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THORLABS

DDR05/M - June 6, 2017

Item # DDR05/M was discontinued on June 6, 2017. For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

COMPACT DIRECT-DRIVE ROTATION MOUNT

- ▶ **Rotational Speeds Up to 5.0 Hz**
- ▶ **SM05 (0.535"-40) Threaded Central Bore**
- ▶ **16 mm and 30 mm Cage System Compatible**
- ▶ **Backlash-Free Direct-Drive Design**

DDR05

Application Idea
Ø1" Linear Film Polarizer in a CRM1 Rotation Mount and Ø1/2" Film Polarizer Threaded into the DDR05 Motorized Rotation Mount

Hide Overview

OVERVIEW

Features

- 360° Continuous Rotation
- High Speeds up to 5.0 Hz (1800 °/s)
- SM05 (0.535"-40) Threaded Central Bore for compatibility with Ø1/2" Lens Tubes
- Tapped Holes for 16 mm and 30 mm Cage System Integration
- Low Profile: 28.9 mm (1.14")
- Integrated Brushless DC Servo Motor Actuators
- High-Quality, Precision-Engineered Bearings

Thorlabs' DDR05(/M) low-profile, direct-drive rotary mount provides continuous rotation of a load with a moment of inertia up to 70 kg•mm^2 with 3 µrad resolution and a maximum rotation speed of up to 5.0 Hz (1800 °/s). An SM05 (0.535"-40) threaded central aperture allows an optical path to pass directly through the body of the mount and provides compatibility with Ø1/2" optical elements and Ø1/2" lens tubes. Components can be threaded into this bore from either side of the rotation mount.

Key DDR05 Specifications[a]	
Travel Range	360° Continuous
Maximum Velocity	5.0 Hz (1800 °/s)
Maximum Acceleration	29.1 Hz/s (10477 °/s^2)
Repeatability	9.42 µrad (0.00054°)
Maximum Moment of Inertia of Load About Rotation Axis	70 kg•mm^2
Central Aperture	SM05 (0.535"-40) Threaded Bore
Motor Type	Brushless DC Rotary Motor
Cable Length	3.0 m (9.8')
Recommended Controller (Sold Separately)	KBD101
Stage Dimensions (L x W x H)	54.0 mm x 54.0 mm x 28.9 mm (2.13" x 2.13" x 1.14")

- More detailed specifications are included in the *Specs* tab.

Click to Enlarge
The rear face of the rotation stage has four stationary tapped holes for 16 mm cage system rods. A 30 mm cage system can be continued from the back side of the stage by using an SP05 30 mm to 16 mm Cage Adapter Plate.

The DDR05(/M) has a 3-phase, slotless, brushless DC motor integrated directly into the frame of the stage. This eliminates all forms of mechanical transmission, resulting in high repeatability, rigidity and reliability. The winding design enables good velocity stability, even at low speeds, by eliminating torque ripple due to magnetic cogging. The high resolution encoder mounted directly on the moving world provides high accuracy and repeatability, while the precision-engineered bearings and tight manufacturing tolerances produce very low axial wobble (500 µrad). An engraved graduated scale with 2° increments allows for coarse positioning.

The mount is designed to be mounted vertically on a post using one of four 8-32 (M4) taps on the sides of the device. The rotating portion of the front face features four 4-40 tapped holes spaced for integration of 16 mm cage system assemblies and components, allowing for the rotation of a cage segment. The non-rotating portion of the front face also includes four 4-40 tapped holes spaced for use with 30 mm cage system components. The back of the device features four more 4-40 tapped holes for 16 mm cage system rods, but this portion of the cage remains stationary. A stationary 30 mm cage system can be continued on the back side of the stage using an SP05 30 mm to 16 mm cage adapter plate, as shown in the image to the right. The position of all of these tapped holes can be seen in the diagram below.

The stage is driven by the KBD101 brushless DC controller (sold separately below), which provides very precise positioning through the stable closed-loop PID control system (see the *PID Tutorial* tab for more information). The controller ships with our Kinesis and legacy APT software packages for easy integration into an existing system. Power supplies for the K-Cube controller are sold separately (see below).

