National Semiconductor

COP472-3 Liquid Crystal Display Controller

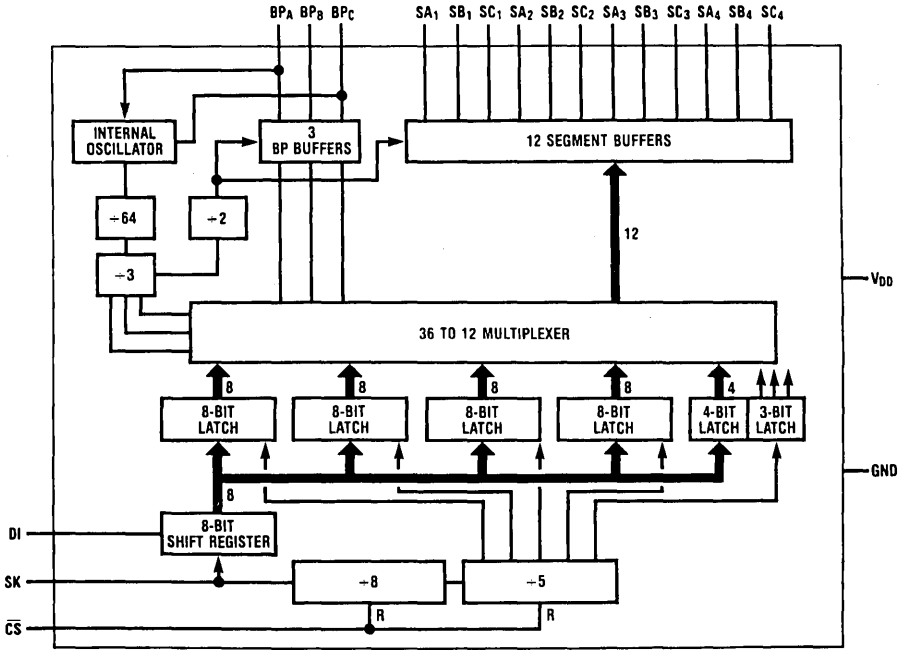
General Description

The COP472-3 Liquid Crystal Display (LCD) Controller is a peripheral member of the COPS™ family, fabricated using CMOS technology. The COP472-3 drives a multiplexed liquid crystal display directly. Data is loaded serially and is held in internal latches. The COP472-3 contains an on-chip oscillator and generates all the multi-level waveforms for backplanes and segment outputs on a triplex display. One COP472-3 can drive 36 segments multiplexed as 3 x 12 (4½ digit display). Two COP472-3 devices can be used together to drive 72 segments (3 x 24) which could be an 8½ digit display.

Features

- Direct interface to TRIPLEX LCD
- Low power dissipation (100 μW typ.)
- Low cost
- Compatible with all COP400 processors
- Needs no refresh from processor
- On-chip oscillator and latches
- Expandable to longer displays
- Software compatible with COP470 V.F. Display Driver chip
- Operates from display voltage
- MICROWIRE™ compatible serial I/O
- 20-pin Dual-In-Line package

Block Diagram



TL/DD/6932-1

Absolute Maximum Ratings

Voltage at CS, DI, SK pins	−0.3V to +9.5V	Storage Temperature	−65°C to +150°C
Voltage at all other Pins	−0.3V to V_{DD}+0.3V	Lead Temp. (Soldering, 10 Seconds)	300°C
Operating Temperature Range	0°C to 70°C		

DC Electrical Characteristics

GND = 0V, V_{DD} = 3.0V to 5.5V, T_A = 0°C to 70°C (depends on display characteristics)

