Technical Notes on The EEC-IV MCU

Compiled by Tom Cloud <cloud@peaches.ph.utexas.edu>
(all fonts are Courier New)

(The information supplied here was gotten through researching e-mail correspondence, technical publications and from information given to the author. If it helps you, great! If you learn more about the EEC, please return the favor by sharing what you learn with me and others.)

DISCLAIMER: Beware -- none of this data is guaranteed to be accurate! Use it at your own risk and please let me know what you learn so that I can add to and correct it.

CONTENTS:

INTRODUCTION

I've collected and compiled data to help you decipher the EEC-IV inner workings. Software algorithms and automotive control techniques are purposely absent as the EEC hardware and chip set are what I'm primarily interested in figuring out. The EEC MCU probably controls one or more vehicles you own plus it contains all the components necessary to build an efi system for any vehicle -- if only we could program and modify it. That is my purpose -- to uncloak the EEC-IV so that we can play with what we bought!

The sections titled EEC DIAGNOSTICS, FUEL CONTROL, IGNITION & TIMING CONTROL, FUNCTIONS, SCALARS AND TABLES are departures from the goals stated above -- but I felt it was informative and hated to discard it. If this were a formal document, I would probably either ditch those sections, re-structure the document's purpose to include them or write a separate document on control algorithms.

THE MCU

The EEC-IV design began in 1978 and was first introduced in 1983 in the 1.6L Escort, Lynx, EXP and LN7 cars. It has gone through several major physical changes, the earliest using a fairly simple two board design with through hole soldered components while the last was more current in technology, showing extensive use of surface mount components and a much more finished and complex appearance. In between, there appears to be a variety of mother/daughter board and other designs. Still, they are all called EEC-IV, although somewhere in its life there was a Ford P/N generational change.

The reader is referred to the SAE paper # 820900, noted in the reference section at the end of this document, for a much more detailed description of the design goals and operation of the EEC-IV MCU.

Roy <spectric@globalnet.co.uk> writes: "The processor used is the 8065 along with several supporting peripheral chips like the DUCE chip which can provide up to 8 PWM outputs and the DARC chip which has 6 channels of timer capture inputs." (Is he talking about the EEC-V here ?)

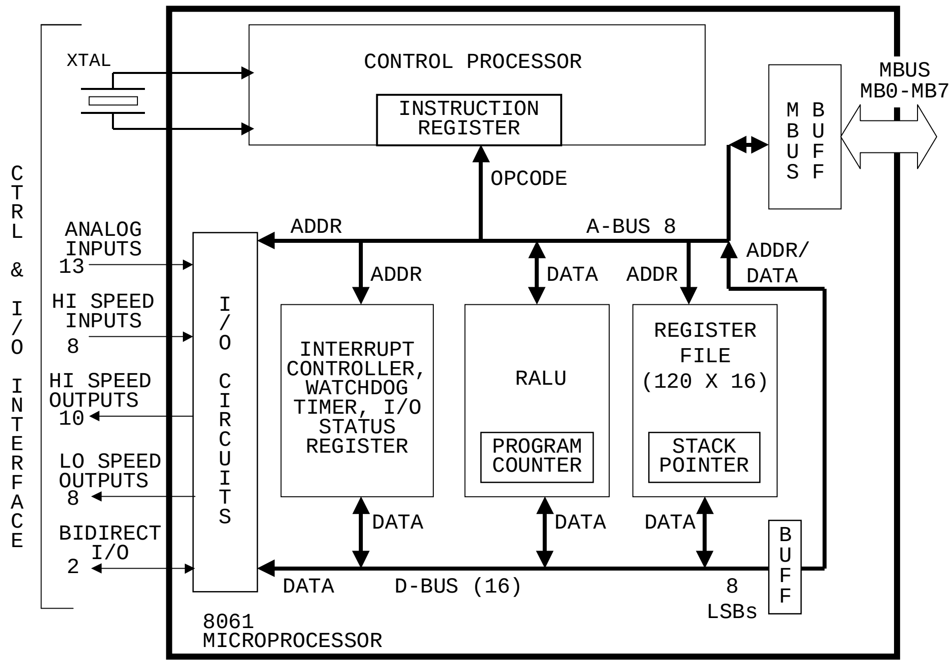
"This control unit is more suited to a history class than modern engine management systems. All of the functions within the EEC, apart from the actual power drivers, are now found within the micro controller such as the 68332 and 336."

The EEC module is rated to 80C (185F) continuous, 100C intermittent, so it will be much happier and live longer in the passenger compartment. Some of the later generation 15 and 18 MHz Motorola 8061 processors have a bus loading/edge timing sensitivity that only gets worse at high temperature, so it's best to keep the EEC in a more hospitable environment. Additionally, mounting the EEC in the passenger compartment will give you better access to the J3 test port, which is where you'll be plugging in a chip and/or the Calibrator.

The J3 test port on the side of the ECU box is for developers to plug into -- this is how the after-market chipmakers and others get into the box. The test connector has the micro-controller's multiplexed address/data bus signals on it. It also, very conveniently, has a PROM disable signal. So the chip makers design something that hangs off that connector, disables the computer's PROM, and substitutes its own PROM in its place.

THE MICROPROCESSOR:

The micro-controller is an Intel 8061, a close cousin to the Intel 8096. It is supplied by three manufacturers: Intel, Toshiba (6127) and Motorola, though the Motorola units seem to slip spec a little and differ in their timing slightly from the others.



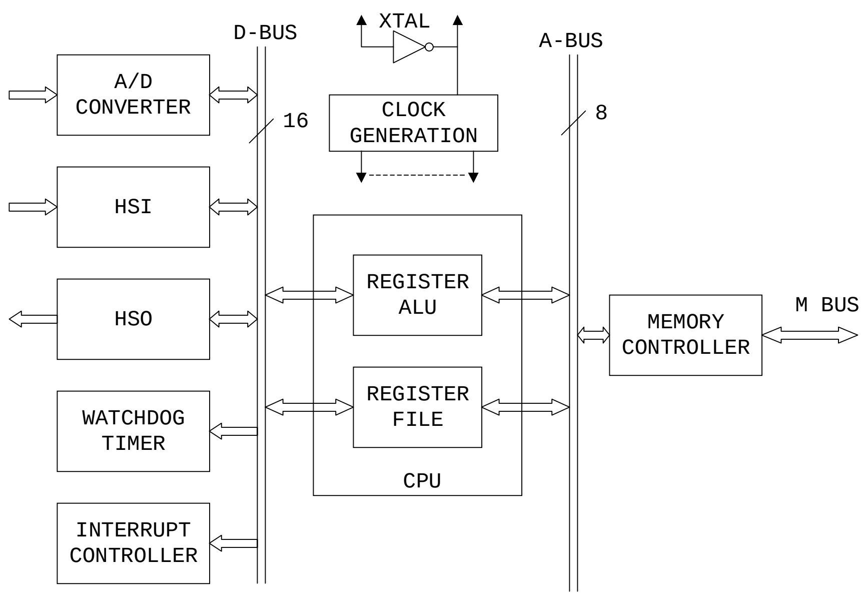
There are some major differences between the 8061 and 8096 (e.g. pinouts, bus layout, etc.), but most of the code is transferable.

It is organized internally as a 16-bit machine with a double bus structure consisting of CPU, memory controller, clock generator, I/O and coprocessors, A/D converter, watchdog timer and interrupt controller.

The high speed hardware / register structure is a design by Ford engineers to simplify the processing of digital I/O signals and patents were issued for some of these concepts. To implement these concepts, and to achieve other design goals, Ford decided to design a custom microprocessor - memory combination -- the 8061 and 8361 were the result. Those two chips, designed in concert with Intel, form a two-chip microcomputer.

