National Semiconductor

COP8640CMH/COP8642CMH Microcontroller Emulator

General Description

The COP8640CMH/COP8642CMH hybrid emulators are members of the COPS™ microcontroller family. The devices (offered in 28-pin DIP LCC and 20-pin DIP) contain transparent windows which allow the EPROM to be erased and reprogrammed. They are fully static parts, fabricated using double-metal silicon gate microCMOS technology. These microcontrollers are complete microcomputers containing all system timing, interrupt logic, EPROM, RAM, EEPROM, and I/O necessary to implement dedicated control functions in a variety of applications. Features include an 8-bit memory mapped architecture, MICROWIRE/PLUS™ serial I/O, a 16-bit timer/counter with capture register and a multi-sourced interrupt. Each I/O pin has software selectable options to adapt the COP8640CMH/COP8642CMH to the specific application. The part operates over a voltage range of 4.5V to 6.0V. High throughput is achieved with an efficient, regular instruction set operating at a 1 microsecond per instruction rate.

COP8640CMH and COP8642CMH are intended primarily as a prototyping design tool. The Electrical Performance Characteristics are not tested but are included for reference only.

Features

- Form fit and function emulation devices for COP8640C/ COP8642C/COP8620C/COP8622C
- Fully static CMOS
- 1 μs instruction time
- Single supply operation: 4.5V to 6.0V
- 8k bytes EPROM/64 bytes RAM/64 bytes EEPROM
- 16-Bit read/write timer operates in a variety of modes
  - Timer with 16-bit auto reload register
  - 16-bit external event counter
  - Timer with 16-bit capture register (selectable edge)
- Multi-source interrupt
  - Reset master clear
  - External interrupt with selectable edge
  - Timer interrupt or capture interrupt
  - Software interrupt
- 8-bit stack pointer (stack in RAM)
- Powerful instruction set, most instructions single byte
- BCD arithmetic instructions
- MICROWIRE/PLUS serial I/O
- 28-pin and 20-pin DIP packages
- 24 input/output pins (28-pin package)
- Software selectable I/O options (TRI-STATE®, push-pull, weal pull-up)
- Schmitt trigger inputs on Port G
- Fully supported by National's Development Systems

Ordering Information

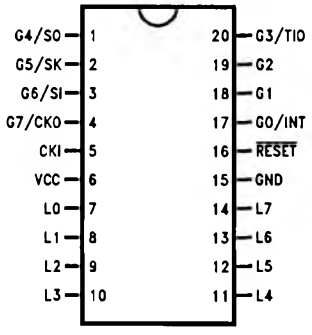
Hybrid Emulator	Package Type	Part Emulated
COP8640CMHD-x	28-DIP	COP8640C-XXX/N COP8620C-XXX/N
COP8642CMHD-x	20-DIP	COP8642C-XXX/N COP8622C-XXX/N

x = 1, 2, 3 corresponds to oscillator option.

Connection Diagrams

DUAL-IN-LINE PACKAGES

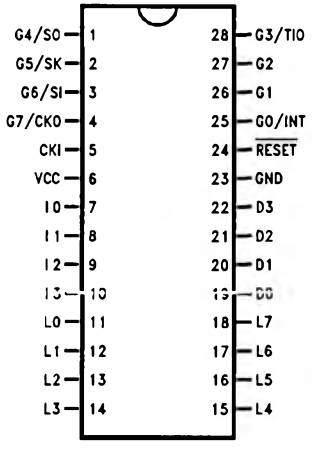
20-Pin DIP



TL/DD/11207–1

Top View

28-Pin DIP



TL/DD/11207–2

Top View

FIGURE 1. COP8640CMH/COP8642CMH Connection Diagrams

COP8640CMH/COP8642CMH Pinouts

Port	Type	Alternate Function	20-Pin DIP	28-Pin DIP/LCC
L0	I/O		7	11
L1	I/O		8	12
L2	I/O		9	13
L3	I/O		10	14
L4	I/O		11	15
L5	I/O		12	16
L6	I/O		13	17
L7	I/O		14	18
G0	I/O	Interrupt	17	25
G1	I/O		18	26
G2	I/O		19	27
G3	I/O	TIO	20	28
G4	I/O	SO	1	1
G5	I/O	SK	2	2
G6	I	SI	3	3
G7	I/CKO	Halt Restart	4	4
I0	I			7
I1	I			8
I2	I			9
I3	I			10
D0	O			19
D1	O			20
D2	O			21
D3	O			22
V_{CC}			6	6
GND			15	23
CKI			5	5
$\overline{\text{RESET}}$			16	24

