5-PHASE STEPPING MOTOR AND MICROSTEP DRIVER PACKAGE

NanoStep™ RFK

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The NanoStep RFK uses 5-phase microstepping, the most advanced stepping motor drive technology available. It takes the basic 5-phase stepping motor angle of 0.72° and divides it electrically into smaller step angles, providing up to 125,000 steps per revolution.

**What is NanoStep?**
NanoStep is a series of stepping motor and driver package that combines high-performance 5-phase microstep drivers with high-torque/low-vibration 5-phase stepping motors. They provide smoother and more precise operation than any stepping motor previously available.

**5-phase Microstep Drive Technology**
The primary features of stepping motors are the ability to obtain precise positioning and the simplicity of design. They achieve this by rotating and stopping at step angle increments that are determined by the pole structure of the rotor and stator. Rotating in step angle increments, however, also produces changes in rotor speed and resonance at certain speeds that can cause vibration.

Microstep driving provides a finer degree of control of the basic motor step angle by regulating the current sent to the motor coils, resulting in slow speeds, low-vibration and low-noise operation.

- Since the basic motor step angle (0.72°/full step) can be divided into proportions ranging from 1/1 to 1/250, smooth operation in fine increments is possible.
- Technology that changes the motor drive current smoothly suppresses motor vibration and makes operation quieter.

**Microstepping Divides Steps Into as many as 250 Units**
NanoStep RFK enables step angles to be set independently on two resolution selection switches (16 resolutions, dividing into as many as 250 parts), it allows switching of the step angles by manipulating the external input step angle. Changing resolution can occur without any error when the motor is at rest.

**Compact Driver**
The gate array and dual surface mount technologies utilized in this New Pentagon microstep driver have resulted in a driver that is only W 1.57in. (40mm) × H 4.72in. (120mm) × D 3.35in. (85mm).

**Phoenix Connectors**
Phoenix connectors are used for easy and secure attachment of the driver's input/output signal lines, motor lead wires and input power line.
**NanoStep.** RFK SYSTEM CONFIGURATION

A high-torque 5-phase stepping motor and **NanoStep.** driver are combined to make high-precision positioning with open loop control possible.

**ACCESSORIES (Sold separately)**

- Motor Mounting Bracket
- Flexible Coupling

- Motor Mounting Brackets
  - Page B-298
- Flexible Couplings
  - Page B-301

**MC Motor Couplings**
NanoStep™ RFK dedicated drivers include many functions for easy-of-use.

A full range of driver functions are on the front panel.

### Resolution Select Switch
Use these rotary switches to set the desired resolution from the 16 resolution levels available.

<table>
<thead>
<tr>
<th>Step Angle</th>
<th>Resolution</th>
<th>Resolution Select Switch</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.72°</td>
<td>1</td>
<td>RS1 0 RS2 0</td>
</tr>
<tr>
<td>0.36°</td>
<td>2</td>
<td>RS1 1 RS2 1</td>
</tr>
<tr>
<td>0.288°</td>
<td>2.5</td>
<td>RS1 2 RS2 2</td>
</tr>
<tr>
<td>0.18°</td>
<td>4</td>
<td>RS1 3 RS2 3</td>
</tr>
<tr>
<td>0.144°</td>
<td>5</td>
<td>RS1 4 RS2 4</td>
</tr>
<tr>
<td>0.09°</td>
<td>8</td>
<td>RS1 5 RS2 5</td>
</tr>
<tr>
<td>0.072°</td>
<td>10</td>
<td>RS1 6 RS2 6</td>
</tr>
<tr>
<td>0.036°</td>
<td>20</td>
<td>RS1 7 RS2 7</td>
</tr>
<tr>
<td>0.0288°</td>
<td>25</td>
<td>RS1 8 RS2 8</td>
</tr>
<tr>
<td>0.018°</td>
<td>40</td>
<td>RS1 9 RS2 9</td>
</tr>
<tr>
<td>0.0144°</td>
<td>50</td>
<td>RS1 A RS2 A</td>
</tr>
<tr>
<td>0.009°</td>
<td>80</td>
<td>RS1 B RS2 B</td>
</tr>
<tr>
<td>0.0072°</td>
<td>100</td>
<td>RS1 C RS2 C</td>
</tr>
<tr>
<td>0.00576°</td>
<td>125</td>
<td>RS1 D RS2 D</td>
</tr>
<tr>
<td>0.0036°</td>
<td>200</td>
<td>RS1 E RS2 E</td>
</tr>
<tr>
<td>0.00288°</td>
<td>250</td>
<td>RS1 F RS2 F</td>
</tr>
</tbody>
</table>

