

# **QD1 INCREMENTAL ENCODER INTERFACE OPERATOR'S MANUAL**

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# QD1 INCREMENTAL ENCODER INTERFACE

## 1. FUNCTION

The QD1 is designed as a general purpose quadrature decoder to interface CSI's CR10, 21X, and CR7 dataloggers to incremental encoders. This manual focuses on using the QD1 with commercially available shaft encoders used in water level applications (see Appendix). If there are other incremental encoders of interest, please contact CSI's Marketing Department for support.

As the encoder rotates, it produces two square waves which are 90° out of phase with each other. When the rotation is reversed, the relation of the two square waves is reversed. The QD1 decodes the two square waves and gates a voltage pulse to a datalogger pulse counting channel (refer to Section 8). Two pulse counting channels are required, one for each direction of encoder rotation.

## 2. SPECIFICATIONS

Datalogger compatibility: CR10, 21X, CR7  
Power supply: 4 to 5.6 V  
Current drain: 0.2 to 0.4 mA avg.  
Operating temperature: -25 to +50°C.  
Humidity: 0 to 95%, noncondensing  
Minimum time between input transitions:  
0.75 ms\*\*\*  
Output pulse width: 0.25 ms @ 25°C  
Signal magnitude, Volts: 0 (low), supply voltage (high)  
Dimensions (L x W x D, inches): 2.9 x 1.7 x 0.85  
Weight (lbs.): 0.22

\*\*\*NOTE: The minimum time between input transitions implies a rate of 1333.3 counts/sec. To realize this specification, the time between transitions must be evenly spaced; a function of the encoder. A diagram explaining "minimum time between transitions" is given in Table 1, Section 8.

## 3. CONNECTIONS

Connections between the QD1 and the datalogger are shown below. Connections from the QD1 to two commercially available shaft encoders are shown in the Appendix.

| <u>(datalogger side)</u> | <u>QD1<br/>DATALOGGER</u>       |
|--------------------------|---------------------------------|
| +5                       | +5V (CR10) or<br>CAO (21X, CR7) |
| P1                       | PULSE CHANNEL                   |
| P2                       | PULSE CHANNEL                   |
| GRND                     | G (CR10) or GRND<br>(21X, CR7)  |

**NOTE:** Datalogger pulse input channels should be sequential for efficient datalogger programming.

## 4. DATALOGGER PROGRAMMING

The program must measure the QD1 output and process the "up" and "down" counts to determine stage. For 21X and CR7 dataloggers, an additional step is required to power the QD1 from a Continuous Analog Output (CAO) channel. The following steps outline the procedure. Notes on the various steps are presented in following sub-sections. An example program is given in the Appendix.

1. Load QD1 power supply level, 5000 mV, into an input location (Instruction 30, required for 21X and CR7 only)
2. Enable CAO to output QD1 supply voltage (Instruction 21; required for 21X and CR7 only)
3. Measure QD1 up count and down count output on 2 pulse count channels (Instruction 3, 2 reps, high frequency option)
4. Stage = up count + stage (Instruction 33)
5. Stage = stage - down count (Instruction 35)

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### 4.1 POWERING THE QD1

21X and CR7 - 5 VDC must be supplied to the QD1 continuously. When used with the 21X or CR7 dataloggers, a Continuous Analog Output (CAO) port may be programmed to power the QD1. CAO channels are located on the panel of the 21X and the 725 Excitation Card of the CR7. Instructions to send 5 V out the CAO port should occur before the measurement instruction, and must be repeated at least every minute. This implies a maximum program execution interval of one minute. If the CAO voltage is not refreshed every minute, the voltage level may sag below the minimum QD1 operating voltage.

CR10 - When used with the CR10, the QD1 may be connected to one of the two 5 VDC terminals located on the CR10WP Wiring Panel.

### 4.2 MEASUREMENT

Output from the QD1 is measured with I/O Instruction 3 (Pulse Count), using the high frequency option. Two pulse count channels must be measured, one for "up" counts and one for "down".

