The REE digital series of interpolators is designed to accompany the RG2 (20 µm) and RG4 (40 µm) encoder systems by offering a wide range of interpolation factors. Industry standard 1 Vpp differential input analogue signals are interpolated to industry standard RS-422A digital quadrature output signals.

These interpolators can be used with any standard 1Vpp differential output encoder system to enable easy integration with industry standard digital controller inputs.

When interfaced with 40 µm pitch systems such as the RGH34, RGH40 and RGH41, the interpolators give resolutions down to 10 nm.

When used with 20 µm pitch systems such as the RGH22, RGH24 and RGH20, the interpolators will resolve down to 5 nm. The REE interpolators are fully RoHS compliant and feature user selectable AGC (Auto Gain Control) that is operational at all speeds. These interpolators are capable of operational speeds of over 3 m/s at 100 nm resolution from a 20 µm encoder signal period.

The REE interpolators have a low cyclic error – less than 50 nm from 20 µm signal period at low speed. This is achieved by active offset, balance and gain control which is operational, when selected, at all speeds.

### Using 20 µm scale
- **REE0004** - 5 µm resolution
- **REE0020** - 1 µm resolution
- **REE0040** - 0.5 µm resolution
- **REE1000** - 0.2 µm resolution
- **REE0200** - 0.1 µm resolution
- **REE4000** - 50 nm resolution
- **REE1000** - 20 nm resolution
- **REE2000** - 10 nm resolution
- **REE4000** - 5 nm resolution

### Using 40 µm scale
- **REE0004** - 10 µm resolution
- **REE0020** - 2 µm resolution
- **REE0040** - 1 µm resolution
- **REE1000** - 0.4 µm resolution
- **REE2000** - 0.2 µm resolution
- **REE0400** - 0.1 µm resolution
- **REE1000** - 40 nm resolution
- **REE2000** - 20 nm resolution
- **REE4000** - 10 nm resolution

- Tri-colour integral set-up LED
- Compatible with all standard 1Vpp analogue output readheads
- Industry standard RS422A output
- Interpolation factors from x4 to x4000
- Binary interpolation factors from x4 to x4096 available on request.
- User selectable automatic gain control (AGC)
- Low cyclic error
- Automatic offset and balance control (AOC and ABC)
- Clock speeds from 1 to 50 MHz
**REE installation drawing**

**Dimensions and tolerances in mm**

**Operating and electrical specifications**

**Power supply**
- 5V -5% +10% current consumption (interface only).
- The interface will be fully active <300 ms after power is applied.
- Provision is given for remote sensing via two cores of the customers cable.

**NOTE:** Current consumption figures refer to unterminated interfaces.

- A further 25 mA per channel pair (eg A+, A-) will be drawn when terminated with 120 Ω.

**Renishaw encoder systems must be powered from a 5 V dc supply complying with the requirements for SELV of standard EN (IEC) 60950. The interface and readhead are protected from reverse voltage and overvoltage up to 12 V. 200 mVpp maximum @ frequency up to 500 kHz maximum**

**Ripple**
- 200 mVpp maximum @ frequency up to 500 kHz maximum

**Acceleration**
- Operating 500 m/s²
- Non-operating 1000 m/s², 6 ms, ½ sine

**Shock**
- Non-operating 1000 m/s², 6 ms, ½ sine

**Vibration**
- Operating 100 m/s² max @ 55 to 2000 Hz

**Temperature**
- Storage -20 °C to +70 °C
- Operating 0 °C to +55 °C

**Humidity**
- Storage 95% maximum relative humidity (non-condensing)
- Operating 80% maximum relative humidity (non-condensing)