### Motor Operating Current Potentiometer
Motor Resting Current Potentiometer

The motor current is easy to adjust with the potentiometer. No ammeter is necessary.

### Pulse Input Method Switch
Switches between 1-pulse input and 2-pulse input.
### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Package Model</th>
<th>Single Shaft</th>
<th>Double Shaft</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RFK543AA</td>
<td>RFK544AA</td>
</tr>
<tr>
<td>Maximum Holding Torque</td>
<td>oz-in</td>
<td>N·m</td>
</tr>
<tr>
<td></td>
<td>18</td>
<td>24.9</td>
</tr>
<tr>
<td>Rotor Inertia</td>
<td>oz-in²</td>
<td>kg·m²</td>
</tr>
<tr>
<td></td>
<td>0.192</td>
<td>54×10⁻⁷</td>
</tr>
<tr>
<td>Rated Current</td>
<td>A/phase</td>
<td>0.75</td>
</tr>
<tr>
<td>Basic Step Angle</td>
<td>0.72°</td>
<td></td>
</tr>
<tr>
<td>Insulation Class</td>
<td>Class B [266°F (130°C)]</td>
<td></td>
</tr>
<tr>
<td>Power Source</td>
<td>DC 24V±10% 1.1A maximum</td>
<td></td>
</tr>
<tr>
<td>Output Current</td>
<td>A/phase</td>
<td>0.75</td>
</tr>
<tr>
<td>Microstep</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excitation Mode</td>
<td>Step command pulse signal ( CW step command signal at 2-pulse input mode )</td>
<td></td>
</tr>
<tr>
<td>Input Signals</td>
<td>Pulse width: 1μs minimum, Pulse rise/fall: 2μs maximum</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motor moves when the photocoupler state changes from ON to OFF.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rotation direction signal, Photocoupler ON: CW, Photocoupler OFF: CCW ( CCW step command signal at 2-pulse input mode, Pulse width: 1μs minimum, Pulse rise/fall: 2μs maximum)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Motor moves when the photocoupler state changes from ON to OFF.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When in the &quot;photocoupler ON&quot; state, a step angle is selected between 0.72° and 0.00288° as preset by step angle setting switch RS1.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>When in the &quot;photocoupler OFF&quot; state, a step angle is selected between 0.72° and 0.00288° as preset by step angle setting switch RS2.</td>
<td></td>
</tr>
<tr>
<td>Functions</td>
<td>Automatic current cutback, Pulse input mode switch, Resolution select switch, All windings off</td>
<td></td>
</tr>
<tr>
<td>Driver Cooling Method</td>
<td>Natural Ventilation</td>
<td></td>
</tr>
<tr>
<td>Weight (Mass)</td>
<td>Motor lb. (kg)</td>
<td>0.56 (0.25)</td>
</tr>
<tr>
<td></td>
<td>Driver lb. (kg)</td>
<td>0.8 (0.36)</td>
</tr>
<tr>
<td>Insulation Resistance</td>
<td>Motor</td>
<td>100MΩ minimum under normal temperature and humidity, when measured by a DC500V megger between the motor coils and the motor casing.</td>
</tr>
<tr>
<td>Dielectric Strength</td>
<td>Motor</td>
<td>Sufficient to withstand 1.0kV (0.5kV for RFK54□ type), 60Hz applied between the motor coils and casing for one minute, under normal temperature and humidity.</td>
</tr>
<tr>
<td>Ambient Temperature Range</td>
<td>Motor</td>
<td>+14°F~+122°F (−10°C~+50°C)</td>
</tr>
<tr>
<td></td>
<td>Driver</td>
<td>+32°F~+104°F (0°C~+40°C)</td>
</tr>
</tbody>
</table>