COP8640CMH/COP8642CMH

Absolute Maximum Ratings (Note)

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

Supply Voltage (V_{CC})	7V
Voltage at Any Pin	−0.3V to V_{CC} + 0.3V
Total Current into V_{CC} Pin (Source)	50 mA
Total Current out of GND Pin (Sink)	60 mA
Storage Temperature Range	−65°C to +140°C

Note: Absolute maximum ratings indicate limits beyond which damage to the device may occur. DC and AC electrical specifications are not ensured when operating the device at absolute maximum ratings.

The following AC and DC Electrical Characteristics are not tested but are for reference only.

DC Electrical Characteristics 0°C ≤ T_A ≤ +70°C unless otherwise specified

Parameter	Condition	Min	Typ	Max	Units
Operating Voltage		4.5		6.0	V
Power Supply Ripple (Note 1)	Peak to Peak			0.1 V_{CC}	V
Supply Current					
CKI = 10 MHz	V_{CC} = 6V, t_c = 1 μs			19	mA
Supply Current during					
Write Operation (Note 2)					
CKI = 10 MHz	V_{CC} = 6V, t_c = 1 μs			25	mA
HALT Current (Note 3)	V_{CC} = 6V, CKI = 0 MHz		500		μA
Input Levels					
$\overline{\text{RESET}}$, CKI					
Logic High		0.9 V_{CC}			V
Logic Low				0.1 V_{CC}	V
All Other Inputs					
Logic High		0.7 V_{CC}			V
Logic Low				0.2 V_{CC}	V
Hi-Z Input Leakage	V_{CC} = 6.0V	−2		+2	μA
Input Pullup Curent	V_{CC} = 6.0V	40		250	μA
G Port Input Hysteresis			0.05 V_{CC}		V
Outut Current Levels					
D Outputs					
Source	V_{CC} = 4.5V, V_{OH} = 3.8V	0.4			mA
Sink	V_{CC} = 4.5V, V_{OL} = 1.0V	10			mA
All Others					
Source (Weak Pull-Up)	V_{CC} = 4.5V, V_{OH} = 3.2V	10		110	μA
Source (Push-Pull Mode)	V_{CC} = 4.5V, V_{OH} = 3.8V	0.4			mA
Sink (Push-Pull Mode)	V_{CC} = 4.5V, V_{OL} = 0.4V	1.6			mA
TRI-STATE Leakage		−2.0		+2.0	μA
Allowable Sink/Source					
Current per Pin					
D Outputs (Sink)				15	mA
All Others				3	mA
Maximum Input Current (Note 4) without Latchup (Room Temp)	Room Temp			±100	mA
RAM Retention Voltage, Vr	500 ns Rise and Fall Time (Min)	2.0			V
Input Capacitance				7	pF

COP8640CMH/COP8642CMH (Continued)

DC Electrical Characteristics $0°C \le T_A \le +70°C$ unless otherwise specified (Continued)

Parameter	Condition	Min	Typ	Max	Units
EEPROM Characteristics					
EEPROM Write Cycle Time				10	ms
EEPROM Number of Write Cycles				10,000	Cycle
EEPROM Data Retention				10	Years

Note 1: Rate of voltage change must be less than 0.5V/ms.

Note 2: Supply current is measured after running 2000 cycles with a square wave CKI input, CKO open, inputs at rails and outputs open.

Note 3: The HALT mode will stop CKI from oscillating in the RC and the Crystal configurations. Test conditions: All inputs tied to V_{CC}, L and G ports at TRI-STATE and tied to ground, all outputs low and tied to ground.