**Sealing**
- IP40

**Mass**
- 95g

**EMC compliance**
- BS EN 61000
- BS EN 55011

**Connectors (input/output)**
- 15-way D type socket/plug

**Maximum analogue input frequency (kHz)**

<table>
<thead>
<tr>
<th>Interpolation (option)</th>
<th>Minimum recommended counter clock frequency (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x4 (0004)</td>
<td>211 250 250 250 250 250 250 250 250 250 250</td>
</tr>
<tr>
<td>x20 (0020)</td>
<td>42 112 202 225 250 250 250 250 250 250 250</td>
</tr>
<tr>
<td>x10 (0050)</td>
<td>8.4 22 40 45 65 81 90 135 162 250 250 250</td>
</tr>
<tr>
<td>x200 (0200)</td>
<td>4.2 11 20 22 32 40 45 67 81 135 162 250 250</td>
</tr>
<tr>
<td>x400 (0400)</td>
<td>2.1 5.6 10 11 16 20 22 33 40 67 81</td>
</tr>
<tr>
<td>x1000 (1000)</td>
<td>0.8 2.2 4 4.5 6.5 8.1 9 13 16 27 32</td>
</tr>
<tr>
<td>x2000 (2000)</td>
<td>0.4 1.1 2 2.2 3.2 4 4.5 6.7 8.1 13 16</td>
</tr>
<tr>
<td>x4000 (4000)</td>
<td>0.2 0.5 1 1.1 1.6 2 2.2 3.4 4 6.7 8.1</td>
</tr>
</tbody>
</table>

**Recommended clock frequency (MHz)**

<table>
<thead>
<tr>
<th>Minimum cable length (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>25</td>
</tr>
<tr>
<td>20</td>
</tr>
</tbody>
</table>

**Maximum cable length Interface to receiving electronics**

**Maximum** 200 mVpp maximum @ frequency up to 500 kHz maximum
REE interpolator features

Self-tuning active correction
The REE interpolator corrects for input signal imperfections to optimise system accuracy.
Corrections are made for the following:
Automatic Offset Control (AOC) – adjusts offset independently for the sine and cosine signals
Automatic Gain Control (AGC) – ensures consistent 1 Vpp signal amplitude
Automatic Balance Control (ABC) – adjusts the gain to equalise the sine and cosine signals

These correction mechanisms operate over the full working speed range of the readhead. The user can disable/enable the AGC by pressing the CALIBRATE button for greater than 3 seconds.

LED indicators
The tri-coloured SETUP LED provides visual feedback of signal strength and error condition for setup and diagnostic use.

<table>
<thead>
<tr>
<th>LED</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flashing Purple</td>
<td>indicates high signal alarm condition &gt;135%</td>
</tr>
<tr>
<td>Purple</td>
<td>indicates high signal &gt;110% and &lt;135%</td>
</tr>
<tr>
<td>Blue</td>
<td>indicates optimum signal &gt;90% and &lt;110%</td>
</tr>
<tr>
<td>Green</td>
<td>indicates acceptable signal &gt;70% and &lt;90%</td>
</tr>
<tr>
<td>Orange</td>
<td>indicates low signal &gt;50% and &lt;70%</td>
</tr>
<tr>
<td>Red</td>
<td>indicates unacceptable signal &gt;20% and &lt;50%</td>
</tr>
<tr>
<td>Flashing Red</td>
<td>indicates unacceptable signal alarm condition &lt;20%</td>
</tr>
<tr>
<td>Flashing Blue</td>
<td>indicates overspeed alarm condition</td>
</tr>
<tr>
<td>Flashing Off</td>
<td>momentarily to indicate a reference mark, up to 100 mm/s only</td>
</tr>
</tbody>
</table>

The Yellow CAL/AGC LED indicates when the REE is in a calibration routine and whether or not AGC is active.
LED on indicates AGC active
LED off indicates AGC inactive
LED slow flashing indicates calibration routine
LED fast flashing indicates calibration failure

Alarm output
The REE interpolator asserts the alarm output (E) for the following conditions:-
Incremental signal level below 20% of nominal
Incremental signal level above 135% of nominal
Readhead speed in excess of specification
Signal offset compensation of sine and cosine excessive
Signal balance compensation excessive

Calibration procedure
The calibration procedure is required to optimise the gain, balance and offset of the analogue input signals in the REF interface. These settings are then stored and recalled for initial use at startup.

To calibrate the system, the following sequence should be carried out:

- Prior to calibration, AGC should be off. To switch AGC on or off, the CALIBRATE button should be pressed for more than 3 seconds. When AGC is on, the CAL/AGC LED will be on and when AGC is off, the CAL/AGC LED will be off.
- Install the readhead and set up to obtain optimum (1 Vpp) signal amplitude
- Enter calibration routine by pressing the CALIBRATE button momentarily. The calibration routine is indicated by slow flashing of the CAL/AGC LED.
- Traverse the readhead slowly past the scale until the CAL/AGC LED stops flashing. The calibration cycle is now complete.
- If calibration fails, the CAL/AGC LED will flash quickly instead of switching off. If this happens the CALIBRATE button should be pressed momentarily to exit the calibration routine. The calibration procedure should then be re-tried.
- If the unit continues to fail calibration, factory default settings should be restored by powering down, then pressing the CALIBRATE button as power is re-applied. The calibration procedure should then be repeated.