Hide Specs

SPECS

DDR05 Specifications	
Travel Range	360° Continuous
Maximum Velocity	5.0 Hz (1800 °/s)
Maximum Acceleration[a]	29.1 Hz/s (10477 °/s^2)
Repeatability	9.42 µrad (0.00054°)
Backlash[b]	None
Encoder Resolution	2 x 10^6 Counts/rev (0.00018 °/Count)
Minimum Incremental Motion	6.28 µrad (0.00036°)
Maximum Moment of Inertia of Load About Rotation Axis[c]	70 kg•mm^2
Minimum Motor Holding Torque	1.8 N•m
Velocity Stability	2.0% (For Speeds 0.5 - 5.0 Hz)
Max Wobble (Axial)	500 µrad
Bearing Type	4-Point Ball Bearing
Limit Switches	None
Central Aperture	SM05 (0.535"-40) Threaded Bore
Operating Temperature Range[d]	5 to 40 °C (41 to 104 °F)
Motor Type	Brushless DC Rotary Motor
Cable Length	3.0 m (9.8')
Recommended Controller	KBD101
Stage Dimensions (L x W x H)	54.0 mm x 54.0 mm x 28.9 mm (2.13" x 2.13" x 1.14")
Weight	0.39 kg (0.86 lbs)

- The acceleration is limited by the peak torque of the stage. Lighter loads will accelerate faster, while heavier loads will accelerate slower.
- The stage does not suffer from backlash because there is no transmission.

Maximum load will vary with the moment of inertia. The estimated maximum load for a 70 kg*mm^2 inertial moment is around 0.25 kg.

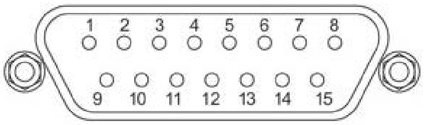
- For operation at temperatures outside normal room temerature, the PID parameters may require optimization.

KBD101 K-Cube Controller Specifications	
Motor Output	
Drive Connector	15-Pin D-Type, Female [Motor Phase Outputs; Stage ID Input; Forward, Reverse Limit Switch Inputs (+ Common Return); 5 V Encoder Supply]
Motor Drive Current (Peak)	2 A
Pulse Width Modulation Frequency	40 kHz
Control Algorithm	16-Bit Digital PID Servo Loop with Velocity and Acceleration Feedforward
Position Feedback	Incremental Encoder
Encoder Feedback Bandwidth	2.5 MHz/ 10 MCounts/sec
Position Counter	32 Bit
Operating Modes	Position, Velocity
Velocity Profile	Trapezoidal/S-Curve
Front Panel Controls	
Sprung Potentiometer Wheel	Bidirectional Velocity Control, Forward/Reverse Jogging, or Position Presets
Input Power Requirements	
Voltage	14.5 - 15.5 V Regulated DC
Current	2 A (Peak)
General	
Housing Dimensions (W x D x H)	60 mm x 60 mm x 47 mm (2.36" x 2.36" x 1.85")
Weight	160 g (5.5 oz)

Hide Pin Diagrams

PIN DIAGRAMS

The cable attached to the DDR05(/M) rotation stage is terminated in a male 15-pin D-type connector. Pin details are given below.



Pin	Description	Pin	Description
1	Quadrature A-	9	Ground
2	Quadrature A+	10	Motor Phase C (Black)
3	Quadrature B+	11	Motor Phase A (Red)
4	Quadrature B-	12	Motor Phase B (White)
5	Encoder Index I-	13	+5 V
6	Encoder Index I+	14	Ground
7	Negative Limit	15	Stage ID
8	Positive Limit	-	-

Hide Motion Control Software

MOTION CONTROL SOFTWARE

Thorlabs offers two platforms to drive our wide range of motion controllers: our legacy APT™ (Advanced Positioning Technology) software package or the new

Kinesis software package. Either package can be used to control devices in the APT or Kinesis family, which covers a wide range of motion controllers ranging from small, low-powered, single-channel drivers (such as the K-Cubes and T-Cubes) to high-power, multi-channel, modular 19" rack nanopositioning systems (the APT Rack System).

Our legacy APT System Software platform is available by clicking on the link below. It features ActiveX-based controls which can be used by 3rd party developers working on C#, Visual Basic, LabVIEW or any Active-X compatible languages to create custom applications, and includes a simulator mode to assist in developing custom applications without requiring hardware.

