

COP472-3

AN-749 Quadrature Signal Interface to a COP400 Microcontroller



Literature Number: SNOA211

Quadrature Signal Interface to a COP400 Microcontroller

National Semiconductor
Application Note 749
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INTRODUCTION

Switches have always been a popular way of getting information into a microcontroller. Two-bit quadrature output devices, also known as two-bit gray code output, use two switches that are mechanically coupled together thru a shaft so that as the shaft is rotated the switches generate two square waves that are 90 degrees out of phase with each other. This is also known as being in quadrature, see *Figure 1*. The reason for doing this is that within the two signals there is the information to detect the direction of rotation, i.e., clockwise (CW) or counterclockwise (CCW). This type of device allows an input variable to be increased or decreased by CW or CCW rotation of the shaft. Additionally, these devices allow continuous rotation in either direction, which lets the span and resolution of the input variable to be a function of the software.

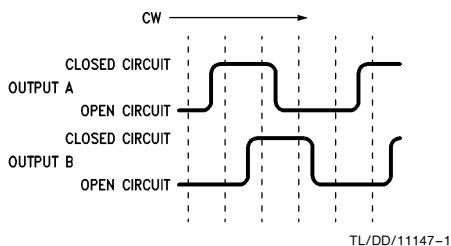


FIGURE 1

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OPERATION

Figure 2 shows a hardware connection of a quadrature output device to the COP400 microcontroller. Although in this example the G0 and G1 I/O pins are used, any pin that can be used as an input could be used with the appropriate changes in the software.

In this example the output of device QD1 is processed to detect a state change in the quadrature signal and which direction the change was in. A 3-digit BCD variable, which is stored in RAM, is then incremented or decremented. The variable is defined to have a range of 200 to 350 units. The routine allows the variable to saturate at it's upper and lower limits when reached.

Figure 3 displays the two waveforms that are generated by QD1 as it's shaft is rotated from an arbitrary starting position. Each edge represents a change of state. By keeping track of the state that was moved from and the state that currently exists, it can be determined which direction the rotation was in.

Referring to *Figure 3*, there are 4 possible states for a starting position, (00, 01, 11, 10), and they will be referred to as the previous state. There are also 4 possible states to move to, (00, 01, 11, 10), and they will be referred to as the current state. *Figure 4* lists the 8 possible combinations of bits that can be formed by starting from each previous state and rotating CW or CCW to the current state. If the two bits of the previous state and current state are concatenated into one 4-bit value, each value will be unique. The routine

