National Semiconductor

COP470/COP370 V.F. Display Driver

General Description

The COP470 is a peripheral member of National's COPS™ Microcontroller family. It is designed to directly drive a multiplexed Vacuum Fluorescent display. Data is loaded serially and held in internal latches. The COP470 has an on-chip oscillator to multiplex four digits of eight segment display and may be cascaded and/or stacked to drive more digits, more segments, or both.

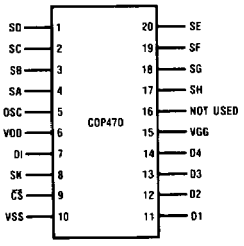
With the addition of external drivers, the COP470 also provides a convenient means of interfacing to a large-digit LED display. The COP370 is the extended temperature range version of the COP470.

Features

- Directly interfaces to multiplexed 4 digit by 8 segment Vacuum Fluorescent displays
- Expandable to drive 8 digits and/or 16 segments
- Compatible with all COP400 processors
- Needs no refresh from processor
- Internal or external oscillator
- No "glitches" on outputs when loading data
- Drives large and small displays
- Programmable display brightness
- Small (20-pin) dual-in-line package
- Operates from 4.5V to 9.5V
- Outputs switch 30V and require no external resistors
- Static latches
- MICROWIRE™ compatible serial I/O
- Extended temperature device COP370 (−40°C to +85°C)

Connection and Block Diagrams

Dual-In-Line Package

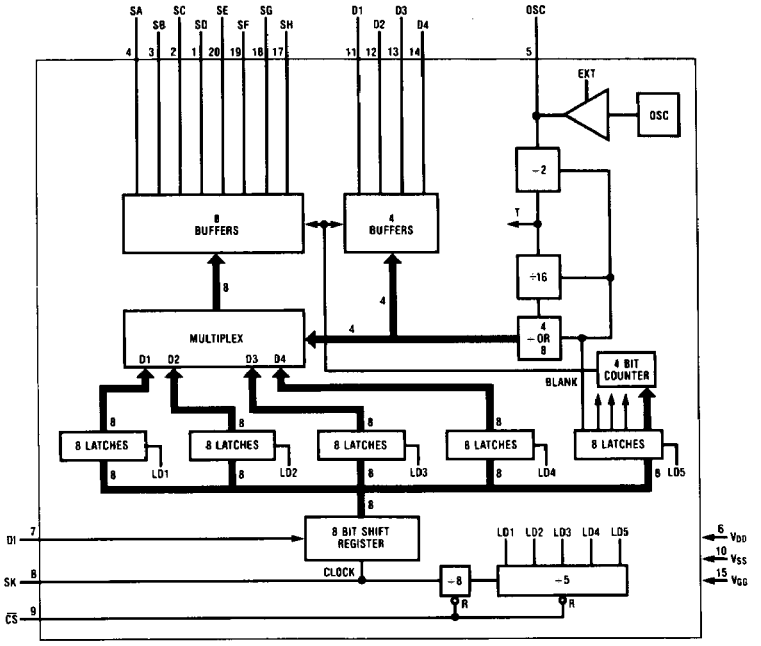


TL/DD/6154-1

Top View

FIGURE 1. COP470

Order Number COP470D, COP370D, COP470N or COP370N
See NS Package Number D20A or N20A



TL/DD/6154-2

FIGURE 2. COP470

Absolute Maximum Ratings (V_{SS} = 0)

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

Voltage at Display Outputs	+0.3V to −30V
Voltage at All Other Pins	+0.3V to −20V
Operating Temperature	
COP470	0°C to +70°C
COP370	−40°C to +85°C
Storage Temperature	−65°C to +150°C
Lead Temperature (Soldering, 10 sec.)	300°C
Package Power Dissipation	400 mW at 25°C 200 mW at 70°C 125 mW at 85°C

DC Electrical Characteristics

V_{SS} = 0, V_{DD} = −4.5V to −9.5V, V_{GG} = −30V, T_A = 0°C to +70°C for COP470 and T_A = 40°C to 85°C for COP370 unless otherwise specified.