NOTE: To exit the calibration routine at any time, the CALIBRATE button should be pressed momentarily.
## Input signals
REE interpolators are designed to be used with industry standard 1 Vpp readheads. Cos ($V_1$), Sin ($V_2$) and reference mark ($V_0$) differential input signals should have nominal signal amplitude of 1 Vpp developed across 120Ω input termination resistor. 

One or two open collector limit switch signals, active high or active low can also be input.

15 way ‘D’ type socket

<table>
<thead>
<tr>
<th>Pin number</th>
<th>Signal name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$V_1^-$</td>
<td>Cosine -ve</td>
</tr>
<tr>
<td>2</td>
<td>$V_2^-$</td>
<td>Sine -ve</td>
</tr>
<tr>
<td>3</td>
<td>$V_0^+$</td>
<td>Reference mark +ve</td>
</tr>
<tr>
<td>4</td>
<td>5 V</td>
<td>5 V power supply</td>
</tr>
<tr>
<td>5</td>
<td>5 V</td>
<td>5 V power supply</td>
</tr>
<tr>
<td>6</td>
<td>–</td>
<td>Not connected</td>
</tr>
<tr>
<td>7</td>
<td>$V_p/V_q$</td>
<td>Setup signal/second (P) limit switch on dual limit readheads</td>
</tr>
<tr>
<td>8</td>
<td>$V_q$</td>
<td>First (Q) limit switch</td>
</tr>
<tr>
<td>9</td>
<td>$V_1^+$</td>
<td>Cosine +ve</td>
</tr>
<tr>
<td>10</td>
<td>$V_2^+$</td>
<td>Sine +ve</td>
</tr>
<tr>
<td>11</td>
<td>$V_0^-$</td>
<td>Reference mark -ve</td>
</tr>
<tr>
<td>12</td>
<td>0 V</td>
<td>0 V power supply</td>
</tr>
<tr>
<td>13</td>
<td>0 V</td>
<td>0 V power supply</td>
</tr>
<tr>
<td>14</td>
<td>–</td>
<td>Do not connect</td>
</tr>
<tr>
<td>15</td>
<td>Inner</td>
<td>Cable’s inner shield connection to 0 V</td>
</tr>
</tbody>
</table>

## Output signals

15 way ‘D’ type plug

<table>
<thead>
<tr>
<th>Pin number</th>
<th>Signal name</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>X</td>
<td>External setup signal</td>
</tr>
<tr>
<td>2</td>
<td>0 V</td>
<td>0 V power supply</td>
</tr>
<tr>
<td>3</td>
<td>$E^-$</td>
<td>Alarm -ve</td>
</tr>
<tr>
<td>4</td>
<td>$Z^-$</td>
<td>Reference mark -ve</td>
</tr>
<tr>
<td>5</td>
<td>$B^-$</td>
<td>Quad B -ve</td>
</tr>
<tr>
<td>6</td>
<td>$A^-$</td>
<td>Quad A -ve</td>
</tr>
<tr>
<td>7</td>
<td>5 V</td>
<td>5 V power supply</td>
</tr>
<tr>
<td>8</td>
<td>5 V</td>
<td>5 V power supply</td>
</tr>
<tr>
<td>9</td>
<td>0 V</td>
<td>0 V power supply</td>
</tr>
<tr>
<td>10</td>
<td>$Q$</td>
<td>$Q$ limit switch</td>
</tr>
<tr>
<td>11</td>
<td>$E^+$/P</td>
<td>Alarm +ve/P limit switch</td>
</tr>
<tr>
<td>12</td>
<td>$Z^+$</td>
<td>Reference mark +ve</td>
</tr>
<tr>
<td>13</td>
<td>$B^+$</td>
<td>Quad B +ve</td>
</tr>
<tr>
<td>14</td>
<td>$A^+$</td>
<td>Quad A +ve</td>
</tr>
<tr>
<td>15</td>
<td>–</td>
<td>Not connected</td>
</tr>
</tbody>
</table>
### Output specifications

**Form** - Square wave differential line driver to EIA RS422A (except open collector limit and external set-up signal X)

<table>
<thead>
<tr>
<th>Incremental</th>
<th>2 channels A and B in quadrature (90° phase shifted)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Signal period</td>
<td>Resolution</td>
</tr>
<tr>
<td>A</td>
<td>B</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Reference</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronised pulse Z, duration as resolution</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wide reference (option C)</th>
<th>Z</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronised pulse Z, duration as signal period</td>
<td></td>
</tr>
</tbody>
</table>

Repeatability of position (uni-directional) is determined by the readhead specification.

