="#">40212 Total Running Hours</a> and <a href="#">40213 Total Running Minutes</a> results in the total ON time for the compressor since last power reset.
<a href="#">40213</a>	Total Running Minutes	[0...65535]	1:1	Minutes	R	-	-	Indicates the amount of compressor running minutes and seconds since the last power reset.
<a href="#">40328</a>	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.
<a href="#">40329</a>	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.
<a href="#">40391</a>	Saturated Suction Temperature (SST)	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The calculated Saturated Suction Temperature (SST) using the reading from the Pressure Sensor at the compressors suction port.
<a href="#">40392</a>	Saturated Discharge Temperature (SDT)	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The calculated Saturated Discharge Temperature (SDT) using the reading from the Pressure Sensor at the compressors discharge port.
<a href="#">40393</a>	Suction Superheat	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The calculated Suction Superheat using the measured Suction Temperature minus the calculated Saturated Suction Temperature (SST).
<a href="#">40397</a>	Pressure Ratio	[0...65535]	1:100	-	R	-	-	The pressure ratio value is the maximum of: <a href="#">(40033 Discharge Pressure/40031 Suction Pressure)</a> or <a href="#">(40048 Spare Pressure/40031 Suction Pressure)</a> .
<a href="#">40499</a>	Compressor Start Ups	[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.

## Compressor Control

### 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 IGV Minimum Steps](#) and [40233 IGV Maximum 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 IGV Initialization Selection](#). For backwards compatibility reasons, the default selection is to initialize to fully closed.

**Table 13 - Inlet Guide Vane (IGV) Parameters**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40030</a>	IGV Open Percentage	[0...1100]	1:10	%	3	T	0	The percentage of Inlet Guide Vane (IGV) opening which is a function of <a href="#">40233 IGV Maximum Steps</a> . 110% is equal to fully open; i.e. the compressor is operating in full vane.
<a href="#">40233</a>	IGV Maximum Steps	[0...16000]	1:1	steps	4	P	11500	The number of steps between the fully closed and fully open positions of the IGV.
<a href="#">41812</a>	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.
<a href="#">41814</a>	Move IGV to Start Position After Reset	[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.
<a href="#">42036</a>	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.
<a href="#">42046</a>	IGV Minimum 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.
<a href="#">42061</a>	IGV Start Position	[0...R <a href="#">40233</a> *)	1:1	steps	2	P	CMS	The <a href="#">40030 IGV Open Percentage</a> , in steps, to which the IGV will be set at motor start up.
<a href="#">40318</a>	IGV Initialization Selection	[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.

\* The max value of IGV Start Position is the IGV Maximum Steps, the value held in register [40233](#).

### 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.

#### ... DANGER ...

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

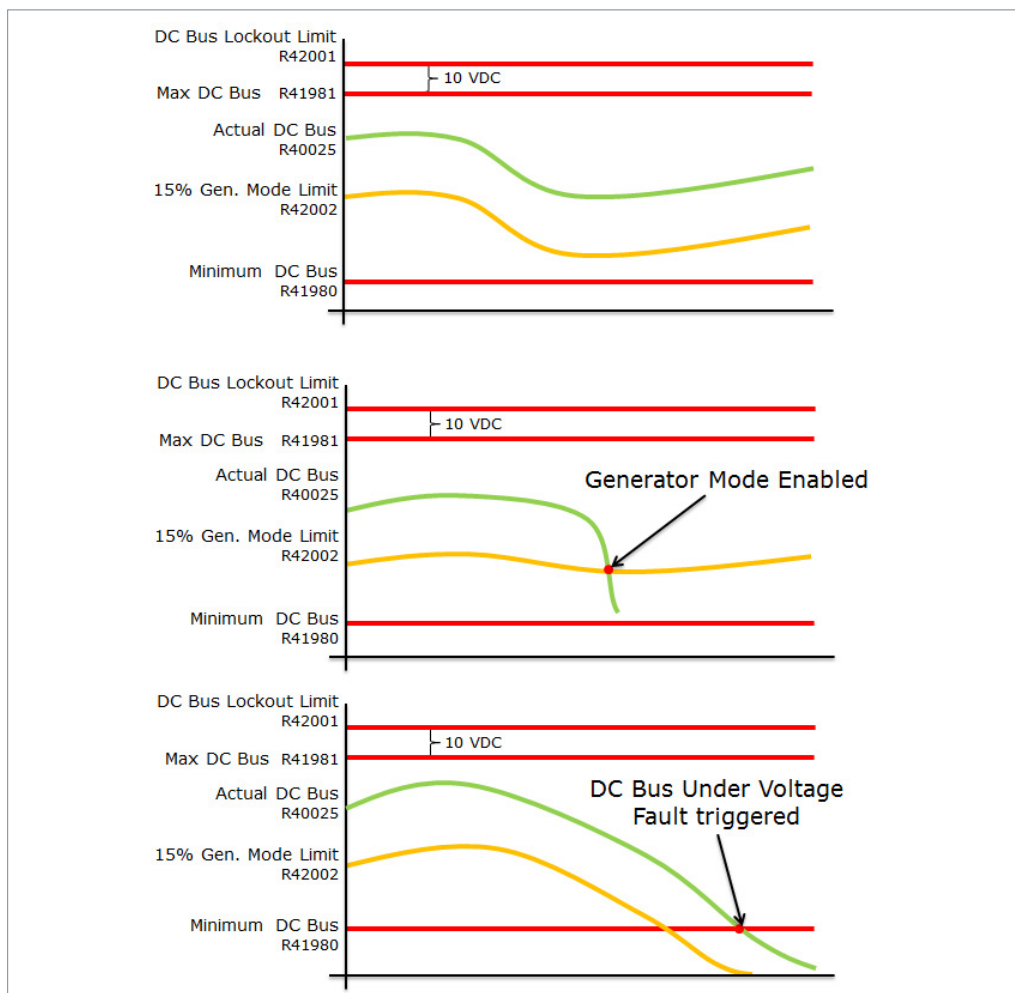
### DC Bus Voltage Monitoring

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 Limit](#) (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 Minimum DC Bus](#), then the DC Bus Voltage Fault will be triggered.

## Compressor Control

**Figure 7 - DC Bus Voltage Monitoring**



**Table 14 - DC Bus Voltage Monitoring Parameters**

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

## Operation Modes

### 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.

### Power Up

At power on, the compressor will reset the IGV to fully closed or fully open prior to reopening to the [42061 IGV Start Position](#). The IGV will move to the [42061 IGV Start Position](#) if the [41814 Move IGV to Start Position After Reset](#) is

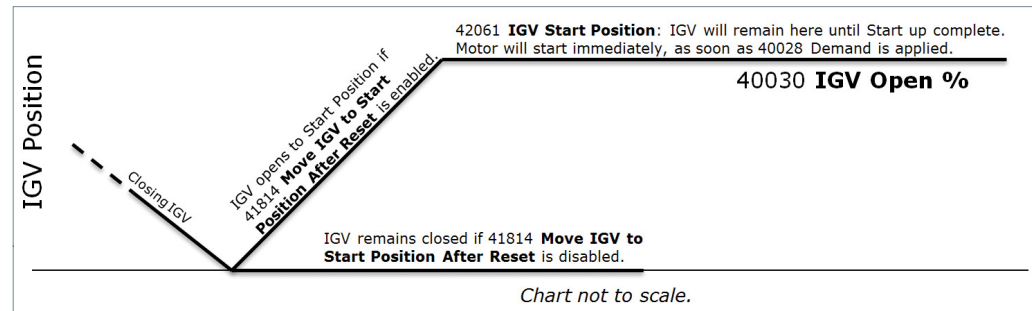
enabled. However, if the compressor experienced a power outage and entered generator mode and Fast Restart is enabled, then the compressor will restart using Fast Restart which is described later.

#### NOTE

The IGV can be initialized to fully open or fully closed by setting the [40318 IGV Initialization Selection](#). Please refer to Inlet Guide Vane (IGV) Parameters section for more information.

Setting the [40318 IGV Initialization Selection](#) to fully open and setting the [42061 IGV Start Position](#) to 11500 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.

**Figure 8 - IGV Position During Power Up**



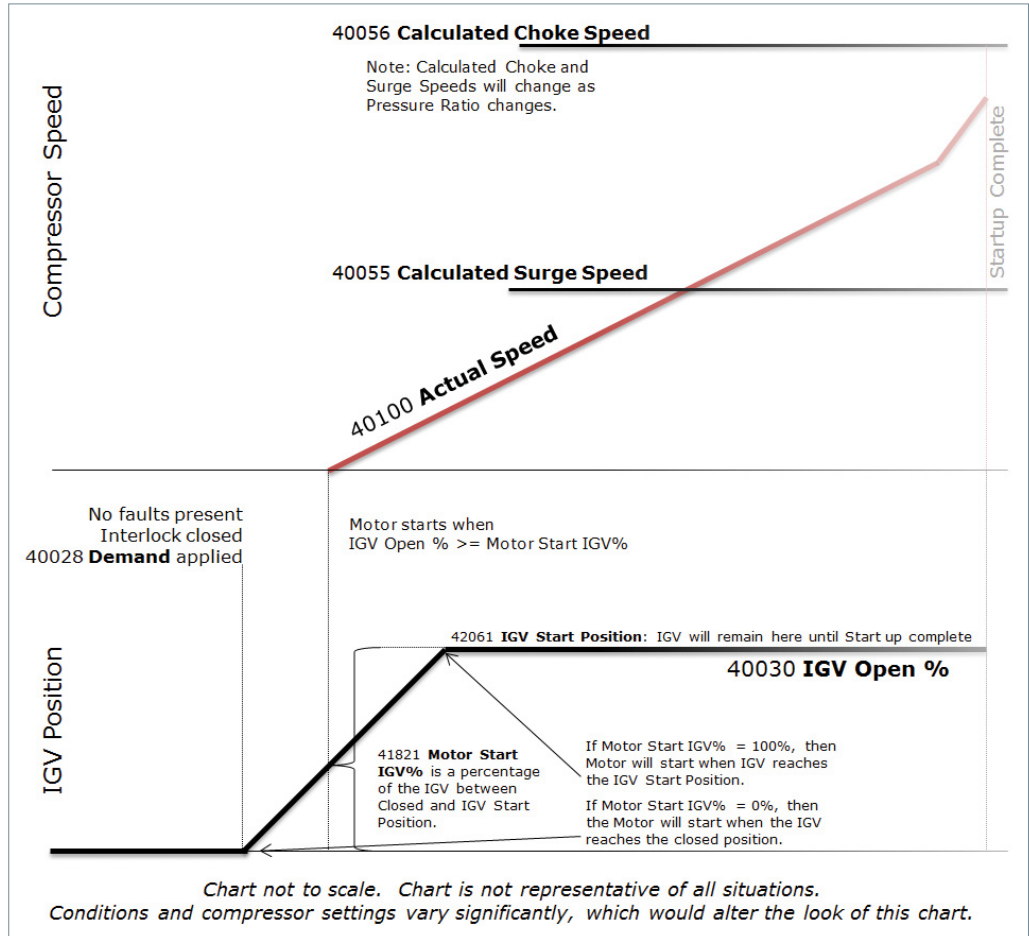
### Ramp Up

The Motor will start when the IGV opens to the [41821 Motor Start IGV %](#). If the IGV is already open to [42061 IGV Start Position](#), because the [41814 Move IGV to Start Position After Reset](#)

was enabled, 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 Start up is complete.

Operation Modes

Figure 9 - IGV Position and Compressor Speed During Ramp Up



## Operation Modes

### 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](#).

### Faults and Alarms During Start Up

During start up, any alarm is ignored. Faults are enabled with the exception of the High Suction Superheat and Suction Pressure Faults provided the [40422 Start Up High Suction Superheat Fault Delay Timer](#) and the [40059 Suction](#)

**Pressure Alarm/Fault Delay** settings are configured and enabled.

### 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 starts spinning.

**Table 15 - High Suction Superheat Fault Delay**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40422</a>	Start Up High Suction Superheat Fault Delay Timer	[0...600]	1:1	Seconds	R	-	-	Shows remaining time until a High Suction Superheat fault will occur. The timer starts/restarts when the <a href="#">40393 Suction Superheat</a> exceeds the <a href="#">42062 Suction Superheat Fault Limit</a> and the <a href="#">40100 Actual Speed</a> has exceeded 50 RPM.
<a href="#">40423</a>	Start Up High Suction Superheat Fault Delay Timer Setting	[0...600]	1:1	Seconds	R	P	180	The starting count for the <a href="#">40422 Start Up High Suction Superheat Fault Delay Timer</a> which is the amount of time that the High Suction Superheat will be delayed.

### 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 starts spinning.

**Table 16 - Suction Pressure Alarm/Fault Delay**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40058</a>	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 <a href="#">40058 Suction Pressure Alarm/Fault Factor</a> to absolute pressure.
<a href="#">40059</a>	Suction Pressure Alarm/Fault Delay	[0...600]	1:1	Seconds	2	P	0	The period of time during start up and operation when the <a href="#">40058 Suction Pressure Alarm/Fault Factor</a> will be used for temporarily adjusting the Suction Pressure Alarm/Fault Limits.



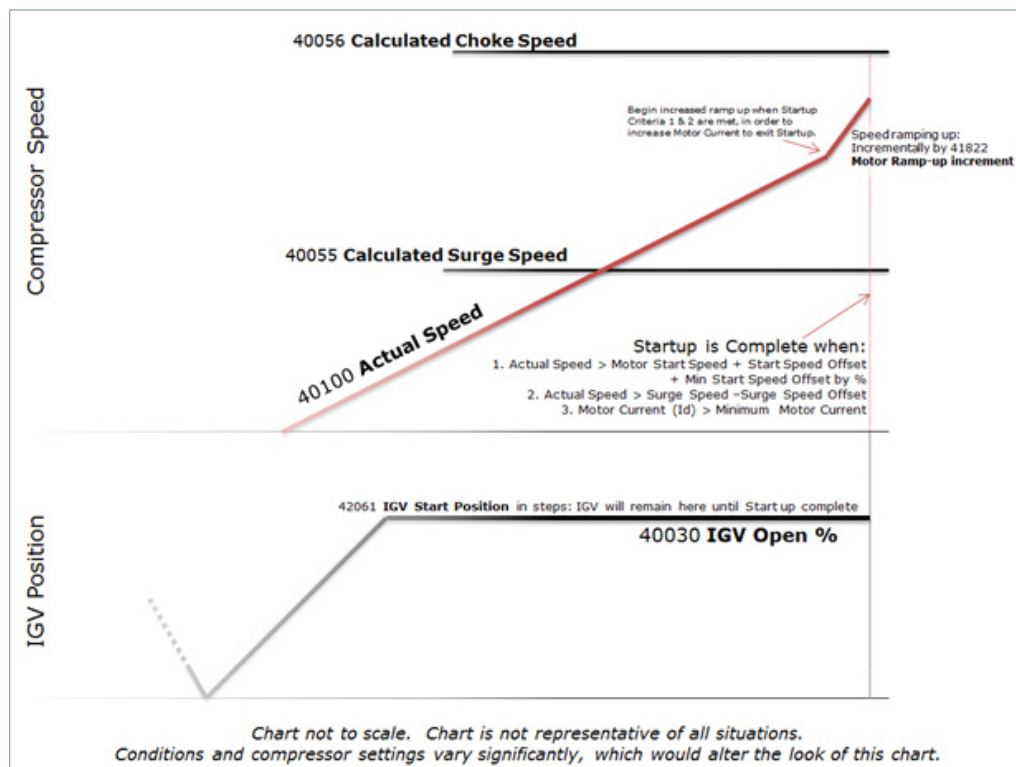
## Operation Modes

### Start Up Complete

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

1. [40100 Actual Speed](#) > [42039 Motor Start Speed](#) + [41818 Start Speed Offset](#) + 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 10 - IGV Position and Compressor Speed at Completion of Start Up**



### Start Speed Offset (Reg. [41818](#))

The Start Speed Offset is a direct speed value that is added to the [42039 Motor Start Speed](#). By setting this value sufficiently high, the compressor will ramp up and will ensure the compressor is well beyond the surge boundary

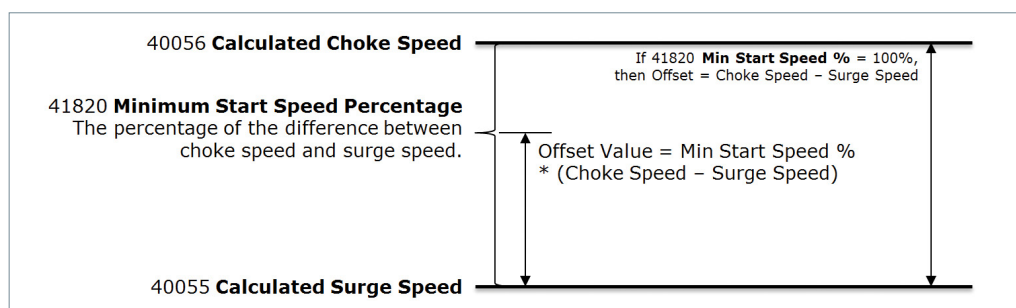
line. Alternatively, setting this value low will allow the compressor to exit Start Up and immediately enter the Mechanical Capacity Control Mode, allowing the IGV to control surge recovery.