There were several design goals for this custom micro-processor:

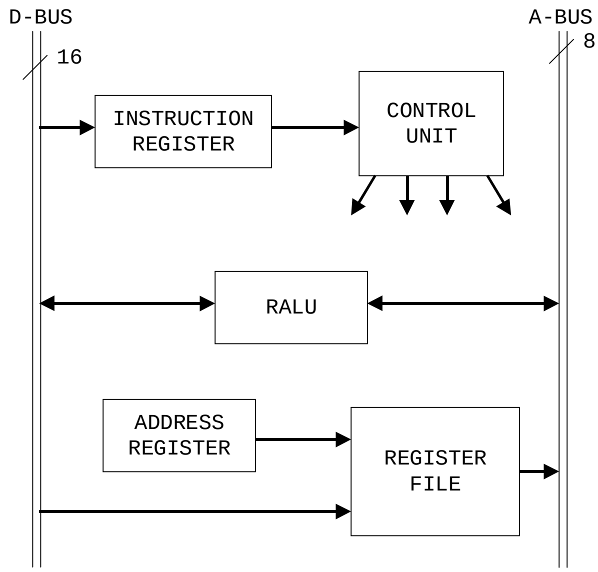
1. An I/O intensive circuit with hi-speed digital I/O capability,
2. A fast, on-chip, multi-channel A/D converter,
3. Hardware multiply and divide,
4. multi-level, prioritized interrupts,
5. variable data types (bit, byte, word & double word),
6. a watchdog timer.



8061 Major Functional Units

7. A powerful yet "regular" software architecture.
8. A large memory address space with minimum off-chip memory access time.

The 8061 microcomputer chip features a CPU, 256 bytes of RAM, an A/D converter and independent coprocessor circuitry to expedite digital signal I/O handling. There are 13 analog lines, 8 hi-speed digital inputs, 10 hi-speed digital outputs, 8 lo-speed digital outputs and 2 bi-directional I/O lines, making a total of 41 I/O lines on the CPU chip. The A/D converter is a 13-channel, 10-bit successive approximation unit.

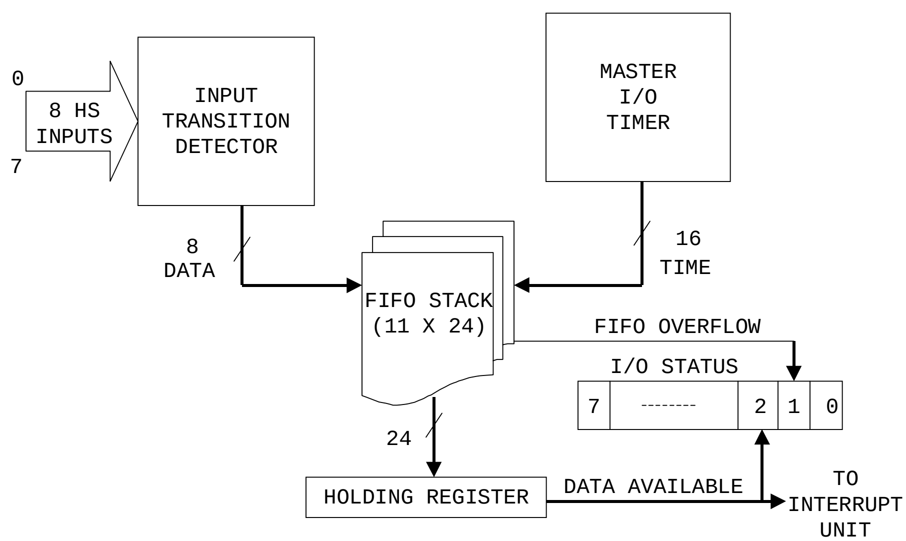


8061 CPU

The internal 256 bytes of RAM in the 8061 can be referenced as bytes, words or double words, allowing frequently used variables to be stored on-chip for faster access.

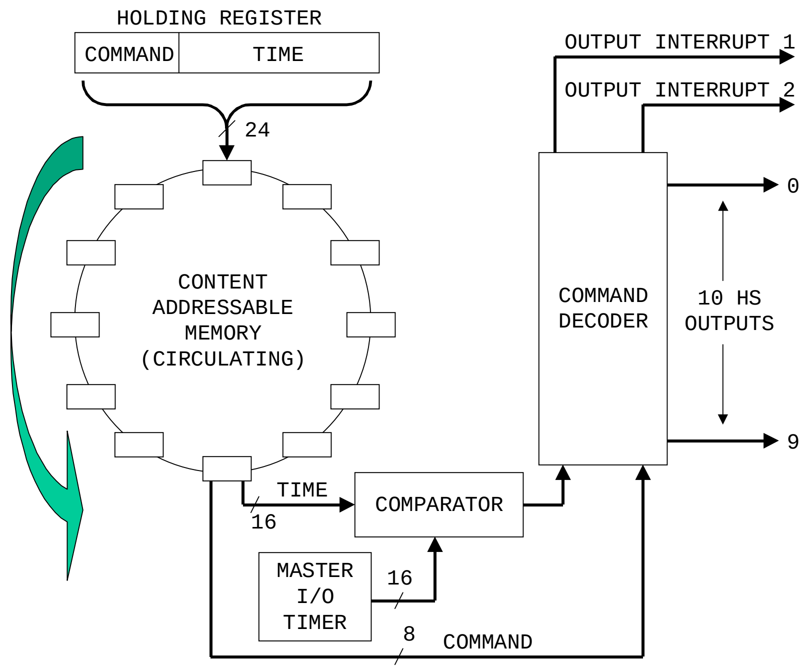
The two high speed coprocessors on the 8061 (HSI and HSO) were implemented to reduce signal processing overhead on the CPU. An 11-deep FIFO for the high speed input (HSI) and a 12-slot content addressable memory (CAM) for the high speed output (HSO) are used. Operation of both HSI & HSO are synchronized with an internal master I/O timer which is clocked every 2.4 micro-seconds (15 MHz crystal).

The HSI looks for transitions on its input lines and records (1) the time, from the master I/O timer, and (2) the transition. It can be programmed to look at selected inputs for positive and negative transitions and can be programmed to generate an interrupt to the CPU when the first entry is made into the FIFO or when the next entry would cause the FIFO to overflow.



High Speed Input Unit

The HSO can be programmed to generate transitions on any of its output lines at specified times. HSO commands are stored in one of the twelve CAM registers, which are 24 bits wide. Of the 24 bits in each register, 16 specify the time the action is to occur, and 8 specify the action(s). The CAM file rotates one position per state time, so it takes 12 state events for the holding buffer to access all 12 registers. Therefore the time resolution of the HSO unit is 12 state times or 2.4 microseconds if a 15 MHz crystal is used.



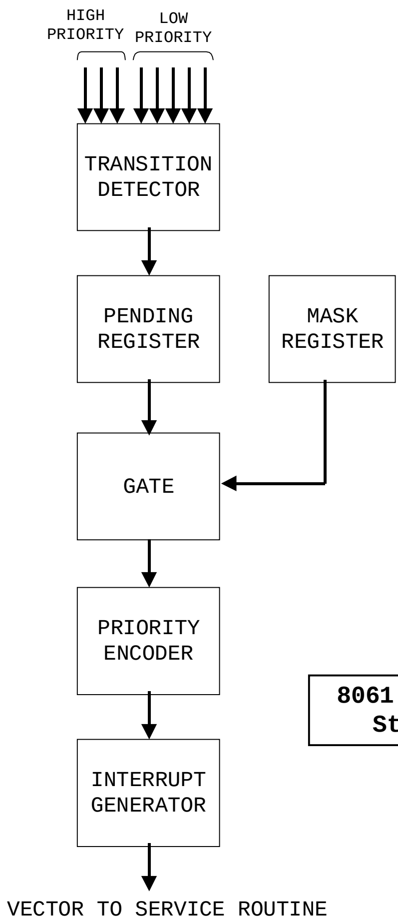
High Speed Output Unit

The 8061 CPU consists of the register file, the register-arithmetic logic unit (RALU), and a control unit. Note that the RALU does not use an accumulator but operates directly on any register in the register file, resulting in code length and execution speed improvements. The control unit consists of the instruction register and associated circuitry which decodes the instructions and generates the correct sequence of internal control signals to execute instructions.