The Kinesis Software features new .NET controls which can be used by 3rd party developers working in the latest C#, Visual Basic, LabVIEW or any .NET compatible languages to create custom applications. Low level DLL libraries are included for applications not expected to use the .NET framework. A Central Sequence Manager supports integration and synchronization of all Thorlabs motion control hardware.

By providing these common software platforms, Thorlabs has ensured that users can easily mix and match any of the APT and Kinesis controllers in a single application, while only having to learn a single set of software tools. In this way, it is perfectly feasible to combine any of the controllers from single-axis to multi-axis systems and control all from a single, PC-based unified software interface.

Driver:1 Ch Piezo Drive T-Cube
Jog Step Size: 0.10
Input Source: +ve BNC (+ SW)
Proportional: 100
Integral: 100

APT GUI Screen

The software packages allow two methods of usage: graphical user interface (GUI) utilities for direct interaction with and control of the controllers 'out of the box', and a set of programming interfaces that allow custom-integrated positioning and alignment solutions to be easily programmed in the development language of choice.

A range of video tutorials are available to help explain our APT system software. These tutorials provide an overview of the software and the APT Config utility. Additionally, a tutorial video is available to explain how to select simulator mode within the software, which allows the user to experiment with the software without a controller connected. Please select the *APT Tutorials* tab above to view these videos, which are also available on the software CD included with the controllers.

Software

APT Version 3.21.0

The APT Software Package, which includes a GUI for control of Thorlabs' APT™ and Kinesis® system controllers.

Also Available:

Software

- Communications Protocol

Software

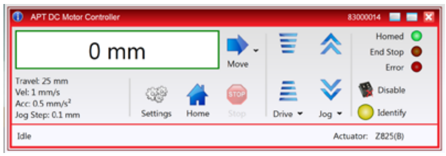
Kinesis Version 1.11.2

The Kinesis Software Package, which includes a GUI for control of Thorlabs' Kinesis and APT™ system controllers.

Also Available:

- Communications Protocol

Software



0 mm
Travel: 25 mm
Vel: 1 mm/s
Acc: 0.5 mm/s²
Jog Step: 0.1 mm
Idle
Actuator: Z825(B)

Kinesis GUI Screen

Hide APT Tutorials

APT TUTORIALS

These videos illustrate some of the basics of using the APT System Software from both a non-programming and a programming point of view. There are videos that illustrate usage of the supplied APT utilities that allow immediate control of the APT controllers out of the box. There are also a number of videos that explain the basics of programming custom software applications using Visual Basic, LabView and Visual C++. Watch the videos now to see what we mean.

Click here to view the video tutorial

To further assist programmers, a guide to programming the APT software in LabView is also available.