### 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 11 (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 11 - Minimum Start Speed Offset by Percentage Explained**



## Operation Modes

### 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 17 - Compressor Start Up Parameters**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40032</a>	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 <a href="#">40032 Minimum Pressure Ratio</a> of the start up compressor. This register should be written back to 1 after startup is complete. <b>NOTE:</b> The feature will be disabled after the compressor exits the Start Up Mode.
<a href="#">40058</a>	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 <a href="#">40058 Suction Pressure Alarm/Fault Factor</a> , then convert back to gauge pressure; i.e. LP trip point with 65% factor and trip setting 20 psi gauge results in a Factor = $(20 + 14.7) * .65 - 14.7$ .
<a href="#">40059</a>	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 <a href="#">40058 Suction Pressure Alarm/Fault Factor</a> will be used for temporarily adjusting the Suction Pressure Alarm/Fault Limits.
<a href="#">40220</a>	Start Up Pre-Cooling Configuration	[0...65283]	<a href="#">Note 9</a>	-	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.
<a href="#">41814</a>	Move IGV to Start Position After Reset	[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.
<a href="#">41817</a>	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.
<a href="#">41818</a>	Start Speed Offset	[0...65535]	1:1	RPM	3	P	CMS	Value that is added to <a href="#">42039 Motor Start Speed</a> to determine the <a href="#">40101 Desired Speed</a> during the "Start Up Phase". This ensures that the controller does not undershoot and fail to reach the <a href="#">42039 Motor Start Speed</a> .
<a href="#">41820</a>	Minimum Start Speed Percentage	[0...1000]	1:10	%	3	P	CMS	Minimum start speed in percentage between <a href="#">40055 Surge Detection Speed</a> and <a href="#">40056 Choke Speed</a> . The register is used in this expression to calculate the <i>Minimum Start Up Speed</i> for the current operating conditions. <b>NOTE:</b> This is not the same as <a href="#">42039 Motor Start Speed</a> . $Minimum\ Start\ Up\ Speed = 40055\ Surge\ Detection\ Speed + (41820\ Minimum\ Start\ Speed\ Percentage / 1000) * (40056\ Choke\ Speed - 40055\ Surge\ Detection\ Speed) + 41818\ Start\ Speed\ Offset$ .
<a href="#">41821</a>	Motor Start IGV Percentage	[0...1000]	1:10	%	3	P	0	IGV position in percentage of <a href="#">42061 IGV Start Position</a> 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 <a href="#">42061 IGV Start Position</a> .

## Operation Modes

**Table 17 - Compressor Start Up Parameters (Continued)**

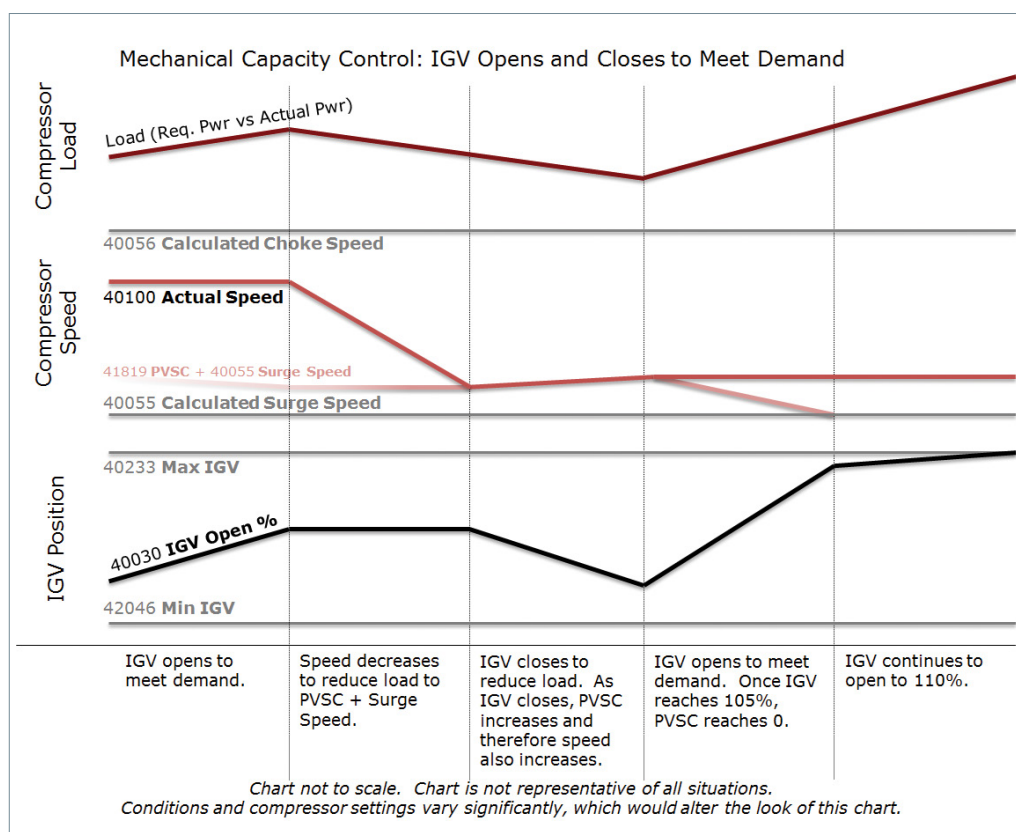
Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">41822</a>	Motor Speed Ramp-Up Increment	[0...65535]	<b>Note 13</b>	-	3	P	CMS	Speed increase in RPM's per compressor control loop iteration (~200Hz) during ramp-up acceleration in the very last period of start up after start speed is reached. The purpose of this is to ensure that the check valve is driven open and that <a href="#">41817 Minimum Motor Current</a> is achieved.
<a href="#">42039</a>	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.
<a href="#">42043</a>	Max Drive Start Up Temperature	[0...65535]	1:1	°C	R	P	50	The maximum <a href="#">40105 Inverter Temperature</a> allowed at start up time. If this temperature is exceeded, the compressor will not start and the <a href="#">40029 Above drive temperature limit - waiting to cool down status</a> will be indicated.
<a href="#">42061</a>	IGV Start Position	[0...R <a href="#">40233</a> ]	1:1	steps	2	P	CMS	The <a href="#">40030 IGV Open Percentage</a> , in steps, to which the IGV will be set at motor start up.

### 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 12 - Compressor Speed and IGV Position as a result of changes in Compressor Load**



## Operation Modes

### 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.

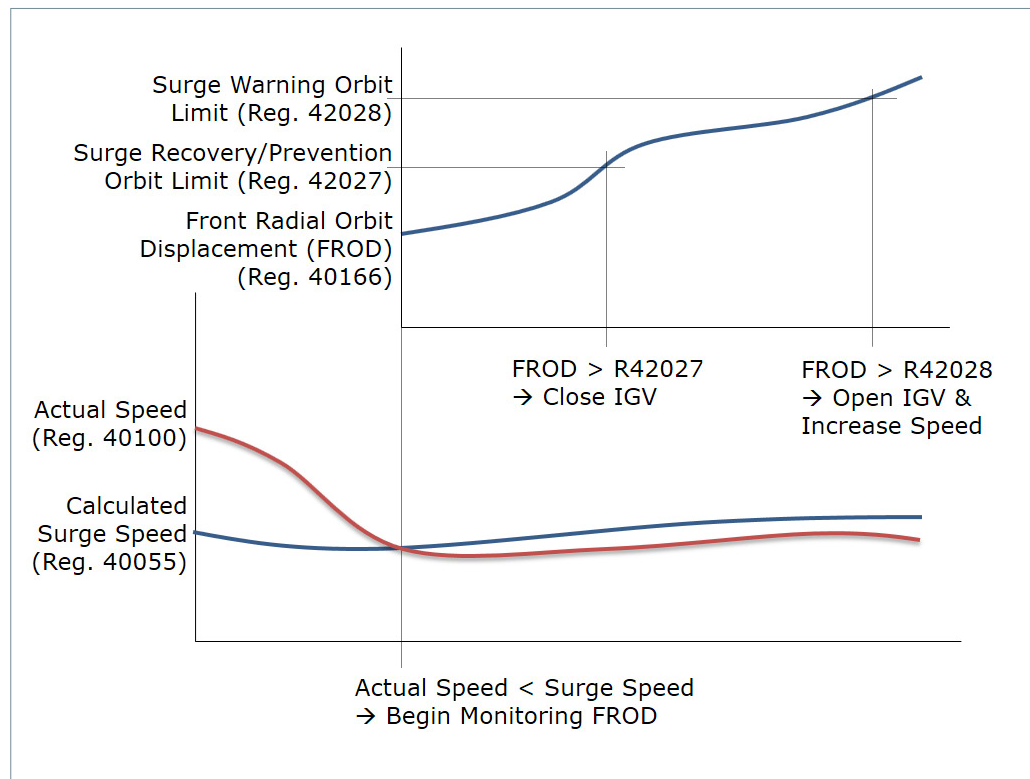
Note: Compressor loads when [40021 Requested Power](#) > [40104 Actual Power](#) and unloads when [40021 Requested Power](#) < [40104 Actual Power](#).

### 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 13 (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 13 - How FROD Relates to IGV**



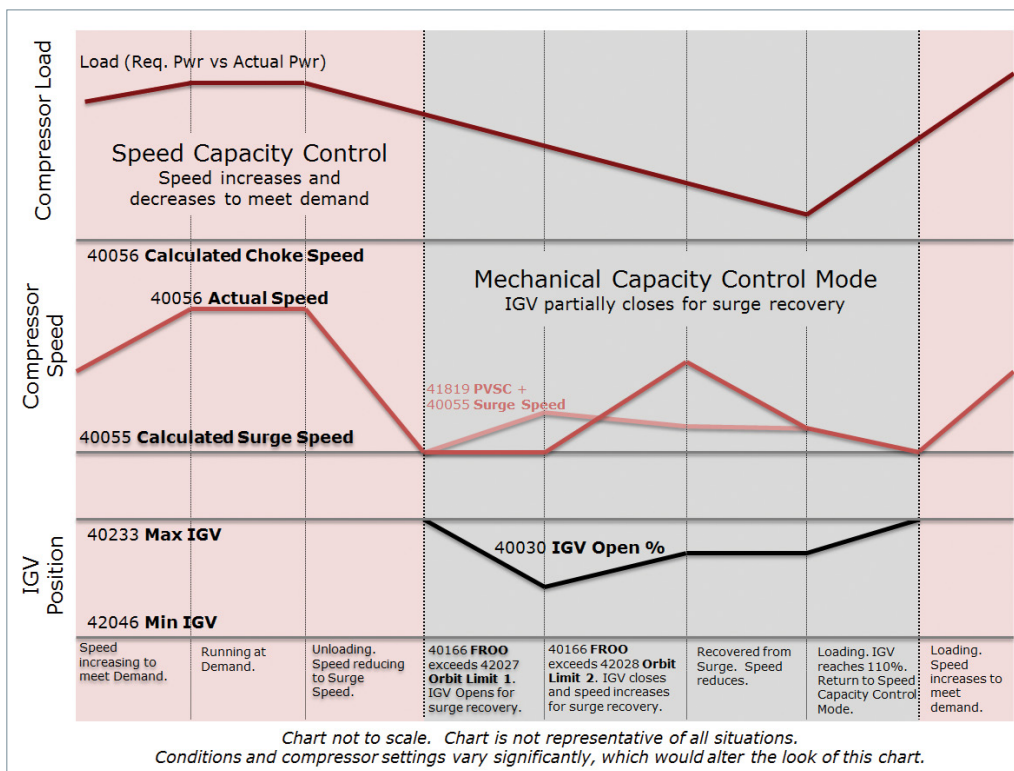
## Operation Modes

### 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 14 - Speed Capacity Control Mode and Mechanical Capacity Control Mode During Normal Operation**



### 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](#).

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.

At certain points during operation, the demand may be lowered so that [40021 Requested Power](#)

## Operation Modes

### 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.

### Calculated Surge and Choke Speed Vary

The minimum IGV Position, [40055 Surge Detection Speed](#) and [40056 Choke Speed](#) are calculated values that are adjusted continuously

during compressor operation according to the running conditions.

### 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.

### Compressor Capacity Control Parameters

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

**Table 18 - Compressor Capacity Control Parameters**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40250</a>	Demand Control Integral Gain	[0...32000]	1:100000	-	2	P	10	The gain of the integral component of the Demand Control loop.
<a href="#">41819</a>	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.
<a href="#">42027</a>	Surge Recovery/Prevention Orbit Limit	[0...400]	1:1	-	3	P	CMS	The maximum amount of <a href="#">40166 Front Radial Orbit Displacement (FROD)</a> 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
<a href="#">42028</a>	Surge Warning Orbit Limit	[0...400]	1:1	-	3	P	CMS	The maximum amount of <a href="#">40166 Front Radial Orbit Displacement (FROD)</a> 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
<a href="#">42033</a>	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.)
<a href="#">42034</a>	Surge Speed Offset	[-5000...5000]	1:1	RPM	3	P	1	The offset of the surge line used for compressor control.

## Operation Modes

### Fast Restart

The Fast Restart feature provides a method to reduce the time required by the compressor to return to an operational state after a Generator Mode Fault 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 start up time can be reduced to less than 30 seconds.

To ensure the Fast Restart sequence is followed, the controller must:

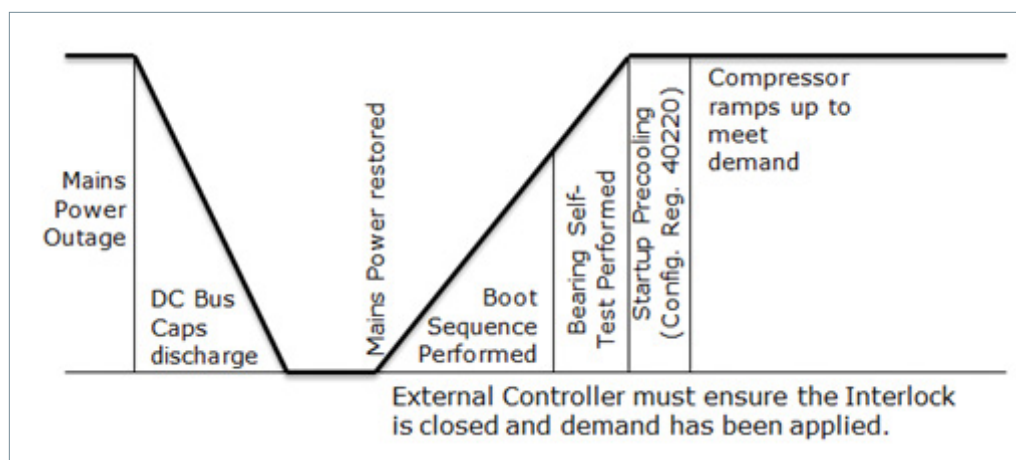
1. Not disable Fast Restart,
2. Not open the interlock,
3. Maintain demand greater than 0, and
4. Clear faults by writing 1 to the Clear Faults register (41895).