The clock generator in the 8061 divides the crystal frequency, internally, by three to provide a duty cycle of 33%. The clock signal period, called one state time, equals three oscillator periods.

A watchdog timer is incremented every state time. It is a 16-bit counter that re-initializes the system when it overflows to provide a means of recovering from a software fault. The user must periodically reset the watchdog timer to prevent register overflow and subsequent re-start.

There are 8 interrupt sources in the 8061. A positive transition from any one of the sources sets a corresponding bit in the pending register. A programmable mask register determines if the particular interrupt will be recognized or not. Interrupts can occur at any time and simultaneous interrupts are accepted. Conflicts are resolved with a two-level sequential priority hierarchy which establishes the order of servicing. A corresponding vector automatically identifies the location of each interrupt service program. A software stack, which can be created anywhere in memory, can be used for temporary storage of important program data (e.g. the PC and PSW) during execution of interrupt service routines.

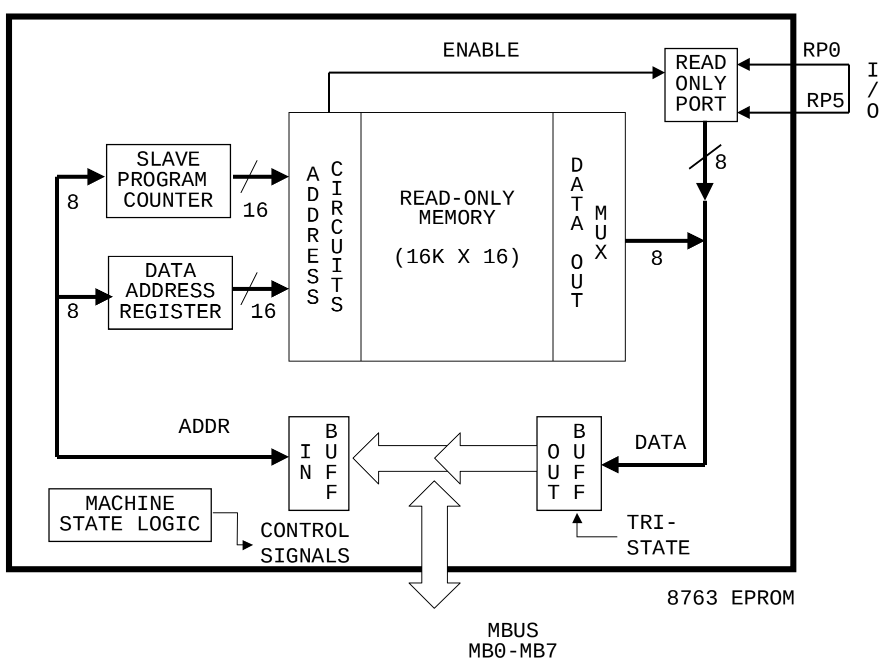


8061 Interrupt Structure

The 8061 can address up to 64k bytes of memory, supports bit, byte, word and double-word data types with six addressing modes and has eleven instruction categories defined. The assembly language programmer can create very fast, compact programs by using the direct addressing mode and careful movement of data between external memory and the register file.

The 8361 ROM chip contains 8k bytes of program memory plus 128 byts of additional RAM. Data transfer between the 8763 ROM and the 8061 are is controlled by the memory controller in the 8061. Addresses for instruction fetches from the ROM are maintained in a slave PC in the 8061 memory controller and in a corresponding counter in the 8763. The slave PC functions like traditional PC, being automatically incremented after each fetch and updated whenever the CPU executes a program jump. The counter in the ROM is independent of the slave PC but is identical to it. Addresses are transmitted on the M-bus from the slave PC to the ROM under two conditions, when the address is initialized at the start of program execution or when a program jump ocurs. The slave PC concept eliminates the need to send an address to external memory for each instruction -- that only being necessary when a branch occurs or at program initiation.

The 8061 is an 8096 with a few extra instructions added. One is a very powerful conditional jump to complement the high speed I/O units. This instruction, the jump on bit equals zero, is used to test any one of the eight bits of a given byte and jump if the bit equals zero (is this the JBC/JNB command?). Other conditional jumps were added to avoid extensive data shifts. With a 15 MHz input frequency, the 8061 can perform a 16-bit

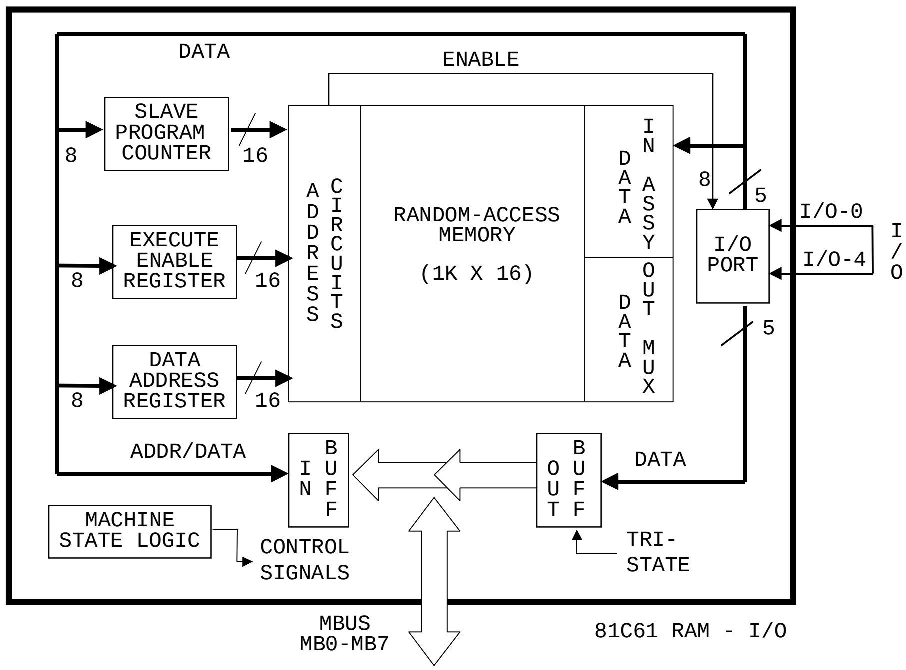


addition in 0.8 microseconds and a 16 x 16 bit multiply or a 32/16 bit divide in 5.2 microseconds (using the hardware multiply and divide feature). For typical applications, based on a normal instruction mix, instruction execution times average 1 to 2 microseconds. It seems to have the same functional pins as the 8096, but it's in a custom package, so the pinout is different. Most of the signals should be able to be found with a scope or logic analyzer. The 8096 has a multiplexed address/data bus. The address/data bus signals are on the service port connector (J3) along with a few others, possibly including the address latch enable, read strobe, write strobe, and EPROM disable.

There are two hardware versions of the 8061 chip. One is a 40 pin DIP, with reduced I/O and the other is a square LCC 68 pin package with all the functions implemented.

The multiplexed M-bus scheme used on the 8061 is not new, but the slave program counter used on the 8763 is.

It appears that the address / multiplexing scheme is similar to that of the 8085 which has AD0 .. AD7 and then A8 .. A15 so the 8085 "latches" the address information A7:0, and maintains A8:15 while it is using AD0 .. AD7 as D7:0 ....