Parameter	Min	Max	Units
Power Supply Voltage			
V_{DD}	−9.5	−4.5	V
V_{GG}	−30	V_{DD}	V
Power Supply Current			
I_{DD}		5	mA
I_{GG} (Displayed Blanked)		1	mA
Input Levels			
V_{IH}	−1.5	+0.3	V
V_{IL}	−10.0	−4.0	V
Output Drive Digits and Segments			
I_{OH} @ V_{OH} = V_{SS} − 3V	10		mA
I_{OH} @ V_{OH} = V_{SS} − 2V	7		mA
I_{OL} @ V_{OL} = V_{GG} + 2V(1)	10		μA
Output Drive @ V_{GG} = V_{DD} = V_{SS} −5V			
I_{OH} @ V_{OH} = V_{SS} −2V	1		mA
Allowable Source Current			
Per Pin		20	mA
Total for Segments		60	mA
Input Capacitance		7	pF
Input Leakage		1	μA

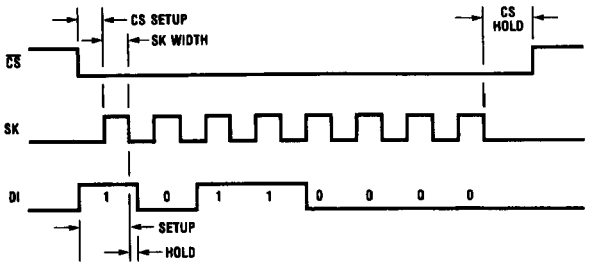
AC Electrical Characteristics

V_{SS} = 0, V_{DD} = −4.5V to −9.5V, V_{GG} = −30V, T_A = 0°C to +70°C for COP470 and T_A = 40°C to 85°C for COP370 unless otherwise specified.

Parameter	Min	Max	Units
OSC Period (internal or external)	4	20	μs
OSC Pulse Width	1.5		μs
Clock Period T (twice Osc. period)	8	40	μs
Display Frequency			
4 digits = 1/64T	390	2000	Hz
8 digits = 1/128T	190	1000	Hz
SK Clock Frequency	0	250	kHz
SK Clock Width	1.5		μs
Data Set-up and Hold Time			
t_{SETUP}	1.0		μs
t_{HOLD}	50		ns
CS Set-up and Hold Time			
t_{SETUP}	1.0		μs
t_{HOLD}	1.0		μs
Duty Cycle			
4 digits	1/64	15/64	
8 digits	1/128	15/128	

Note 1: I_{OL} current is to V_{GG} with the chip running. Current is measured just after the output makes a high-to-low transition.

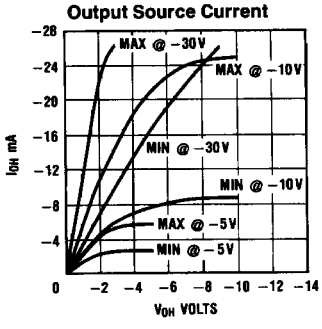
Timing Diagram



TL/DD/6154-3

FIGURE 3. Serial Load Timing Diagram

Performance Characteristic



TL/DD/6154-4

Functional Description

SEGMENT DATA BITS

Data is loaded in serially in sets. 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.

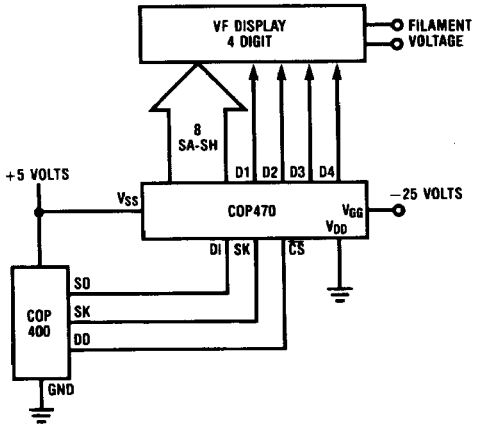
DISPLAY ON TIME AND CONTROL BITS

The fifth set of 8 data bits contains blank time data and control data in the following format:

		Display Digits				
Sync	Ext.	Right	Left	←	On Time	→
	Osc.	4 of 8	4 of 8	LSB		MSB

The first four bits shifted in contain the on time. This is used to control display brightness. The brightness is a function of the on time of each segment divided by the total time (duty cycle). The on time is programmable from 0 to 15 and the total time is 64. For example, if the on time is 15, the duty cycle is 15/64 which is maximum brightness. If on time is 8, the duty cycle is 8/64, about 1/2 brightness. There are 16 levels of brightness from 15/64 to 0/64 (off).

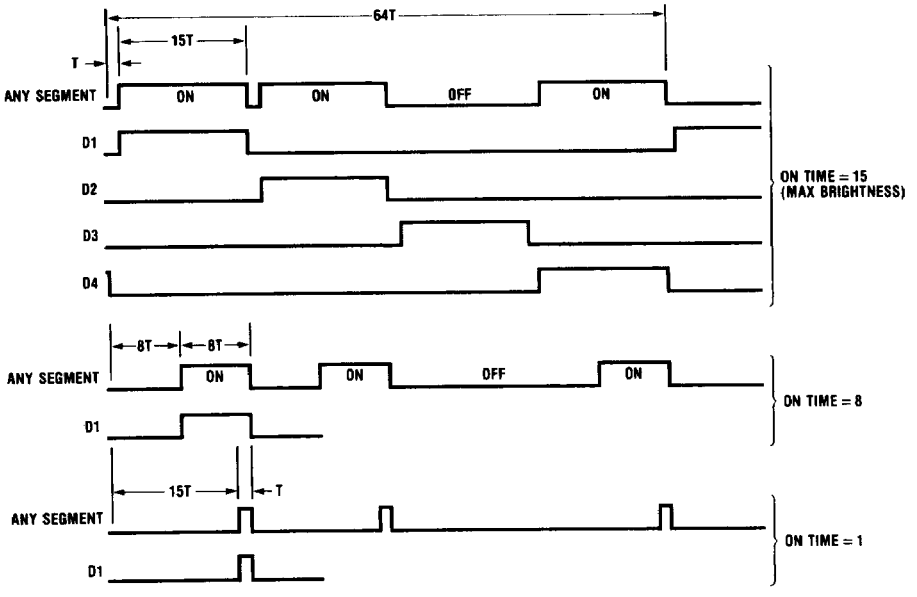
The fifth and sixth bits control the multiplex digits. To enable the COP470 to drive a 4 digit multiplex display, set both bits to one. If two COP470s are used to drive an 8 digit display, bit five is set on the left COP470 and bit six is set on the right COP470 (see *Figure 6*). In the eight digit mode, the display duty cycle is on time/128.



TL/DD/6154-5

FIGURE 4. System Diagram—4 Digit Display

Functional Description (Continued)



TL/DD/6154–6

FIGURE 5. Segment and Digit Output Timing Diagram

The seventh bit selects internal or external oscillator. The OSC pin of the COP470 is either an output of the internal oscillator (bit 7 = 0) or is an input allowing the COP470 to run from an external oscillator (bit 7 = 1).

The eighth bit is set to synchronize two COP470s. For example, to set the COP470 to internal osc, 4 digits, and maximum brightness, send out six ones and two zeros.

LOADING SEQUENCE

Step

1. Turn $\overline{CS}$ 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 on time and control bits.
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.

8 DIGIT Displays

Two COP470s may be tied together in order to drive an eight digit multiplexed display. This is shown in *Figure 6.* The following is the loading sequence to drive an eight digit display using two COP470s.