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](#). Additionally, 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.

Note: Do not toggle demand to clear any faults. This will not allow the Fast Restart to work properly. Instead, continue to write demand at the same value (greater than 0) and write 1 to the clear faults register ([41895](#)). This will allow the Fast Restart to work properly and the compressor to ramp up and meet demand. Additionally, opening the interlock or failure to clear the fault will prevent the compressor from restarting immediately after power is restored. Persistently, writing demand and sending the clear faults command may assist in ensuring a quick recovery.

**Figure 15 - Fast Restart After Power Outage**



**Table 19 - Fast Restart Register**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">41813</a>	Fast Restart Enabled	[0...1] 0 = False 1 = True	1:1	Boolean	3	T	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.

## 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.

### 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.

### 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.

### Temperature Monitoring

The compressor will monitor all temperatures regardless of the configuration of the compressor. If the cavity, inverter or 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 20 - Low Lift Selector**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40531</a>	Low Lift Selector	[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.



## Inverter, Cavity and SCR Temperature Monitoring

Temperatures in the compressor are monitored from startup and throughout all runtime. Beginning with startup and continuing for a configurable amount of time, the alarm and fault limits are slightly higher than during normal operation.

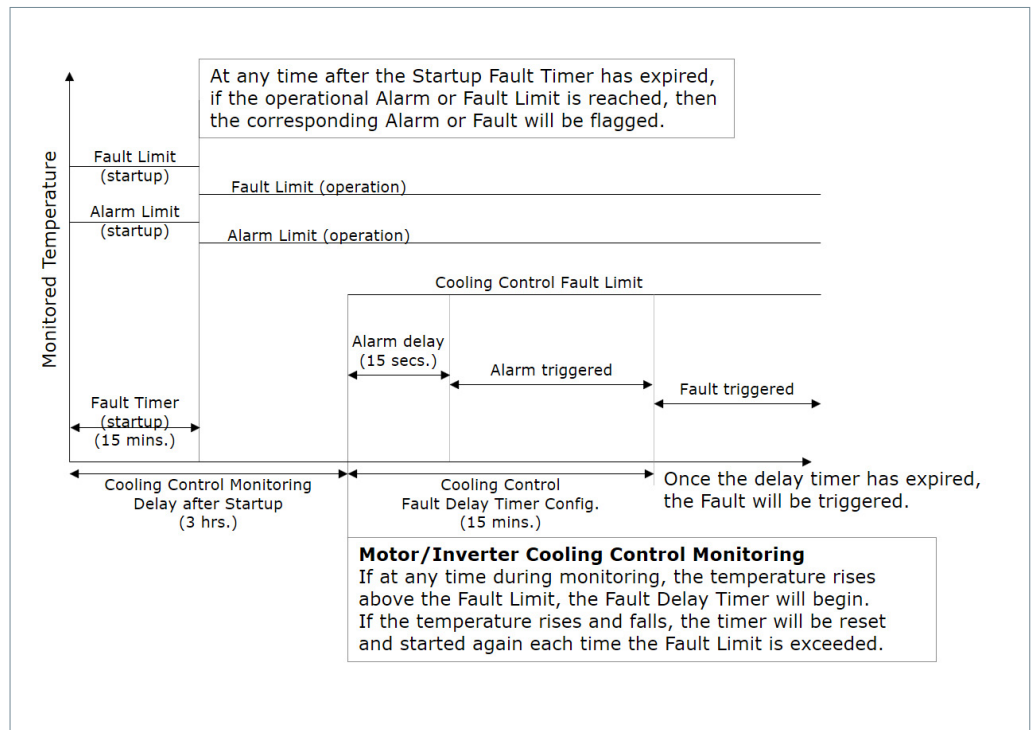
Additionally, a delay timer will begin at startup and control of cooling will be monitored once that timer has expired. This delay is referenced in the graph below as Motor/Inverter Cooling Control Monitoring Delay after Startup. If the monitored temperature rises above the Fault Limit, then a Fault Delay timer is started. This is shown in the Example 2 graph in Figure 18 (Persistent Lack of Cooling). 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. See below for all relevant fault and alarm registers.

**Figure 16 - Temperature Monitoring: Startup through Operation**



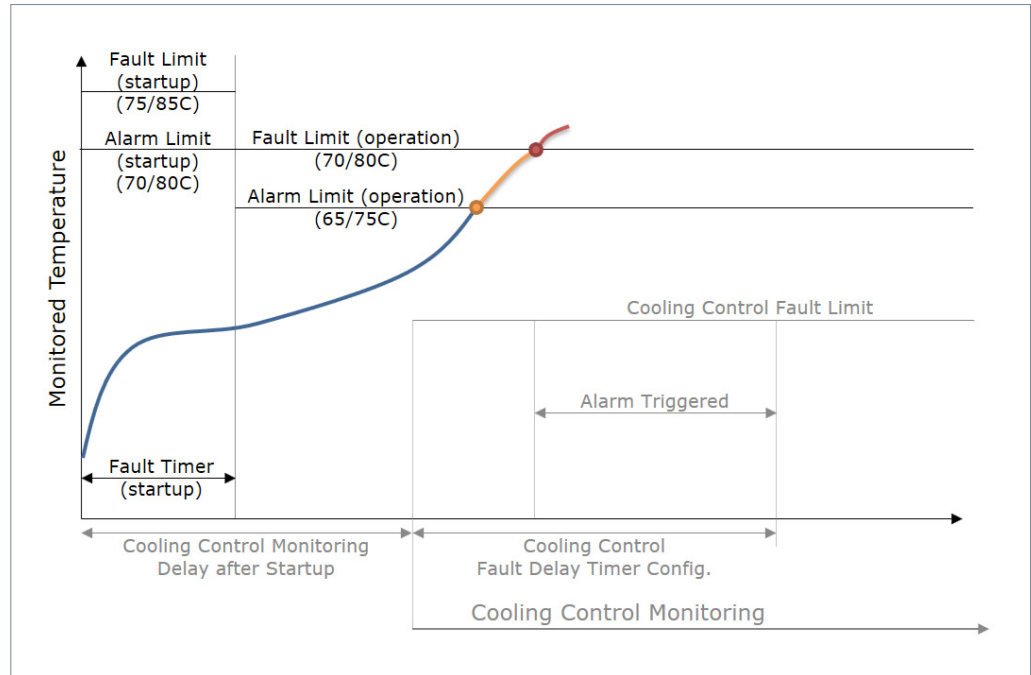
## Inverter, Cavity and SCR Temperature Monitoring

### 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 17 - Operational Alarm and Fault Triggering**



## Inverter, Cavity and SCR Temperature Monitoring

### Example 2: Persistent Lack of Cooling

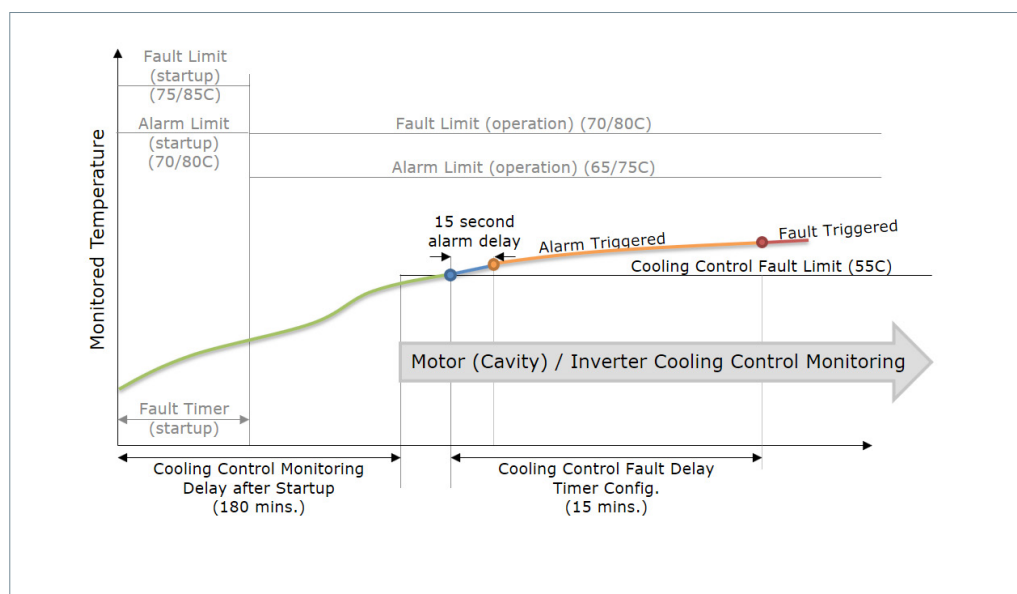
Once the Cooling Control Monitoring Delay after Startup timer expires, the Inverter and Cavity temperatures will be monitored for Cooling Control. If the Inverter or Cavity temperatures rise above the Cooling Control Fault Limit, then the Fault Delay Timer will begin.

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.

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

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 18 - Persistent Lack of Cooling**



**Table 21a - Inverter, Cavity, and SCR Temperature Monitoring (registers added in 4.0.0 firmware)**

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

**Table 21b - 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	<a href="#">R40355</a>	<a href="#">R40356</a>	<a href="#">R40352</a>	<a href="#">R40353</a>	<a href="#">R40354</a>	<a href="#">R40351</a>
	Default	180	-	15	-	14 mins. 45 secs.	55
Motor Cavity	Register	<a href="#">R40349</a>	<a href="#">R40350</a>	<a href="#">R40346</a>	<a href="#">R40347</a>	<a href="#">R40348</a>	<a href="#">R40345</a>
	Default	180	-	15	-	14 mins. 45 secs.	55

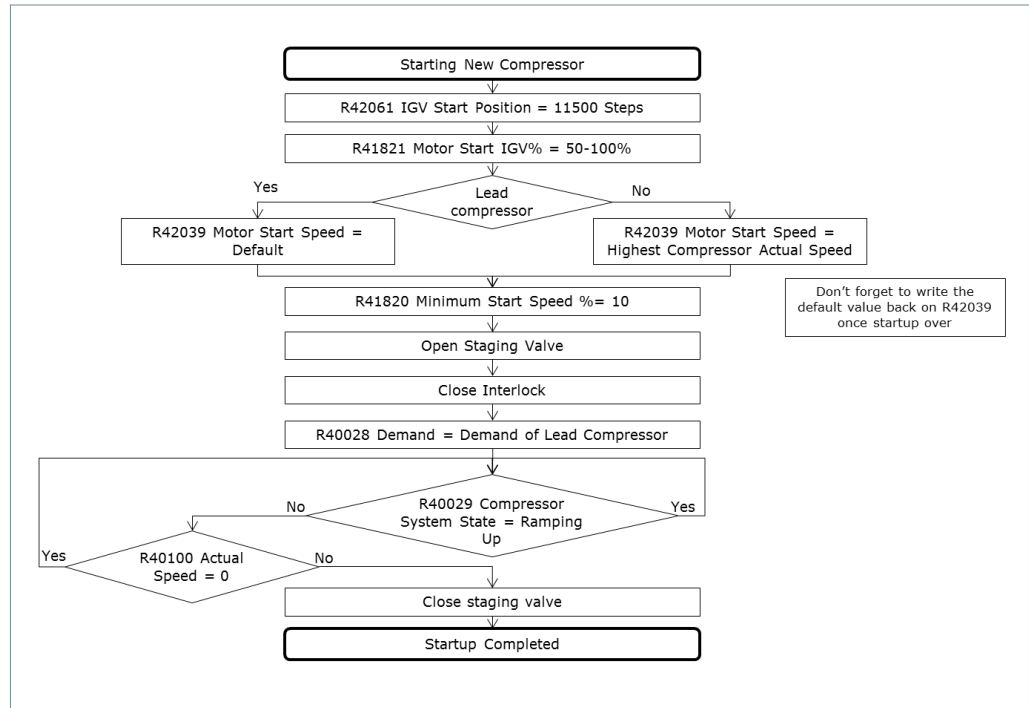
## Multiple Compressor Staging

### Multiple Compressor Staging

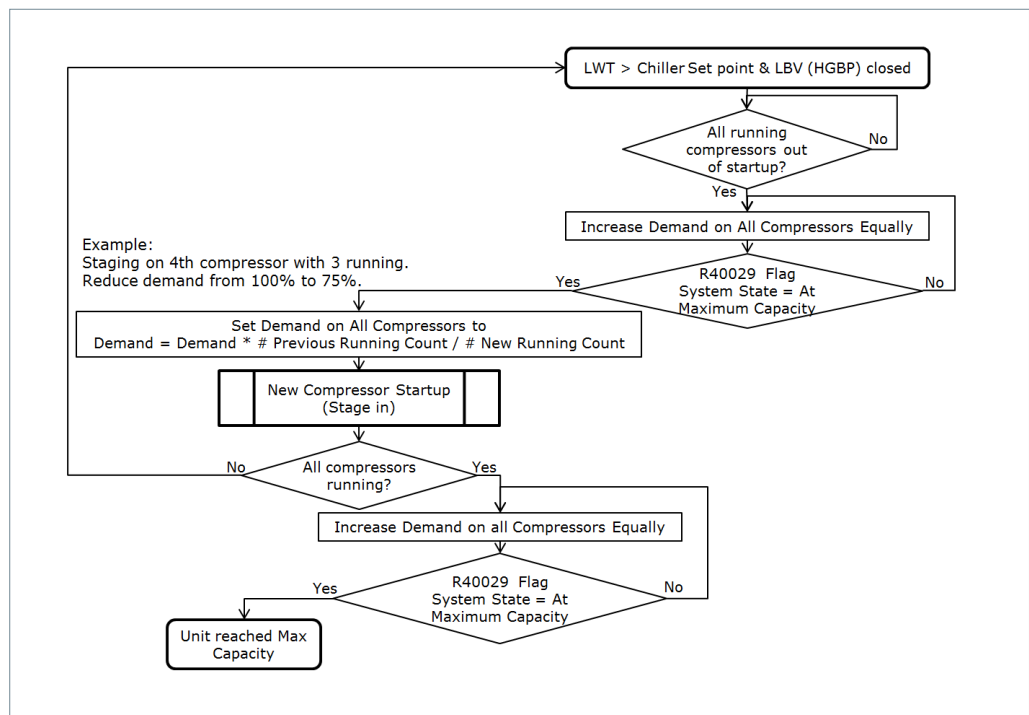
When staging up compressors, the sequence and timing must be properly coordinated to avoid surge and ensure a proper start. Surging will cause the check valve to flutter, which will cause undue stress on the shaft and may reduce the life expectancy of the compressor. Any control

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 19 - How to Startup a Lead or Lag Compressor**

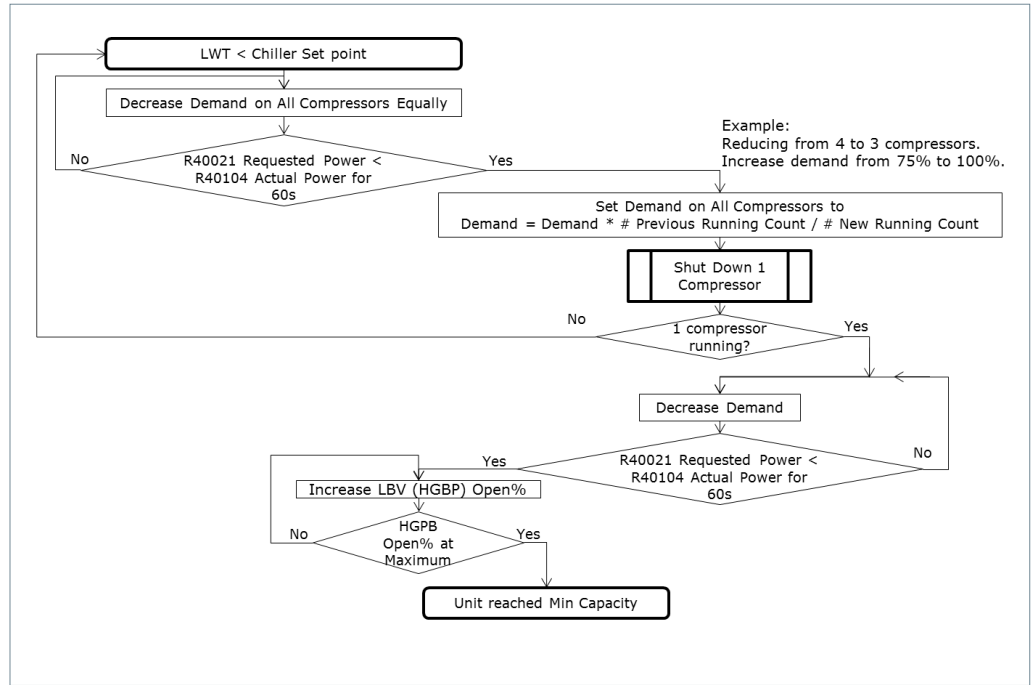


**Figure 20 - When to Stage on the Next Compressor**



Multiple Compressor Staging

Figure 21 - When to Shut Down a Compressor



## 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** (register [40063](#) or [40072](#)) is a percent of this maximum value.