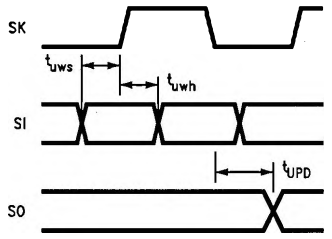
Note 4: Pins G6 and $\overline{\text{RESET}}$ are designed with a high voltage input network for factory testing. These pins allow input voltages greater than V_{CC} and the pins will have sink current to V_{CC} when biased at voltages greater than V_{CC} (the pins do not have source current when biased at a voltage below V_{CC}). The effective resistance to V_{CC} is 750Ω (typical). These two pins will not latch up. The voltage at the pins must be limited to less than 14V.

AC Electrical Characteristics $0°C \le T_A \le +70°C$ unless otherwise specified

Parameter	Condition	Min	Typ	Max	Units
Instruction Cycle Time (t_c)					
Ext, Crystal/Resonator (Div-by 10)		1		DC	μs
R/C Oscillator Mode (Div-by 10)		3		DC	μs
CKI Clock Duty Cycle (Note 4)		40		60	%
Rise Time (Note 4)	fr = 10 MHz Ext Clock			12	ns
Fall Time (Note 4)	fr = 10 MHz Ext Clock			8	ns
Inputs					
t_{SETUP}		200			ns
t_{HOLD}		60			ns
Output Propagation Delay t_{PD1}, t_{PD0}	C_L = 100 pF, R_L = 2.2 kΩ				
SO, SK				0.7	μs
All Others				1	μs
MICROWIRE™ Setup Time (t_{UWS})		20			ns
MICROWIRE Hold Time (T_{UWH})		56			ns
MICROWIRE Output Propagation Delay Time (t_{UPD})				220	ns
Input Pulse Width					
Interrupt Input High Time		1			t_c
Interrupt Input Low Time		1			t_c
Timer Input High Time		1			t_c
Timer Input Low Time		1			t_c
Reset Pulse Width		1.0			μs

Note 4: Parameter sampled but not 100% tested.

Timing Diagram



TL/DD/11207–3

FIGURE 2. MICROWIRE/PLUS Timing

Pin Descriptions

V_{CC} and GND are the power supply pins.

CKI is the clock input. This can come from an external source, a R/C generated oscillator or a crystal (in conjunction with CKO). See Oscillator description.

$\overline{\text{RESET}}$ is the master reset inupt. See Reset description.

PORT I is a four bit Hi-Z input port.

PORT L is an 8-bit I/O port.

There are two registers associated with each L I/O port: a data register and a configuration register. Therefore, each L I/O bit can be individually configured under software control as shown below:

Port L Config.	Port L Data	Port L Setup
0	0	Hi-Z Inupt (TRI-STATE)
0	1	Input with Weak Pull-Up
1	0	Push-Pull "0" Output
1	1	Push-Pull "1" Output

Three data memory address locations are allocated for these ports, one for data register, one for configuration register and one for the input pins.

PORT G is an 8-bit port with 6 I/O pins (G0–G5) and 2 input pins (G6, G7). All eight G-pins have Schmitt Triggers on the inputs. The G7 pin functions as an input pin under normal operation and as the continue pin to exit the HALT mode. There are two registers with each I/O port: a data register and a configuration register. Therefore, each I/O bit can be individually configured under software control as shown below:

Port G Config.	Port G Data	Port G Setup
0	0	Hi-Z Input (TRI-STATE)
0	1	Input with Weak Pull-Up
1	0	Push-Pull "0" Output
1	1	Push-Pull "1" Output

Three data memory address locations are allocated for these ports, one for data register, one for configuration register and one for the input pins. Since G6 and G7 are input only pins, any attempt by the user to set them up as outputs by writing a one to the configuration register will be disregarded. Reading the G6 and G7 configuration bits will return zeros. Note that the chip will be placed in the HALT mode by setting the G7 data bit.

Six bits of Port G have alternate features:

G0 INTR (an external interrupt)

G3 TIO (timer/counter input/output)

G4 SO (MICROWIRE serial data output)

G5 SK (MICROWIRE clock I/O)

G6 SI (MICROWIRE serial data input)

G7 CKO crystal oscillator output (selected by mask option) or HALT restart input (general purpose input)

Pins G1 and G2 currently do not have any alternate functions.