LEGEND				
ADDR	ADDRESS		I/O	INPUT/OUTPUT
ASSY	ASSEMBLY		LO	LOW
A-BUS	ADDRESS BUS		LSB	LEAST SIGNIFICANT BIT
BIDIRECT	BIDIRECTIONAL		MBus	MEMORY BUS
BUFF	BUFFER		EPROM	ERASABLE READ-ONLY MEMORY
CTRL	CONTROL		MUX	MULTIPLEXER
D-BUS	DATA BUS		RAM	RANDOM ACCESS MEMORY
HI	HIGH		RPn	READ-ONLY PORT INPUT

CPU, ROM, RAM PINOUT

8061 CPU (IC-1)						
1	unused			35	GND	
2	unused			36	VSS +	
3				37	TPS	
4				38	GND	
5				39		
6				40		
7				41		
8				42		
9				43		
10				44		
11				45		
12				46		
13				47		
14				48		
15	xtal2			49		
16	xtal1			50		
17				51		
18				52	Vss	
19				53		
20				54		
21				55		
22				56		
23				57	control 1A	
24				58	control 2A	
25				59	control 3A	
26				60		
27				61	MB0	
28	Vcc			62	MB1	
29				63	MB2	
30				64	MB3	
31				65	MB4	
32				66	MB5	
33				67	MB6	
34				68	MB7	

87C61 RAM/IO (IC-7)						
1				13	CPU-65, J3-13	MB3
2		/OE		14	CPU-64, J3-11	MB4
3				15	CPU-63, J3-9	MB5
4	GND (?)			16	CPU-62, J3-7	MB6
5				17	CPU-61, J3-5	MB7
6	GND (?)			18		
7	KAPWR			19	GND (?)	
8				20	control 1A	
9				21	control 2A	
10	CPU-68, J3-19	MB0		22	control 3A	
11	CPU-67, J3-17	MB1		23		
12	CPU-66, J3-15	MB2		24	GND	
CPU is IC-1, J3 is service connector						

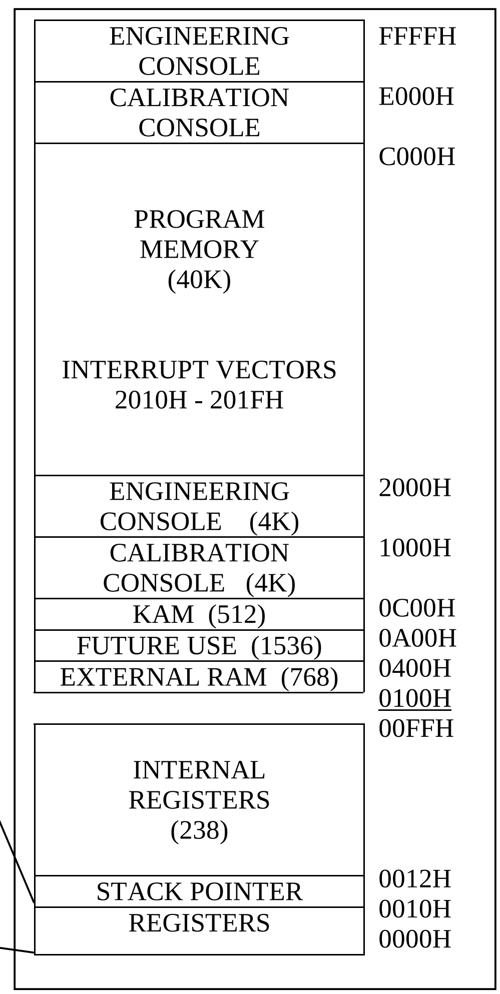
8763 EPROM (IC-8)						
1	J3-22, 1K to +5V			13	CPU-65, J3-13	MB3
2	J3-16, 10K to +5			14	CPU-64, J3-11	MB4
3				15	CPU-63, J3-9	MB5
4	GND			16	CPU-62, J3-7	MB6
5				17	CPU-61, J3-5	MB7
6				18	1k to +5V	
7	+5			19	+5V	
8	GND			20	CPU-59, J3-21	ctl
9	J3-12			21	CPU-58, J3-23	ctl
10	CPU-68, J3-19	MB0		22	CPU-57, J3-25	ctl
11	CPU-67, J3-17	MB1		23		/CE
12	CPU-66, J3-15	MB2		24	GND	
CPU is IC-1, J3 is service connector						

[As far as the memory chips go on the ram chip pins 4, 6, 19, 24 all connected to GND, and 3, 5, 7 all went to VRef (Dan S.)]

8061 MEMORY MAP

The 8061 uses the same address space for program and for data memory and can execute instructions from any memory address. Its addressing range is 64k locations and the first 256 locations are on-chip and refer to the internal register file. All other memory resides externally.

	READ	WRITE
0F 0E	H.S. TIME	H.S. TIME
0D	H.S. BUFFER	H.S. COMMAND
0C	H.S. MASK	H.S. MASK
0B	H.S. DATA	NOT USED
0A	I/O STATUS	I/O STATUS
09	INT. PEND	INT. PEND
08	INT. MASK	INT. MASK
07 06	TIMER	NOT USED
05	A/D HI	WATCHDOG
04	A/D LO	A/D COMMAND
03	I/O PORT	I/O PORT
02	L.S. PORT	L.S. PORT
01 00	ZERO REG	NOT USED



Hardware development tools used in conjuction with the EEC-IV include:

1 - Engineering Console -- a lab instrument for real-time program debug and monitor of the EEC-IV system.

2 - Calibration Console -- a portable unit for vehicle use to permit field display and modification of program memory.

3 - D/A Converter Unit -- an add-on feature to the calibration console that converts eec-iv system digital outputs to analog form for data logging by external recording equipment.

There is a "Production Code Release System" binary file verification and comparison program for release of production binary files to outside suppliers for ROM manufacturing.

8061 INSTRUCTION SET

```
===========================================================================
Summary,    8096 instructions vs.  8061 instructions
===========================================================================
     32    instructions the same
     43    instructions the same, but renamed
      8    instructions the same, but split into 2 pseudo-ops (2 vs. 3 operands)
      7    instructions in 8061, not in 8096
                -- bank0/1/2/3
                -- retei
                -- rombank
                -- signd
      6    instructions in 8096, not in 8061
                -- br
                -- divu/divub
                -- mulu/mulub
                -- rst
```

Instructions in 8096 alphabetical order

op-code	8096	8061	description	difference
64-67	add	ad2w	add words (2 operands)	-- split
44-47	"	ad3w	add words (3 operands)	-- split
74-77	addb	ad2b	add bytes (2 operands)	-- split
54-57	"	ad3b	add bytes (3 operands)	-- split
A4-A7	addc	adcw	add words with carry	-- rename
B4-B7	addcb	adcb	add bytes with carry	-- rename
60-63	and	an2w	logical and words (2 operands)	-- split
40-43	"	an3w	logical and words (3 operands)	-- split
70-73	andb	an2b	logical and bytes (2 operands)	-- split
50-57	"	an3b	logical and bytes (3 operands)	-- split
	-----	bank0		-- not in 96
	-----	bank1		-- not in 96
	-----	bank2		-- not in 96
	-----	bank3		-- not in 96
E3	br		branch indirect	-- not in 61
01	clr	clrw	clear word	-- rename
11	clrb	clrb	clear byte	-- same
F8	clrc	clc	clear carry flag	-- same
FC	clrvt	clrvt	clear overflow trap	-- same
88-8B	cmp	cmpw	compare words	-- rename
98-9B	cmpb	cmpb	compare bytes	-- same
05	dec	decw	decrement word	-- rename
15	decb	decb	decrement byte	-- same
FA	di	di	disable interrupts	-- same
FE/8C-8F	div	divw	divide signed integers (FE prefix)	-- rename
FE/9C-9F	divb	divb	divide signed bytes (FE prefix)	-- same
8C-8F	divu		divide unsigned words	-- not in 61