The Multiplier to be used depends on the number of counts per revolution of the shaft encoder and the circumference of the attached wheel, as shown below.

$$\text{MULTIPLIER} = \frac{\text{WHEEL CIRCUMFERENCE}}{(\text{COUNTS/REVOLUTION})}$$

Engineering units logged by the datalogger are the same as those used for wheel circumference.

An Offset of zero should be entered in the Pulse Count I/O Instruction. Section 5 discusses entering an offset to set the measurement equal to a reference elevation.

### 4.3 PROCESSING

Processing Instructions are used to determine the stage from the measured up and down counts. The new stage is calculated by adding

the existing stage to the up counts and storing the sum back in the existing stage location. The down count value is then subtracted from the sum, and the result is stored back in the stage location. This routine minimizes the number of Input Locations required to calculate stage.

## 5. ENTERING THE REFERENCE OFFSET

The offset, which sets the stage value equal to some reference point, should be entered after the system has been installed and the float is resting on the water surface. Enter the \*6 Mode and advance to the stage Input Location. Press the "C" key to enable the \*6C function, allowing a value to be entered into the stage Input Location. Key in the reference offset and press the "A" key to view the offset value now located in the stage Input Location. Refer to the \*6 Mode in the datalogger manual(s) for additional information on the \*6C function.

If changes to the datalogger program are made and the program is recompiled in the \*0 Mode, all \*6C entries are erased. THE REFERENCE OFFSET SHOULD BE ENTERED AFTER ALL PROGRAM CHANGES HAVE BEEN MADE.

## 6. ON-SITE CHECK-OUT

Testing is recommended to ensure that when the float rises or falls, the correct pulse counting channel is incremented. While viewing the stage Input Location in the \*6 Mode, rotate the shaft in the direction corresponding to a rise in stage. Wait for the next program execution and confirm that the reading increases. If the reading decreases, simply exchange the input leads to the pulse count channels.

## 7. RANGE VS. RESOLUTION

If recorded data are to reflect the resolution of the encoder, consideration must be given to the datalogger output resolution as well as the reference offset. Table 7.1 shows minimum and maximum values stored in the datalogger using low and high resolution, and associated memory consumption.

**TABLE 1. Datalogger Maximum and Minimum Range Limits and Storage Efficiency for Given Output Resolution**

|                 | <u>Zero</u> | <u>Minimum Magnitude</u> | <u>Maximum Magnitude</u> | <u>Final Memory Locations/Data Pt.</u> |
|-----------------|-------------|--------------------------|--------------------------|--|
| Low Resolution  | 0.000       | ±0.001                   | ±6999.                   | 1                                      |
| High Resolution | 0.000       | ±0.00001                 | ±99999.                  | 2                                      |

The resolution of the low resolution format is reduced to 3 significant digits when the first (left most) digit is 7 or greater, as shown in Table 2.

**TABLE 2. Format Range and Decimal Location for Datalogger Low Resolution Output**

| <u>Range (Absolute Value)</u> | <u>Decimal Location</u> |
|-------------------------------|-------------------------|
| 0-6.999                       | X.XXX                   |
| 7-69.99                       | XX.XX                   |
| 70-699.9                      | XXX.X                   |
| 700-6999.                     | XXXX.                   |

It may be necessary to use high resolution or an offset to maintain the desired resolution. For example, if water level is to be measured and output to the nearest 0.01 ft., the level must be

