ENCODER DATA SHEET
LSI MicroSeries µS/23 Family

Features:
- Resolution to 0.17 Arc Minutes
- Accuracy to 0.2 Arc Minutes
- Small Size
- Absolute Non-Volatile Output
- LED Illuminators
- High Reliability
- Low Power, Single + 5V Input
- 3-State Outputs
- Microprocessor Interface Capability
- Environmentally Sealed Case
- Versatile Input/Output interfaces

General Description

MicroSeries Encoders are ultra small, absolute, optical shaft encoders. They have substantially better accuracy than other shaft angle digitizers. MicroSeries Encoders are designed for applications where small size, medium resolution and insensitivity to power interruptions are desired. The LSI MicroSeries was introduced to significantly reduce the size of the Encoder, lower the cost, and provide a more versatile electrical interface.

The basic model in the LSI MicroSeries family is designated L. In this model, the outputs are 3-State and can interface directly with a microprocessor. The microprocessor demultiplexes the signals and converts them to natural binary code. The microprocessor can be provided by the user, or by BEI. For those applications where a microprocessor is not available or suitable, BEI offers a MicroSeries Digital Decoder. The MicroSeries Digital Decoder is a custom, monolithic gate array which can be separate (LS Models) or can be contained within the Encoder package (LC Models).

Detailed technical information is contained in Technical Bulletins "LSI MicroSeries Encoders - Principles of Operation/Microprocessor Control and Decoding" and "MicroSeries Digital Decoder." These bulletins are available upon request. For encoders of smaller size with comparable resolution, refer to Encoder Data Sheet "LSI MicroSeries µS__/16 Family.” For encoders with a through hole, refer to Encoder Data Sheets “Pancake LSI MicroSeries µS__/40 Family, µS__/50 Family and µS__/80 Family.” For reference to other BEI Models refer to the Short Form Catalog.

Specifications applicable to all members of the µS__/23 Family are listed on the back page. Individual models are described on the pages headed µS__/23L (pp. 2 & 3), µS__/23LS (pp. 4 & 5), and µS__/23LC (pp. 6&7).

Approved for general release.

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Detailed Description

The L model is the basic encoder configuration which outputs a 4 wire multiplexed, 3-State Logic Level, MicroSeries Code Word. The encoder is addressed by 3 Enable Lines activated in a controlled sequence. This model is intended for direct interface with a user (or BEI) furnished microprocessor where the microprocessor can be programmed to perform the encoder's digital logic functions. For programming details, request BEI Technical Bulletin “LSI MicroSeries Encoders - Principles of Operation/Microprocessor Control and Decoding.”

Detailed Specifications

Mechanical
Length: 2.09-inches max. (Dimension A on back page)
Standard Cable: 9 Conductors (12 conductors with optional Tach and/or BITE)
© MicroSeries Optical Encoders are protected by one or more of the following USA patents:
4,443,788 4,445,110 4,465,928
Electrical

- Typical Power Requirements (+5V DC, 2% Regulation, 1% max. pp Ripple)

<table>
<thead>
<tr>
<th></th>
<th>1 Station</th>
<th>2 Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Peak</td>
<td>425 mW</td>
<td>600 mW</td>
</tr>
<tr>
<td>Average*</td>
<td>250 mW</td>
<td>425 mW</td>
</tr>
</tbody>
</table>

* Average power calculated at 100 interrogations/second. (For power requirements at other interrogation rates refer to Technical Bulletin.)

- Input Octal Address (EN0, EN1, EN2) 0/5V CMOS Compatible
  1 μA Max., 20pf Max.

- Output (DØ, D1, D2, D3) 0/5V
  Loading: 5 LSTTL Loads per Output

- Pin/Wire Designations:

<table>
<thead>
<tr>
<th>PIN or WIRE #</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 (Red Edge)</td>
<td>GND</td>
</tr>
<tr>
<td>2</td>
<td>+5V</td>
</tr>
<tr>
<td>3</td>
<td>EN2</td>
</tr>
<tr>
<td>4</td>
<td>EN1</td>
</tr>
<tr>
<td>5</td>
<td>ENØ</td>
</tr>
<tr>
<td>6</td>
<td>DATA 3</td>
</tr>
<tr>
<td>7</td>
<td>DATA 2</td>
</tr>
<tr>
<td>8</td>
<td>DATA 1</td>
</tr>
<tr>
<td>9</td>
<td>DATA Ø</td>
</tr>
<tr>
<td>10</td>
<td>TACH</td>
</tr>
<tr>
<td>11</td>
<td>BITE</td>
</tr>
<tr>
<td>12</td>
<td>GND</td>
</tr>
</tbody>
</table>

Ordering Information

- Specify options as follows:
  MS1 Hi Rel Integrated Circuits
  MS2 Extended Temperature
  MS3 Built-in Test (BITE)
  MS4 Tach