9C-9F	divub		divide unsigned bytes	-- not in 61
E0	djnz	djnz	decrement and jump if not zero	-- same
FB	ei	ei	enable interrupts	-- same
06	ext	sexw	sign extend int to long	-- rename
16	extb	sexb	sign extend 8-bit int to 16 bit int	-- rename
07	inc	incw	increment word	-- rename
17	incb	incb	increment byte	-- same
30-37	jbc	jnb	jump if bit clear	-- rename
38-3F	jbs	jb	jump if bit set	-- rename
DB	jc	jc	jump if carry flag is set	-- same
DF	je	je	jump if equal	-- same
D6	jge	jge	jump if signed greater than or equal	-- same
D2	jgt	jgt	jump if signed greater than	-- same
D9	jh	jgtu	jump if unsigned higher	-- rename
DA	jle	jle	jump if signed less than or equal	-- same
DE	jlt	jlt	jump if signed less than	-- same
D3	jnc	jnc	jump if carry flag is clear	-- same
D7	jne	jne	jump if not equal	-- same
D1	jnh	jleu	jump if unsigned not higher	-- rename
D0	jnst	jnst	jump if sticky bit is clear	-- same
D5	jnv	jnv	jump if overflow flag is clear	-- same
D4	jnvt	jnvt	jump if overflow trap is clear	-- same
D8	jst	jst	jump if sticky bit is set	-- same
DD	jv	jv	jump if overflow flag is set	-- same
DC	jvt	jvt	jump if overflow trap is set	-- same
EF	lcall	call	long call	-- rename
A0-A3	ld	ldw	load word	-- rename
B0-B3	ldb	ldb	load byte	-- same
BC-BF	ldbse	ldsbw	load integer with byte, sign extended	-- rename
AC-AF	ldbze	ldzbw	load word with byte, zero extended	-- rename
E7	ljmp	jump	long jump	-- rename
FE/6C-6F	mul	ml2w	multiply integers (2 operands)	-- split
FE/4C-4F	"	ml3w	multiply integers (3 operands)	-- split
FE/7C-7F	mulb	ml2b	multiply bytes (2 operands)	-- split
FE/5C-5F	"	ml3b	multiply bytes (3 operands)	-- split
6C-6F	mulu		multiply unsigned words (2 operands)	-- not in 61
4C-4F	"		multiply unsigned words (3 operands)	-- not in 61
7C-7F	mulub		multiply unsigned bytes (2 operands)	-- not in 61
5C-5F	"		multiply unsigned bytes (3 operands)	-- not in 61
03	neg	negw	negate integer	-- rename
13	negb	negb	negate byte	-- same
FD	nop	nop	no operation	-- same
0F	norml	norm	normalize long integer	-- rename
02	not	cplw	complement word	-- rename
12	notb	cplb	complement byte	-- rename
80-83	or	orrw	logical or words	-- rename
90-93	orb	orrb	logical or bytes	-- rename
CC/E/F	pop	popw	pop word	-- rename
F3	popf	popp	pop flags	-- rename
C8	push	pushw	push word	-- rename
F2	pushf	pushp	push flags	-- rename
F0	ret	ret	return from subroutine	-- same
	-----	retei		-- not in 96
	-----	rombank		-- not in 96
FF	rst		reset system	-- not in 61
28-2F	scall	scall	short call	-- same
F9	setc	stc	set carry flag	-- rename
09	shl	shlw	shift word left	-- rename
19	shlb	shlb	shift byte left	-- same
0D	shll	shldw	shift double word left	-- rename
08	shr	shrw	logical right shift word	-- rename
0A	shra	asrw	arithmetic right shift word	-- rename

1A	shrab	asrb	arithmetic right shift byte	-- rename
0E	shral	asrdw	arithmetic right shift double word	-- rename
18	shrb	shrb	logical right shift byte	-- same
0C	shrl	shrdw	logical right shift double word	-- rename
	-----	signd		-- not in 96
20-27	sjmp	sjmp	short jump	-- same
00	skip	skp	skip - 2 byte no operation	-- rename
C0/2/3	st	stw	store word	-- rename
C4/6/7	stb	stb	store byte	-- rename
68-6B	sub	sb2w	subtract words (2 operands)	-- split
48-4B	"	sb3w	subtract words (3 operands)	-- split
78-7B	subb	sb2b	subtract bytes (2 operands)	-- split
58-5B	"	sb3b	subtract bytes (3 operands)	-- split
A8-AB	subc	sbbw	subtract words with borrow	-- rename
B8-BB	subcb	sbbb	subtract bytes with borrow	-- rename
F7	trap		software trap (internal use only, not in assembler)	
84-87	xor	xrw	logical exclusive or words	-- rename
94-97	xorb	xrb	logical exclusive or bytes	-- rename

The bank selection opcodes are 8063 -- as that is the difference between them, memory bank selection capabilities...

8061 Interrupt Vectors and Priorities:

Priority:	Interrupt	16-Bit Address
Highest	High-Speed Input #0	0x201E
High	High-Speed Input #1	0x201C
High	HSO Port Output Interrupt #1	0x201A
Low	External Interrupt	0x2018
Low	HSI Port Input Data Available	0x2016
Low	A/D End-Of-Conversion	0x2014
Low	Master I/O Timer Overflow	0x2012
Lowest	HSO Port Output Interrupt #2	0x2010

At Reset, PC = 0x2000 in Memory Bank #8

THE MCU:

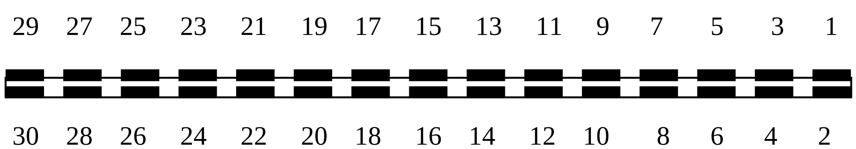
There is custom EPROM and RAM in the EEC that is integral with the 8061 in that it works directly with the multiplexed address/data bus of the 8061. The test connector also has the micro-controller's multiplexed address/data bus signals on it as well as a PROM disable signal. Many Intel 8 bit processors and the 8088 16-bit used this multiplexed address and data bus. The chips in the EEC are soldered in and the things that look like PROMs don't have useful markings on them. The memory chips are not industry standard types, which is why EEC modifiers always use the service port to attach external memory.

Mike Wesley said: "None of the CPU's seem to have any on board ROM, just some scratchpad RAM. Everything is outside either in an EPROM or FLASH, and it's not a standard EPROM so exercise caution when trying to read these devices -- they are easily destroyed using typical procedures.

"... to do word transfers, put the address of the low byte data on the bus, strobe it in, put on the low byte data, strobe that in, put on the high byte data and strobe that in. You don't need to place the address for the high order byte on the bus. The OEM code (especially in the EEC-V) places the low byte address on the bus, strobes, places the low byte data on the bus, strobes, places the high byte address on the bus, strobes, places the high byte data, and strobes. The CPU will do the high byte addressing for you."

ECM TEST PORT (J3) PINOUT

The pinouts are derived from the J3 Test Port on a SD unit for an '87 Mustang (DA1 / E7SF-12A650-A1B). Looking at the MCU facing the service port (from the rear of the mating plug) the connector is numbered from right-to-left with odd numbers on the component side and the even numbers on the wiring side. It is a 15/30 terminal, card-edge connector with .1" spacing. (The table below is arranged for the pins to be read from left-to-right, top first.)