### NOTE

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

### 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 this number of steps in the closing direction to ensure the valve is fully closed.

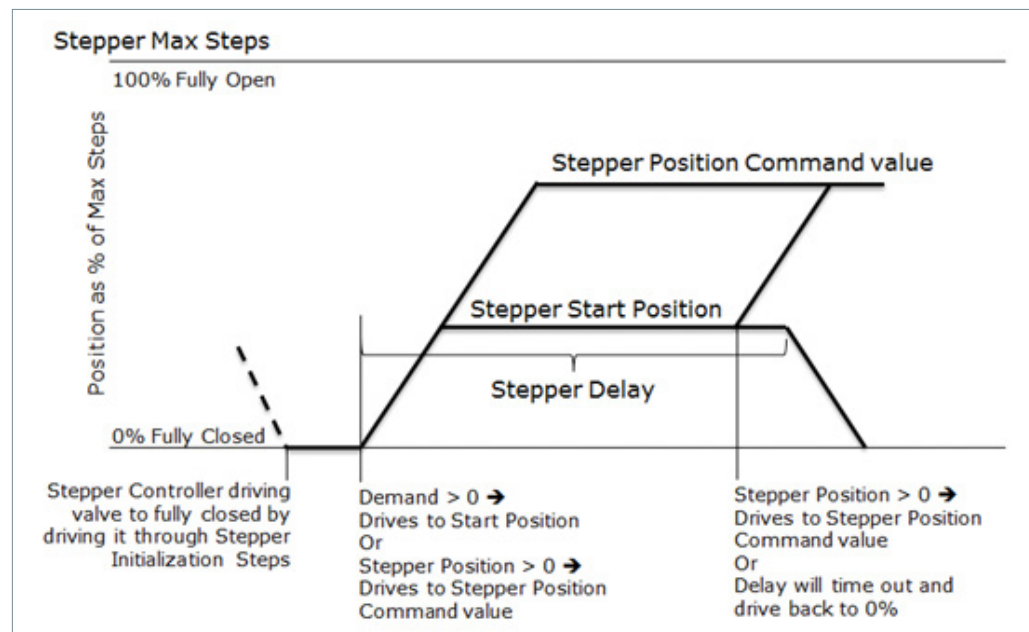
### Operation

Once initialization is completed, the Stepper Controller maintains the 0% position until the **Stepper Position** ([40063](#) or [40072](#)) is set or **Stepper Position Demand** ([40028](#)) is applied. If **Stepper Position Command** ([40063](#) or [40072](#)) is changed, the stepper controller will drive the valve to the given percent position. 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 steppers to the 0% position,

1. Unless the time delay is 0 then it will remain at the current position or
2. Unless the **Stepper Position Command** ([40063](#) or [40072](#)) is set to a specific value > 0 before the delay expires.

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 22 - Stepper Motor Control



## Stepper Motor Control Mechanism

**Table 22 - Stepper Control Parameters**

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40063</a>	Stepper 1 Position Command	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of Stepper Maximum Steps.
<a href="#">40064</a>	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 <a href="#">40065 Stepper 1 Stepper Start Delay Time</a> has expired.
<a href="#">40065</a>	Stepper 1 Stepper Delay	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the <a href="#">40064 Stepper 1 Start Position</a> is in held. The Stepper Start Delay Timer starts to count down when drive is enabled.
<a href="#">40072</a>	Stepper 2 Position Command	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of Stepper Maximum Steps.
<a href="#">40073</a>	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 <a href="#">40074 Stepper 2 Stepper Start Delay Time</a> has expired.
<a href="#">40074</a>	Stepper 2 Stepper Delay	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the <a href="#">40073 Stepper 2 Start Position</a> is in held. The <a href="#">40074 Stepper 2 Stepper Start Delay Time</a> starts to count down when drive is enabled.
<a href="#">40235</a>	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.
<a href="#">40236</a>	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 <a href="#">40235 Stepper 1 Maximum Steps</a> for the initialization feature to function as expected.
<a href="#">40237</a>	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.
<a href="#">40238</a>	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 <a href="#">40237 Stepper 2 Maximum Steps</a> for the initialization feature to function as expected.
<a href="#">40301</a>	Stepper Control Mode	[0...1]	1:1	-	R	P	0	Mode to define the Stepper Control Type. <b>0</b> : Control as described above; <b>1</b> : Control as described in Appendix B 3.0.X Functionality Definition.

## Controlled Assist Shutdown

### 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 open during compressor startup and shutdown. Please refer to the Multiple Compressor Staging section for additional information on recommended control algorithms.

### Controlled Assist

The controlled assist shutdown allows the compressor to gradually ramp down. 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.

The controlled assist shutdown procedure can bypass the interlock by configuring the [40416 Shutdown Interlock Bypass](#). The defaults by compressor model are shown in Table 23 (Controlled Assist Default Values). When most faults occur, the Controlled Assist Shutdown Procedure will be used. However, the compressor will shutdown immediately with a Three-Phase Overcurrent or a High Discharge Pressure fault. These faults are considered higher risk and could cause damage to the compressor

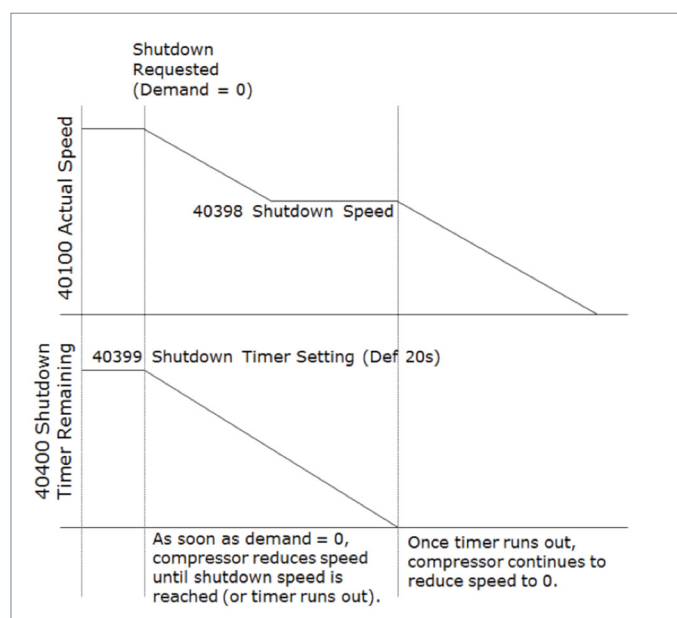
**Table 23 - Controlled Assist Default Values**

Parameter	TT300/TG230	TT350/TG310	TT400/TG390	TT700/TG520
<a href="#">40398</a> Shutdown Speed (RPM)	22,200	10,800	10,800	10,800
<a href="#">40399</a> Shutdown Timer Setting (secs)	20	20	20	20

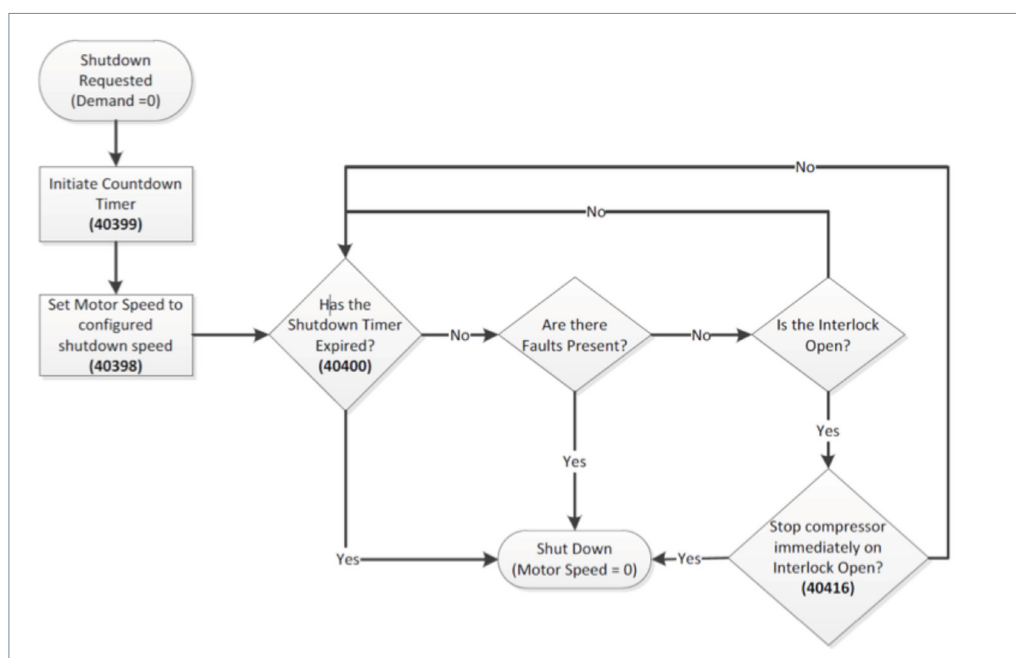


## Controlled Assist Shutdown

**Figure 23 - Controlled Assist Shutdown**



**Figure 24 - Controlled Assist Shutdown Logic Flow**



**Table 24 - Controlled Assist Shutdown Parameters**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40398</a>	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.
<a href="#">40399</a>	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.
<a href="#">40400</a>	Shutdown Timer Remaining	[0...65535]	1:1	s	R	T	-	The amount of time remaining before the shutdown sequence expires.
<a href="#">40414</a>	Shutdown Timer Setting Max Value	[0...65535]	1:1	s	3	P	30	The maximum value which can be set in register <a href="#">40399</a> .
<a href="#">40416</a>	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.

## 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 25 (Analog Output Example) for more information. The [40080 Analog Output Mode](#) will determine how the output is controlled.

**Table 25 - 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 26 - Analog Output Registers**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40080</a>	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 <a href="#">40081 Analog Output Control/Status</a> . 0 = Manual Control Mode 1 = Discharge Pressure Control Mode
<a href="#">40081</a>	Analog Output Control/Status	[0...1000]	1:10	%	1	T	0	The Analog Output voltage controlled as described in Table 25 (Analog Output Example), based on the <a href="#">40080 Analog Output Mode</a> .

## 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.

**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 27 - Motor Control and Status Parameters**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40249</a>	Run Status Indication Speed	[0...50000]	1:1	RPM	2	P	1000	The motor speed above which the external run signal is active.
<a href="#">40100</a>	Actual Speed	[0...65535]	1:1	RPM	R	-	-	Calculated shaft speed in revolutions per minute.
<a href="#">40101</a>	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 <a href="#">40029 Compressor Control Mode</a> is set to Manual Control.
<a href="#">40102</a>	Motor Current (Id)	[0...65535]	<a href="#">Note 14</a>	A	R	-	-	The Id part of the motor drive current.
<a href="#">40106</a>	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 <a href="#">40026 Bearing/Motor Controller Fault</a> is indicated. See Table 32 (Compressor Alarm and Fault Registers) for more information on interpreting this register.

**Power Configuration and Status** Table 28 (Power Configuration and Status Parameters) contains parameters associated with configuring or viewing power configuration settings.

**Table 28 - Power Configuration and Status Parameters**

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

## Motor/Power Electronics Control

### 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 29 (Compressor Current Limit and Operating Range Settings).

**Table 29 - Compressor Current Limit and Operating Range Settings**

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

\* The max value of Register [40230 3-Phase Overcurrent Alarm Limit \(FLA\)](#) 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 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).

## Motor/Power Electronics Control

### Cooling of the Compressor

Compressor temperatures indicate the status of components and alarms will be activated if temperatures exceed the expected values. See the next section (Alarms, Faults and Status Descriptions) for the maximum and minimum values for each.

Also, refer to the Inverter, Cavity and SCR Temperature Monitoring section for more information on how the compressor monitors and handles rising temperatures.

**Table 30 - Compressor Cooling Parameters**

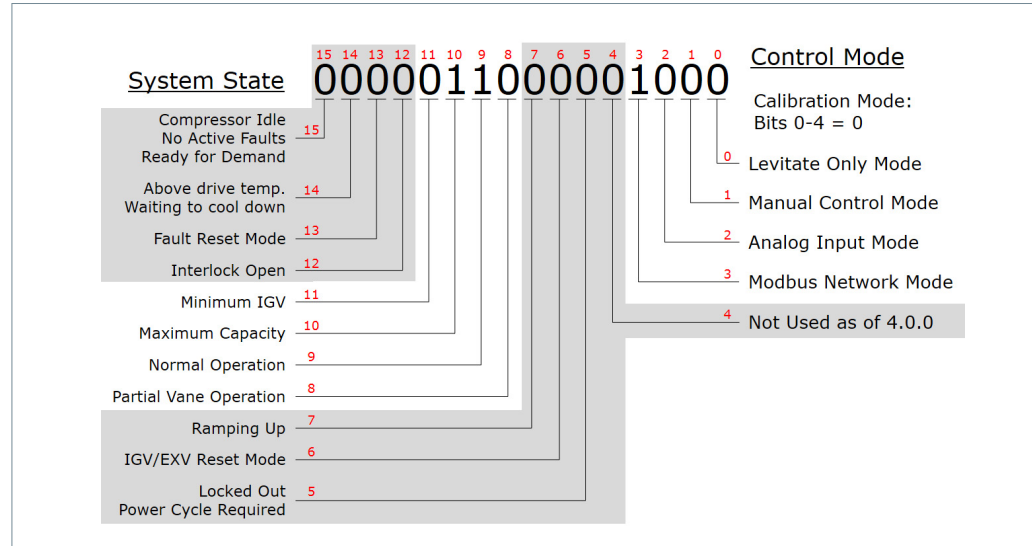
Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40035</a>	SCR Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured on the Silicon Controlled Rectifiers (SCR).
<a href="#">40037</a>	Cavity Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured in the motor cavity.
<a href="#">40041</a>	Motor Raw Thermal Value (MTRV)	[0...65535]	1:1	-	R	-	-	The readout from the motor winding thermistor.
<a href="#">40088</a>	Cooling Status	[0...3]	1:1	-	R	-	-	Indicates the current status of the cooling solenoid valves: <b>0</b> (No Cooling) <b>1</b> ('Cool L') <b>2</b> ('Cool H') <b>3</b> ('Cool L' & 'Cool H') <b>Note:</b> When in split cooling configuration, 'Cool L' active implies Inverter or SCR Cooling and 'Cool H' active implies Cavity or MTRV cooling.
<a href="#">40105</a>	Inverter Temperature	[0...65535]	1:10	<b>Note 1</b>	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 ( <a href="#">42043 Max Drive Start Up Temperature</a> ).
<a href="#">42064</a>	Cavity Temperature Cooling Setpoint	[0...65535]	1:1	°C	4	P	CMS	The maximum <a href="#">40037 Cavity Temperature</a> at or above which the Cavity Cooling Solenoid will be opened.
<a href="#">42065</a>	Drive Temperature Cooling Setpoint	[0...65535]	1:1	°C	4	P	44	The maximum <a href="#">40035 SCR Temperature</a> or <a href="#">40105 Inverter Temperature</a> at or above which the Drive Cooling Solenoid will be opened.