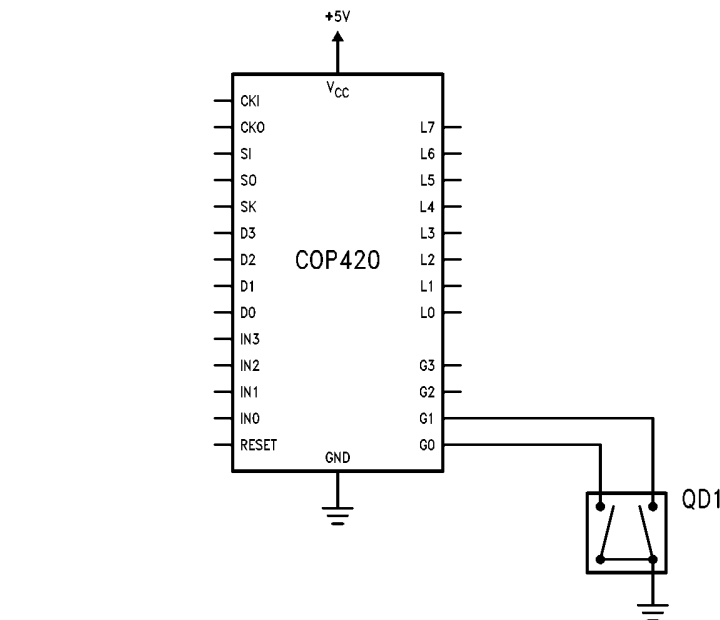


FIGURE 2

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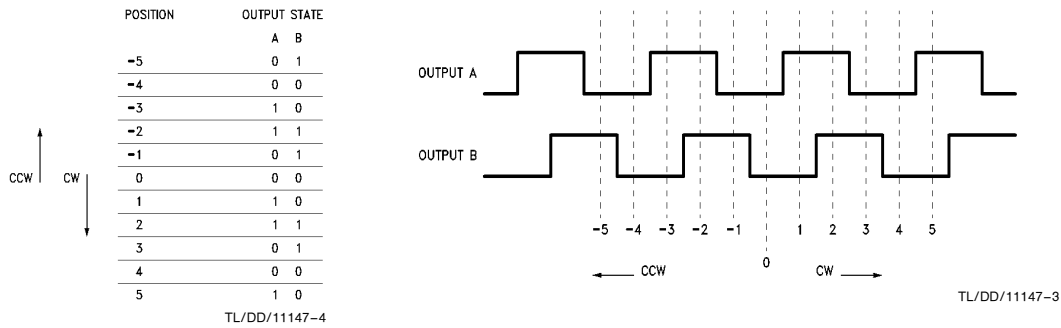


FIGURE 3. Quadrature Signal Output (Gray Code)

used in this example assigns the two bits of the current state to the low 2 bits of a 4-bit value, and the 2 bits of the previous state to the high 2 bits of a 4-bit value. This 4-bit value (see the column under the PS/CS heading in *Figure 4*) is then used as a pointer into a jump table which branches to the add or subtract part of the routine. This method takes advantage of the "jump indirect" instruction which implements a multiway branch based on the value of a pointer.

The routine to input data from the quadrature device reads the value of G0 and G1 and compares it to the value stored from the previous read operation. If the two values are equal there is no input to process. If the two values are not equal there is an input and the data is processed to determine if one is to be added to or subtracted from the variable.

The flow chart details the operation of the subroutine "QUAD".

In *Figure 4*, only 8 of the possible 16 combinations are used. To account for potential spurious operation if one of the 8 undefined combinations occur, they are ignored by this routine by branching to a return instruction which bypasses any additional processing.

The source listing for this example subroutine, which is named "QUAD", is provided. An initialization routine that is required to set up the starting parameters is also included.