Parameter	Conditions	Min	Max	Units
Power Supply Voltage, V_{DD}		3.0	5.5	Volts
Power Supply Current, I_{DD} (Note 1)	V_{DD}=5.5V		250	μA
	V_{DD}=3V		100	μA
Input Levels				
DI, SK, CS				
V_{IL}			0.8	Volts
V_{IH}		0.7 V_{DD}	9.5	Volts
BPA (as Osc. in)				
V_{IL}			0.6	Volts
V_{IH}		V_{DD}−0.6	V_{DD}	Volts
Output Levels, BPC (as Osc. Out)				
V_{OL}			0.4	Volts
V_{OH}		V_{DD}−0.4	V_{DD}	Volts
Backplane Outputs (BPA, BPB, BPC)				
$V_{BPA, BPB, BPC}$ ON	During	$V_{DD}-\Delta V$	V_{DD}	Volts
$V_{BPA, BPB, BPC}$ OFF	BP+ Time	$\frac{1}{3}V_{DD}-\Delta V$	$\frac{1}{3}V_{DD}+\Delta V$	Volts
$V_{BPA, BPB, BPC}$ ON	During	0	ΔV	Volts
$V_{BPA, BPB, BPC}$ OFF	BP− Time	$\frac{2}{3}V_{DD}-\Delta V$	$\frac{2}{3}V_{DD}+\Delta V$	Volts
Segment Outputs (SA_1 ~ SA_4)				
V_{SEG} ON	During	0	ΔV	Volts
V_{SEG} OFF	BP+ Time	$\frac{2}{3}V_{DD}-\Delta V$	$\frac{2}{3}V_{DD}+\Delta V$	Volts
V_{SEG} ON	During	$V_{DD}-\Delta V$	V_{DD}	Volts
V_{SEG} OFF	BP− Time	$\frac{1}{3}V_{DD}-\Delta V$	$\frac{1}{3}V_{DD}+\Delta V$	Volts
Internal Oscillator Frequency		15	80	kHz
Frame Time (Int. Osc. ÷ 192)		2.4	12.8	ms
Scan Frequency ($1/T_{SCAN}$)		39	208	Hz
SK Clock Frequency		4	250	kHz
SK Width		1.7		μs
DI				
Data Setup, t_{SETUP}		1.0		μs
Data Hold, t_{HOLD}		100		ns
$\overline{CS}$				
t_{SETUP}		1.0		μs
t_{HOLD}		1.0		μs
Output Loading Capacitance			100	pF

Note 1: Power supply current is measured in stand-alone mode with all outputs open and all inputs at V_{DD}.

Note 2: $\Delta V = 0.05V_{DD}$.

Absolute Maximum Ratings

If Military/Aerospace specified devices are required, please contact the National Semiconductor Sales Office/Distributors for availability and specifications.

Voltage at CS, DI, SK Pins	−0.3V to +9.5V
Voltage at All Other Pins	−0.3V to V_{DD}+0.3V
Operating Temperature Range	−40°C to +85°C
Storage Temperature	−65°C to +150°C
Lead Temperature (Soldering, 10 seconds)	300°C

DC Electrical Characteristics

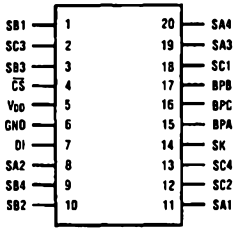
GND = 0V, V_{DD} = 3.0V to 5.5V, T_A = −40°C to +85°C (depends on display characteristics)

Parameter	Conditions	Min	Max	Units
Power Supply Voltage, V_{DD}		3.0	5.5	Volts
Power Supply Current, I_{DD} (Note 1)	V_{DD}=5.5V		300	μA
	V_{DD}=3V		120	μA
Input Levels				
DI, SK, CS				
V_{IL}			0.8	Volts
V_{IH}		0.7 V_{DD}	9.5	Volts
BPA (as Osc. In)				
V_{IL}			0.6	Volts
V_{IH}		V_{DD}−0.6	V_{DD}	Volts
Output Levels, BPC (as Osc. Out)				
V_{OL}			0.4	Volts
V_{OH}		V_{DD}−0.4	V_{DD}	Volts
Backplane Outputs (BPA, BPB, BPC)				
$V_{BPA, BPB, BPC}$ ON	During	$V_{DD}-\Delta V$	V_{DD}	Volts
$V_{BPA, BPB, BPC}$ OFF	BP+ Time	$\frac{1}{3} V_{DD}-\Delta V$	$\frac{1}{3} V_{DD}+\Delta V$	Volts
$V_{BPA, BPB, BPC}$ ON	During	0	ΔV	Volts
$V_{BPA, BPB, BPC}$ OFF	BP− Time	$\frac{2}{3} V_{DD}-\Delta V$	$\frac{2}{3} V_{DD}+\Delta V$	Volts
Segment Outputs (SA_1 ~ SA_4)				
V_{SEG} ON	During	0	ΔV	Volts
V_{SEG} OFF	BP+ Time	$\frac{2}{3} V_{DD}-\Delta V$	$\frac{2}{3} V_{DD}+\Delta V$	Volts
V_{SEG} ON	During	$V_{DD}-\Delta V$	V_{DD}	Volts
V_{SEG} OFF	BP− Time	$\frac{1}{3} V_{DD}-\Delta V$	$\frac{1}{3} V_{DD}+\Delta V$	Volts
Internal Oscillator Frequency		15	80	kHz
Frame Time (Int. Osc. ÷ 192)		2.4	12.8	ms
Scan Frequency ($1/T_{SCAN}$)		39	208	Hz
SK Clock Frequency		4	250	kHz
SK Width		1.7		μs
DI				
Data Setup, t_{SETUP}		1.0		μs
Data Hold, t_{HOLD}		100		ns
$\overline{CS}$				
t_{SETUP}		1.0		μs
t_{HOLD}		1.0		μs
Output Loading Capacitance			100	pF

Note 1: Power supply current is measured in stand-alone mode with all outputs open and all inputs at V_{DD}.