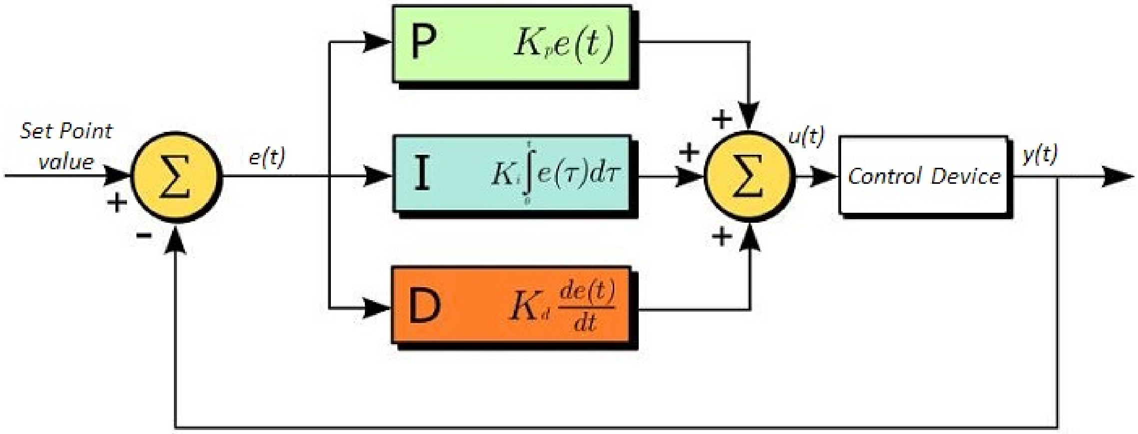
Click here to view the LabView guide

Hide PID Tutorial

PID TUTORIAL

PID Basics

The PID circuit is often utilized as a control loop feedback controller and is very commonly used for many forms of servo circuits. The letters making up the acronym PID correspond to Proportional (P), Integral (I), and Derivative (D), which represents the three control settings of a PID circuit. The purpose of any servo circuit is to hold the system at a predetermined value (set point) for long periods of time. The PID circuit actively controls the system so as to hold it at the set point by generating an error signal that is essentially the difference between the set point and the current value. The three controls relate to the time-dependent error signal; at its simplest, this can be thought of as follows: Proportional is dependent upon the present error, Integral is dependent upon the accumulation of past error, and Derivative is the prediction of future error. The results of each of the controls are then fed into a weighted sum, which then adjusts the output of the circuit, u(t). This output is fed into a control device, its value is fed back into the circuit, and the process is allowed to actively stabilize the circuit's output to reach and hold at the set point value. The block diagram below illustrates very simply the action of a PID circuit. One or more of the controls can be utilized in any servo circuit depending on system demand and requirement (i.e., P, I, PI, PD, or PID).



Through proper setting of the controls in a PID circuit, relatively quick response with minimal overshoot (passing the set point value) and ringing (oscillation about the set point value) can be achieved. Let's take as an example a temperature servo, such as that for temperature stabilization of a laser diode. The PID circuit will ultimately servo the current to a Thermo Electric Cooler (TEC) (often times through control of the gate voltage on an FET). Under this example, the current is referred to as the Manipulated Variable (MV). A thermistor is used to monitor the temperature of the laser diode, and the voltage over the thermistor is used as the Process Variable (PV). The Set Point (SP) voltage is set to correspond to the desired temperature. The error signal, e(t), is then just the difference between the SP and PV. A PID controller will generate the error signal and then change the MV to reach the desired result. If, for instance, e(t) states that the laser diode is too hot, the circuit will allow more current to flow through the TEC (proportional control). Since proportional control is proportional to e(t), it may not cool the laser diode quickly enough. In that event, the circuit will further increase the amount of current through the TEC (integral control) by looking at the previous errors and adjusting the output in order to reach the desired value. As the SP is reached [e(t) approaches zero], the circuit will decrease the current through the TEC in anticipation of reaching the SP (derivative control).

Please note that a PID circuit will not guarantee optimal control. Improper setting of the PID controls can cause the circuit to oscillate significantly and lead to instability in control. It is up to the user to properly adjust the PID gains to ensure proper performance.

PID Theory

The output of the PID control circuit, u(t), is given as

$$u(t) = MV(t) = K_p e(t) + K_i \int_0^t e(\tau)d\tau + K_d \frac{d}{dt} e(t)$$

where

K_p= Proportional Gain

K_i = Integral Gain

K_d = Derivative Gain

e(t) = SP - PV(t)

From here we can define the control units through their mathematical definition and discuss each in a little more detail. Proportional control is proportional to the error signal; as such, it is a direct response to the error signal generated by the circuit:

$$P = K_p e(t)$$

Larger proportional gain results is larger changes in response to the error, and thus affects the speed at which the controller can respond to changes in the system. While a high proportional gain can cause a circuit to respond swiftly, too high a value can cause oscillations about the SP value. Too low a value and the circuit cannot efficiently respond to changes in the system.

Integral control goes a step further than proportional gain, as it is proportional to not just the magnitude of the error signal but also the duration of the error.

$$I = K_i \int_0^t e(\tau) d\tau$$

Integral control is highly effective at increasing the response time of a circuit along with eliminating the steady-state error associated with purely proportional control. In essence integral control sums over the previous error, which was not corrected, and then multiplies that error by K_i to produce the integral response. Thus, for even small sustained error, a large aggregated integral response can be realized. However, due to the fast response of integral control, high gain values can cause significant overshoot of the SP value and lead to oscillation and instability. Too low and the circuit will be significantly slower in responding to changes in the system.