## Compressor Control Mode and System State

This section represents a detailed breakdown of the Bit Flag/Flag words for register [40029 Compressor Control Mode/Compressor System State](#). Bits 0-4 represent the control mode, while bits 5-15 represent the system status. The value shown in Figure 25 (Compressor Control Mode/

System State 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 25 - Compressor Control Mode/System State Register Interpretation**



**Table 31 - Compressor Control Mode/System State 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 <a href="#">40028 Demand</a> .
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 <a href="#">40028 Demand</a> .
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 <a href="#">40028 Demand</a> .
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 <a href="#">40028 Demand</a> .
3	Modbus Network Mode	0x0008	Modbus Network control mode allows the user to write <a href="#">40028 Demand</a> 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 <a href="#">40028 Demand</a> or a <a href="#">40026 Compressor Faults (critical)</a> occurs.
7	Ramping up	0x0080	The compressor is currently accelerating the shaft to meet the requested <a href="#">40028 Demand</a> .
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 <a href="#">40028 Demand</a> 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 <a href="#">41895 Clear Faults</a> command or <a href="#">40028 Demand</a> toggle (see Section "Fault Reset") before it clears the fault.
14	Above drive temperature limit - waiting to cool down	0x4000	The IGBT/Inverter is currently above the <a href="#">42043 Max Drive Start Up Temperature</a> and must cool down before it can react to <a href="#">40028 Demand</a> .
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 <a href="#">40028 Demand</a> .

**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.

compressor to repeatedly operate beyond alarm levels is inadvisable, may lead to compressor or system damage and may void the warranty.

Chiller control software must take these limits into account and operate the compressor within normal compressor limits. Forcing the

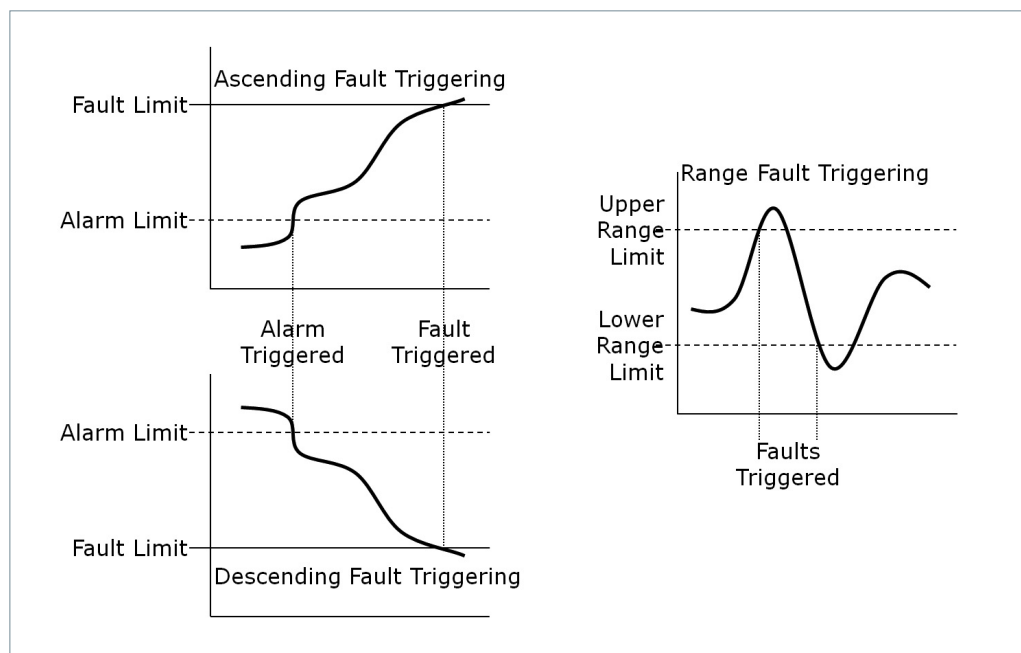
Faults and alarms are indicated through certain parameter values. For definitions of the terms fault and alarm, refer to Section “Definitions”.

**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 26 - Alarm and Fault Triggering Methods**



**Compressor Alarms and Faults**

This section contains a detailed definition of the word composition for various Bit Flags / Flag Words 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 “Alarm/Fault Trigger Method”) so it is clear under what conditions the alarm or fault will be triggered.

## Alarms and Faults Descriptions and Limits

**Table 32 - Compressor Alarm and Fault Registers**

Reg. #	Reg. Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def.	Detailed Description
<a href="#">40026</a>	Compressor 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.
<a href="#">40027</a>	Compressor 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.
<a href="#">40098</a>	Bearing Faults	[0...65535]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the Bearing controller.
<a href="#">40099</a>	Bearing Alarms	[0...65535]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the Bearing controller.
<a href="#">40106</a>	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 <a href="#">40026</a> <b>Bearing/Motor Controller Fault</b> is indicated.
<a href="#">40288</a>	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.
<a href="#">40290</a>	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.



## Alarms and Faults Descriptions and Limits

**Table 33 - Compressor Alarms and Faults**

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

\* Refer to Figure 26 (Alarm and Fault Triggering Methods) on page 55 for explanation.

†SCR Temperature Alarm is flagged as bit #8 (0x0100) in Compressor Alarms (Reg. [40027](#))

‡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.

## Alarms and Faults Descriptions and Limits

**Table 33 - Compressor Alarms and Faults (Continued)**

Type & Regs.	Alarm/Fault Name	Bit	Hex	Dec.	Alarm or Fault?	Trigger Method*	Register of			Additional Notes
							Actual Value	Alarm Limit	Fault Limit	
Bearing Alarm <a href="#">40099</a> Fault <a href="#">40098</a>	Rear Radial Static Load X	14	0x4000	16384	Both	Ascending				
	Rear Radial Static Load Y	15	0x8000	32768	Both	Ascending				
BMC Fault: <a href="#">40106</a>	Motor Single Phase Overcurrent	0	0x0001	1	Fault	Ascending			<a href="#">42006</a>	
	DC Bus Overvoltage	1	0x0002	2	Fault	Ascending	<a href="#">40025</a>		<a href="#">42001</a>	
	Motor High Current Warning	2	0x0004	4	Fault	Ascending				
	Motor High Current Fault	3	0x0008	8	Fault	Ascending				
	Inverter Error Signal Active	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	<a href="#">40104</a>		<a href="#">42015</a>	
	DC Bus Under/Over Voltage Fault	9	0x0200	512	Fault	Range	<a href="#">40025</a>		<a href="#">41980 / 41981</a>	
	24 VDC Out of Range	10	0x0400	1024	Fault	Range				
	Low Motor Back EMF	11	0x0800	2048	Fault	Descending	<a href="#">42032</a>			
	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	<a href="#">40025</a>		<a href="#">42002</a>	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 <a href="#">40290</a> Fault <a href="#">40288</a>	Inverter Temperature Sensor Error	0	0x0001	1	Fault		<a href="#">40105</a>			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		<a href="#">40037</a>			

\* Refer to Figure 26 (Alarm and Fault Triggering Methods) on page 55 for explanation.

†SCR Temperature Alarm is flagged as bit #8 (0x0100) in Compressor Alarms (Reg. [40027](#))

\*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.

## Alarms and Faults Descriptions and Limits

**Table 33 - Compressor Alarms and Faults (Continued)**

Type & Regs.	Alarm/Fault Name	Bit	Hex	Dec.	Alarm or Fault?	Trigger Method*	Register of			Additional Notes
							Actual Value	Alarm Limit	Fault Limit	
Compressor /Sensor	Suction Temperature Sensor Error	2	0x0004	4	Fault		<a href="#">40034</a>			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.
	Discharge Temperature Sensor Error	3	0x0008	8	Fault		<a href="#">40036</a>			
	Suction Pressure Sensor Error	4	0x0010	16	Fault		<a href="#">40031</a>			
	Discharge Pressure Sensor Error	5	0x0020	32	Fault		<a href="#">40033</a>			
Alarms: R40290	Invalid Bearing Calibration	6	0x0040	64	Fault					
	Inverter Cooling Control	7	0x0080	128	Both					
Faults: R40288	Motor Cooling Control	8	0x0100	256	Both					
	Soft Start Temperature Sensor Error	9	0x0200	512	Fault		<a href="#">41894</a>			
		10	0x0400	1024						
		11	0x0800	2048						
		12	0x1000	4096						
		13	0x2000	8192						
	14	0x4000	16384							
	15	0x8000	32768							

\* Refer to Figure 26 (Alarm and Fault Triggering Methods) on page 55 for explanation.

†SCR Temperature Alarm is flagged as bit #8 (0x0100) in Compressor Alarms (Reg. [40027](#))

‡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.

## Alarms and Faults Descriptions and Limits

### 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.

- 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**.

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.

### 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.

Table 33 (Compressor Alarms and Faults). Finally, Bearing Faults (reg. **40277** or **40281**) can be included using the Bearing Faults as described for reg. 40098 in Table 33 (Compressor Alarms and Faults).

To define what faults to include, configure Fault Word 1 (Reg. **40274** or **40278**) with a combination of faults as defined in the list of Compressor Alarms and Faults (Table 33). 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

**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 34 - Lockout Fault Configurable Slot Registers**

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

\* Not Configurable

## Alarms and Faults Descriptions and Limits

### 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.

### 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.

### 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 35 - Clear Faults Register**

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

## Register Definitions

Table 36 (Register Descriptions) displays each register and its definition.

**Table 36 - Register Descriptions**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40021</a>	Requested Power	[0...65535]	1:10	kW	R	-	-	The maximum power currently demanded by the compressor controller. This is a calculated value based on <a href="#">40028 Demand</a> and other parameters.
<a href="#">40022</a>	3-Phase Mains Voltage	[0...65535]	1:1	VAC	R	-	-	The 3-phase AC mains input voltage calculated from the DC bus voltage.
<a href="#">40023</a>	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.
<a href="#">40024</a>	BMC Operation Mode	[0...3]	1:1	-	R	-	-	Indicates the current operational status of the BMC control system: <b>0</b> (Standby); <b>1</b> (Levitate); <b>2</b> (Drive); <b>3</b> (Calibrate)
<a href="#">40025</a>	DC Bus Voltage	[0...65535]	1:1	VDC	R	-	-	The DC bus voltage measured by the inverter drive module.
<a href="#">40026</a>	Compressor 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 32 (Compressor Alarm and Fault Registers).
<a href="#">40027</a>	Compressor 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 32 (Compressor Alarm and Fault Registers).
<a href="#">40028</a>	Demand	[0...1000]	1:10	%	1	T	-	The target cooling capacity the compressor is asked to provide.
<a href="#">40029</a> (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 Compressor Control Mode and System State Section.
<a href="#">40029</a> (Upper 12 bits)	Compressor System State	[32...65520]	1:1	FW	R	-	-	Indicates the current operational state of the compressor controller. See Compressor Control Mode and System State Section.
<a href="#">40030</a>	IGV Open Percentage	[0...1100]	1:10	%	3	T	0	The percentage of Inlet Guide Vane (IGV) opening which is a function of <a href="#">40233 IGV Maximum Steps</a> . 110% is equal to fully open; i.e. the compressor is operating in full vane.
<a href="#">40031</a>	Suction Pressure	[0...65535]	1:10	<a href="#">Note 4</a>	R	-	-	The pressure measured at the compressor's suction port.
<a href="#">40032</a>	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 register <a href="#">40032 Minimum Pressure Ratio</a> of the start up compressor. This register should be written back to 1 after startup is complete. <b>NOTE:</b> The feature will be disabled after the compressor exits the "Ramping Up" Start Up Phase.
<a href="#">40033</a>	Discharge Pressure	[0...65535]	1:10	<a href="#">Note 4</a>	R	-	-	The pressure measured at the compressor's discharge port.
<a href="#">40034</a>	Suction Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	R	-	-	The temperature measured at the compressor's suction port.
<a href="#">40035</a>	SCR Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	R	-	-	The temperature measured on the Silicon Controlled Rectifiers (SCR).
<a href="#">40036</a>	Discharge Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	R	-	-	The temperature measured at the compressor's discharge port.
<a href="#">40037</a>	Cavity Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	R	-	-	The temperature measured in the motor cavity.
<a href="#">40038</a>	Entering Fluid Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	R	-	-	The externally measured entering fluid temperature ('ENTRY' on the I/O board).
<a href="#">40039</a>	BMCC Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	R	-	-	The temperature measured on the BMCC.
<a href="#">40040</a>	Backplane Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	R	-	-	The temperature measured at the compressor's backplane.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40041</a>	Motor Thermal Raw Value (MTRV)	[0...65535]	1:1	-	R	-	-	The readout from the motor winding thermistor.
<a href="#">40042</a>	Liquid (LIQ) Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured by the external sensor, connected to the LIQDT input on the I/O board.
<a href="#">40043</a>	DC/DC Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured on the DC/DC.
<a href="#">40044</a>	PWM Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The temperature measured on the PWM.
<a href="#">40045</a>	24 VDC Voltage	[0...65535]	1:10	VDC	R	-	-	The internally measured voltage of the 24V DC Bus.
<a href="#">40046</a>	Leaving Fluid Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The externally measured fluid temperature ('LEAVE' on the I/O board). <b>Note:</b> If there is not a sensor connected to this point, jumper 'Leave' must be installed to permit compressor operation.
<a href="#">40047</a>	Interlock Closed	[0...1] 0 = Open 1 = Closed	1:1	Boolean	R	-	-	The current status indicated by the interlock signal. It must be in the <i>closed</i> state for normal operation of the compressor and in the <i>open</i> state for service operations, such as bearing calibration, levitation, etc.
<a href="#">40048</a>	Spare Pressure	[0...65535]	1:10	<b>Note 4</b>	R	-	-	The indicated pressure as measured at the external pressure sensor ("SPARE P" on the I/O board).
<a href="#">40049</a>	Spare Temperature	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The indicated temperature as measured at the external, application-specific thermistor ("SPARE T" on the I/O board).
<a href="#">40050</a>	Chiller Demand Percentage	[0...1000]	1:10	%	R	-	-	The resulting value of <b>(40104 Actual Power/40021 Requested Power) * 40028 Demand</b> giving the compressor demand from the internal chiller controller.
<a href="#">40055</a>	Surge Detection 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 <b>40166 Front Radial Orbit Displacement (FROD)</b> value for indication of Surge. See Section "Mechanical Capacity Control Phase" for more information.
<a href="#">40056</a>	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.
<a href="#">40057</a>	Display Units	[0...1] 0 = US Customary 1 = Metric	1:1	-	2	P	1	This setting affects all parameters which have <b>Note 1</b> or <b>Note 4</b> in the Type/Unit column. When in "Metric", the values read out/written to the compressor are interpreted as kPa, °C and K. In "US Customary", they are interpreted as psi, °F and °R.
<a href="#">40058</a>	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 <b>40058 Suction Pressure Alarm/Fault Factor</b> , then convert back to gauge pressure; i.e. LP trip point with 65% factor and trip setting 20 psi gauge results in a Factor = $(20 + 14.7) * .65 - 14.7$ .
<a href="#">40059</a>	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 <b>40058 Suction Pressure Alarm/Fault Factor</b> will be used for temporarily adjusting the Suction Pressure Alarm/Fault Limits.
<a href="#">40060</a>	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.
<a href="#">40063</a>	Stepper 1 Position	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of EXV Maximum Steps.
<a href="#">40064</a>	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 <b>40065 EXV 1 Stepper Start Delay Time</b> has expired.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40065</a>	Stepper 1 Stepper Start Delay Time	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the <a href="#">40064 EXV 1 Start Position</a> is in held. The Stepper Start Delay Timer starts to count down when drive is enabled.
<a href="#">40072</a>	Stepper 2 Position	[0...1000]	1:10	%	1	-	-	The current valve position as a percentage of EXV Maximum Steps.
<a href="#">40073</a>	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 <a href="#">40074 EXV 2 Stepper Start Delay Time</a> has expired.
<a href="#">40074</a>	Stepper 2 Stepper Start Delay Time	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the <a href="#">40073 EXV 2 Start Position</a> is in held. The <a href="#">40074 EXV 2 Stepper Start Delay Time</a> starts to count down when drive is enabled.
<a href="#">40080</a>	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 <a href="#">40081 Analog Output Control/Status</a> . <b>0</b> = Manual Control Mode <b>1</b> = Discharge Pressure Control Mode
<a href="#">40081</a>	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.								
<a href="#">40088</a>	Cooling Status	[0...3]	1:1	-	R	-	-	Indicates the current status of the cooling solenoid valves: <b>0</b> (No Cooling) <b>1</b> ('Cool L') <b>2</b> ('Cool H') <b>3</b> ('Cool L' & 'Cool H') <b>Note:</b> When in split cooling configuration, 'Cool L' active implies Inverter or SCR Cooling and 'Cool H' active implies Cavity or MTRV cooling.
<a href="#">40089</a>	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 <a href="#">40029 Compressor Control Mode</a> is set to Levitate Only.
<a href="#">40098</a>	Bearing Faults	[0x0001...0xFFFF]	1:1	FW	R	-	-	Indication of any active faults which are relevant to the Bearing controller. See Table 30 (Compressor Cooling Parameters) for more information.
<a href="#">40099</a>	Bearing Alarms	[0x0001...0xFFFF]	1:1	FW	R	-	-	Indication of any active alarms which are relevant to the Bearing controller. See Table 30 (Compressor Cooling Parameters) for more information.
<a href="#">40100</a>	Actual Speed	[0...65535]	1:1	RPM	R	-	-	Calculated shaft speed in revolutions per minute.



## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40101</a>	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 <a href="#">40029 Compressor Control Mode</a> is set to Manual Control.
<a href="#">40102</a>	Motor Current (Id)	[0...65535]	<a href="#">Note 14</a>	A	R	-	-	The Id part of the motor drive current.
<a href="#">40104</a>	Actual Power	[0...65535]	1:10	kW	R	-	-	The actual power consumption of the compressor as calculated by the Motor Controller.
<a href="#">40105</a>	Inverter Temperature	[0...65535]	1:10	<a href="#">Note 1</a>	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 ( <a href="#">42043 Max Drive Start Up Temperature</a> ).
<a href="#">40106</a>	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 <a href="#">40026 Bearing/Motor Controller Fault</a> is indicated. See Table 30 (Compressor Cooling Parameters) for more information on interpreting this register.
<a href="#">40166</a>	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.
<a href="#">40177</a> <a href="#">40178</a> <a href="#">40179</a>	Compressor Real Time Clock (RTC) Current Time	[0...65535]	<a href="#">Note 8</a>	-	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.
<a href="#">40196</a>	Total Standby Hours	[0...65535]	1:1	Hours	2	-	-	Indicates the amount of compressor standby hours since last power reset. The sum of <a href="#">40196 Total Standby Hours</a> , <a href="#">40197 Total Standby Minutes</a> , <a href="#">40212 Total Running Hours</a> and <a href="#">40213 Total Running Minutes</a> results in the total ON time for the compressor since last reset.
<a href="#">40197</a>	Total Standby Minutes	[0...65535]	1:1	Minutes	2	-	-	Indicates the amount of compressor standby minutes and seconds since the last power reset.
<a href="#">40212</a>	Total Running Hours	[0...65535]	1:1	Hours	2	-	-	Indicates the amount of compressor running hours since last power reset. The sum of <a href="#">40196 Total Standby Hours</a> , <a href="#">40197 Total Standby Minutes</a> , <a href="#">40212 Total Running Hours</a> and <a href="#">40213 Total Running Minutes</a> results in the total ON time for the compressor since last power reset.
<a href="#">40213</a>	Total Running Minutes	[0...65535]	1:1	Minutes	2	-	-	Indicates the amount of compressor running minutes.
<a href="#">40220</a>	Start Up Pre-Cooling Configuration	[0...65283]	<a href="#">Note 9</a>	-	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.
<a href="#">40221</a>	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.
<a href="#">40222</a>	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.
<a href="#">40223</a>	Discharge Pressure Alarm Limit	[0...R <a href="#">40241</a> ]	1:1	<a href="#">Note 5</a>	2	P	CMS	The highest acceptable <a href="#">40033 Discharge Pressure</a> at which point the <a href="#">40027 Discharge Pressure alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40224</a>	Inverter Temperature Alarm Limit Operation	[0...R <a href="#">40242</a> ]	1:1	°C	2	P	65	The highest acceptable <a href="#">40105 Inverter Temperature</a> at which point the <a href="#">40027 Inverter Temperature alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40226</a>	Suction Pressure Alarm Limit	[R <a href="#">40244</a> ...499]	1:1	<a href="#">Note 5</a>	2	P	CMS	The lowest acceptable <a href="#">40031 Suction Pressure</a> at which point the <a href="#">40027 Suction Pressure alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40227</a>	Cavity Temperature Alarm Limit Operation	[0...R <a href="#">40245</a> ]	1:1	°C	2	P	75	The highest acceptable <a href="#">40037 Cavity Temperature</a> at which point the <a href="#">40027 Cavity Temperature alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40229</a>	Pressure Ratio Alarm Limit	[0...R <a href="#">40247</a> ]	1:10	-	2	P	CMS	The highest acceptable <a href="#">40397 Pressure Ratio</a> at which point the <a href="#">40027 Pressure Ratio alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40230</a>	3-Phase Overcurrent Alarm Limit (FLA)	[0...R <a href="#">40248</a> ]	1:1	A	2	P	CMS	The highest acceptable <a href="#">40023 3-Phase Mains Current</a> at which point the <a href="#">40027 3-Phase Overcurrent alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40233</a>	IGV Maximum Steps	[0...32767]	1:1	steps	R	P	11500	The number of steps between the fully closed and fully open positions of the IGV.
<a href="#">40235</a>	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.
<a href="#">40236</a>	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 <a href="#">40235 Stepper 1 Maximum Steps</a> for the initialization feature to function as expected.
<a href="#">40237</a>	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.
<a href="#">40238</a>	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 <a href="#">40237 Stepper 2 Maximum Steps</a> for the initialization feature to function as expected.
<a href="#">40241</a>	Discharge Pressure Fault Limit	[0...R <a href="#">40402</a> ]	1:1	<b>Note 5</b>	3	P	CMS	The highest acceptable <a href="#">40033 Discharge Pressure</a> at which point the <a href="#">40026 Discharge Pressure fault</a> is indicated and the compressor motor is stopped.
<a href="#">40242</a>	Inverter Temperature Fault Limit Operation	[0...90]	1:1	°C	R	P	70	The highest acceptable <a href="#">40105 Inverter Temperature</a> at which point the <a href="#">40026 Inverter Temperature fault</a> is indicated and the compressor motor is stopped.
<a href="#">40243</a>	Discharge Temperature Fault Limit	[0...150]	1:1	°C	R	P	CMS	The highest acceptable <a href="#">40036 Discharge Temperature</a> at which point the <a href="#">40026 Discharge Temperature fault</a> is indicated and the compressor motor is stopped.
<a href="#">40244</a>	Suction Pressure Fault Limit	[R <a href="#">40403</a> ...499]	1:1	<b>Note 5</b>	3	P	CMS	The lowest acceptable <a href="#">40031 Suction Pressure</a> at which point the <a href="#">40026 Suction Pressure fault</a> is indicated and the compressor motor is stopped.
<a href="#">40245</a>	Cavity Temperature Fault Limit Operation	[0...100]	1:1	°C	R	P	80	The highest acceptable <a href="#">40037 Cavity Temperature</a> at which point the <a href="#">40027 Cavity Temperature alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40247</a>	Pressure Ratio Fault Limit	[0...100]	1:10	-	R	P	CMS	The highest acceptable <a href="#">40397 Pressure Ratio</a> at which point the <a href="#">40026 Pressure Ratio fault</a> is indicated and the compressor is stopped.
<a href="#">40248</a>	3-Phase Overcurrent Fault Limit (LRA)	[0... R <a href="#">40401</a> ]	1:1	A	3	P	CMS	The highest acceptable <a href="#">40023 3-Phase Mains Current</a> at which point the <a href="#">40026 3-Phase Overcurrent fault</a> is indicated and the motor is stopped. Temporary fluctuations above this limit are allowed but cannot be sustained for more than ~2 seconds.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40249</a>	Run Status Indication Speed	[0...50000]	1:1	RPM	2	P	1000	The motor speed above which the external run signal is active.
<a href="#">40250</a>	Demand Control Integral Gain	[0...32000]	1:100000	-	2	P	10	The gain of the integral component of the Demand Control loop.
<a href="#">40251</a>	Modbus Slave ID	[0...64]	1:1	-	2	P	1	A unique identifier for the compressor on the Modbus network.
<a href="#">40252</a>	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.
<a href="#">40253</a>	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. <b>0</b> = None; <b>1</b> = Odd; <b>2</b> = Even; <b>3</b> = Mark; <b>4</b> = Space
<a href="#">40254</a>	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.
<a href="#">40255</a>	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.
<a href="#">40256</a>	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. <b>0</b> = None; <b>1</b> = Odd; <b>2</b> = Even; <b>3</b> = Mark; <b>4</b> = Space
<a href="#">40257</a>	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.
<a href="#">40261</a>	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 <a href="#">40262 Lockout Fault Count Limit</a> , a Lockout fault is triggered.
<a href="#">40262</a>	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.
<a href="#">40263</a>	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 <a href="#">40261 Lockout Fault Count</a> exceeds the <a href="#">40262 Lockout Fault Count Limit</a> .
<a href="#">40264</a>	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 <a href="#">40265 Lockout Fault Count Limit Slot 2</a> , a Lockout fault is triggered.
<a href="#">40265</a>	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.
<a href="#">40266</a>	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 <a href="#">40264 Lockout Fault Count Slot 2</a> exceeds the <a href="#">40265 Lockout Fault Count Limit Slot 2</a> .

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40267</a>	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 <a href="#">40268 Lockout Fault Count Limit Slot 3</a> , a Lockout fault is triggered.
<a href="#">40268</a>	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.
<a href="#">40269</a>	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 <a href="#">40267 Lockout Fault Count Slot 3</a> exceeds the <a href="#">40268 Lockout Fault Count Limit Slot 3</a> .
<a href="#">40274</a>	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 <a href="#">40026</a> .
<a href="#">40275</a>	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 <a href="#">40288</a> .
<a href="#">40276</a>	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 <a href="#">40106</a> .
<a href="#">40277</a>	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 <a href="#">40098</a> .
<a href="#">40278</a>	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 <a href="#">40026</a> .
<a href="#">40279</a>	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 <a href="#">40288</a> .
<a href="#">40280</a>	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 <a href="#">40106</a> .
<a href="#">40281</a>	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 <a href="#">40098</a> .
<a href="#">40288</a>	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.
<a href="#">40290*</a>	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.
<a href="#">40292</a>	Earth Leakage Current (Filtered)	[0...65535]	1:100	Amps	R	-	-	This value represents the calculated amount of motor current (A) to ground.
<a href="#">40296</a>	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. <b>1</b> = RS-485 <b>2</b> = RS-232

\* Registers added with 4.1.0 firmware.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40297</a>	Privilege Source	[0...2]	1:1	-	2	P	0	This register allows the user to restrict changes to <a href="#">40028 Demand</a> and <a href="#">40029 Control Mode</a> to the communication port set in this register. <b>0</b> = This feature is disable and both ports can write to these registers (behavior in builds prior to 4.0.0). <b>1</b> = RS-485 is set as the privilege source and write operations to these registers will only be accepted from this port. <b>2</b> = RS-232 is set as the privilege source and write operations to these registers will only be accepted from this port.
<a href="#">40301</a>	Stepper Control Mode	[0...1]	1:1	-	R	P	0	Mode to define the Stepper Control Type. <b>0</b> : Control as described above; <b>1</b> : Control as described in Appendix B 3.0.X Functionality Definition.
<a href="#">40304</a>	Soft Start Temperature Fault Limit	[0...65535]	1:1	K	R	-	75	The highest acceptable <a href="#">41894 Soft Start Temperature</a> at which point the <a href="#">40026 Soft Start Temperature Fault</a> bit is indicated and the compressor motor is stopped.
<a href="#">40306</a>	Shutdown Sequence Trigger Offset	[0... <a href="#">R40398</a> ]	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. Refer to the Shutdown Sequence section for additional information.
<a href="#">40307</a>	RS-232 Current Access Level	[1...3]	1:1	-	R	-	-	Current Access Level of the RS-232 port. Refer to the Access Control section for details.
<a href="#">40308</a>	RS-485 Current Access Level	[1...3]	1:1	-	R	-	-	Current Access Level of the RS-485 port. Refer to the Access Control section for details.
<a href="#">40318*</a>	IGV Initialization Selection	[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).
<a href="#">40325</a>	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 <a href="#">40031 Suction Pressure</a> exceeds the <a href="#">40226 Suction Pressure Alarm Limit</a> or <a href="#">40244 Suction Pressure Fault Limit</a> .
<a href="#">40326</a>	Low Suction Pressure Alarm/Fault Delay Timer Setting	[0...600]	1:1	Seconds	3	P	0	The starting count for the <a href="#">40325 Low Suction Pressure Alarm/Fault Delay Timer</a> which is the amount of time that the Suction Pressure alarm/fault will be delayed.
<a href="#">40328</a>	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.
<a href="#">40329</a>	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.
<a href="#">40330</a>	Voltage Configuration	[0...65535]	1:1	V	R	P	CMS	The decimal value read is the actual voltage.
<a href="#">40345*</a>	Motor Cooling Control Fault Limit	[0...65535]	1:1	V	R	P	55	The decimal value read is the actual voltage.
<a href="#">40346*</a>	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.
<a href="#">40347*</a>	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.
<a href="#">40348*</a>	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.
<a href="#">40349*</a>	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.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40350*</a>	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.
<a href="#">40351*</a>	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.
<a href="#">40352*</a>	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.
<a href="#">40353*</a>	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.
<a href="#">40354*</a>	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.
<a href="#">40355*</a>	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.
<a href="#">40356*</a>	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.
<a href="#">40391</a>	Saturated Suction Temperature (SST)	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The calculated Saturated Suction Temperature (SST) using the reading from the Pressure Sensor at the compressors suction port.
<a href="#">40392</a>	Saturated Discharge Temperature (SDT)	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The calculated Saturated Discharge Temperature (SDT) using the reading from the Pressure Sensor at the compressors discharge port.
<a href="#">40393</a>	Suction Superheat	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The calculated Suction Superheat using the measured Suction Temperature minus the calculated Saturated Suction Temperature (SST).
<a href="#">40397</a>	Pressure Ratio	[0...65535]	1:100	-	R	-	-	The pressure ratio value is the maximum of: ( <a href="#">40033 Discharge Pressure/40031 Suction Pressure</a> ) or ( <a href="#">40048 Spare Pressure/40031 Suction Pressure</a> ).
<a href="#">40398</a>	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. Max values: TT300 - 21845; TT350 - 19114; TT400 - 15837; TT700 - 12561.
<a href="#">40399</a>	Shutdown Timer Setting	[0...R40414]	1:1	Seconds	3	P	20	The length of time the compressor will remain in the shutdown sequence before stopping the motor completely.
<a href="#">40400</a>	Shutdown Timer Remaining	[0...65535]	1:1	Seconds	R	T	-	The amount of time remaining before the shutdown sequence expires.
<a href="#">40401</a>	3-Phase Current Maximum Adjustable Limit	[0...400]	1:1	A	R	P	CMS	The upper limit that the <a href="#">40248 3-Phase Overcurrent Fault Limit (LRA)</a> can be set.
<a href="#">40402</a>	Discharge Pressure Maximum Adjustable Limit	[0...2399]	1:1	kPa	R	P	CMS	The upper limit that the <a href="#">40241 Discharge Pressure Fault Limit</a> can be set.
<a href="#">40403</a>	Suction Pressure Maximum Adjustable Limit	[0...32666]	1:1	kPa	R	P	CMS	The lower limit that the <a href="#">40244 Suction Pressure Fault Limit</a> can be set.