- MicroSeries L S 1 7 / 2 3 (2) L

- Resolution
- Bits/Turn
- 2.3 inch
- Outside Diameter
- Reading Stations (1) or (2)

Note: 1 Special modifications for Space/Vacuum operation can be provided.
2 Consult factory for 18 or 19-bit resolution (only applicable to L Model).
Detailed Description
The LS model consists of the basic L encoder (described in the preceding pages) and a separate Digital Decoder. The use of the external Digital Decoder is suggested when the user does not have a microprocessor available to perform the digital processing of the outputs of the L Model encoder. The external digital decoder affords the user the flexibility to access the various input/output programming modes available with MicroSeries encoders. The external Digital Decoder can be user programmed for three output modes: serial, 8-bit byte, or parallel*. Additionally, two data acquisition modes are possible: Update and Read. Request BEI Technical Bulletin "MicroSeries Digital Decoder."

Detailed Specifications
Mechanical
Encoder:
Length:
2.09 inches max. (Dimension A on back page)
Standard Cable:
9 Conductors (12 conductors with optional Tach and/or BITE)

Digital Decoder:
CMOS, Monolithic Gate Array
40 Pin; 4 Sided, Flatpack with leads on .040 centers

* 8-bit bytes with strobe signals to latch external registers
Electrical

- Typical Power Requirements (+5V DC, 2% Regulation, 1% max. pp Ripple)
  - **Peak**
    - 1 Station: 450 mW
    - 2 Stations: 625 mW
  - **Average**
    - 1 Station: 275 mW
    - 2 Stations: 450 mW

  *Average power calculated at 100 interrogations/second.*

(For power requirements at other interrogation rates refer to Technical Bulletin.)

- **Input Levels**: 0/5V, TTL and CMOS Compatible, 1 CMOS unit load
- **Output Levels**: 0/5V, Short Circuit Protected
- **Loading**: 8 LSTTL Loads per Output

- **Pin/Wire Designations**:
  - **Encoder**: Same as LS__/23L
  - **Digital Decoder**: Refer to BEI Technical Bulletin "MicroSeries Digital Decoder."
- **Output Code**: Unambiguous Natural Binary

Ordering Information

MicroSeries LS__/23LS

** specify options as follows:**

- **Resolution**
- **Bits/Turn**
- **2.3 inch**
- **Outside Diameter**
- **Reading Stations**
  - (1) or (2)

Note: Special modifications for Space/Vacuum operation can be provided.
Detailed Description
The LC Model contains an integral MicroSeries Digital Decoder Chip. This model, essentially similar to the μS/___23LS, is appropriate when an encoder without external processing circuits is desired. Output modes available are serial with differential line drivers, 8-bit bytes with TTL-compatible outputs, and parallel (8-bits at a time) with strobe signals to latch user-supplied external registers. Both Update and Read acquisition modes are available. User must specify the input and output modes of operation at time of order.

Detailed Specifications
Length (Dimension A on back page): 2.47 inches max.
Standard Number of Cable Conductors:
- Serial Output - 12 standard*
- Byte or parallel Output - 17 standard

Electrical
ALL OUTPUT MODES
☐ Typical Power Requirements (+5V DC, 2% Regulation, 1% Ripple):

<table>
<thead>
<tr>
<th></th>
<th>PARALLEL/8-BIT BYTE</th>
<th>SERIAL (Excludes Tach Option)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 Station</td>
<td>2 Stations</td>
</tr>
<tr>
<td></td>
<td>2 Stations</td>
<td></td>
</tr>
<tr>
<td>Peak</td>
<td>450 mW</td>
<td>775 mW</td>
</tr>
<tr>
<td>Average**</td>
<td>275 mW</td>
<td>450 mW</td>
</tr>
</tbody>
</table>

☐ Data Acquisition Time 120μ Sec. Min.
128μ Sec. Min. (Parallel Output)

☐ Output Code Unambiguous Natural Binary

* 9 conductor cable available without Update Complete/Data Valid Line and without Tach option.
** Average power calculated at 100 interrogations/second. For other interrogation rates refer to Technical Bulletin.
## SERIAL OUTPUT MODE
- Input/Output levels: 9637/38 Receivers/Drivers
- Shift Clock: 1MHz (User Supplied)

### Pin/Wire Designations:

<table>
<thead>
<tr>
<th>WIRE NO.</th>
<th>FUNCTION</th>
<th>WIRE NO.</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(Red Edge)</td>
<td>GND</td>
<td>7</td>
<td>Serial Clock’</td>
</tr>
<tr>
<td>2</td>
<td>Tach</td>
<td>8</td>
<td>Serial Output</td>
</tr>
<tr>
<td>3</td>
<td>Tach’</td>
<td>9</td>
<td>Serial Output’</td>
</tr>
<tr>
<td>4</td>
<td>Update/Read Command</td>
<td>10</td>
<td>Update Complete/Data Valid</td>
</tr>
<tr>
<td>5</td>
<td>Update/Read Command’</td>
<td>11</td>
<td>Update Complete/Data Valid’</td>
</tr>
<tr>
<td>6</td>
<td>Serial Clock</td>
<td>12</td>
<td>+5V</td>
</tr>
</tbody>
</table>