Note 2: ΔV = 0.05 V_{DD}.

Dual-In-Line Package



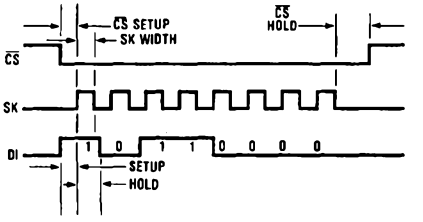
Top View

TL/DD/6932-2

Pin	Description
$\overline{CS}$	Chip select
V_{DD}	Power supply (display voltage)
GND	Ground
DI	Serial data input
SK	Serial clock input
BP_A	Display backplane A (or oscillator in)
BP_B	Display backplane B
BP_C	Display backplane C (or oscillator out)
SA1 ~ SC4	12 multiplexed outputs

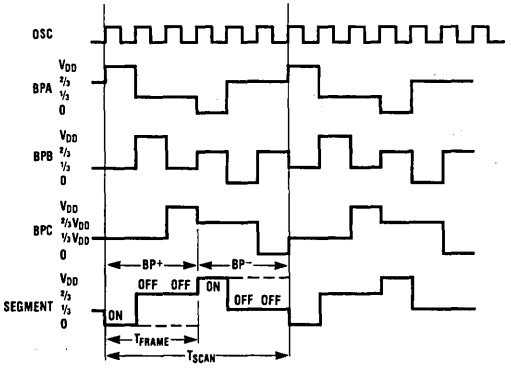
Order Number COP472MW-3 or COP472N-3
See NS Package Number M20A or N20A

FIGURE 2. Connection Diagram



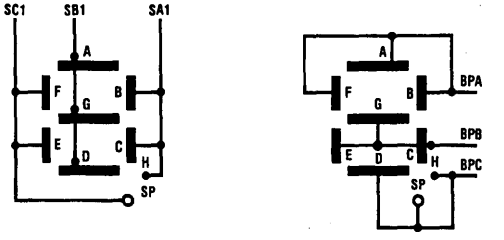
TL/DD/6932-3

FIGURE 3. Serial Load Timing Diagram



TL/DD/6932-4

FIGURE 4. Backplane and Segment Waveforms



TL/DD/6932-5

FIGURE 5. Typical Display Internal Connections
Epson LD-370

Functional Description

The COP472-3 drives 36 bits of display information organized as twelve segments and three backplanes. The COP472-3 requires 40 information bits: 36 data and 4 control. The function of each control bit is described below. Display information format is a function of the LCD interconnections. A typical segment/backplane configuration is illustrated in *Figure 5*, with this configuration the COP472-3 will drive 4 digits of 9 segments.

To adapt the COP472-3 to any LCD display configuration, the segment/backplane multiplex scheme is illustrated in Table I.

Two or more COP472-3 chips can be cascaded to drive additional segments. There is no limit to the number of COP472-3's that can be used as long as the output loading capacitance does not exceed specification.

TABLE I. COP472-3 Segment/Backplane Multiplex Scheme

Bit Number	Segment, Backplane	Data to Numeric Display	
1	SA1, BPC	SH	
2	SB1, BPB	SG	
3	SC1, BPA	SF	
4	SC1, BPB	SE	Digit 1
5	SB1, BPC	SD	
6	SA1, BPB	SC	
7	SA1, BPA	SB	
8	SB1, BPA	SA	
9	SA2, BPC	SH	
10	SB2, BPB	SG	
11	SC2, BPA	SF	
12	SC2, BPB	SE	Digit 2
13	SB2, BPC	SD	
14	SA2, BPB	SC	
15	SA2, BPA	SB	
16	SB2, BPA	SA	
17	SA3, BPC	SH	
18	SB3, BPB	SG	
19	SC3, BPA	SF	
20	SC3, BPB	SE	Digit 3
21	SB3, BPC	SD	
22	SA3, BPB	SC	
23	SA3, BPA	SB	
24	SB3, BPA	SA	
25	SA4, BPC	SH	
26	SB4, BPB	SG	
27	SC4, BPA	SF	
28	SC4, BPB	SE	Digit 4
29	SB4, BPC	SD	
30	SA4, BPB	SC	
31	SA4, BPA	SB	
32	SB4, BPA	SA	
33	SC1, BPC	SPA	Digit 1
34	SC2, BPC	SP2	Digit 2
35	SC3, BPC	SP3	Digit 3
36	SC4, BPC	SP4	Digit 4
37	not used		
38	Q6		
39	Q7		
40	SYNC		

