



## Application Note #2503

### DMC-40x0 Hardware & Command Set Changes

#### Overview

The command set of the Optima series is fairly similar to that of the Accelera controllers; however, some commands have been modified to optimize the increased power of the Accelera controller as well as some new additions to the command set that utilize specific functionalities associated with the DMC-40x0. This means that a program written for an Optima controller might need slight adjustment to run on a DMC-40X0 controller. This application note discusses command modifications that must be considered to convert a program from an older series controller to run on a DMC-40x0. The new commands are listed in this bulletin.

#### Increased Capability

<b>Features</b>	<b>21X3</b>	<b>22X0</b>	<b>40X0</b>
Servo Encoder Frequency	12Mhz	12Mhz	22Mhz
Memory	1000 lines	1000 lines	2000 lines
Array Elements	8,000	8,000	16,000
Velocity(counts/sec)	Up to 12 million for servo	Up to 12 million for servo	Up to 22 million for servo
Acceleration(counts/second <sup>2</sup> )	67 million	67 million	1 billion
Standard 1-2 Axis Servo Update	250µsec	250µsec	62µsec
Stepper Motor Jumpers	Yes	Yes	No
Analog Inputs	0	8	8
Optoisolated Outputs	No	Yes	Yes
LCD	No	No	Yes
<b>Communication</b>	<b>21X3</b>	<b>22X0</b>	<b>40X0</b>
Ethernet	10BASE-T	10/100BASE-T	10/100BASE-T
Ethernet Fiber	No	Yes	Consult Factory
Number of Serial Ports	1	2	2
RS422 Compatible	No	Yes	No
Baud Rate(BPS)	1200-19200	1200-115200	9600-115200
Serial Software Handshaking	No	Yes	No

The DMC-40x0 motion controller is Galil's highest performance, stand-alone motion controller. It belongs to Galil's latest generation motion controller family: the Accelera Series, which accepts encoder inputs up to 22 MHz, provides servo update rates as high as 32 kHz, and processes commands as fast as 40 microseconds-10 times the speed of prior generation controllers.

The DMC-40x0 is a full-featured motion controller packaged with optional multi-axis drives in a compact, metal enclosure. The unit operates stand-alone or interfaces to a PC with Ethernet 10/100Base-T or RS232. The controller includes optically isolated I/O, high-power outputs capable of driving brakes or relays, and analog inputs for interfacing to analog sensors. The DMC-40x0 controller and drive unit accepts power from a single 20-80 VDC source. The DMC-40x0 is available in one through eight-axis formats, and each axis is user-configurable for stepper or servo motor operation.

### **PID Changes**

When using control parameters for an Optima controller on a new Accelera controller, the values for KP, KD, and KI must be scaled. KP and KD must be increased by a factor of 4 compared to what would have been used on an Optima controller. KI on the other hand, must be divided by 2 in order to have an equivalent Integral Loop. The resolution of KI is 1/128 for Optima controllers, and is 1/1024 for Accelera controllers. The effective resolution of KP and KD has been increased by 4, but the command resolution is still 0.125. Therefore, to convert PID parameters from a DMC-18x0 to their equivalent DMC-40x0 parameters, multiply KP and KD by 4, and divide KI by 2.

Example : If the DMC-18x0 PID parameters were KP=10, KD=100, and KI=4, then the DMC-40x0 new PID parameters will be KP=40, KD=400 and KI=2.

### **Other Considerations**

#### Hardware Latch for Find Home and Find Index

With the DMC-40x0 controller, the Homing Routine and Find Index Routine now both use a hardware latch to define the index position. This latched position is returned to and defined as 0. In prior generation controllers, the index was not latched.

#### Programmable Homing and Find Index Speed

The slew speed for the final 2 stages of the homing routine, and the last stage of the Find Index Routine are set by the new HV (Homing Velocity) command. The default for HV is 256 counts/sec.

