Implementing an 8-Bit Buffer in COPS™

National Semiconductor
Application Note 329
David Pointer
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Sometimes a COP microcontroller must input and/or output 8-bit data; for instance, when handling ASCII data. In some applications, the processor must also provide temporary storage for 8-bit data before it is output. The COP instruction set and RAM structure lend themselves very nicely to providing a 32 digit, 8-bit buffer for a solution to these applications.

Such a large buffer is possible using a COP440 or a COP444L. The other members of the COP400 family with half as much RAM as these two would provide a 16 digit 8-bit buffer using the techniques described in this example.

Four adjacent RAM registers (16 digits each) are required. Referring to *Figure 1*, registers 4, 5, 6, and 7 are used for the buffer. Each RAM location contains 4 bits, so 2 locations will be used to store a byte of data. But these RAM locations are not adjacent to each other. You will note that the MSD of digit number 0A hex is in RAM location (4, A) while the LSD of the same digit is in RAM location (6, A).

The 2 RAM locations CHARM and CHARL are used for temporary storage of an 8-bit value.

In addition, 4 RAM locations are used for buffer pointers: those labelled IPM and IPL are the MSD and LSD of the input pointer, and those labelled OPM and OPL are the MSD and LSD of the output pointer. Each pointer's function is to store an 8-bit counter whose value ranges from 00 hex thru 1F hex. The input pointer's value is used for storing the temporary storage buffer contents into the digit with the same number. For example, if the input pointer equals 14 hex, then the contents of CHARM would be stored in RAM location (5, 4) and the contents of CHARL would be stored in RAM location (7, 4). The output pointer's value is used for retrieving a digit from the buffer and putting it in CHARM and CHARL. For instance, if the output pointer equals 05 hex, then the contents of RAM location (4, 5) would be transferred to CHARM and the contents of RAM location (6, 5) would be transferred to CHARL.

A simple example of one possible application of the buffer is flowcharted in *Figure 2.* In this example, data is input to CHARM and CHARL, then stored in the buffer. An output device (a printer) is checked to see if it is ready to receive data. If it is, data is brought out of the buffer and put in CHARM and CHARL for output to the printer.

Pages 3 and 4 contain a listing of the subroutines needed to perform the data transfers in the 32-digit, 8-bit buffer.

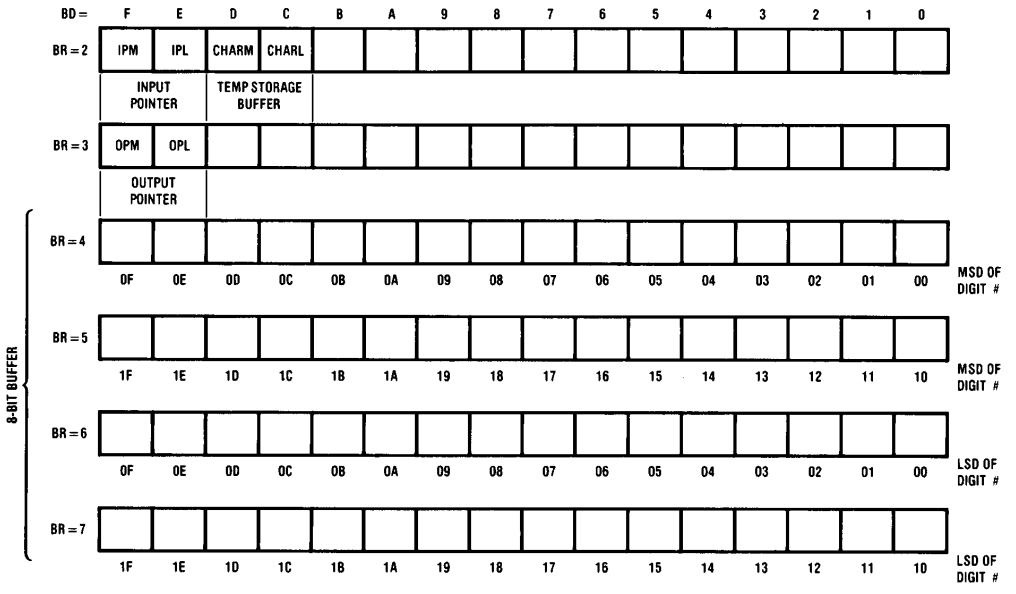

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FIGURE 1. 8-Bit Buffer RAM Map