- Maximum holding torque refers to the holding torque at motor standstill when the rated current is supplied to the motor (5 phase excitation).
- Use this value to compare motor torque performance. When using the motor with the included driver, the driver’s “Automatic Current Cutback” function at motor standstill reduces maximum holding torque by approximately 50%.
- The power source input current value represents the maximum current. (The input current varies according to the pulse frequency.)

**Note:** Do not measure insulation resistance or perform the dielectric strength test while the motor and driver are connected for RFK54□ type.
SPEED vs. TORQUE CHARACTERISTICS

RFK543AA
RFK543BA

Without Damper: Jₐ=0 oz-in²

- Power Input: DC24V
- Current: 0.75A/Phase
- Step angle: 0.72°/step

- Driver Input Current [A]
- Without Damper: JL=0 oz-in²

- Speed [r/min]
- Torque [oz-in]
- Pulse Speed [kHz]
- Driver Input Current [A]

Note:

- Pay attention to heat dissipation from the motor and driver. The motor will produce a considerable amount of heat under certain conditions.
- Be sure to keep the temperature of the motor case under 212˚F (100˚C).
- When using the motor with the dedicated driver, the driver's “Automatic Current Cutback” function at motor standstill reduces maximum holding torque by approximately 50%.
**DIMENSIONS** Scale 1/4, Unit = inch (mm)

- **Motor**
  - **RFK543AA** (Single shaft)
    Motor Model: PK543AUA. Weight 0.56lb. (Mass 0.25kg)
  - **RFK543BA** (Double shaft)
    Motor Model: PK543BUA. Weight 0.56lb. (Mass 0.25kg)

- **RFK564AA** (Single shaft)
  Motor Model: PK564AUA. Weight 1.33lb. (Mass 0.6kg)
- **RFK564BA** (Double shaft)
  Motor Model: PK564BUA. Weight 1.33lb. (Mass 0.6kg)

- **RFK569AA** (Single shaft)
  Motor Model: PK569AUA. Weight 2.87lb. (Mass 1.3kg)
- **RFK569BA** (Double shaft)
  Motor Model: PK569BUA. Weight 2.87lb. (Mass 1.3kg)

* .59 ± .01 (15 ± 0.25) indicates the length of milling on motor shaft.

See page B-36 for information on motor installation.
Driver
Driver: DFR1507A
Weight: 0.8lb. (Mass 0.36kg)
DFR1514A

See page B-38 for information on driver installation.

LIST OF MOTOR AND DRIVER COMBINATIONS

<table>
<thead>
<tr>
<th>Type</th>
<th>Package model</th>
<th>Stepping motor</th>
<th>Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Model</td>
<td>Current</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>A/phase</td>
</tr>
<tr>
<td>STANDARD</td>
<td>RFK543□A</td>
<td>PK543□UA</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>RFK544□A</td>
<td>PK544□UA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RFK545□A</td>
<td>PK545□UA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RFK564□A</td>
<td>PK564□UA</td>
<td>1.4</td>
</tr>
<tr>
<td></td>
<td>RFK566□A</td>
<td>PK566□UA</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RFK569□A</td>
<td>PK569□UA</td>
<td></td>
</tr>
</tbody>
</table>

Enter A (single shaft) or B (double shaft) in the □ within the model numbers.
**WIRING DIAGRAM**