## New Commands for the DMC 40x0

	<b>Command</b>	<b>21X3</b>	<b>22X0</b>	<b>40X0</b>
%	Modulo of an encoder position	No	No	Yes
<u>IA5</u>	Query Ethernet speed	No	No	Yes
^L^K	Lock DMC program	No	No	Yes
{Lx}	Message string to LCD display	No	No	Yes
AQ	Analog input configuration	No	No	Yes
BW	Delay set for Brake operation	No	No	Yes
EY	ECAM cycle count	No	No	Yes
HV	Velocity set during Homing phase 2 & 3	No	No	Yes
ID	Check for Amplifier ID - Type	No	No	Yes
LD	Limit Disable – Ignore Limit inputs	No	No	Yes
LB	LCD bias for contrast	No	No	Yes
LU	LCD updates manually / automatically	No	No	Yes
OA	Off on Encoder failure enable / disable	No	No	Yes
OT	Off on encoder – over time	No	No	Yes
OV	Off on encoder – over voltage	No	No	Yes
PW	Password for program lock	No	No	Yes
SD	Deceleration when limit switch activated	No	No	Yes
SM	Set subnet mask for Ethernet handle	No	No	Yes
VT	Vector speed smoothing	Yes	Yes	No*
VV	Variable Vector speed on segments	No	No	Yes
WC	Wait for Contour data complete	Yes	Yes	No*
ZA	User variables in data record	No	No	Yes

\*These commands were removed or replaced

## New Commands From 18X6 To 40X0

*Note: All commands listed below are quick references. Full explanations of commands can be found in the command reference for the controller.*

### **{Lx}**

String to LCD. This command allows the user to send a message to the LCD screen. The x will choose the line number, either 1 or 2.

### **IA5**

Query Ethernet speed. Returns auto negotiation Ethernet speed. Returns 10 for 10-Base T and returns 100 for 100-Base T, it will return -1 if there is no physical link

### **AQ**

Analog Configuration. This command allows the user to select an analog range for a specific analog input. For example, analog input 1 can be set to range from -10V to +10V and analog input 2 can be set to range from 0V to 5V.

## **BW**

Brake Wait. This command is used to set the delay, in samples, between the time the brake output changes state and the amp enable changes state. This allows the user to set a delay in order to account for mechanical delay in the braking system.

## **ID**

Identify. This command will return the accessories that are attached, including amplifiers and daughter boards.

## **LB**

LCD bias contrast. Allows the user to control the contrast of the LCD screen on a scale from 0-15.

## **LU**

LCD Update. Puts the controller's LCD in to automatic update mode. In this mode the LCD will display all the axis names on line one, and a one letter status indicator on line two.

## **SM**

Subnet Mask. This command allows the user to set a subnet mask for the controller which will force the controller to either ignore or accept packets from certain IP addresses. A controller with SM of 255.255.0.0 and IA of 10.0.51.1 will only accept packets from IP addresses 10.0.XXX.XXX

## **VV**

Vector Variable. This command allows the user to adjust the vector speed dynamically while in a vector mode. This is useful when you have multiple VM commands in the buffer and want to be able to change the vector speed on the fly.

## **New Commands for all Accelera Series**

### **%**

This new Math Operand will return the integer remainder of a division. This operand is especially useful for rotary applications where knowledge of an absolute position is desired. For example, the position of a motor shaft can be found in degrees between 0-360o by using the following sequence of commands.

```
V1= _TPX%4000  
Angle=360*(V1/4000)
```

In this example, if TPX is 4350, then V1 will be 350, and the angle will be 31.5o.

### **EY**

CAM Cycle Count. This command is used to determine the absolute position of an axis that is involved in an ECAM profile, and to also simply report how many ECAM cycles have been executed. It returns the number of ECAM cycles that have been executed. To determine the absolute position of an axis while in ECAM mode, the formula below is used:

Absolute Position = EM\*EY +TP

EY may be initialized or reset by the user by issuing EYn, where n is the ECAM cycle count.

### **HV**

Homing Velocity. Useful when using custom homing routines, this function will set the slew speed in the last stage of the FI routine, and in all stages except the first in the HM routine. See FI and HM in 40x0 Command Reference.

### **LD**

Limit Disable. This command can be used for debugging an application that is subject to noise problems that may be tripping the limit switches. Setting this command will cause the controller to ignore when a limit switch has been reached. When the Limit Switches are disabled, \_LF and \_LR will still return the state of the limit switch.

### **^L^K**

Lock Program. This new command locks user access to the application program. When locked, error #106 will occur if ED, UL, LS or TR commands are executed.

### **OA**

Off on Encoder Error Failure. This command turns on and off the encoder failure feature. The threshold for encoder failure is established with the OV command. See OT and OV below.