PORT D is a four bit output port that is set high when $\overline{\text{RESET}}$ goes low.

Functional Description

OSCILLATOR CIRCUITS

Figure 3 shows the three clock oscillator configurations. Table III shows the clock options per package.

A. CRYSTAL OSCILLATOR

The COP8640CMH/COP8642CMH can be driven by a crystal clock. The crystal network is cnonected between the pins CKI and CKO.

Table I shows the component values required for various standard crystal values.

B. EXTERNAL OSCILLATOR

CKI can be driven by an external clock signal. CKI is available as a general purpose input and/or HALT restart control.

C. R/C OSCILLATOR

CKI is configured as a single pin RC controlled Schmitt trigger oscillator. CKO is available as a general purpose input and/or HALT restart control.

Table II shows the variation in the oscillator frequencies (due to the part) as functions of the R/C component values (R/C tolerances not included).

TABLE I. Crystal Oscillator Configuration
T_A = 25°C, V_{CC} = 5.0V

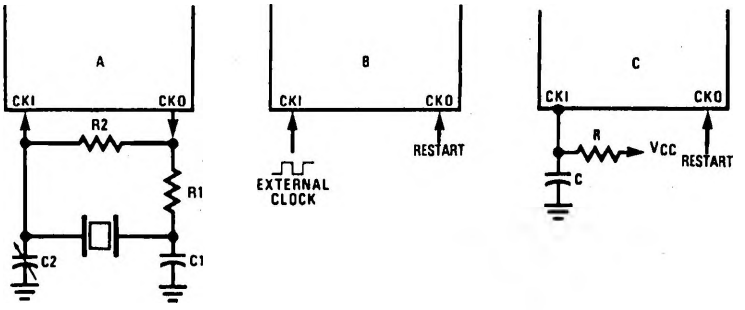
R1 (kΩ)	R2 (MΩ)	C1 (pF)	C2 (pF)	CKI Freq (MHz)
0	1	30	30–36	10
0	1	30	30–36	4
5.5	1	100	100	0.455

TABLE II. RC Oscillator Configuration
T_A = 25°C, V_{CC} = 5.0V

R (kΩ)	C (pF)	CKI Freq. (MHz)	Instr. Cycle (μs)
3.3	82	2.2 to 2.7	3.7 to 4.6
5.6	100	1.1 to 1.3	7.4 to 9.0
6.8	100	0.9 to 1.1	8.8 to 10.8

Note: 3k ≤ R ≤ 200k
50 pF ≤ C ≤ 200 pF

Functional Description (Continued)



TL/DD/11207–4

FIGURE 3. Crystal and R–C Connection Diagrams

TABLE III. Clock Option per Package

Order Part Number	Package	Clock Option
COP8640CMHD-1 COP8642CMHD-1	28 DIP 20 DIP	Crystal Oscillator ÷ 10
COP8640CMHD-2 COP8642CMHD-2	28 DIP 20 DIP	External Oscillator ÷ 10
COP8640CMHD-3 COP8642CMHD-3	28 DIP 20 DIP	R/C Oscillator ÷ 10

Programming the COP8640CMH/COP8642CMH

Programming the hybrid emulators is accomplished through the duplicator board which is a stand alone programmer capable of supporting different package types. It works in conjunction with a pre-programmed EPROM (either via the NSC development system or a standard programmer) holding the application program. The duplicator board essentially copies the information in the EPROM into the hybrid emulator.

The last byte of program memory (EPROM location 01FFF Hex) must contain the proper value specified in the following table:

TABLE IV

Device	Package Type	Contents of Last Byte (Address 01FFF)
COP8640CMHD	28 DIP	6F
COP8642CMHD	20 DIP	E7

ERASING THE PROGRAM MEMORY

Erasure of the EPROM program memory is achieved by removing the device from its socket and exposing the transparent window to an ultra-violet light source.

The erasure characteristics of the device are such that erasure begins to occur when exposed to light with wavelengths shorter than approximately 4000 Angstroms (Å). It should be noted that sunlight and certain types of fluorescent lamps have wavelengths in the 3000Å to 4000Å range.