- **Controller**
  - Twisted Pair Line
  - Pulse Signal
  - Direction Signal
  - All Windings Off Signal
  - Resolution Select Signal
  - Excitation Timing Signal

- **Driver**
  - +PLS
  - +CW/CCW
  - +A.W.OFF
  - +R/S1/2
  - +TIM

- **5-Phase Stepping Motor**
  - BLUE
  - RED
  - ORANGE
  - GREEN
  - BLACK

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**Power Supply**

Use a power supply that can supply sufficient input current. When power supply capacity is insufficient, a decrease in motor output can cause the following malfunctions:
- Motor does not rotate properly at high-speed (insufficient torque)
- Motor startup and stopping is slow.

**Note:**
- When voltage is above DC 5V, connect external resistance $R_1$ and keep the input current below 20mA.
- If the current exceeds 10mA, connect external resistance $R_2$.
- Use twisted-pair wire of $3.1 \times 10^{-4}$ in$^2$ (0.2mm$^2$) or thicker and 6.6 feet (2m) or less in length for the signal line.
- Use wire $7.8 \times 10^{-4}$ in$^2$ (0.5mm$^2$) or thicker for motor lines (when extended) and power supply lines, and use $1.2 \times 10^{-3}$ in$^2$ (0.75mm$^2$) or thicker for the wire for the grounding line.
- Use spot grounding for the grounding of the driver and external controller.
- Signal lines should be kept at least 3.94 inch (10cm) away from power lines (power supply lines and motor lines). Do not bind the signal line and power line together.

Do not turn on the power or operate the motor until confirming that the auto-diagnosis switch is set to NORM. If it is set to TEST, there is a danger that the motor will start rotating as soon as the power to the driver is turned on.

Use open collector transistors (sink type) for the signal output sections of the controller.
**DESCRIPTION OF INPUT/OUTPUT SIGNALS**

1. Pulse Input

   **Input circuit and sample connection**

   - **Controller**
     - Open-collector Output
   - **Pulse**
     - Input circuit and sample connection
   - **Driver**
     - 220Ω
     - 20mA max.

   Keep the voltage between DC 5V and DC 24V. When voltage is equal to DC 5V, external resistance (R) is not necessary. When voltage is above DC 5V, connect external resistance (R) and keep the input current below 20mA.

1. **1-Pulse Input Mode**

   **Pulse Signal**
   - "Pulse" signal is input to the pulse signal terminal. When the photocoupler state changes from "ON" to "OFF", the motor rotates one step. The direction of rotation is determined by the following rotation direction signal.

   **Rotation Direction Signal**
   - The "Rotation Direction" signal is input to the rotation direction signal input terminal. A "photocoupler ON" signal input commands a clockwise direction rotation. A "photocoupler OFF" signal input commands a counterclockwise direction rotation.

2. **2-Pulse Input Mode**

   **CW Pulse Signal**
   - When the photocoupler state changes from "ON" to "OFF", the motor rotates one step in the clockwise direction.

   **CCW Pulse Signal**
   - When the photocoupler state changes from "ON" to "OFF", the motor rotates one step in the counterclockwise direction.

   CW and CCW refer to clockwise and counterclockwise direction respectively, from a reference point of facing the motor output shaft.

**Pulse Signal Characteristics**

<table>
<thead>
<tr>
<th>Pulse Signal</th>
<th>Photocoupler ON</th>
<th>90%</th>
<th>1µs minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photocoupler OFF</td>
<td>10%</td>
<td>2µs maximum</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rotation Direction Signal</th>
<th>Photocoupler ON</th>
<th>1µs minimum</th>
<th>2µs maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Photocoupler OFF</td>
<td>10µs minimum</td>
<td>10µs minimum</td>
<td></td>
</tr>
</tbody>
</table>

The shaded area indicates when the photocoupler diode is ON. The motor moves when the photocoupler state changes from ON to OFF as indicated by the arrow.