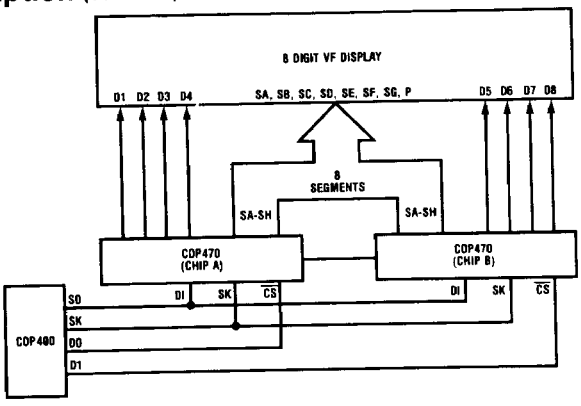
1. Turn $\overline{CS}$ lwo on both COP470s.
2. Shift in 32 bits of data for the right 4 digits.
3. Shift in 4 bits of on time, a zero and three ones. This synchronizes both chips, sets to external oscillator, and to right four of eight digits. Thus both chips are synchronized and the oscillator is stopped.
4. Turn $\overline{CS}$ high to both chips.
5. Turn $\overline{CS}$ low to the left COP470.
6. Shift in 32 bits of data for the left 4 digits.
7. Shift in 4 bits of on time, a one and three zeros. This sets this COP470 to internal oscillator and to left four of eight digits. Now both chips start and run off the same oscillator.
8. Turn $\overline{CS}$ high.

The chips are now synchronized and driving eight digits of display. To load new data simply load each chip separately in the normal manner.

16 SEGMENT DISPLAY

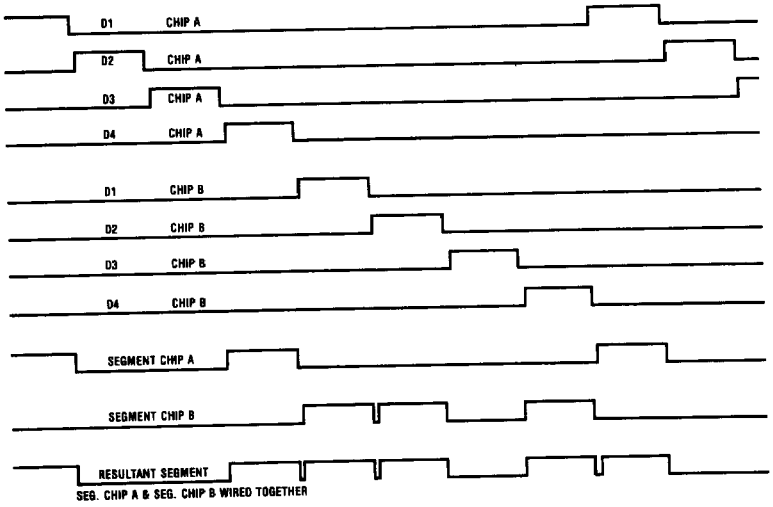
Two COP470s may be tied together in order to drive a sixteen segment display. This is shown in *Figure 8.* To do this, both chips must be synchronized, one must run off external oscillator while the other runs off its internal oscillator outputting to the other. Similarly, four COP470s could be tied together to drive eight digits of sixteen segments.

Functional Description (Continued)



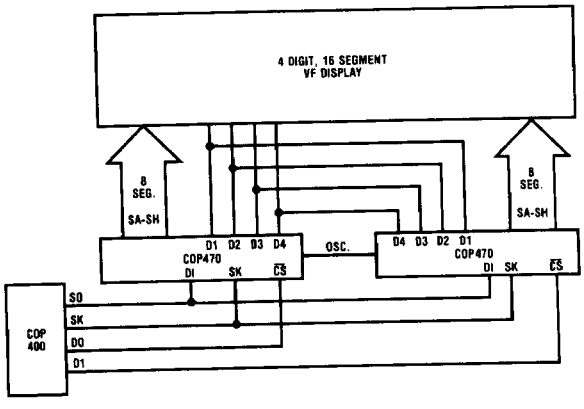
TL/DD/6154-7

FIGURE 6. System Diagram 8 Digit Display



TL/DD/6154-8

FIGURE 7. Segment and Digit Output Timing Diagram for 8 Digits



TL/DD/6154-9

FIGURE 8. System Diagram for 16 Segment Display

Functional Description (Continued)