After programming, opaque labels should be placed over the window of the device to prevent temporary functional failure due to the generation of photo currents, erasure, and excessive HALT current. Note that the device will also draw more current than normal (especially in HALT mode) when the window of the device is not covered with an opaque label.

The recommended erasure procedure for the devices is exposure to short wave ultraviolet light which has a wavelength of 2537Å. The integrated dose (UV intensity × exposure time) for erasure should be a minimum of 15 W-sec/cm^2.

An erasure system should be calibrated periodically. The distance from lamp to device should be maintained at one inch. The erasure time increases as the square of the distance. Lamps lose intensity as they age. When a lamp has aged, the system should be checked to make certain that adequate UV dosages are being applied for full erasure.

The device should be placed within one inch of the lamp tubes during erasure. Some lamps have a filter on their tubes which should be removed before erasure. The following table shows the minimum erasure time for various light intensities:

TABLE V. Minimum Erasure Time

Package Type	Light Intensity (Micro-Watts/cm^2)	Erasure Time (Minutes)
28 DIP	15,000	20
	10,000	25
	5,000	50
20 DIP	15,000	40
	10,000	50
	5,000	100

Development Support

IN-CIRCUIT EMULATOR

The MetaLink iceMASTER™-COP8 Model 400 In-Circuit Emulator for the COP8 family of microcontrollers features high-performance operation, ease of use, and an extremely flexible user-interface for maximum productivity. Interchangeable probe cards, which connect to the standard common base, support the various configurations and packages of the COP8 family.

The iceMASTER provides real time, full speed emulation up to 10 MHz, 32 kbytes of emulation memory and 4k frames of trace buffer memory. The user may define as many as 32k trace and break triggers which can be enabled, disabled, set or cleared. They can be simple triggers based on code or address ranges or complex triggers based on code address, direct address, opcode value, opcode class or immediate operand. Complex breakpoints can be ANDed and ORed together. Trace information consists of address bus values, opcodes and user selectable probe clips status (external event lines). The trace buffer can be viewed as raw hex or as disassembled instructions. The probe clip bit values can be displayed in binary, hex or digital waveform formats.

During single-step operation the dynamically annotated code feature displays the contents of all accessed (read and write) memory locations and registers, as well as flow-of-control direction change markers next to each instruction executed.

The iceMASTER's performance analyzer offers a resolution of better than 6 μs. The user can easily monitor the time spent executing specific portions of code and find "hot spots" or "dead code". Up to 15 independent memory areas based on code address or label ranges can be defined. Analysis results can be viewed in bar graph format or as actual frequency count.

Emulator memory operations for program memory include single line assembler, disassembler, view, change and write to file. Data memory operations include fill, move, compare, dump to file, examine and modify. The contents of any memory space can be directly viewed and modified from the corresponding window.

The iceMASTER comes with an easy to use windowed interface. Each window can be sized, highlighted, color-controlled, added, or removed completely. Commands can be accessed via pull-down-menus and/or redefineable hot keys. A context sensitive hypertext/hyperlinked on-line help system explains clearly the options the user has from within any window.

The iceMASTER connects easily to a PC® via the standard COMM port and its 115.2 kBaud serial link keeps typical program download time to under 3 seconds.

The following tables list the emulator and probe cards ordering information.

Emulator Ordering Information

Part Number	Description
IM-COP8/400	MetaLink base unit in-circuit emulator for all COP8 devices, symbolic debugger software and RS 232 serial interface cable
MHW-PS3	Power Supply 110V/60 Hz
MHW-PS4	Power Supply 220V/50 Hz

Probe Card Ordering Information

Part Number	Package	Voltage Range	Emulates
MHW-8640C20D5PC	20 DIP	4.5V–5.5V	COP8642C, 8622C
MHW-8640C20DWPC	20 DIP	2.5V–6.0V	COP8642C, 8622C
MHW-8640CG28D5PC	28 DIP	4.5V–5.5V	COP8640C, 8620C
MHW-8640CG28DWPC	28 DIP	2.5V–6.0V	COP8640C, 8620C

Development Support (Continued)

MACRO CROSS ASSEMBLER

National Semiconductor offers a COP8 macro cross assembler. It runs on industry standard compatible PCs and supports all of the full-symbolic debugging features of the MetaLink iceMASTER emulators.