SEGMENT DATA BITS

Data is loaded in serially, in sets of eight bits. Each set of segment data is in the following format:

SA	SB	SC	SD	SE	SF	SG	SH

Data is shifted into an eight bit shift register. The first bit of the data is for segment H, digit 1. The eighth bit is segment A, digit 1. A set of eight bits is shifted in and then loaded into the digit one latches. The second set of 8 bits is loaded into digit two latches. The third set into digit three latches, and the fourth set is loaded into digit four latches.

CONTROL BITS

The fifth set of 8 data bits contains special segment data and control data in the following format:

SYNC	Q7	Q6	X	SP4	SP3	SP2	SP1

The first four bits shifted in contain the special character segment data. The fifth bit is not used. The sixth and seventh bits program the COP472-3 as a stand alone LCD driver or as a master or slave for cascading COP472-3's. BPC of the master is connected to BPA of each slave. The following table summarizes the function of bits six and seven:

Q7	Q6	Function	BPC Output	BPA Output
1	1	Slave	Backplane Output	Oscillator Input
0	1	Stand Alone	Backplane Output	Backplane Output
1	0	Not Used	Internal Osc. Output	Oscillator Input
0	0	Master	Internal Osc. Output	Backplane Output

The eighth bit is used to synchronize two COP472-3's to drive an 8½-digit display.

LOADING SEQUENCE TO DRIVE A 4½-DIGIT DISPLAY

Steps:

1. Turn $\overline{CE}$ low.
2. Clock in 8 bits of data for digit 1.
3. Clock in 8 bits of data for digit 2.
4. Clock in 8 bits of data for digit 3.
5. Clock in 8 bits of data for digit 4.
6. Clock in 8 bits of data for special segment and control function of BPC and BPA.

0	0	1	1	SP4	SP3	SP2	SP1

7. Turn $\overline{CS}$ high.

Note: $\overline{CS}$ may be turned high after any step. For example to load only 2 digits of data, do steps 1, 2, 3, and 7.

$\overline{CS}$ must make a high to low transition before loading data in order to reset internal counters.

LOADING SEQUENCE TO DRIVE AN 8½-DIGIT DISPLAY

Two or more COP472-3's may be connected together to drive additional segments. An eight digit multiplexed display is shown in *Figure 7*. The following is the loading sequence to drive an eight digit display using two COP472-3's. The right chip is the master and the left the slave.

Steps:

1. Turn $\overline{CS}$ low on both COP472-3's.
2. Shift in 32 bits of data for the slave's four digits.
3. Shift in 4 bits of special segment data: a zero and three ones.

1	1	1	0	SP4	SP3	SP2	SP1

This synchronizes both the chips and BPA is oscillator input. Both chips are now stopped.

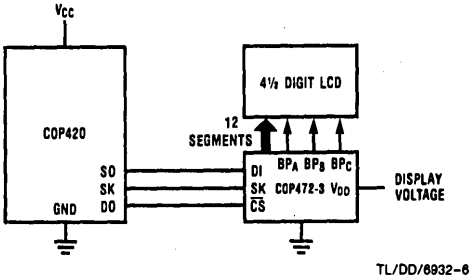
4. Turn CS high to both chips.
5. Turn CS low to master COP472-3.
6. Shift in 32 bits of data for the master's 4 digits.
7. Shift in four bits of special segment data, a one and three zeros.

0	0	0	1	SP4	SP3	SP2	SP1

This sets the master COP472-3 to BPA as a normal backplane output and BPC as oscillator output. Now both the chips start and run off the same oscillator.

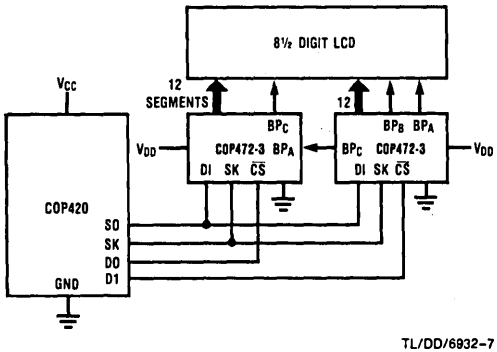
8. Turn $\overline{CS}$ high.

The chips are now synchronized and driving 8 digits of display. To load new data simply load each chip separately in the normal manner, keeping the correct status bits to each COP472-3 (0110 or 0001).