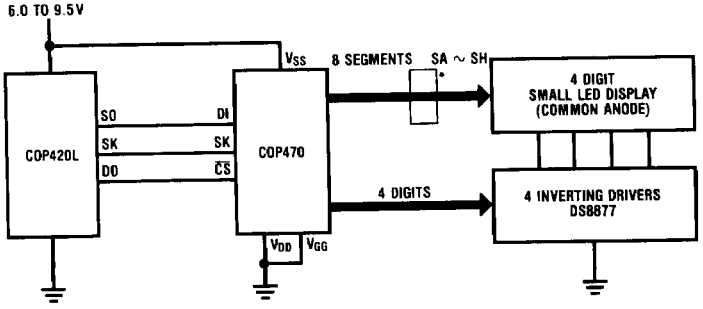
LED DISPLAY

The COP470 may be used to drive LED displays. The COP470 can drive the segments directly on small, low current LED displays as shown in *Figure 9.* By adding display drivers, large, high current LED displays can be driven as shown in *Figure 10.*

Example:
COP420 Code to Load COP470
(Display Data is in Memory 0, 12–0, 15)

```
        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
        CLRA            ;
        AISC 15         ; 15 to A
        XAS             ; Output on time (max brightness)
        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)
```

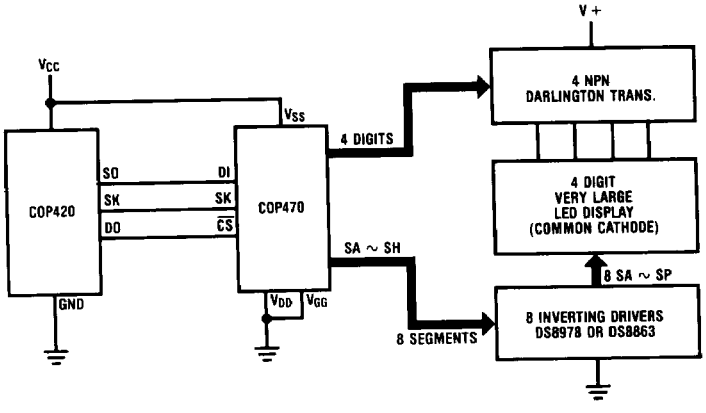
Functional Description (Continued)



TL/DD/6154-10

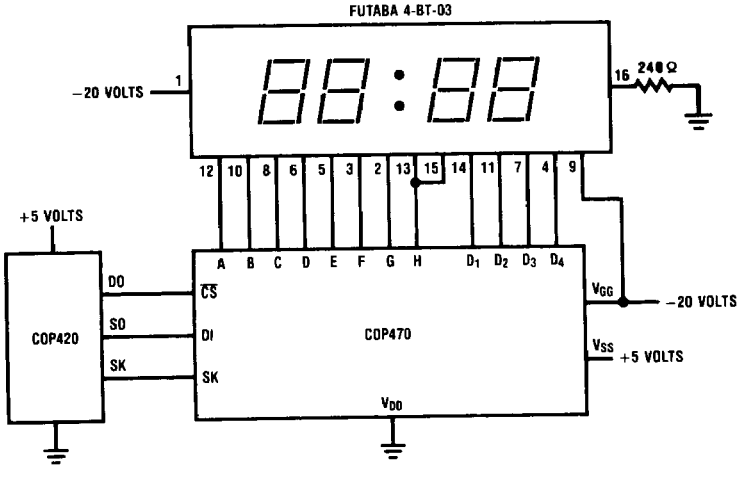
*Segment buffer may be added for larger display.

FIGURE 9. LED Display



TL/DD/6154-11

FIGURE 10. Large LED Display



TL/DD/6154-12

FIGURE 11. Sample V.F. System