## BYTE (OR PARALLEL) OUTPUT MODE
- Input Levels: 0/5V, TTL and CMOS Compatible, 1 CMOS Unit Load
- Output Levels: 0/5V, Short Circuit Protected

### Pin/Wire Designations:

<table>
<thead>
<tr>
<th>WIRE NO.</th>
<th>FUNCTION</th>
<th>WIRE NO.</th>
<th>FUNCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(Red Edge)</td>
<td>DB7</td>
<td>10</td>
<td>+5V</td>
</tr>
<tr>
<td>2</td>
<td>DB6</td>
<td>11</td>
<td>Update Complete/Data Valid*</td>
</tr>
<tr>
<td>3</td>
<td>DB5</td>
<td>12</td>
<td>Guard/NC</td>
</tr>
<tr>
<td>4</td>
<td>DB4</td>
<td>13</td>
<td>ADRØ(Latch1)</td>
</tr>
<tr>
<td>5</td>
<td>DB3</td>
<td>14</td>
<td>Guard/NC</td>
</tr>
<tr>
<td>6</td>
<td>DB2</td>
<td>15</td>
<td>ADR 1(Latch 2)</td>
</tr>
<tr>
<td>7</td>
<td>DB1</td>
<td>16</td>
<td>GND</td>
</tr>
<tr>
<td>8</td>
<td>DBØ</td>
<td>17</td>
<td>Update/Read Command</td>
</tr>
<tr>
<td>9</td>
<td>Tach</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Pin 11 is Latch 3 on 16-bit units with BITE and 17 bit units

## Ordering Information

<table>
<thead>
<tr>
<th>Resolution</th>
<th>Data Output mode:</th>
<th>Data Acquisition Mode:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bits/ Turn</td>
<td>B = Byte</td>
<td>U = Update</td>
</tr>
<tr>
<td>2.3 inch</td>
<td>S = Serial</td>
<td>R = Read</td>
</tr>
<tr>
<td>Outside Diameter (1) or (2)</td>
<td>P = Parallel with (User Supplied) external latches</td>
<td></td>
</tr>
</tbody>
</table>

### Specify Options As Follows:
- MS1 Hi-Rel Integrated Circuits
- MS3 Built-in Test (BITE)
- MS5 CCW For Increasing Count Facing the Mtg. Surface
- MS2 Extended Temperature
- MS4 Tach
## General Specifications (L, LS and LC)

<table>
<thead>
<tr>
<th>Quanta/Revolution</th>
<th>Resolution (Arc Minutes)</th>
<th>Accuracy&lt;sup&gt;(1)&lt;/sup&gt; (Arc Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>µS14/23</td>
<td>16384</td>
<td>1.32</td>
</tr>
<tr>
<td>µS15/23</td>
<td>32768</td>
<td>0.66</td>
</tr>
<tr>
<td>µS16/23</td>
<td>65536</td>
<td>0.33</td>
</tr>
<tr>
<td>µS17/23</td>
<td>131072</td>
<td>0.17</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>No. of Stations</th>
<th>1</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.0</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>0.7</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>0.5</td>
<td>0.25</td>
</tr>
<tr>
<td></td>
<td>----</td>
<td>0.2</td>
</tr>
</tbody>
</table>

- **Interrogation Rate/Acquisition Time**: 5kHz max./Data Acquisition Time 120 µsec min.
- **Operating Speed**: 250 rpm max.
- **Rotation (for increasing count)**: Clockwise facing mounting surface
- **Slew Speed (nonoperating)**: 3600 rpm max.
- **Operating Temperature Range**:
  - Standard: -40 to +71°C
  - Optional: -54 to +85°C
- **Torque**:
  - Breakaway: 1.5 oz-in max. at 25°C
  - Running: 1.5 oz-in max. at 25°C
- **Moment of Inertia**: 0.068 oz-in² max. (0.18 x 10⁻³ oz-in-sec² max.)
- **Shaft Loading**:
  - Axial: 2.0 lb max.
  - Radial: 1.0 lb max. (at 0.125 inch from front face)
- **Weight**: 16 oz. max. (Stainless steel base)
- **Rated Life, Bearings**: 10⁷ revolutions min.
- **Rated Life, LED**: 100,000 hours min.
- **MTBF**: 300,000 hours typical (calculated per MIL-HDBK-217 Ground Fixed)
- **Digital Tach Output Option**: 32768 Cycles/Revolution Square Wave

<sup>(1)</sup> Peak transition error of transducer and electronics. Excludes quantizing error of ½ LSB.

*Specifications subject to change without notice.*