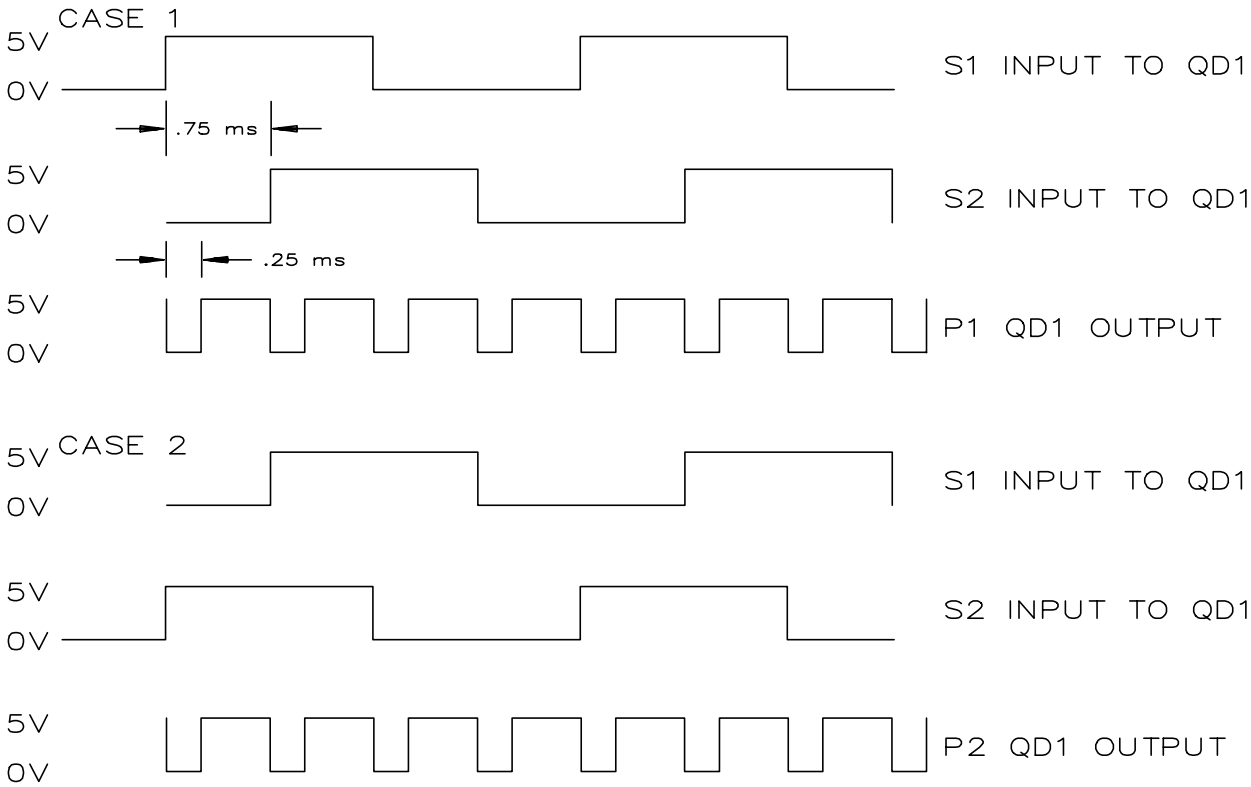
less than 70 ft. for 0.01 ft. increments to be maintained in low resolution. If the water level is expected to range from 50 to 80 feet, the data could either be output in high resolution or could be offset by -20 ft., transforming the range to 30 to 60 ft. If the datalogger's storage capacity is limiting, it is best to maintain the measurement resolution with an offset and store the data in the more memory efficient low resolution format.

## 8. QD1 TIMING DIAGRAM

Figure 1 is a simplified timing diagram of the pulses into and out of the QD1. In actual operation, the 5 V supply to the encoder is strobed which causes the encoder output (S1, S2 QD1 inputs) to be strobed. S1 and S2 inputs are shown as full square waves in Figure 1 for ease of conception. The time between transitions shown is the minimum 0.75 ms.