Derivative control attempts to reduce the overshoot and ringing potential from proportional and integral control. It determines how quickly the circuit is changing over time (by looking at the derivative of the error signal) and multiplies it by K_d to produce the derivative response.

$$D = K_d \frac{d}{dt} e(t)$$

Unlike proportional and integral control, derivative control will slow the response of the circuit. In doing so, it is able to partially compensate for the overshoot as well as damp out any oscillations caused by integral and proportional control. High gain values cause the circuit to respond very slowly and can leave one susceptible to noise and high frequency oscillation (as the circuit becomes too slow to respond quickly). Too low and the circuit is prone to overshooting the SP value. However, in some cases overshooting the SP value by any significant amount must be avoided and thus a higher derivative gain (along with lower proportional gain) can be used. The chart below explains the effects of increasing the gain of any one of the parameters independently.

Parameter Increased	Rise Time	Overshoot	Settling Time	Steady-State Error	Stability
K_p	Decrease	Increase	Small Change	Decrease	Degrade
K_i	Decrease	Increase	Increase	Decrease Significantly	Degrade
K_d	Minor Decrease	Minor Decrease	Minor Decrease	No Effect	Improve (for small K_d)

Tuning

In general the gains of P, I, and D will need to be adjusted by the user in order to best servo the system. While there is not a static set of rules for what the values should be for any specific system, following the general procedures should help in tuning a circuit to match one's system and environment. In general a PID circuit will typically overshoot the SP value slightly and then quickly damp out to reach the SP value.

Manual tuning of the gain settings is the simplest method for setting the PID controls. However, this procedure is done actively (the PID controller turned on and properly attached to the system) and requires some amount of experience to fully integrate. To tune your PID controller manually, first the integral and derivative gains are set to zero. Increase the proportional gain until you observe oscillation in the output. Your proportional gain should then be set to roughly half this value. After the proportional gain is set, increase the integral gain until any offset is corrected for on a time scale appropriate for your system. If you increase this gain too much, you will observe significant overshoot of the SP value and instability in the circuit. Once the integral gain is set, the derivative gain can then be increased. Derivative gain will reduce overshoot and damp the system quickly to the SP value. If you increase the derivative gain too much, you will see large overshoot (due to the circuit being too slow to respond). By playing with the gain settings, you can maximize the performance of your PID circuit, resulting in a circuit that quickly responds to changes in the system and effectively damps out oscillation about the SP value.

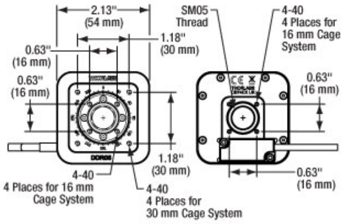
While manual tuning can be very effective at setting a PID circuit for your specific system, it does require some amount of experience and understanding of PID circuits and response. The Ziegler-Nichols method for PID tuning offers a bit more structured guide to setting PID values. Again, you'll want to set the integral and derivative gain to zero. Increase the proportional gain until the circuit starts to oscillate. We will call this gain level K_u. The oscillation will have a period of P_u. Gains are for various control circuits are then given below in the chart.

Control Type	K_p	K_i	K_d
P	$0.50\ K_u$	-	-
PI	$0.45\ K_u$	$1.2\ K_p/P_u$	-
PID	$0.60\ K_u$	$2\ K_p/P_u$	$K_pP_u/8$

Hide Compact Direct Drive Rotation Mount

Compact Direct Drive Rotation Mount

- Rotational Speeds up to 5.0 Hz (1800 °/s)
- Integrated Brushless DC Servo Motor
- SM05 (0.535"-40) Threaded Bore for Ø1/2" Lens Tubes
- 16 mm and 30 mm Cage System Compatible
- Four 8-32 (M4) Mounting Holes



Click to Enlarge
Diagram Showing the Dimensions of the DDR05(/M) Rotation Stage and the Position of Tapped Holes for Cage System Rods

Characterized by high-speed rotation and high-positional accuracy, the DDR05(/M) mount is well-suited for applications where there is a need to rotate components at high speed within a cage or other system. This mount is driven by the KBD101 brushless DC controller (sold separately below), which provides very precise positioning through the stable closed-loop PID control system.