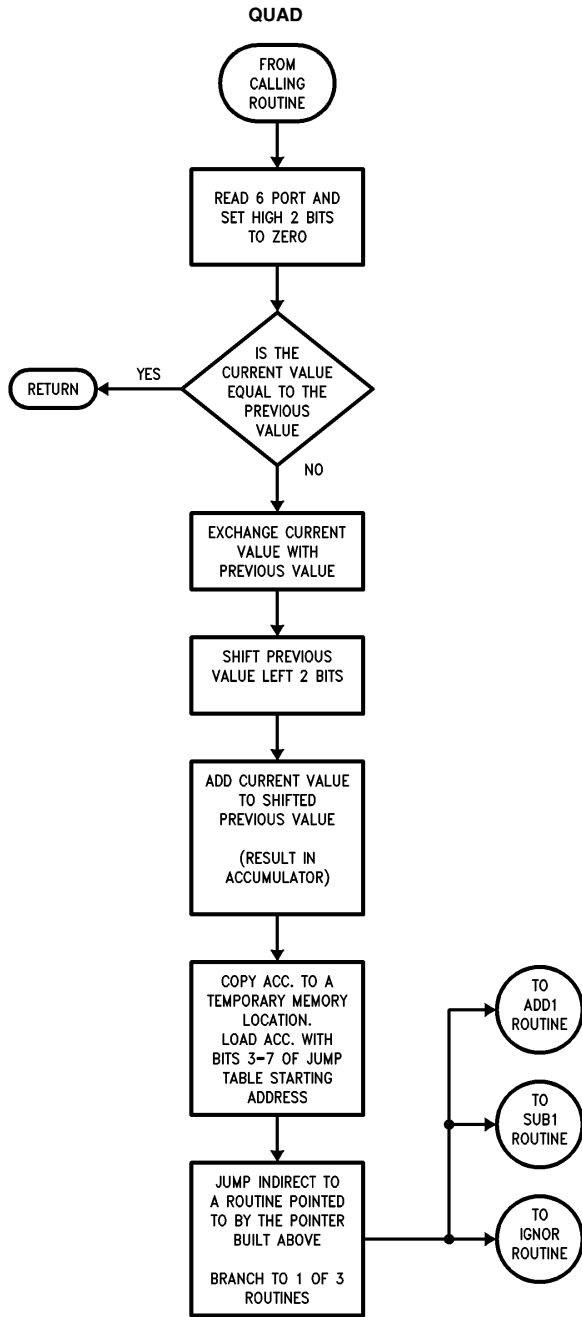
CONCLUSION

This application note demonstrates the relative ease of interfacing a quadrature device to a COP400 microcontroller. The combination of a low cost microcontroller and input device can provide the basis for a cost effective instrument or appliance design.

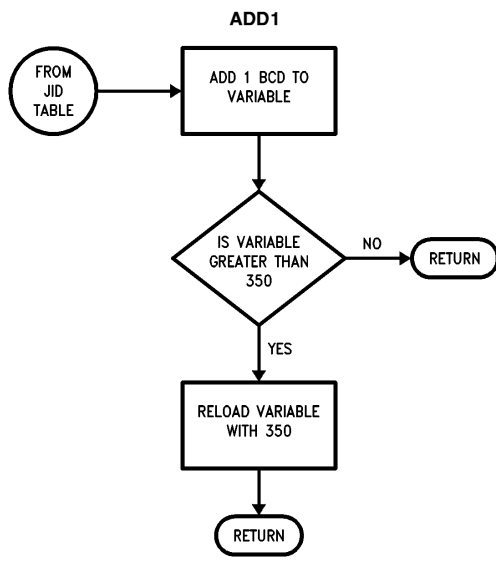
Direction	PS/CS	Hex Value	Operation
CW	00 10	2	Add 1
CCW	00 01	1	Subtract 1
CW	01 00	4	Add 1
CCW	01 11	7	Subtract 1
CW	11 01	D	Add 1
CCW	11 10	E	Subtract 1
CW	10 11	B	Add 1
CCW	10 00	8	Subtract 1

PS = Previous State
CS = Current State

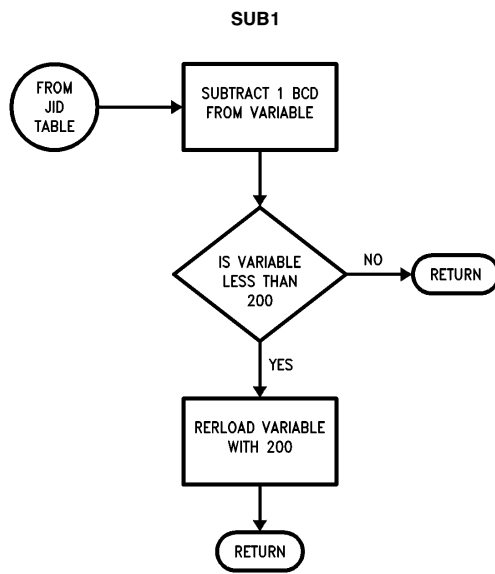
FIGURE 4



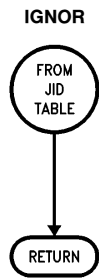
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 COP400 CROSS ASSEMBLER, REV:D, 8 MAY 85
 QUAD

```

1          ;
2          ;
3          ;           QUAD.MAC
4          ;           QUADRATURE SIGNAL INTERFACE TO THE COP420
5          ;           AUGUST 1, 1990
6          ;           WALTER BACHAROWSKI
7          ;
8          ;           .TITLE QUAD
9          ;           .CHIP 420
10         ;
11         ;*****
12         ;
13         ;ASSIGNMENTS
14         ;
15         ;*****
16         ;
17         ;
18         ;
19         ;
20         ;
21         ;
22         ;
23         ;
24         ;*****
25         ;
26         ;PROGRAM START
27         ;
28         ;*****
29         ;
30         ;
31         ;   POR:
32         ;
33         ;
34         ;
35         ;
36         ;
37         ;
38         ;
39         ;
40         ;
41         ;
42         ;
43         ;
44         ;   IDLE:
45         ;
46         ;
47         ;
48         ;
49         ;
50         ;
51         ;