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**FIGURE 1. QD1 Timing Diagram**



|        | TRANSITION OF | WHEN       | GATE PULSE TO |
|--------|---------------|------------|---------------|
| CASE 1 | S1 TO HIGH    | S2 IS LOW  | P1            |
|        | S2 TO HIGH    | S1 IS HIGH | P1            |
|        | S1 TO LOW     | S2 IS HIGH | P1            |
|        | S2 TO LOW     | S1 IS LOW  | P1            |
| CASE 2 | S2 TO HIGH    | S1 IS LOW  | P2            |
|        | S1 TO HIGH    | S2 IS HIGH | P2            |
|        | S2 TO LOW     | S1 IS HIGH | P2            |
|        | S1 TO LOW     | S2 IS LOW  | P2            |

## APPENDIX A. SHAFT ENCODER CONNECTIONS AND EXAMPLE PROGRAM

### A.1 SHAFT ENCODER CONNECTIONS

QD1 to shaft encoder connections shown below are for HANDAR's Model 436A and SYNERGETICS's Model 501A. These connections were verified in July of 1987. CSI is not responsible for subsequent changes in encoder pin configurations by the respective vendors.

| ENCODER<br>6 PIN<br>CONNECTOR | QD1 (encoder side)<br>CONNECTIONS TO<br><u>HANDAR</u> | <u>SYNERGETICS</u> |
|-------------------------------|---|--------------------|
| A                             | N/C   | GROUND             |
| B                             | N/C   | S1 or S2           |
| C                             | +5  | N/C                |
| D                             | S1 or S2  | GROUND             |
| E                             | S1 or S2  | S1 or S2           |
| F                             | GROUND  | N/C                |

### A.2 EXAMPLE PROGRAM

The following program is an example only and is not meant to be used verbatim. Sensor calibration, input channels, and Input Locations selected must be adjusted for actual circumstances. The example goes so far as to place the calculated stage into an Input Location only. The user must program the necessary instructions to obtain the data in the form desired, and store it in Final Memory.

In this example the reference offset would be keyed into Input Location 4 (STAGE) via \*6C. Refer to the \*6 Mode in the datalogger manual for detailed information on the \*6C function.

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|     |      |                         |                          |
|-----|------|-------------------------|--------------------------|
| *   | 1    | Table 1 Programs        |                          |
| 01: | 60   | Sec. Execution Interval |                          |
| 01: | P30  | Z=F                     | LOAD THE POWER SUPPLY mV |
| 01: | 5000 | F                       | LEVEL INTO LOCATION 1    |
| 02: | 1    | Z Loc [:mV LEVEL ]      |                          |
| 02: | P21  | Analog Out              | ENABLE CAO 1 TO OUTPUT   |
| 01: | 1    | CAO Chan                | 5000 mV TO POWER THE QD1 |
| 02: | 1    | mV Loc mV LEVEL         |                          |

#### THE STEPS ABOVE ARE REQUIRED FOR 21X AND CR7 DATALOGGERS ONLY.

|     |     |                  |                             |
|-----|-----|------------------|-----------------------------|
| 03: | P3  | Pulse Count      | MEASURE THE TWO PULSE       |
| 01: | 2   | Reps             | COUNT CHANNELS              |
| 02: | 1   | Pulse Input Chan | LOCATION 2 = UP COUNT       |
| 03: | 0   | High frequency   | LOCATION 3 = DOWN COUNT     |
| 04: | 2   | Loc [:UP COUNT ] | MULTIPLIER = .01 FOR OUTPUT |
| 05: | .01 | Mult             | IN FEET (1 FT CIRCUMFERENCE |
| 06: | 0   | Offset           | WHEEL,100 COUNTS/REV)       |
| 04: | P33 | Z=X+Y            | STAGE = STAGE + UP COUNT    |
| 01: | 4   | X Loc STAGE      |                             |
| 02: | 2   | Y Loc UP COUNT   |                             |
| 03: | 4   | Z Loc [:STAGE ]  |                             |
| 05: | P35 | Z=X-Y            | STAGE = STAGE - DWN COUNT   |
| 01: | 4   | X Loc STAGE      |                             |
| 02: | 3   | Y Loc DWN COUNT  |                             |
| 03: | 4   | Z Loc [:STAGE ]  |                             |
| 06: | P   | End Table 1      |                             |

## **APPENDIX A. SHAFT ENCODER CONNECTIONS AND EXAMPLE PROGRAM**

### **INPUT LOCATIONS USED:**

1:mV LEVEL  
2:UP COUNT  
3:DWN COUNT  
4:STAGE