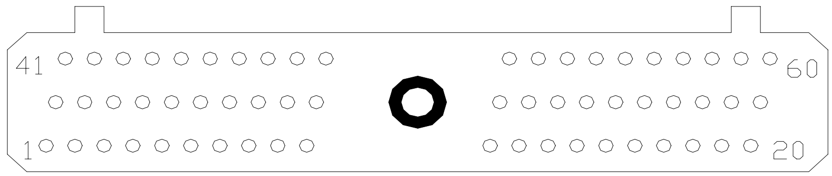


PIN NO.	SIGNAL / FUNCTION	MCU PIN	CPU 8061	RAM 81C61	EPROM 8763	notes
29	PWR GND	40,60				
27	VPWR	37,57				battery +
25	control		57	22	22	
23	control		58	21	21	
21	control		59	20	20	
19	D7		68	10	10	
17	D6		67	11	11	
15	D5		66	12	12	
13	D4		65	13	13	
11	D3		64	14	14	
9	D2		63	15	15	
7	D1		62	16	16	
5	D0		61	17	17	
3				7		
1	VREF (+5)	26				

30	PWR GND					
28	VPWR	37,57				battery +
26	NC					
24	NC					
22					1	1K TO +5 only
20	NC (some MCU)					
18	NC					
16	EPROM /OE				2	10K TO +5 only
14	NC					
12					9	
10			3	9		
8			60			1K TO +5 only
6	NC					
4	(high for access)					IC4-74001 pin 13
2	ACT	25				

There're 14 pins from the 8763 EPROM on the connector, 2 pins from the 87C61 RAM-I/O on the connector, 1 pin from the 8061 CPU and 1 pin from a 16-pin logic chip.

MCU CABLE PINOUT



(looking at connector from outside MCU)

The table below lists several MCU cabling pinouts. The first, for a Mustang EEC was submitted by Bernt Frisk <bernt@mbox301.swipnet.se>. The second, for a 1991 Ranger 2.3L Dual Plug EFI Engine (from Mitchell International On-line manual (c) 1992) was submitted by <tnye@mansci.watstar.uwaterloo.ca>. The next three columns were done by the author and are from the Ford wiring diagrams (yes, I actually buy the factory manuals) -- and they don't use the same naming convention as the first two.

No	Mustang	'91 Ranger 2.3	'91 4.9, 5.0, 5.8 F-series w/o E4OD	'91 4.9, 5.0, 5.8 F-series w E4OD	'91 7.3 diesel F-series w E4OD	
1	Kapwr	Kapwr	Bty to load	Bty to load	Bty to load	keep-alive power
2		BOO		stop lamp sw to turn sig sw	stop lamp sw to stop lamp	Brake On/Off switch
3	VSS +	VSS +	VSS	VSS	VSS	Vehicle speed sensor positive
4	IDM	IDM	elect sw to ignition coil	elect sw to ignition coil	elect sw to ignition coil	Ignition Diagnostic monitor
6	VSS -	VSS -	VSS return	VSS return	VSS return	Vehicle speed sensor negative
7	ECT	ECT	engine coolant	engine coolant	xmsn oil temp	Engine coolant temp sensor
8	FPM	FPM	fuel sply pump relay	fuel sply pump relay		Fuel pump monitor
9		DATA -	EEC data -	EEC data -		
10	ACC	ACC	compressor clutch feed	compressor clutch feed		A/C compressor clutch
11	AM 2		thermactor diverter valve	thermactor diverter valve		Air management solenoid 2
12				4X4 lo-range indicator	4X4 lo-range indicator	
14		MAF (CA only)				
15		MAF RTN (CA only)				
16	IGN GND	IGN GND	dedicated GND to TFI	dedicated GND to TFI		Ignition ground
17	STO/MIL	STO/MIL	check engine lamp	check engine lamp	check engine lamp	Self-test output check Engine
20	CSE GND	CSE GND	GND	GND	GND	Case ground
21	ISC/BPA	ISC/BPA	ISC	ISC		Idle speed control / bypass air
22	FP	FP	fuel pump	fuel pump		Fuel pump

			relay	relay		
23	KS		KS	KS		Knock sensor
24	PSPS	PSPS	PSPS	PSPS		Power steering pressure switch
25	ACT	ACT	ACT	ACT		Air charge temperature
26	VREF	VREF	pwr to sensors	pwr to sensors	pwr to sensors	Reference voltage
27	EVP	HEGO	EGR posn feed	EGR posn feed		EGR valve position sensor
28		NDS	EEC data +	EEC data +		
29	HEGO	HEGO	EGO	EGO		Heated exhaust gas oxygen sensor
30	NDS	NDS/CES	fuel sensor GND	fuel sensor GND	man'l lever pos or clutch	Neutral drive switch (automatic)
31			canister purge solenoid	canister purge solenoid		
32				O/D cancel lamp	O/D cancel lamp	
33	EVR	EVR	EGR valve	EGR valve		EGR vacuum regulator solenoid
35					EEC to xmsn	
36	SPOUT	SPOUT	SPOUT from TFI	SPOUT from TFI	tach feed	Spark out timing control
37	VPWR	VPWR	pwr rly to EEC	pwr rly to EEC	pwr rly to EEC	Vehicle power
38				electronic pressure ctl	electronic pressure ctl	
40	PWR GND	PWR GND	dedicated GND	dedicated GND	dedicated GND	Power ground
41				xmsn O/D switch	xmsn O/D switch	
42				xmsn oil temp		
43		ACD	A/C demand	A/C demand		
44					tach retn	
45	MAP	MAP	MAP feed	MAP feed	MAP feed	Manifold absolute pressure
46	SIG RTN	SIG RTN	sensor sig rtn	sensor sig rtn	sensor sig rtn	Signal return
47	TPS	TPS	TAPS	TAPS	TAPS	Throttle angle position sensor
48	STI	STI	EEC to test conn #1	EEC to test conn #1	EEC to test conn #1	Self-test input
49	HEGOG	HEGOG	fuel sensor GND	fuel sensor GND		Heated EGO sensor ground
51	AM 1		thermactor dump valve	thermactor dump valve		Air management solenoid 1
52		SS		xmsn throttle valve sol #1	xmsn throttle valve sol #1	
53		CCO		clutch sw	clutch sw	Converter Clutch Overide
54		WAC				
55				coast clutch sol	coast clutch sol	
56	PIP	PIP	PIP from TFI	PIP from TFI		Profile ignition pickup
57	VPWR	VPWR	pwr rly to EEC	pwr rly to EEC	pwr rly to EEC	Vehicle power
58	INJ 1	INJ 1	INJ 1	INJ 1		Injector bank 1
59	INJ 2	INJ 2	INJ 2	INJ 2		Injector bank 2
60	PWR/GND	PWR/GND	dedicated GND	dedicated GND	dedicated GND	Power ground

EEC DIAGNOSTICS

Two types of diagnostics are performed by the EEC (this was written for early 80's model units so it may be expanded now). They are On-Demand and Continuous. On-Demand is conducted during key-on/engine-off and during engine running modes to permit the microprocessor to test itself. Continuous, as the name implies, is on-going whenever the system is in operation. Beginning in the latter part of 1983, the EEC-IV began to remember conditions found during continuous testing, even after the key is turned off with a special custom memory chip called Keep Alive Memory (KAM). The KAM chip, which contains 128 bytes of read/write memory, is powered by a separate low current connection to the vehicle battery. Faults, even intermittent ones, are recognized and stored away for recall during dealer service.

EEC FUEL CONTROL

The Air Flow sensor used in production EFI's typically compensates for temperature and density changes in the intake air mass. Then the oxygen sensor is used to fine tune the mixture. Almost all use barometric compensation in one form or another. Some systems take a barometric reading from the MAP sensor after the ignition key is turned on, but before the engine starts, and store this as a reference. This can also be updated at WOT, since manifold pressure is essentially = barometric pressure at this point (with some flow related pressure drop). Some systems have a separate barometric sensor in addition to MAP. Some MAP's are not absolute sensors at all, but differential sensors, referenced on one side to the atmosphere. So as the atmospheric pressure changes, the MAP reference point changes as well. Some compensation is possible with the fuel pressure regulator, since it is usually referenced to manifold pressure and thus atmospheric indirectly. This helps regulate the pressure across the injector so the amount of fuel delivered is related to only the injector pulse width. Some systems have no barometric pressure compensation at all.