```

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NATIONAL SEMICONDUCTOR CORPORATION
 COP400 CROSS ASSEMBLER, REV:D, 8 MAY 85
 QUAD

```

52          ;*****
53          ;
54          ;START OF JUMP TABLE FOR PROCESSING INPUTS
55          ;
56          ;*****
57          ;
58          QUADJT:          ;POINTER VALUE IN HEX
59 0200 10          .ADDR  IGNOR  ;0
60 0201 28          .ADDR  ADD1   ;1
61 0202 3D          .ADDR  SUB1   ;2
62 0203 10          .ADDR  IGNOR  ;3
63 0204 3D          .ADDR  SUB1   ;4
64 0205 10          .ADDR  IGNOR  ;5
65 0206 10          .ADDR  IGNOR  ;6
66 0207 28          .ADDR  ADD1   ;7
67 0208 28          .ADDR  ADD1   ;8
68 0209 10          .ADDR  IGNOR  ;9
69 020A 10          .ADDR  IGNOR  ;A
70 020B 3D          .ADDR  SUB1   ;B
71 020C 10          .ADDR  IGNOR  ;C
72 020D 3D          .ADDR  SUB1   ;D
73 020E 28          .ADDR  ADD1   ;E
74 020F 10          .ADDR  IGNOR  ;F          END OF JUMP TABLE
75          ;
76          IGNOR:          ;BYPASS ANY ADDITIONAL PROCESSING
77 0210 48          RET
78          ;
79          ;*****
80          ;
81          ;PROCESS INPUT TO CHECK FOR A CHANGE OF STATE
82          ;
83          ;*****
84          ;
85          QUAD:
86 0211 3E          LBI    SCR2          ;GET CURRENT INPUT STATE
87 0212 332A        ING          ;AND MASK HIGH TWO BITS
88 0214 06          X          ;THEN COMPARE PREVIOUS AND CURRENT
89 0215 42          RMB    2          ;STATE
90 0216 43          RMB    3          ;
91 0217 35          LD     3          ;COPY MASKED VALUE TO ACCUM. AND POINT
92 0218 21          SKE          ;TO PREVIOUS STATE. CHECK IF EQUAL
93 0219 DB          JP    QUAD2
94 021A 48          RET          ;THEY ARE EQUAL SO RETURN
95          ;
96          QUAD2:
97 021B 36          X     3          ;EXCHANGE CURRENT AND PREVIOUS VALUES
98 021C 06          X          ;AND POINT TO SCRATCH LOCATION
99 021D 00          CLRA
100 021E 31         ADD          ;DO A LEFT SHIFT OF 2 BITS
101 021F 31         ADD          ;THIS FORMS THE 2 HIGH BITS OF THE
102 0220 31         ADD          ;JUMP POINTER

```

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NATIONAL SEMICONDUCTOR CORPORATION
 COP400 CROSS ASSEMBLER, REV:D, 8 MAY 85
 QUAD

```

103 0221 31      ADD
104              ;
105 0222 0E      LBI    PV          ;NOW ADD THE CURRENT STATE THAT WAS JUST
106 0223 31      ADD              ;PROCESSED. BECOMES THE 2 LOW BITS OF
107              ;THE JUMP POINTER
108 0224 3E      LBI    SCR2       ;SET UP THE POINTER FOR THE
109 0225 06      X              ;JUMP INDIRECT POINTER
110 0226 00      CLRA
111              ;
112 0227 FF      JID              ;BRANCH TO REQUIRED ROUTINE
113              ;
114              ;*****
115              ;
116              ;ADD 1 TO THE VALUE OF THE VARIABLE AND CHECK FOR ITS MAX
117              ;VALUE.
118              ;
119              ;*****
120              ;
121              ;
122 0228 1C      ADD1:  LBI    VLD          ;POINT TO LEAST SIGNIFICANT DIGIT
123 0229 22      SC              ;USE CARRY TO ADD 1
124              ;
125 022A 00      ADD1L: CLRA          ;
126 022B 56      AISC    6          ;BCD CORRECTION
127 022C 30      ASC
128 022D 4A      ADT
129 022E 04      XIS              ;STORE DIGIT AND POINT TO NEXT DIGIT
130 022F EA      JP    ADD1L
131 0230 3C      LBI    SCR0       ;STORE VALUE TO CHECK FOR MAX VALUE
132 0231 79      STII   9
133 0232 74      STII   4
134 0233 76      STII   6
135 0234 6A53   JSR    ADDLIM
136 0236 20      SKC              ;IF CARRY IS SET ON RETURN FROM
137 0237 48      RET              ;ADDLIM THEN THE VARIABLE IS LARGER
138 0238 1C      LBI    VLD          ;THEN ITS MAXIMUM VALUE
139 0239 70      STII   0          ;SO RESET IT TO ITS MAX VALUE
140 023A 75      STII   5
141 023B 73      STII   3
142 023C 48      RET
143              ;
144              ;*****
145              ;
146              ;SUBTRACT ONE FROM THE VARIABLE AND CHECK FOR
147              ;IT BEING GREATER THEN THE MINIMUM VALUE.
148              ;
149              ;*****
150              ;
151              ;
152 023D 1C      SUB1:  LBI    VLD          ;SUBTRACT 1 BY FORCING A BORROW
153 023E 32      RC