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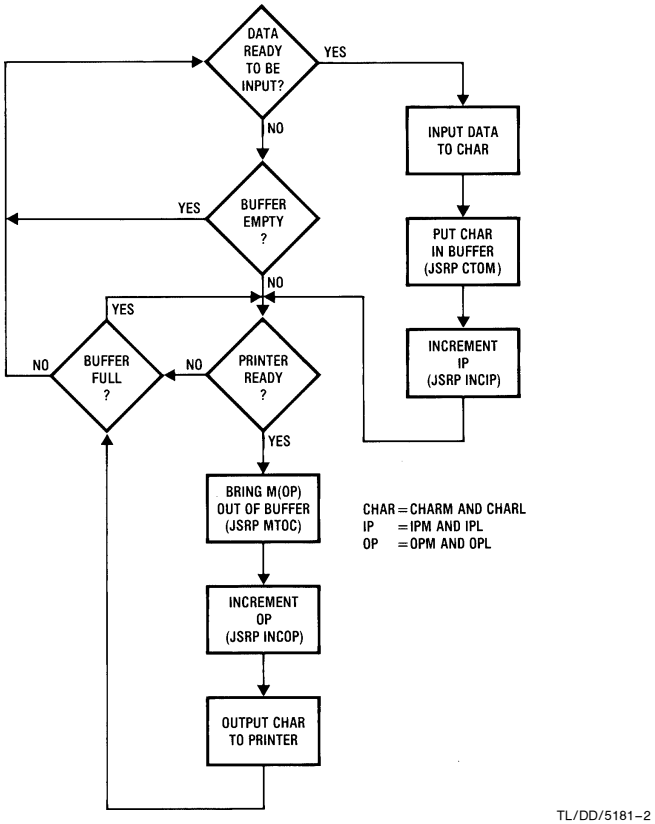

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FIGURE 2. Buffer Example Flowchart

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COP CROSS ASSEMBLER    PAGE:  1
BUFFER