### **OT**

Off on Encoder Failure Time. This command establishes the time, in number of samples, which the controller will wait for motion before issuing an error due to encoder failure. The OV command sets voltage threshold that will trip the OT to start. See OV below.

### **OV**

Off on Encoder Failure Voltage. Sets the threshold voltage pertaining to the commanded torque output of an axis in which the OA command has been set. If the controller has failed to register a change of at least 4 encoder counts by the time defined by OT have passed after the torque threshold has been exceeded, then an Encoder Failure will occur.

### **PW**

Sets the password for the ^L^K lock setting.

### **SD**

Limit Switch Deceleration. SD sets the deceleration rate (counts/second<sup>2</sup>) that will be used when a limit switch is reached. This eliminates the need to immediately set DC in a #LIMSWI subroutine. Like AC and DC, SD defines rates from 1024 to 1,073,740,800 counts/sec<sup>2</sup> in increments of 1024, and is individually specified per axis.

### **ZA**

User Data Record Variables. ZA allows the user to write data to part of the data record. There are 4 bytes of memory available per axis. This is useful if there is a need to send extra information when retrieving the data record, or if there is a need to visually monitor a variable while viewing the data record.

## **Modified Commands for the Accelera Series**

### **AC/DC**

Acceleration and Deceleration Rates. The ranges of AC and DC commands have been expanded. On an Optima series controller the range is 1024 to 67,107,840 counts/sec<sup>2</sup>. With the new Accelera series controller, the range of AD and DC is now 1024 to 1,073,740,800counts/sec<sup>2</sup>.

### **Automatic Subroutines**

Except for #CMDERR, all automatic subroutines in the Galil software architecture no longer require thread 0 to be running in order for them to operate. This means that if a program fails and thread 0 stops running, the automatic subroutines such as #LIMSWI, will still operate.

### **AL**

Arm Latch. The latch function of the controller can be used to very accurately capture the encoder position of an axis via a digital input. For the Accelera series controllers, this command has been expanded so that a high speed capture of the encoder position can be latched to the index pulse.

### **CD**

Contour Data. The CD command has been modified for use without the WC command. See WC below.

### **ER**

Error Limit. The range of the Error Limit command has been expanded. On an Optima series controller, the range of ER is 1 to 32,767 counts. With the new Accelera series controller, the range of ER is now 1 to 2,147,483,647 counts. A value of -1 will still disable the position error limit for the specified axis.

### **Homing**

Homing Routine. The homing routine now uses a hardware latch to mark the position of the index, and will return to that position on the final move of the routine with a speed specified by the HV command. This is different from the Optima controllers, where the index triggered a high deceleration stop, and the position is defined when motion had ceased.

### **IT**

The functionality of the IT command has been expanded to operate over the entire sequence of a vector or linear interpolated sequence of moves. The IT command is now effectively a 1st order low pass filter which smoothes out basic movements, coordinated motion and contoured mode motion. While in coordinated vector motion, the IT command will act on

the individual vector components. This is different than the VT command which acted over the resultant vector movement. Because of the expanded functionality of the IT command, the VT command is now longer needed.

### **JG/SP**

Jog and Speed. The range of the SP and JG commands has been expanded. On an Optima series controller, the range of SP is 0 to 12,000,000 counts/sec for servo motors and 0 to 3,000,000 steps/sec for steppers, and the range of JG is +/-12,000,000 counts/sec for servos and +/-3,000,000 steps/sec for steppers. With the new Accelera series controller, the range of SP is now 0 to 22,000,000 counts/sec for servos and 0 to 6,000,000 steps/sec for steppers, and the range of JG is +/- 22,000,000 counts/sec and +/-6,000,000 steps/sec for steppers.

### **KP/KD/KI**

PID Filter Parameters. When using control parameters for an Optima controller on a new Accelera controller, the values for KP, KD, and KI must be scaled. KP and KD must be increased by a factor of 4 compared what would have been used on an Optima controller. KI on the other hand, must be divided by 2 in order to have an equivalent Integral Loop. The resolution of KI is 1/128 for Optima controllers, and is 1/1024 for Accelera controllers. The effective resolution of KP and KD has been increased by 4, but the command resolution is still 0.125.