- The pulse voltage is 4~5V in the "photocoupler ON" state, and 0~0.5V in the "photocoupler OFF" state.
- Input pulse signals should have a pulse width over 1µs, pulse rise/fall below 2µs, and a pulse duty below 50%.
- Keep the pulse signal at "photocoupler OFF" when no pulse is being input.
- The minimum interval time when changing rotation direction is 10µs. This value varies greatly depending on the motor type, pulse frequency, and load inertia. It may be necessary to increase this time interval.
- In 1-pulse input mode, leave the pulse signal at rest ("photocoupler OFF") when changing rotation directions.

2. **A.W. OFF (All Windings Off) Input**

   **Input circuit and sample connection**

   Keep the voltage between DC 5V and DC 24V. When voltage is equal to DC 5V, external resistance (R) is not necessary. When voltage is above DC 5V, connect external resistance (R) and keep the input current below 20mA.

   When the "All Windings Off" signal is in the "photocoupler ON" state, the current to the motor is cut off and motor torque is reduced to zero. The motor output shaft can then be rotated freely by hand.

   When the "All Windings Off" signal is in the "photocoupler OFF" state, the motor holding torque is proportional to the current set by the current adjustment rotary switches. During motor operation be sure to keep the signal in the "photocoupler OFF" state.

   This signal is used when moving the motor by external force or manual home position is desired. If this function is not needed, it is not necessary to connect this terminal.

   Switching the "All Windings Off" signal from "photocoupler ON" to "photocoupler OFF" does not alter the excitation sequence.

   When the motor shaft is manually adjusted with the "All Windings Off" signal input, the shaft will shift up to ±3.6˚ from the position set after the "All Windings Off" signal is released.

**Manual Setting of the Home Position**

Input the "All Windings Off" signal, set the motor to the desired position, then release the "All Windings Off" signal.
3. R/S (Resolution Select Switching) Input

- Input circuit and sample connection

Keep the voltage between DC 5V and DC 24V. When voltage is equal to DC 5V, external resistance (R) is not necessary. When voltage is above DC 5V, connect external resistance (R) and keep the input current below 20mA.

When the 'Resolution Select' signal is in the 'photocoupler ON' state, the step angle set by resolution select switch RS1 is selected, and when the 'Resolution Select' signal is in the 'photocoupler OFF' state, the step angle set by resolution select switch RS2 is selected. This signal can be used to change the motor speed or amount of rotation without altering the input pulses.

Note: Input the 'Resolution Select' signal when the driver power is off, or when pulse signals are not being input. If the 'Resolution Select' signal is input at other times, the excitation timing signal output may not function properly.

4. TIMING (Excitation Timing)

- Output Circuit and Sample Connection

Keep the voltage between DC 5V and DC 24V. Keep the current below 10mA. If the current exceeds 10mA, connect external Resistance (R).

The 'Excitation Timing' signal is output to indicate when the motor excitation (current flowing through the winding) is in the initial stage (step '0' at power up). The 'Excitation Timing' signal can be used to increase the accuracy of home position detection by setting the mechanical home position of your equipment (for example, a photo-sensor) to coincide with the excitation sequence initial stage (step '0').

The motor excitation stage changes simultaneously with pulse input, and returns to the initial stage for each 7.2° rotation of the motor output shaft.

When power is turned ON, the excitation sequence is reset to step '0'. The 'Excitation Timing' signal is output once for each number of pulses equivalent to 7.2° divided by the step angle setting.

Example: At a step angle setting of 0.72°/step (Division of 1): The signal is output once every 10 pulses

At a step angle setting of 0.072°/step (Division of 10): The signal is output once every 100 pulses

When using the 'Excitation Timing' signal, set the number of input pulses and the step angle in combinations which allow the motor shaft to stop at positions which are multiples of 7.2°.

When using the 'Resolution Select' signal to change the step angle, be aware that depending on the number of pulses and step angle setting, there are conditions, such as those shown below, in which the 'Excitation Timing' signal will not be output.