**NOTE:** The set-up LED on the REE interpolator cannot be used for reference mark set-up. Only the readhead LED (on Renishaw readheads) should be used for this purpose.

**NOTE:** Wide reference mark option useful when using long cable lengths and/or high speed operation to overcome effects of skew

<table>
<thead>
<tr>
<th>Limit</th>
<th>RGH22, RGH40 and RGH41 only</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open collector output</td>
<td></td>
</tr>
</tbody>
</table>

#### Set-up

- **Setup voltage at X**
- Setup signal voltage proportional to signal amplitude

#### Alarm

- Asynchronous pulse E
- REE alarm asserted for:
  - Incremental signal <20% of nominal
  - Incremental signal >135% of nominal
  - Readhead speed in excess of specification
  - Signal offset excessive

**NOTE:** 3-state alarm option available

The presence of a reference mark and limit signal is dependent on the specification of the installed readhead.

Inverse signal not shown for clarity

#### Limit

- **Single limit**
  - Length of actuating magnet Q
  - Repeatability <0.1 mm typical
  - Asynchronous pulse Q

- **Dual limit**
  - Repeatability P, Q <0.1 mm typical
  - Length of actuating magnet
  - Asynchronous pulse P, Q

#### Termination

- 5 V to 25 V
- Select R so that the maximum current does not exceed 20 mA. Alternatively use a relay or opto-isolator.

#### Recommended signal termination

- Standard RS422A line receiver circuitry.
- Only required on alarm channel E for fail safe operation.

**NOTE:** Extension cable inner shield must be connected to 0 V at customer electronics only

**IMPORTANT:** The outer shield should be connected to the machine earth (Field Ground). The inner shield should be connected to 0 V. Care should be taken to ensure that the inner and outer shields are insulated from each other. If the inner and outer shields are connected together, this will cause a short between 0 V and earth, which could cause electrical noise issues.
EMC compliance
The REE interpolator conforms to the relevant harmonised European standards for electromagnetic compatibility as detailed below.

BS EN 61000  BS EN 55011

Patents
Features of Renishaw’s encoder systems and similar products are the subjects of the following patents and patent applications:

- US4959542
- US4974962
- US4926566
- EP0383901
- US5068209
- JP2963926
- EP0388453
- US5063685
- JP2837483
- EP0514081
- US5241173
- JP3202316
- EP0543513
- US5302820
- JP5248895
- EP0748436
- US5861953
- EP826138B
- US6051971
- JP367819
- EP1094302
- US6481115
- US6588333 B1
- EP1147377
- JP2003-512,611
- US6772531
- GB2397040
- CN1585685
- WO 03/041905
- US2005-0079499
- CN1620353
- WO 03/061891
- EP1469969
- US2005-0045586
- EP1552251
- WO 2004/008079
- EP1552248
- WO 2004/008076

Further information
For further information relating to the installation of REE systems, see also related readhead installation guides. These can be downloaded from our website www.renishaw.com/encoder and are also available from your local representative.

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E uk@renishaw.com
www.renishaw.com

**NOTE:** Not all combinations are valid. Check valid options online at www.renishaw.com/epc

<table>
<thead>
<tr>
<th>Interpolator part numbers</th>
<th>REE</th>
<th>0100</th>
<th>E</th>
<th>25</th>
<th>A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Options</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - Dual limit switch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B - Single limit switch</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C - Wide reference mark</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clocked output</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>50 - 50 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40 - 40 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 - 25 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - 20 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 - 12 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 - 10 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>08 - 8 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>06 - 6 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>05 - 5 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>03 - 3 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01 - 1 MHz customer clock</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Alarms
Standard alarm E
A - All alarms
B - High and low signal alarms only
C - High and low signal, and overspeed alarms only
9 - state alarms
E - All alarms
F - High and low signal alarms only
G - High and low signal, and overspeed alarms only

Interpolation factor*

| 0004 | 0020 | 0040 | 0100 | 0200 | 0400 | 1000 | 2000 | 4000 |

Interpolator series

*Binary interpolation factors from x4 to x4096 also available

NOTE: Not all combinations are valid. Check valid options online at www.renishaw.com/epc