```

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NATIONAL SEMICONDUCTOR CORPORATION
 COP400 CROSS ASSEMBLER, REV:D, 8 MAY 85
 QUAD

```

154                                SUB1L:
155 023F 00                        CLRA

156 0240 10                        CASC
157 0241 4A                        ADT                ;BCD CORRECTION
158 0242 04                        XIS                ;STORE DIGIT AND POINT TO NEXT DIGIT
159 0243 623F                      JMP      SUB1L
160                                ;
161 0245 3C                        LBI      SCR0    ;STORE VALUE TO CHECK LOWER LIMIT OF THE VARIABLE
162 0246 70                        STII     0
163 0247 70                        STII     0
164 0248 78                        STII     8
165 0249 6A53                      JSR      ADDLIM
166                                ;
167 024B 20                        SKC                ;IF CARRY IS NOT SET ON RETURN THEN VARIABLE
168 024C CE                        JP       SUB2    ;LESS THEN IT'S MINIMIUM VALUE
169 024D 48                        RET
170                                SUB2:
171 024E 1C                        LBI      VLD     ;FORCE VARIABLE TO ITS MIN VALUE
172 024F 70                        STII     0
173 0250 70                        STII     0
174 0251 72                        STII     2
175 0252 48                        RET
176                                ;
177                                ;*****
178                                ;
179                                ;ADD A VALUE STORED IN SCR0 TO SCR3 TO THE VALUE OF THE
180                                ;VARIABLE NONDESTRUCTIVELY. THE STATE OF THE CARRY BIT
181                                ;IS USED BY THE CALLING ROUTINE AS A RESULT.
182                                ;
183                                ;*****
184                                ;
185                                ADDLIM:
186 0253 1C                        LBI      VLD
187 0254 32                        RC
188                                ADLIM1:
189 0255 25                        LD       2        ;BCD ADDITION OF 3 DIGITS
190 0256 56                        AISC     6
191 0257 30                        ASC
192 0258 4A                        ADT
193 0259 24                        XIS
194 025A D5                        JP       ADLIM1  ;PROCESS NEXT DIGIT
195 025B 48                        RET
196                                ;
197                                .END

```

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NATIONAL SEMICONDUCTOR CORPORATION
COP400 CROSS ASSEMBLER, REV:D, 8 MAY 85
QUAD
SYMBOL TABLE

PAGE: 5

ADD1	0228	ADD1L	022A	ADDLIM	0253	ADLIM1	0255
IDLE	000D	IGNOR	0210	FOR	0000 *	PV	000F
QUAD	0211	QUAD2	021B	QUADJT	0200 *	SCRO	003D
SCR1	003E *	SCR2	003F	SUB1	023D	SUB1L	023F
SUB2	024E	VHD	001F *	VLD	001D	VMD	001E *

NO ERROR LINES

108 ROM BYTES USED

COP 420 ASSEMBLY

SOURCE CHECKSUM = 2177

OBJECT CHECKSUM = 01FF

INPUT FILE C:QUAD.MAC

LISTING FILE C:QUAD.PRN

OBJECT FILE C:QUAD.LM

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