SIMULATOR

The COP8 Designers' Toolkit is available for evaluating National Semiconductor's COP8 microcontroller family. The kit contains programmer's manuals, device datasheets, pocket reference guides, assembler and simulator which allow the user to write, test, debug and run code on an industry standard compatible PC. The simulator has a windowed user interface and can handle script files that simulate hardware inputs, interrupts and automatic command processing. The capture file feature enables the user to record to a file current cycle count and output port changes which are caused by the program under test.

SINGLE CHIP EMULATOR DEVICE

The COP8 family is fully supported by single chip form, fit and function emulators. For more detailed information refer to the emulation device specific data sheets and the form, fit, function emulator selection table below.

PROGRAMMING SUPPORT

Programming of the single chip emulator devices is supported by different sources. National Semiconductor offers a duplicator board which allows the transfer of program code from a standard programmed EPROM to the single chip emulator and vice versa. Data I/O supports COP8 emulator device programming with its uniSite 48 and System 2900 programmers. Further information on Data I/O programmers can be obtained from any Data I/O sales office or the following USA numbers:

Telephone: (206) 881-6444 FAX: (206) 882-1043

Assembler Ordering Information

Part Number	Description	Manual
MOLE-COP8-IBM	COP8 Macro Cross Assembler for IBM® PC-XT®, PC-AT® or Compatible	424410527-001

Simulator Ordering Information

Part Number	Description	Manual
COP8-TOOL-KIT	COP8 Designer's Tool Kit Assembler and Simulator	420420270-001 424420269-001

Single Chip Emulator Selection Table

Device Number	Clock Option	Package	Description	Emulates
COP8640CMHD-X	X = 1 : Crystal X = 2 : External X = 3 : R/C	28 DIP	Multi-Chip Module (MCM), UV Erasable	COP8640C, 8620C
COP8640CMHEA-X	X = 1 : Crystal X = 2 : External X = 3 : R/C	28 LCC	MCM (Same Footprint as 28 SO), UV Erasable	COP8640C, 8620C
COP8642CMHD-X	X = 1 : Crystal X = 2 : External X = 3 : R/C	20 DIP	MCM, UV Erasable	COP8642C, 8622C

Duplicator Board Ordering Information

Part Number	Description	Devices Supported
COP8-PRGM-28D	Duplicator Board for 28 DIP and for use with Scrambler Boards	COP8640CMHD
COP8-SCRM-DIP	Scrambler Board for 20 DIP Socket	COP8642CMHD
COP8-SCRM-SBX	Scrambler Board for 28 LCC Socket	COP8640CMHEA
COP8-PRGM-DIP	Duplicator Board with COP8-SCRM-DIP Scrambler Board	COP8642CMHD, COP8640CMHD

Development Support (Continued)

DIAL-A-HELPER

Dial-A-Helper is a service provided by the Microcontroller Applications group. The Dial-A-Helper is an Electronic Bulletin Board Information system.

INFORMATION SYSTEM

The Dial-A-Helper system provides access to an automated information storage and retrieval system that may be accessed over standard dial-up telephone lines 24 hours a day. The system capabilities include a MESSAGE SECTION (electronic mail) for communications to and from the Microcontroller Applications Group and a FILE SECTION which consists of several file areas where valuable application software and utilities could be found. The minimum requirement for accessing the Dial-A-Helper is a Hayes compatible modem.

If the user has a PC with a communications package then files from the FILE SECTION can be down loaded to disk for later use.

ORDER P/N: MOLE-DIAL-A-HLP

Information System Package contains:
- Dial-A-Helper Users Manual
- Public Domain Communications Software

FACTORY APPLICATIONS SUPPORT

Dial-A-Helper also provides immediate factor applications support. If a user has questions, he can leave messages on our electronic bulletin board, which we will respond to.

Voice:	(408) 721-5582	
Modem:	(408) 739-1162	
	Baud:	300 or 1200 Baud
	Set-up:	Length: 8-Bit
		Parity: None
		Stop Bit: 1
	Operation:	24 Hrs., 7 Days