TL/DD/6932-6

FIGURE 6. System Diagram – 4½ Digit Display



TL/DD/6932-7

FIGURE 7. System Diagram – 8½ Digit Display

Example Software

Example 1

COP420 Code to load a COP472-3 [Display data is in M(0, 12)-M(0, 15), special segment data is in M(0, 0)]

```
                LBI 0, 12          ; POINT TO FIRST DISPLAY DATA
                OBD                ; TURN CS LOW (DO)
LOOP:           CLRA
                LQID               ; LOOK UP SEGMENT DATA
                CQMA               ; COPY DATA FROM Q TO M & A
                SC                 ; SET C TO TURN ON SK
                XAS                ; OUTPUT LOWER 4 BITS OF DATA
                NOP                ; DELAY
                NOP                ; DELAY
                LD                 ; LOAD A WITH UPPER 4 BITS
                XAS                ; OUTPUT 4 BITS OF DATA
                NOP                ; DELAY
                NOP                ; DELAY
                RC                 ; RESET C
                XAS                ; TURN OFF SK CLOCK
                XIS                ; INCREMENT B FOR NEXT DATA
                JP LOOP            ; SKIP THIS JUMP AFTER LAST DIGIT
                SC                 ; SET C
                LBI 0, 0           ; ADDRESS SPECIAL SEGMENTS
                LD                 ; LOAD INTO A
                XAS                ; OUTPUT SPECIAL SEGMENTS
                NOP                ;
                CLRA               ;
                AISC 12            ; 12 to A
                XAS                ; OUTPUT CONTROL BITS
                NOP                ;
                LBI 0, 15          ; 15 to B
                RC                 ; RESET C
                XAS                ; TURN OFF SK
                OBD                ; TURN CS HIGH (DO)
```

Example Software (Continued)

Example 2

COP420 Code to load two COP472-3 parts [Display data is in M(0, 12)-M(0, 15) and M(1, 12)-M(1, 15), special segment data is in M(0, 0) and M(1, 0)]

```
INIT:           LBI     0, 15
                OBD                     ; TURN BOTH CS'S HIGH
                LEI     8               ; ENABLE SO OUT OF S. R.
                RC
                XAS                     ; TURN OFF SK CLOCK
                LBI     3, 15           ; USE M(3, 15) FOR CONTROL BITS
                STII    7               ; STORE 7 TO SYNC BOTH CHIPS
                LBI     0, 12           ; SET B TO TURN BOTH CS'S LOW
                JSR     OUT             ; CALL OUTPUT SUBROUTINE

MAIN DISPLAY SEQUENCE
DISPLAY         LBI     3, 15
                STII    8               ; SET CONTROL BITS FOR SLAVE
                LBI     0, 13           ; SET B TO TURN SLAVE CS LOW
                JSR     OUT             ; OUTPUT DATA FROM REG. 0
                LBI     3, 15
                STII    6               ; SET CONTROL BITS FOR MASTER
                LBI     1, 14           ; SET B TO TURN MASTER CS LOW
                JSR     OUT             ; OUTPUT DATA FROM REG. 1

OUTPUT SUBROUTINE
OUT:            OBD                     ; OUTPUT B TO CS'S
                CLRA
                AISC    12              ; 12 TO A
                CAB                     ; POINT TO DISPLAY DIGIT (BD = 12)
LOOP            CLRA
                LQID                    ; LOOK UP SEGMENT DATA
                CQMA                    : COPY DATA FROM Q TO M & A
                SC
                XAS                     ; OUTPUT LOWER 4 BITS OF DATA
                NOP                     ; DELAY
                NOP                     ; DELAY
                LD                      ; LOAD A WITH UPPER 4 BITS
                XAS                     ; OUTPUT 4 BITS OF DATA
                NOP                     ; DELAY
                NOP                     ; DELAY
                RC                      ; RESET C
                XAS                     ; TURN OFF SK
                XIS                     ; INCREMENT B FOR NEXT DISPLAY DIGIT
                JP      LOOP            ; SKIP THIS JUMP AFTER LAST DIGIT
                SC                      ; SET C
                NOP
                LD                      ; LOAD SPECIAL SEGS. TO A (BD = 0)
                XAS                     ; OUTPUT SPECIAL SEGMENTS
                NOP
                LBI     3, 15
                LD                      ; LOAD A
                XAS                     ; OUTPUT CONTROL BITS
                NOP
                NOP
                RC
                XAS                     ; TURN OFF SK
                OBD                     ; TURN CS'S HIGH (BD = 15)
                RET
```