### **LC**

Low Current Stepper Mode. Rather than just using a 1 for “on” or a 0 for “off”, any number from 1 to 32,767 may be used to activate this mode. A non-zero number represents the number of samples after the motion is complete in which the controller will wait until Low Current Stepper Mode is activated. A zero is normal (stepper drive always on) operation.

### **M-Axis**

M Virtual Axis. A second virtual axis has been added to the Accelera series controllers. This gives even more flexibility and versatility to applications involving ECAM and Geared motion. This axis, like the N axis, may be used as the master axis in ECAM mode.

### **MT1.5**

Motor Type. Setting MT to 1.5 for a given axis will send a PWM signal over the PWM/STEP OUT line and a high or low direction signal over the Sign/Direction line of the DMC 40x0. This is useful when using a servo driver that accepts a PWM signal for motor command. An MT of 1.5 on the DMC 40x0 is the same as setting MT to 1 and having the SM jumper installed for that axis when using any non accelera series controllers.

### **\_NO**

No Operation. \_NO is an operand which gives the decimal value of a binary representation of which threads are running on the controller. The decimal value can be interpreted by the equation:

$$n = n_0 + 2*n_1 + 4*n_2 + 8*n_3 + 16*n_4 + 32*n_5 + 64*n_6 + 128*n_7$$

Where  $n_x$  represents the thread. A 0 means no threads are running, and 255 means that all threads are running.

## **OE2**

Off On Error. The Off On Error command now has the capability to automatically shut off the motor command signal when a limit switch is triggered. The options now for the OE command are Motor off by position error or abort input, Motor off by Limit Switch being triggered, or both.

## **TM**

Update Time. Most functions that were previously affected by changes to the Update Time are now automatically scaled by the controller and there is no need for the user to manually make changes to those functions. The three functions that are not scaled with the new controller are KD, KI and PL.

True Dampening =  $KD * TM$

True Integral =  $KI / TM$

See PL in user manual for effect of TM.

## **TR<sub>n,m</sub>**

Trace. The trace function can now be configured to specify which threads to trace and send their commands down the communications port prior to execution. This is done by specifying  $m$  as a decimal value that is determined by using the binary weighted formula given below:

$$m = n_0 + 2 * n_1 + 4 * n_2 + 8 * n_3 + 16 * n_4 + 32 * n_5 + 64 * n_6 + 128 * n_7$$

Where  $n_x$  represents the thread. TR 1,7 will command the controller to trace threads 1,2 and 3.

## **VA/VD**

Vector Acceleration and Deceleration Rates. The ranges of VA and VD commands have been expanded. On an Optima series controller the range is 1024 to 68,461,360 counts/sec<sup>2</sup>. With the new Accelera series controller, the range of VA and VD is now 1024 to 1,073,740,800 counts/sec<sup>2</sup>.

## **VS**

Vector Speed. The range of the VS command has been expanded. On an Optima series controller the range is 2 to 12,000,000 counts/sec for servo motors and 2 to 3,000,000 steps/sec for steppers. With the new Accelera series controller, the range of VS is now 2 to 22,000,000 counts/sec for servo motors and 2 to 6,000,000 steps/sec for steppers.

## **Removed Commands and Hardware for the Accelera Series**

### WC command in Contour Mode

The architecture of the contour mode has changed with the DMC-40x0. The moves are now buffered similar to that of Vector and Linear Interpolation moves. Because of this, WC has been removed from the new command set, and CD has been modified to operate without the need of WC.

### Replacement of VT command by IT

The VT command has been removed from the DMC-40x0 command set. The functionality of the IT command has been expanded to operate over the entire sequence of a vector or linear interpolated sequence of moves. The IT command is now effectively a 1st order low pass filter which smoothes out basic movements, coordinated motion and contoured mode motion. While in coordinated vector motion, the IT command will act on the individual vector components. This is different than the VT command which acted over the resultant vector movement. Because of the expanded functionality of the IT command, the VT command is no longer needed.

### Stepper Motor Jumpers

The Stepper Motor Jumpers have been removed from the DMC-40x0 controller. For operating in Stepper mode, MT must be set to the correct setting, but no hardware needs to be changed. Servo drives that accept a PWM signal for their motor command will now use MT 1.5, rather than having the SM jumpers installed and an MT of 1.