\* Registers added with 4.1.0 firmware.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description																																																								
<a href="#">40404</a> <a href="#">40405</a> <a href="#">40406</a>	BMCC Serial Number	[0...65535]	<b>Note 11</b>	-	R	-	-	Every BMCC has a unique fixed Serial Number.																																																								
<a href="#">40410</a> <a href="#">40411</a>	Compressor Software (Configuration) Part Number	[0...65535]	<b>Note 12</b>	-	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 <a href="#">40412 Configuration Revision</a> determines the complete software configuration including which <a href="#">42044 Compressor Control (CC) Version</a> is downloaded.																																																								
<a href="#">40412</a>	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 <a href="#">40410 Compressor Software (Configuration) Part Number</a> for configuration management traceability and tracking.																																																								
<a href="#">40413</a>	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. <table border="1" style="margin-top: 10px; width: 100%; border-collapse: collapse;"> <thead> <tr style="background-color: #f28b82; color: white;"> <th>Type</th> <th>Refrigerant</th> <th></th> <th>Reg. Value</th> </tr> </thead> <tbody> <tr><td>TR300/TT300</td><td>R134a</td><td>1</td><td>8449</td></tr> <tr><td>TT300-R22</td><td>R22</td><td>2</td><td>8706</td></tr> <tr><td>TT350</td><td>R134a</td><td>1</td><td>17665</td></tr> <tr><td>TT400</td><td>R134a</td><td>1</td><td>17153</td></tr> <tr><td>TT700</td><td>R134a</td><td>1</td><td>26113</td></tr> <tr><td>TG310</td><td>R1234ZE</td><td>3</td><td>18179</td></tr> <tr><td>TG230</td><td>R1234ZE</td><td>3</td><td>10243</td></tr> <tr><td>TG390</td><td>R1234ZE</td><td>3</td><td>18691</td></tr> <tr><td>TG520</td><td>R1234ZE</td><td>3</td><td>27139</td></tr> <tr><td>TT300</td><td>R513A*</td><td>8</td><td>8456</td></tr> <tr><td>TT350</td><td>R513A*</td><td>8</td><td>17672</td></tr> <tr><td>TT400</td><td>R513A*</td><td>8</td><td>17160</td></tr> <tr><td>TT700</td><td>R513A*</td><td>8</td><td>26120</td></tr> </tbody> </table> <p style="margin-top: 10px; font-size: small;">* Refrigerant R513A is only available in firmware version 4.1.0 and later.</p>	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
Type	Refrigerant		Reg. Value																																																													
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TG310	R1234ZE	3	18179																																																													
TG230	R1234ZE	3	10243																																																													
TG390	R1234ZE	3	18691																																																													
TG520	R1234ZE	3	27139																																																													
TT300	R513A*	8	8456																																																													
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TT400	R513A*	8	17160																																																													
TT700	R513A*	8	26120																																																													
<a href="#">40414</a>	Shutdown Timer Setting Max Value	[0...65535]	1:1	Seconds	R	P	30	The maximum value which can be set in register <a href="#">40399 Shutdown Timer Setting</a> .																																																								
<a href="#">40416</a>	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.																																																								
<a href="#">40422</a>	Start Up High Suction Superheat Fault Delay Timer	[0...600]	1:1	Seconds	R	-	-	Shows remaining time until a High Suction Superheat fault will occur. The timer starts/restarts when the <a href="#">40393 Suction Superheat</a> exceeds the <a href="#">42062 Suction Superheat Fault Limit</a> and the <a href="#">40100 Actual Speed</a> has exceeded 50 RPM.																																																								
<a href="#">40423</a>	Start Up High Suction Superheat Fault Delay Timer Setting	[0...600]	1:1	Seconds	R	P	180	The starting count for the <a href="#">40422 Start Up High Suction Superheat Fault Delay Timer</a> which is the amount of time that the High Suction Superheat will be delayed.																																																								
<a href="#">40425</a>	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.																																																								
<a href="#">40431</a>	Motor Thermal Limit	[0...65535]	1:1	-	R	-	-	Motor Thermal Limit is an indication that the stator requires cooling.																																																								

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40432</a>	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 Alarms will be active.
<a href="#">40433</a>	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 Alarms will be active.
<a href="#">40434</a>	SCR Temperature Fault (Startup)	[0...65535]	1:1	C	R	P	70	SCR temperature fault limit for start-up.
<a href="#">40435</a>	SCR Temperature Alarm (Startup)	[0...65535]	1:1	C	R	P	65	SCR temperature warning limit for start-up.
<a href="#">40436</a>	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 Alarms will be active.
<a href="#">40437</a>	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 Alarms will be active.
<a href="#">40438</a>	Inverter Temperature Fault (Startup)	[0...65535]	1:1	C	R	P	70	Inverter temperature fault limit for start-up.
<a href="#">40439</a>	Inverter Temperature Alarm (Startup)	[0...65535]	1:1	C	R	P	65	Inverter temperature alarm limit for start-up
<a href="#">40440</a>	Cavity 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 Alarms will be active.
<a href="#">40441</a>	Cavity 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 Alarms will be active.
<a href="#">40442</a>	Cavity Temperature Fault (Startup)	[0...65535]	1:1	C	R	P	80	Cavity temperature fault limit for start-up.
<a href="#">40443</a>	Cavity Temperature Alarm (Startup)	[0...65535]	1:1	C	2	P	75	Temperature alarm limit used during startup.
<a href="#">40444</a>	Earth Leakage Fault Limit	[0...65535]	1:1	V	R	P	500	If the Earth Leakage Current goes above this limit, then the <a href="#">40026</a> Earth Leakage Fault will be triggered.
<a href="#">40465</a>	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. <b>0</b> = Suction Pressure <b>1</b> = Discharge Pressure
<a href="#">40491</a> <a href="#">40492</a>	EEPROM Writes	[0...65535]	<b>Note 12</b>	-	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 "Memory Operation Overview" for more information.
<a href="#">40499</a>	Compressor Start Ups	[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.
<a href="#">40516</a>	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 <a href="#">40516-40519</a> should be read at the same time to provide an indication that the system is executing inside of a given logic path.
<a href="#">40517</a>	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 <a href="#">40516-40519</a> should be read at the same time to provide an indication that the system is executing inside of a given logic path.



## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">40518</a>	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 <a href="#">40516-40519</a> should be read at the same time to provide an indication that the system is executing inside of a given logic path.
<a href="#">40519</a>	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 <a href="#">40516-40519</a> should be read at the same time to provide an indication that the system is executing inside of a given logic path.
<a href="#">40531*</a>	Low Lift Selector	[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.
<a href="#">41812</a>	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.
<a href="#">41813</a>	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.
<a href="#">41814</a>	Move IGV to Start Position After Reset	[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.
<a href="#">41817</a>	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.
<a href="#">41818</a>	Start Speed Offset	[0...65535]	1:1	RPM	3	P	CMS	Value that is added to <a href="#">42039 Motor Start Speed</a> to determine the <a href="#">40101 Desired Speed</a> during the "Start Up Phase". This ensures that the controller does not undershoot and fail to reach the <a href="#">42039 Motor Start Speed</a> .
<a href="#">41819</a>	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.
<a href="#">41820</a>	Minimum Start Speed Percentage	[0...1000]	1:10	%	3	P	CMS	Minimum start speed in percentage between <a href="#">40055 Surge Detection Speed</a> and <a href="#">40056 Choke Speed</a> . The register is used in this expression to calculate the <i>Minimum Start Up Speed</i> for the current operating conditions. <b>NOTE:</b> This is not the same as <a href="#">42039 Motor Start Speed</a> . $Minimum\ Start\ Up\ Speed = 40055\ Surge\ Detection\ Speed + (41820\ Minimum\ Start\ Speed\ Percentage / 1000) * (40056\ Choke\ Speed - 40055\ Surge\ Detection\ Speed) + 41818\ Start\ Speed\ Offset$ .
<a href="#">41821</a>	Motor Start IGV Percentage	[0...1000]	1:10	%	3	P	500	IGV position in percentage of <a href="#">42061 IGV Start Position</a> 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 <a href="#">42061 IGV Start Position</a> .
<a href="#">41822</a>	Motor Speed Ramp-Up Increment	[0...65535]	<b>Note 13</b>	-	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 <a href="#">41817 Minimum Motor Current</a> is achieved.
<a href="#">41858</a>	Earth Leakage Current Actual Value	[0...65535]	<b>1:1</b>	A	R	T	-	Actual value of Earth Leakage at the time of a fault.
<a href="#">41892</a>	MTRV Fault Limit	[0...65535]	1:1	-	R	P	3000	The limit at which point and MTRV Fault will be indicated.
<a href="#">41894</a>	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.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/ Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">41895</a>	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.
<a href="#">41898</a>	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.
<a href="#">41899</a>	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.
<a href="#">41979</a>	SCR Mains Frequency	50 or 60	1:1	Hz	R	P	CMS	Indicates the SCR Mains Input Frequency which is typically 50Hz or 60Hz.
<a href="#">41980</a>	DC Bus (Softstart) Undervoltage (Charge) Limit	[-32768...32767]	<a href="#">Note 18</a>	VDC	R	P	CMS	The minimum <a href="#">40025 DC Bus Voltage</a> below which the <a href="#">40106 DC Bus Under/Over Voltage Fault</a> would be indicated and the motor is stopped or prevented from starting. <b>NOTE:</b> This limit was originally intended to be enforced at the Softstart but instead applies to the DC Bus.
<a href="#">41981</a>	DC Bus (Softstart) Overvoltage Limit	[-32768...32767]	<a href="#">Note 18</a>	VDC	R	P	CMS	The maximum <a href="#">40025 DC Bus Voltage</a> above which the <a href="#">40106 DC Bus Overvoltage fault</a> would be indicated and the motor is stopped or prevented from starting. <b>NOTE:</b> This limit was originally intended to be enforced at the Softstart but instead applies to the DC Bus.
<a href="#">41982</a>	DC Bus Voltage Bearing Self-Test Enabled Limit	[-32768...32767]	<a href="#">Note 7</a>	VDC	R	P	CMS	The minimum <a href="#">40025 DC Bus Voltage</a> below which the "Bearing Self-Test (Startup Check)" will not occur.
<a href="#">42001</a>	DC Bus Overvoltage Limit	[-32768...32767]	<a href="#">Note 18</a>	VDC	R	P	CMS	The highest acceptable <a href="#">40025 DC Bus Voltage</a> above which the <a href="#">40106 DC Bus Overvoltage</a> is indicated and the motor is stopped.
<a href="#">42002</a>	Generator Mode Enabled Limit	[-32768...32767]	<a href="#">Note 7</a>	%	R	P	27851	Percentage of the filtered <a href="#">40025 DC Bus Voltage</a> below which Generator Mode Active fault will occur.
<a href="#">42006</a>	Maximum Single Phase Motor Current	[-32768...32767]	<a href="#">Note 14</a>	A	R	P	CMS	The highest acceptable Single-Phase Motor Current (Ia, Ib or Ic) at which point the <a href="#">40106 Motor Single Phase Overcurrent</a> fault is set and the motor is stopped.
<a href="#">42015</a>	Motor Minimum Magnetized Power Fault Limit	[-32768...32767]	1:64	kW	R	P	2	The lowest acceptable <a href="#">40104 Actual Power</a> (before accounting for 2.5% Inverter losses) at which point the <a href="#">40106 Motor Voltage Generates No Current fault</a> is indicated and the motor is stopped.
<a href="#">42027</a>	Surge Recovery/Prevention Orbit Limit	[0...R <a href="#">42028</a> ]	1:1	-	3	P	CMS	The maximum amount of <a href="#">40166 Front Radial Orbit Displacement (FROD)</a> 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.
<a href="#">42028</a>	Surge Warning Orbit Limit	[0...R <a href="#">42029</a> ]	1:1	-	3	P	CMS	The maximum amount of <a href="#">40166 Front Radial Orbit Displacement (FROD)</a> 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.

## Register Definitions

**Table 36 - Register Descriptions (Continued)**

Reg.#	Register Name	Range*	Conv.	Type/Unit	R/W Lev.	P/T	Def**	Detailed Description
<a href="#">42029</a>	Orbit Limit Max	[0...65535]	1:1	-	R	P	CMS	The maximum value which can be set in register <a href="#">42028 Surge Warning Orbit Limit</a> . Default Values: TT300/TT350/TT400/TG230/TG310/TG390: 400 TT700/TG520: 1200
<a href="#">42032</a>	Motor Back EMF	[0...65535]	<a href="#">Note 15</a>	-	R	T	-	The calculated Motor Back EMF feedback.
<a href="#">42033</a>	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.
<a href="#">42034</a>	Surge Speed Offset	[-5000 to 5000]	1:1	RPM	3	P	1	The offset of the surge line used for compressor control.
<a href="#">42036</a>	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.
<a href="#">42037</a>	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.
<a href="#">42038</a>	Motor Speed Range	[0...65535]	1:1	RPM	R	P	CMS	The range of speeds beyond <a href="#">42037 Motor Minimum Speed</a> that the compressor can operate. <a href="#">42038 Motor Speed Range</a> + <a href="#">42037 Motor Minimum Speed</a> denotes the absolute maximum speed the compressor can obtain.
<a href="#">42041</a>	SCR Temperature Alarm Limit Operation	[0...65535]	1:10	<a href="#">Note 1</a>	2	P	65	The highest acceptable <a href="#">40035 SCR Temperature</a> at which point the <a href="#">40027 SCR Temperature alarm</a> is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">42042</a>	SCR Temperature Fault Limit Operation	[0...65535]	1:10	<a href="#">Note 1</a>	R	P	70	The highest acceptable <a href="#">40035 SCR Temperature</a> at which point the <a href="#">40026 SCR Temperature fault</a> is indicated and the compressor motor is stopped.
<a href="#">42043</a>	Max Drive Start Up Temperature	[0...65535]	1:1	°C	R	P	50	The maximum <a href="#">40105 Inverter Temperature</a> allowed at start up time. If this temperature is exceeded, the compressor will not start and the <a href="#">40029 Above drive temperature limit - waiting to cool down status</a> will be indicated.
<a href="#">42044</a> <a href="#">42045</a>	Compressor Control (CC) Version	[0...65535]	<a href="#">Note 10</a>	-	R	-	FVS	The current version of the compressor firmware.
<a href="#">42046</a>	IGV Minimum 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.
<a href="#">42060</a>	Serial Driver Temperature	[0...65535]	1:1	<a href="#">Note 1</a>	R	T	-	Actual recorded temperature of Serial Driver.
<a href="#">42061</a>	IGV Start Position	[0... <a href="#">R40233</a> ]	1:1	Steps	2	P	11500	The <a href="#">40030 IGV Open Percentage</a> , in steps, to which the IGV will be set at motor start up.
<a href="#">42062</a>	Suction Superheat Fault Limit	[0...65535]	1:1	K	R	P	38	The maximum acceptable <a href="#">40393 Suction Superheat</a> at which the <a href="#">40026 High Suction Superheat</a> fault is indicated and the compressor motor is stopped.