The EEC does 4 point interpolation on all tables. There is a minimal number of cells in the fuel lookup tables. The EEC doesn't look up 'injector on time', it calculates the injector pulse width by looking at the desired Lambda and then, using the mass of air entering the engine and the injector size, it calculates the duty cycle needed to get the desired A/F ratio. (Lambda is an engineering term where stoich is 1, anything smaller than 1 is rich, anything larger than 1 is lean. To get A/F numbers from Lambda, multiply lambda value by 14.64. For example, an A/F ratio of 14.05:1 is a lambda of .85 lambda.)

Mike Wesley wrote: "The ECU controls both the fuel mixture and the timing. The fuel mixture operates in either "open loop" or "closed loop" mode. Anything external to the EEC that tries to mess with fuel mixture at points where the engine is in closed loop operation will cause the computer to try and compensate. This can cause more problems than it's likely to solve. Timing and WOT fuel settings aren't closed loop functions, and can be changed without the computer trying to correct them. This is why "piggy-back" units, i.e. units that connect between the cable and the ECU, aren't very effective.

"Closed loop operation can sometimes be altered without problems. This ability has allowed some manufacturers to be able to market cars and parts that are fully emissions legal (e.g. KB, Saleen, etc). The after-market devices that go between the engine harness and the EEC interfere with closed loop. The software modules that connect to the service connector (Hypertech, Superchips, Calibrator, etc.) do not interfere with closed loop - rather they can define new values for closed loop. The EEC will do whatever it's told -- it's a computer running a program and your data can be substituted for the factory's through the service port connector. The EEC can not 'learn' around a software module.

"Closed loop operation basically consists of a controller with a target A/F ratio, HEGO information as its feedback and the injectors as the main control mechanism. The 'factory' target A/F ratio is 14.64:1, but this can be changed.

"Approximately 900 items can be changed or logged in a 93 5.0 Mustang. For example, during a shift, the EEC might look at spark, load, TP, fuel, and transient fuel. By logging this data, you can tell exactly where in the spark tables the EEC is travelling and tune just those cells. Most people would normally tweak the whole curve down or try and tune in areas the EEC isn't even looking at. With the data-logging, you can see exactly where it's pulling its data from.

"Examples of some of the functions controlled by the EEC are: A:F ratio in closed loop, transient fuel, EGR, Canister Purge, Thermactor, adaptive control system, control of OBD-I and OBD-II testing (on/off/change test values...), fuel, spark, MAF's, VE tables, injectors, rev limits speed limits, electronic transmission control, and lots more.

"If you have a later car (91 or newer), there is an integrated controller module (ICM) (12B577 basic #). This is located in the engine compartment. It is a black metal box about 8"X6"X1.5". It runs the cooling fan, the fuel pump, and the EEC power.

EEC IGNITION and TIMING CONTROL:

The EEC only sees one Crankshaft Position Sensor signal, but where it comes from depends on the age of the EEC. Early EEC's used a sectored wheel in the distributor which produced a square wave of frequency of Number-Cylinders per 2-revs with a nominal 50% duty cycle unless SEFI was used whereupon there was a "short" tooth. The spark was output by a TFI unit.

Later and perhaps all current EEC's, including the EEC-V, utilize a 36-1 tooth wheel for CPS which is pre-processed by a unit known as the EDIS (Electronic DIStributor). The EDIS converts the 36-1 into a 2 pulses/rev 50% duty cycle square wave which is then fed into the EEC to be used for RPM and injector timing calculations. The EEC sends a PWM signal to the EDIS defining the spark advance required, and the EDIS unit then times out the signals to the coils (wasted spark). This gives a more accurate spark delivery as the EDIS has access to timing data which is updated every 10 crank degrees whereas the EEC only gets timing data every 90 degrees.

The EEC gets one and only one timing signal from the TFI unit. It is called the PIP (Profile Ignition Pickup). The PIP signal is 45 - 55Hz @ 1000 RPM, for 4, 6 and 8 cylinder engines and, with the exception of SEFI, has a duty cycle of 50%. SEFI uses Signature PIP where the #1 vane on the PIP reluctor is roughly 35% duty cycle and the rest are roughly 50%. The EEC uses this to detect cylinder #1. On a stock car, the leading edge of the PIP signal is @ 10 BTDC.

The EEC controls the spark timing. The TFI's function at this point is to basically clean up the PIP signal, charge and fire the coil. The TFI module conditions the hall sensor output and sends it off to the EEC. The only delay is just propagation delay through the TFI electronics. The EEC sends out the SPOUT signal which starts the TFI modules charging the coil. Depending on what advance the EEC is looking for, the falling edge of the SPOUT can vary. The coil fires on the falling edge. Since the EEC 'knows' where 10 BTDC of each cylinder is, by using timers and things, it can calculate when to drop the SPOUT signal. The MCU uses the previous PIP value to determine where the crank was. The TFI module can handle acceleration rates of up to 250 HZ/sec. Another function of the TFI modules is to provide LOS spark (limp mode). If the TFI detects a loss of SPOUT, it will generate it's own 'SPOUT' to coincide with the rising edge of PIP (10 BTDC...assuming you haven't moved the distributor).

To determine timing values, the EEC uses crank position (CPS), engine temperature (ECT), air-charge temperature (ACT), throttle position (TPS), EGO data and Cylinder-ID to name the significant ones. It's relatively easy to calculate the spark required for optimum power from these, but the compromises made to meet emissions and driveability complicate matters.

The "TFI" (EDIS) units are all very similar. The differences are in the EECs which, though electrically similar, are totally different in terms of code and calibration content. The EDIS gets the required spark advance from the EEC and, using the regularly updated crankshaft position, determines the ignition firing time.

The return from the EEC to the TFI module (SPOUT or SPark OUT) is the timing information and has the same specifications as PIP. What I gleaned from this is that the PIP does 2 things:

1) It lets the EEC know how fast the engine is turning (frequency alone).
2) It gives a base signal to be sent back to the TFI after being delayed a bit. This delay or phase change (relative to the PIP) is what lets the EEC control timing. But indirectly, the TFI is doing _most_ of the work.

The EEC does the timing. The TFI's function is to charge and fire the coil. The TFI basically just cleans up the PIP signal. If you measure it right off the Hall effect sensor, it can look pretty nasty. It goes into the TFI module, gets cleaned up and sent off to the EEC. The only delay is propagation delay through the TFI electronics. The EEC sends out the SPOUT signal which starts the TFI modules charging the coil. The coil fires on the falling edge and, depending on what advance the EEC is looking for, the falling edge of the SPOUT varies. Since the EEC knows where 10 BTDC of each cylinder is, by using timers and things, it can calculate when to drop the SPOUT signal. The PIP information the EEC uses to calculate SPOUT is not current, it uses the previous PIP value to determine where the crank was. The TFI module can handle acceleration rates of up to 250 HZ/sec. Another function of the TFI modules is to provide LOS spark (limp mode). If the TFI detects a loss of SPOUT, it will generate it's own 'SPOUT' to coincide with the rising edge of PIP (10 BTDC...assuming you haven't moved the distributor).

The return signal from the EEC to the EDIS is unrelated to the PIP. It purely indicates to the EDIS unit the amount of spark advance required.