    1            ;************************************
    2            ;***                                ***
    3            ;***  8-BIT RAM BUFFER SUBROUTINES  ***
    4            ;***                                ***
    5            ;************************************
    6            ;THESE ARE SUBROUTINES FOR IMPLEMENTING A 32 BYTE
    7            ;BUFFER IN A COP440 OR COP444L RAM  9/3/82
    8     01BC   .CHIP 444
    9            .TITLE BUFFER
   10     002D   CHARM   =       2,13            ;TEMPORARY STORAGE BUFFER MSD
   11     002C   CHARL   =       2,12            ;TEMPORARY STORAGE BUFFER LSD
   12     002F   IPM     =       2,15            ;INPUT POINTER MSD
   13     002E   IPL     =       2,14            ;INPUT POINTER LSD
   14     003F   OPM     =       3,15            ;OUTPUT POINTER MSD
   15     003E   OPL     =       3,14            ;OUTPUT POINTER LSD
   16 000 00             CLRA
   17     0080   .PAGE 2
   18            ;MTOC IS A SUBROUTINE THAT TRANSFERS M(OPM) AND M(OPL) TO
   19            ;CHARM AND CHARL
   20 080 233E   MTOC:    LDD     OPL             ;LOAD LSD OUTPUT POINTER
   21 082 50              CAB                     ;WHICH IS BD
   22 083 233F            LDD     OPM              ;LOAD MSB OUTPUT POINTER FOR B
   23 085 54              AISC    4                ;MAKE BR EQUAL 4 OR 5
   24 086 12              XABR
   25 087 25              LD      2               ;LOAD M(OPM), MAKE BR = 6 OR 7
   26 088 23AD            XAD     CHARM           ;M(OPM) TO CHARM
   27 08A 05              LD                       ;LOAD M(OPL)
   28 08B 23AC            XAD     CHARL           ;M(OPL) TO CHARL
   29 08D 48              RET
   30            ;
   31            ;
   32            ;CTOM IS A SUBROUTINE THAT TRANSFERS CHARM AND CHARL TO
   33            ;M(IPM) AND M(IPL)
   34 08E 232E   CTOM:    LDD     IPL             ;LOAD LSD INPUT POINTER
   35 090 50              CAB                     ;WHICH IS BD
   36 091 232F            LDD     IPM             ;LOAD MSD INPUT POINTER FOR BR
   37 093 54              AISC    4               ;MAKE BR = 4 OR 5
   38 094 12              XABR
   39 095 232D            LDD     CHARM           ;LOAD MSD TEMP STORAGE
   40 097 26              X       2               ;TO M(OPM), MAKE BR = 6 OR 7
   41 098 232C            LDD     CHARL           ;LOAD LSD TEMP STORAGE
   42 09A 06              X                       ;TO M(OPL)
   43 09B 48              RET
   44            ;
   45            ;
```

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COP CROSS ASSEMBLER    PAGE:  2
BUFFER

   46            .FORM
   47            ;INCREMENTS INPUT POINT OR OUTPUT POINTER, ROLLS OVER
   48            ;AT 1F HEX
   49 09C 2D     INCIP:  LBI     IPL             ;POINT TO LSD OF POINTER
   50 09D 3D     INCOP:  LBI     OPL
   51 09E 22             SC                      ;C=1 FOR INCREMENT
   52 09F 00             CLRA
   53 0A0 30             ASC                     ;INCREMENT RAM VALUE
   54 0A1 44             NOP                     ;NEGATES SKIP CONDITION
   55 0A2 04             XIS                     ;STORE AND POINT TO (X,F)
   56 0A3 00             CLRA
   57 0A4 30             ASC                     ;PROPAGATE CARRY, IF ANY, TO MS
   58 0A5 44             NOP
   59 0A6 06             X                       ;STORE
   60 0A7 45             RMB     1               ;ROLL OVER AT X'1F
   61 0A8 48             RET
   62            ;
   63            ;
   64            .END


COP CROSS ASSEMBLER    PAGE:  3
BUFFER

CHARL  002C     CHARM  002D     CTOM   008E *   INCIP  009C *
INCOP  009D *   IPL    002E     IPM    002F     MTOC   0080 *
OPL    003E     OPM    003F
NO ERROR LINES
   42  ROM WORDS USED
COP   444  ASSEMBLY
SOURCE CHECKSUM = C6A5
INPUT FILE    6:RBUFFC. SRC  VN:    5
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National Semiconductor Corporation
1111 West Bardin Road
Arlington, TX 76017
Tel: 1(800) 272-9959
Fax: 1(800) 737-7018

National Semiconductor Europe
Fax: (+49) 0-180-530 85 86
Email: cnjwge@tevm2.nsc.com
Deutsch Tel: (+49) 0-180-530 85 85
English Tel: (+49) 0-180-532 78 32
Français Tel: (+49) 0-180-532 93 58
Italiano Tel: (+49) 0-180-534 16 80

National Semiconductor Hong Kong Ltd.
13th Floor, Straight Block,
Ocean Centre, 5 Canton Rd.
Tsimshatsui, Kowloon
Hong Kong
Tel: (852) 2737-1600
Fax: (852) 2736-9960

National Semiconductor Japan Ltd.
Tel: 81-043-299-2309
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