<a href="#">42064</a>	Cavity Temperature Cooling Setpoint	[0...65535]	1:1	°C	R	P	CMS	The maximum <a href="#">40037 Cavity Temperature</a> at or above which the Cavity Cooling Solenoid will be opened.
<a href="#">42065</a>	Drive Temperature Cooling Setpoint	[0...65535]	1:1	°C	R	P	44	The maximum <a href="#">40035 SCR Temperature</a> or <a href="#">40105 Inverter Temperature</a> at or above which the Drive Cooling Solenoid will be opened.
<a href="#">42100 - 42199</a>	Configurable Bulk Readout Values	<b>Note 17</b>	<b>Note 17</b>	<b>Note 17</b>	R	-	-	The values of the corresponding Modbus register addresses configured in <a href="#">42200 - 42299 Configurable Bulk Readout Addresses</a> . See Section "Configurable Bulk Register Readout" for more information.
<a href="#">42200 - 42299</a>	Configurable Bulk Readout Addresses	[0...65535]	1:1	-	1	T	-	Section "Configurable Bulk Register Readout" Modbus register addresses that the user would like to read in the corresponding <a href="#">42100 - 42199 Configurable Bulk Readout Values</a> .

\* 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.

## Appendix A: 3.1.X Functionality Definition

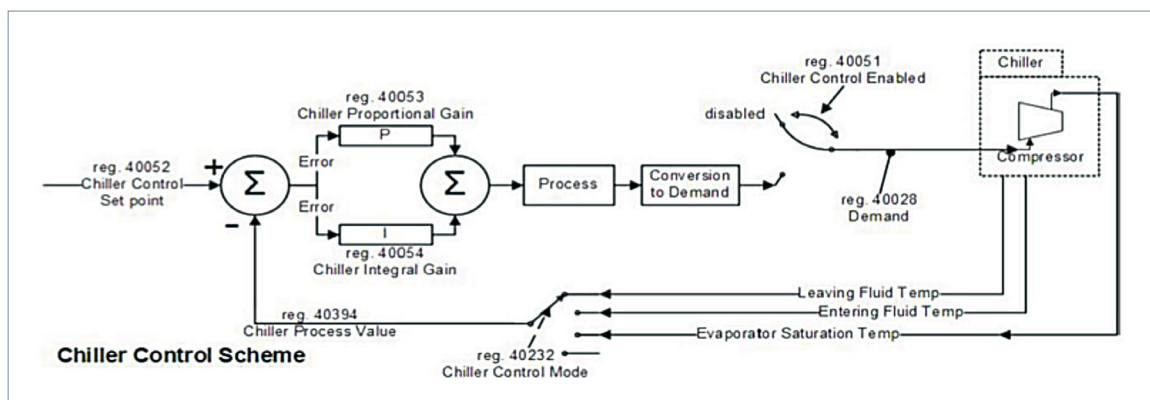
This appendix is dedicated to providing the detail that was removed from the software and likewise, the manual, for 4.X.X software.

### ... 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
<a href="#">40051</a>	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.
<a href="#">40052</a>	Chiller Control Mode Controller Set Point	[2530...3030]	1:10	K	2	P	2801	Represents the operational target for the Chiller Control Mode Controller.
<a href="#">40053</a>	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.
<a href="#">40054</a>	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.
<a href="#">40232</a>	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: <b>0</b> (Leaving Fluid Temperature) <b>1</b> (Entering Fluid Temperature) <b>2</b> (Evaporator Saturation Temperature)
<a href="#">40394</a>	Chiller Control Mode Controller Process Value	[0...65535]	1:10	<b>Note 1</b>	R	-	-	The process value used by the compressor in Chiller Control mode. This value is dependent on the <a href="#">40232</a> Chiller Control Mode Controller Process Value Parameter.

EXV Control Algorithm

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

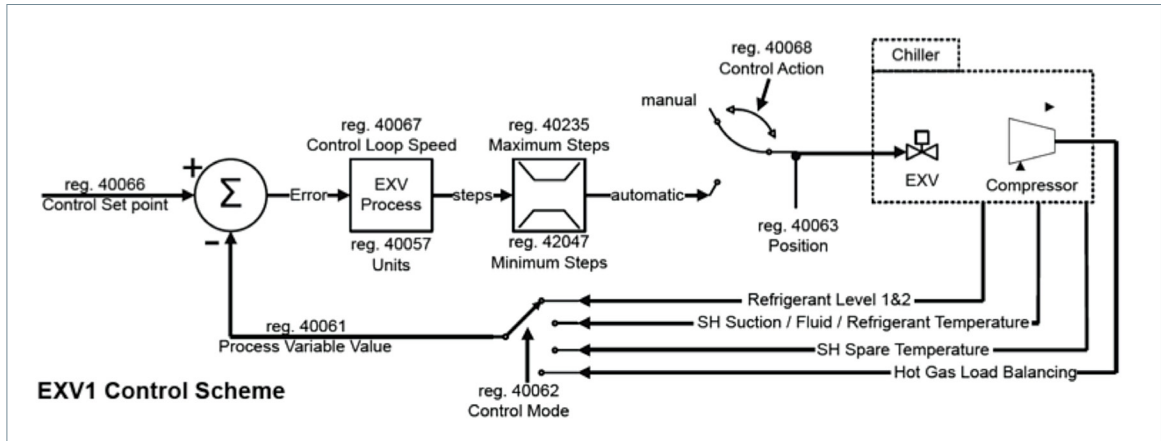
The Figure A-2 (EXV Control Diagram) describes the EXV control loop and the parameters involved in setting up/controlling the EXV output. An important note is that **42062 EXV 1 Control Mode**, together with **40057 Display Units**, depicts the process variable used in the control loop, and therefore, 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.

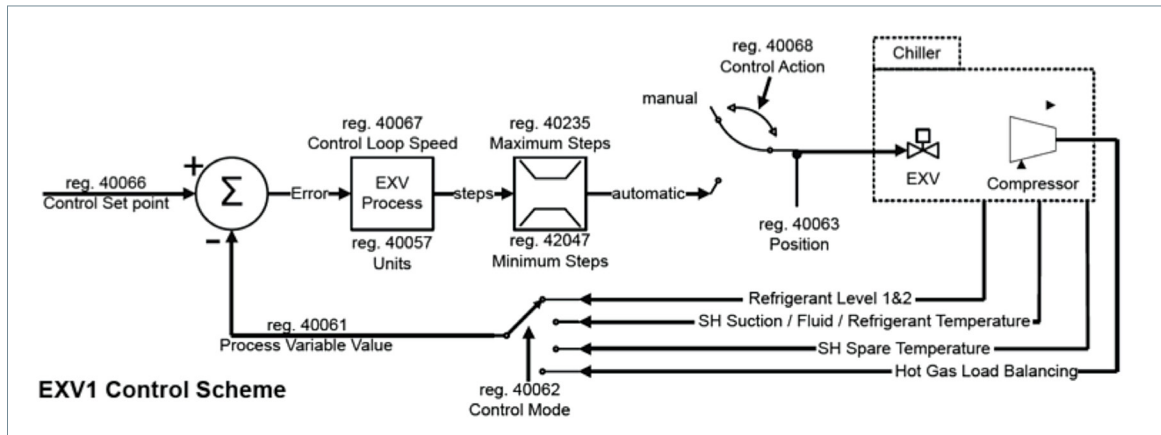
Figure A-2 - EXV Control Diagram



The EXV position in Figure A-3 (EXV Configuration and Setup) 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.

Figure A-3 - EXV Configuration and Setup



## Appendix A: 3.1.X Functionality Definition

Table A-2 (Control Modes) 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	<p>The calculation of superheat is based on the temperature and pressure measurements from one of the following sources:</p> <ul style="list-style-type: none"> <li>• 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).</li> <li>• Superheat control, using the compressor flange pressure and a thermistor that is connected to the terminals labeled "ENTRY" on the IO-Board.</li> <li>• Superheat control using the compressor flange pressure and a thermistor that is connected to the terminals labeled "LIQDT" on the IO-Board.</li> <li>• 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 <b>EXV2 Minimum Steps</b> 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 <b>EXV2 Minimum Steps</b> using a 0-5 VDC output for a 0-3447 kPa (0-500 psi) range when a sensor is connected.</li> </ul> <p><b>NOTE:</b> Thermistors must be an NTC type 10k @ 25° C, curve type F</p>
Liquid Level	<p>Liquid level can be measured from one of the following sources:</p> <ul style="list-style-type: none"> <li>• Liquid Level 1 control using a level sensor connected to the terminals on the Compressor IO-Board labeled "LIQ LEV1".</li> <li>• Liquid Level 2 control using a level sensor connected to the terminals on the Compressor IO-Board labeled "LIQ LEV2".</li> </ul> <p>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.</p>
Load Balance	<p>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.</p> <p>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.</p>

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
<a href="#">40061</a>	EXV 1 Process Variable Value	[0...65535]	<b>Note 3</b>	<b>Note 2</b>	R	-	-	The EXV's process value by which the EXV position is controlled. The value depends on EXV Control Mode and <a href="#">40057 Display Units</a> . <b>NOTE:</b> Value in register does not change when unit type is changed between Metric and US Customary.
<a href="#">40062</a>	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. <b>0</b> = No Function <b>1</b> = SH Suction Temp/Pressure <b>2</b> = SH Entering Fluid Temp/Suction Pressure <b>3</b> = SH Liquid Refrigerant Temp/Suction Pressure <b>4</b> = SH Spare Temp/Spare Pressure <b>5</b> = Liquid Level 1 <b>6</b> = Liquid Level 2 <b>7</b> = Hot Gas Load Balancing
<a href="#">40063</a>	EXV 1	[0...65535]	<b>Note 3</b>	<b>Note 2</b>	R	-	-	The EXV's process value by which the EXV position is controlled. The value depends on EXV Control Mode and <a href="#">40057 Display Units</a> . <b>NOTE:</b> Value in register does not change when unit type is changed between Metric and US Customary.

## Appendix A: 3.1.X Functionality Definition

**Table A-3 - Chiller Control Mode Parameters  
(Continued)**

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40064</a>	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 <a href="#">40065</a> EXV 1 Stepper Start Delay Time has expired.
<a href="#">40065</a>	EXV 1 Stepper Start Delay Time	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the <a href="#">40064</a> EXV 1 Start Position is in held. The Stepper Start Delay Timer starts to count down when drive is enabled.
<a href="#">40066</a>	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.
<a href="#">40067</a>	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.
<a href="#">40068</a>	EXV 1 Control Action	[0...1] 0 = Manual 1 = Automatic	1:1	-	2	P	1	<b>Manual:</b> Write directly to <a href="#">40063</a> EXV 1 Position to make the EXV open or close. <b>Automatic:</b> See <a href="#">40062</a> EXV 1 Control Mode for available EXV Control Modes.
<a href="#">40070</a>	EXV 2 Process Variable Value	[0...65535]	<a href="#">Note 3</a>	<a href="#">Note 2</a>	R	-	-	The process value of the EXV by which the EXV position is controlled. The value depends on <a href="#">40071</a> EXV 2 Control Mode and register <a href="#">40057</a> Display Units. <b>NOTE:</b> Value in register does not change when unit type is changed between Metric and US Customary.
<a href="#">40071</a>	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. <b>0</b> = No Function <b>1</b> = SH Suction Temp/Pressure <b>2</b> = SH Entering Fluid Temp/Suction Pressure <b>3</b> = SH Liquid Refrigerant Temp/Suction Pressure <b>4</b> = SH Spare Temp/Spare Pressure <b>5</b> = Liquid Level 1 <b>6</b> = Liquid Level 2 <b>7</b> = Hot Gas Load Balancing
<a href="#">40072</a>	EXV 2 Position	[0...1000]	1:10	%	R	-	-	The current valve position as a percentage of EXV Maximum Steps.
<a href="#">40073</a>	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 <a href="#">40074</a> EXV 2 Stepper Start Delay Time has expired.
<a href="#">40074</a>	EXV 2 Stepper Start Delay Time	[0...600]	1:1	Seconds	2	P	90	Represents the time in seconds that the <a href="#">40073</a> EXV 2 Start Position is in held. The <a href="#">40074</a> EXV 2 Stepper Start Delay Time starts to count down when drive is enabled.
<a href="#">40075</a>	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.
<a href="#">40076</a>	EXV 2 Control Loop Speed	[0...50]	2:1	%	2	P	5	Represents the reaction time of the control loop to a process error. <b>1</b> (2%) is slow and <b>50</b> (100%) is fast.
<a href="#">40077</a>	EXV 2 Control Action	[0...1] 0 = Manual 1 = Automatic	1:1	-	2	P	1	<b>Manual:</b> Write directly to register <a href="#">40072</a> EXV 2 Position to make the EXV open or close. <b>Automatic:</b> See register <a href="#">40071</a> EXV 2 Control Mode for EXV position control.



## Appendix A: 3.1.X Functionality Definition

**Table A-3 - Chiller Control Mode Parameters (Continued)**

Reg.#	Register Name	Range	Conv.	Type/ Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40235</a>	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.
<a href="#">40236</a>	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 <a href="#">40235 EXV 1 Maximum Steps</a> for the initialization feature to function as expected.
<a href="#">40237</a>	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.
<a href="#">40238</a>	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 <a href="#">40237 EXV 2 Maximum Steps</a> for the initialization feature to function as expected.
<a href="#">42035</a>	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 <a href="#">40062 EXV 1 Control Mode</a> and/or <a href="#">40071 EXV 2 Control Mode</a> are set equal to 7 (Hot Gas Load Balancing).
<a href="#">42047</a>	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.
<a href="#">42048</a>	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) 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.

## Appendix A: 3.1.X Functionality Definition

**Table A-4 - Fast Restart Registers**

Reg.#	Register Name	Range	Conv.	Type/Unit	R/W Lev.	P/T	Def	Detailed Description
<a href="#">40210</a>	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".
<a href="#">40211</a>	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 <a href="#">40210 Fast Restart Bearing Self Test Skipped Max Limit</a> a Bearing Self Test will be performed and the counter will be reset to 0.
<a href="#">41813</a>	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
<a href="#">40225</a>	Discharge Temperature Alarm Limit	[0... <a href="#">R40243</a> ]	1:1	°C	2	P	CMS	The highest acceptable <a href="#">40036 Discharge Temperature</a> at which point the <a href="#">40027 Discharge Temperature</a> alarm is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40228</a>	Leaving Fluid Temperature Alarm Limit	[40246...65535]	1:10	°K	2	P	2761	The lowest acceptable <a href="#">40046 Leaving Fluid Temperature</a> at which point the <a href="#">40027 Leaving Fluid Temperature</a> alarm is indicated and the compressor motor is slowed down to overcome the alarm condition.
<a href="#">40246</a>	Leaving Fluid Temperature Fault Limit	[0...65535]	1:1	°K	4	P	2741	The lowest acceptable <a href="#">40046 Leaving Fluid Temperature</a> at which point the <a href="#">40026 Leaving Fluid Temperature</a> 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
<a href="#">40425</a>	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.

## Appendix B: 3.0.x Functionality Definition

### 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 Registers) 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 value reads 0 the motor has reached the its commanded position.

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

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

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

• The OEM can monitor motor movement progress by inspecting the [40061 EXV 1 Process Variable Value](#) or [40070 EXV 2 Process Variable Value](#).

— Once register [40061 EXV 1 Process Variable Value](#) or [40070 EXV 2 Process Variable Value](#) reads 0, the motor has reached the commanded steps.

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

**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

— Once [40061 EXV 1 Process Variable Value](#) or [40070 EXV 2 Process Variable Value](#) reads 0, the motor has reached the commanded steps.

## Appendix B: 3.0.x Functionality Definition

### 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
- [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,
- 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.
- 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
<a href="#">40061</a>	EXV 1 Process Variable Value	[-32768...32767]	1:1	Steps	R	-	-	The current position of the stepper motor on EXV1.
<a href="#">40063</a>	EXV 1 Position	[-32768...32767]	4:1	Steps	2	-	-	The desired position of the stepper motor on EXV1.
<a href="#">40070</a>	EXV 2 Process Variable Value	[-32768...32767]	1:1	Steps	R	-	-	The current position of the stepper motor on EXV2.
<a href="#">40072</a>	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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