Part Number	Description	Price	Availability
DDR05/M	**Direct Drive Continuous Rotation Mount, SM05 Bore, M4 Taps**	**$1,841.00**	**Today**
DDR05	**Direct Drive Continuous Rotation Mount, SM05 Bore, 8-32 Taps**	**$1,841.00**	**Lead Time**

Hide K-Cube Brushless DC Servo Driver

K-Cube Brushless DC Servo Driver

- Front Panel Velocity Wheel and Digital Display for Controlling Motorized Stages or Actuators
- Two Bidirectional SMC Trigger Ports to Read or Control External Equipment
- Interfaces with Computer Using Included USB Cable
- Fully Compatible with Kinesis® or APT™ Software Packages
- Compact Footprint: 60.0 mm x 60.0 mm x 49.2 mm (2.42" x 2.42" x 1.94")
- Power Supply Not Included (See Below)

Click to Enlarge
KCH601 USB Controller Hub (Sold Separately) with Installed K-Cube and T-Cube Modules (T-Cubes shown on the KAP101 Adapter)

Thorlabs' KBD101 K-Cube Brushless DC Motor Controller provides local and computerized control of a single motor axis. It features a top-mounted control panel with a velocity wheel that supports four-speed bidirectional control with forward and reverse jogging as well as position presets. A backlit digital display is also included that can have the backlit dimmed or turned off using the the top-panel menu options. The front of the unit contains two bidirectional SMC trigger ports that can be used to read a 5 V external logic signal or output a 5 V logic signal to control external equipment. Each port can be independently configured.

The unit is fully compatible with our new Kinesis software package and our legacy APT control software.

Please note that this controller does not ship with a power supply. Compatible power supplies are listed below. Additional information can be found on the main KBD101 Brushless DC Servo Motor Controller page.

Part Number	Description	Price	Availability
KBD101	**K-Cube Brushless DC Servo Driver (Power Supply Not Included)**	**$731.00**	**Today**

Hide Compatible Power Supplies

Compatible Power Supplies

Click to Enlarge

- Power Supplies
    - KPS101: For One K-Cube or T-Cube
- USB Controller Hubs Provide Power and Communications
    - KCH301: For up to Three K-Cubes or T-Cubes
    - KCH601: For up to Six K-Cubes or T-Cubes
    - KAP101: Adapter Plate for Connecting 60 mm Wide T-Cubes to KCH Hubs
    - KAP102: Adapter Plate for Connecting 120 mm Wide T-Cubes to KCH Hubs

Click to Enlarge
The KPS101 Power Supply Unit

Click for Details
A location-specific adapter is shipped with the power supply unit based on your location. The adapters for the KPS101 are shown here.

The KPS101 can supply up to 2.4 A and power a single K-Cube or T-Cube. It plugs into a standard wall outlet and provides +15 VDC.

The KCH301 and KCH601 USB Controller Hubs each consist of two parts: the hub, which can support up to three (KCH301) or six (KCH601) K-Cubes or T-Cubes, and a power supply that plugs into a standard wall outlet. The hub draws a maximum current of 10 A; please verify that the cubes being used do not require a total current of more than 10 A. In addition, the hub provides USB connectivity to any docked K-Cube or T-Cube through a single USB connection.

A KAP101 or KAP102 Adapter Plate (sold separately) is required for each T-Cube to operate on the KCH301 or KCH601 controller hub. The KAP101 is designed to adapt 60 mm wide T-Cubes to the hubs, while the KAP102 is designed to adapt 120 mm wide T-Cubes to the hubs.

For more information on the USB Controller Hubs, see the full web presentation.

Part Number	Description	Price	Availability
KPS101	**15 V, 2.4 A Power Supply Unit for One K-Cube or T-Cube**	**$26.25**	**Today**
KCH301	**USB Controller Hub and Power Supply for Three K-Cubes or T-Cubes**	**$485.00**	**Today**
KCH601	**USB Controller Hub and Power Supply for Six K-Cubes or T-Cubes**	**$587.00**	**Today**
KAP101	**Adapter Plate for KCH Series Hubs and 60 mm Wide T-Cubes**	**$56.25**	**Today**
KAP102	**Adapter Plate for KCH Series Hubs and 120 mm Wide T-Cubes**	**$61.25**	**Today**