EEC FUNCTIONS

(Taken from Mike Wesley's Calibrator demo and other sources.)

load scaling
MAF transfer
WOT spark advance vs RPM
WOT spark advance vs ECT
WOT spark advance vs ACT
accelerator enrichment
WOT fuel multiplier vs RPM
WOT fuel multiplier vs TP
part throttle spark advance vs ACT
open loop fuel vs ACT
closed throttle open loop fuel multiplier
spark advance vs BAP
spark advance rate

dwell
altitude fuel adjustment
cranking fuel vs ECT
injector adjustment for low battery
dashpot clip and decrement rate
transmission TV pressure vs TP
torque converter lockup vs TP
upshift speed vs TP
downshift speed vs TP
idle airflow

EEC SCALARS

(Taken from Mike Wesley's Calibrator demo and other sources.)

injector size
injector slope
minimum injector pulse width
accelerator pump multiplier
open loop fuel multiplier
part throttle timing adder
dwell minimum
dwell maximum
ACT minimum for adaptive control
ACT maximum for adaptive control
minimum ECT for deceleration fuel shutoff
minimum RPM for deceleration fuel shutoff
minimum load (MAP) for closed loop
hi-load timeout to open loop
idle speed neutral
idle speed drive
CID
number HEGO sensors
WOT TPS value
EGR multiplier
EGR type
PIP filter
half fuel rev limit
speed limit
maximum spark retard
cooling fan ECT hi/lo/hysteresis
intake manifold volume
thermactor presence

EEC TABLES

(Taken from Mike Wesley's Calibrator demo and other sources.)

accelerator enrichment (lb/min)
startup fuel (A:F ratio)
base fuel (A:F ratio)
injector timing (crank degrees)
injector firing order
base spark (deg BTDC)
limp mode spark (deg BTDC)
injector output port
borderline detonation spark
borderline compensation vs ECT
borderline compensation vs ACT
borderline compensation vs lambda

acceleration fuel time constant
exhaust pulse delay
HEGO amplitude
HEGO bias
engine torque
engine frictional torque

MAF CONVERSION

Information on MAF conversion sent to me by Bob Nell <bnell@utk.edu>

(this is specifically for '87-'88 SC 5.0 Mustangs)
attach these 4 wires from the MAF to the EEC

Air Meter Pin C-T/LB to EEC pin #9
Air Meter Pin D-DB/O to EEC pin #50
Air Meter Pin A- Red to EEC (splice into the existing red wire on pin #37)
(this is VPWR)
Air Meter Pin B- Black to EEC(splice this into the existing blk wire on #40 or #60)
(this is PWR GRND)

Also, these changes must be made:

Pin 51 must be moved to pin 38 on EEC
Pin 11 must be moved to pin 32 on EEC

To hook up the VSS:

VSS + must be hooked up to Pin #3 on EEC
VSS - must be hooked up to pin #6 on EEC

you can get the VSS signal right from the VSS or tap it off the speed control amplifier which is located near the dead pedal

Its the yellowish box in the corner there..
The DG/W wire is VSS+ and the black wire is VSS -

To hook up Fuel Pump Signal:

Splice into the PK/BL wire that goes into the Fuel Pump Relay (located under the driver's seat on pre-93 Mustangs) and run it to pin #19 on the EEC.

Mike Wesley said: "The setup for the '95 Mustang Cobra R, (351 CID) was an 80 mm Lincoln Mark VIII MAF and 24# per hour injectors. These injectors will easily support 350 HP and the 80mm MAF is a better choice than the 70mm, as you get to use more of its linear range, so fueling can be more accurate.

To convert SD trucks with E4OD/AODE transmissions to MAF, Mike suggested: "The one most people use is the CA 5.8 MAF/E4OD (F5TF-12A650-BYA). It is obtainable through any Ford dealer (Pro-M, Kenne Bell, LCA, Downs Ford). I use the F5TF-12A650-HB (95 CA 5.0 MAF/E4OD) on a 750+ HP daily driver 415 stroker Lightning with a Vortech S trim. It is running open loop, has been reprogrammed, drives like stock, gets 17 MPG and will run low 10's at 130+ in the 1/4 mile and A/C and cruise work great. Both of these EEC's are set to use 4.10 gears. If a smaller ratio is used, say 3.55, you could use the F5TF-12A650-GB. There are probably 15-20 EEC's available to convert a SD (later model) to MAF.

"If you have an early SD truck with AOD, re-wire to the Mustang EEC (Ford Motor-Sport sells this kit). You'll have to move/add quite a few wires, and you might not like the results if you're not able to re-calibrate the EEC (like the Pro-M 'low cost' kit, Kenne Bell, LCA and Downs Ford come pre-re-calibrated). The engine shuts down at 85 MPH, shifting is fairly sloppy and too early (at least on a Lightning). All Ford EECs shift poorly -- except for the Lightning which is only slightly firmer."

"To use the Mustang EEC on a truck with an E4OD/AODE, you would need to run two EECs in parallel. The Mustang EEC runs the engine, the existing truck EEC controls the trans. Pro-M sells a kit like this."

TESTING AFMs

To test a MAF, supply it with +12V and ground. The output will vary from roughly 0.25V to 0.5V at no flow, up to 4.75 to 5.00V at full flow.

John Lloyd <john@anergy.demon.co.uk> sent the following MAF calibration tables

"I calibrated an air meter the other day in the lab... A slight discontinuity between the hi and lo flow masters but it may be of use?

Calibration of air meters with Ford AFM
Vs=5.0
Tamb=19C
19-Mar-97

l/min Lo meter	v	Hi meter	V
0	1.113	200	3.045
25	1.113	250	3.339
30	1.113	300	3.564
40	1.113	350	3.766
50	1.113	400	3.854
60	1.113	450	3.971
70	1.262	500	4.076
80	1.463	550	4.158
90	1.824	600	4.201
100	1.882	650	4.245
120	2.262	200	3.097
140	2.515	400	3.868
160	2.63	200	3.087
180	2.83		
200	3.014		
110	2.106		
160	2.629		
0	1.113		

Below data as promised for what came straight of a Ford Calibration of air meters with AFM
Vs=5.00
Tamb=19C

AFM1   Bosch 0 280 200 025   19-Mar-97
AFM2   Ford 86GB12B529-AA with ref 0 280 200 047   29-Apr-97
From 2.9i V6 using two off

l/min	AFM1	AFM2		AFM1	AFM2

Lo meter		V		Hi meter		V
0	1.113	0.25	200	3.045	1.16	
25	1.113		250	3.339		
30	1.113	0.25	300	3.564	1.73	
40	1.113		350	3.766		
50	1.113	0.25	400	3.854	2.09	
60	1.113		450	3.971		
70	1.262	0.25	500	4.076	2.35	
80	1.463		550	4.158		
90	1.824	0.25	600	4.201	2.58	
100	1.882	0.25	650	4.245		
120	2.262	0.45	680		2.75	
140	2.515	0.68	400	3.868		
160	2.63	0.83	200	3.087		
180	2.83	0.98				
200	3.014	1.15				
110	2.106					
160	2.629					
0	1.113					

TERMS

A/C	Air Conditioning
ACCS	A/C Cycling Switch
ACC	A/C Clutch Compressor
ACT	Air Charge Temperature sensor
ACV	Thermactor Air Control Valve
AXOD	Automatic Transaxle Overdrive
BOO	Brake On/Off switch
BP	Barometric Pressure sensor
CANP	Canister Purge solenoid
CCO	Converter Clutch Override
CFI	Central Fuel Injection
CID	Cylinder Identification sensor
CKT	Circuit
DIS	Direct Ignition System (see also EDIS, TFI)
DVOM	Digital Volt/Ohm Meter
ECA	Electronic Control Assembly (processor, computer) (see MCU)
ECM	Electronic Control Module (see MCU)
ECT	Engine Coolant Temperature sensor
ECU	Electronic Control Unit (see MCU)
EDF	Electric Drive Fan relay assembly
EDIS	Electronic DIStributor (see also DIS, TFI)
EED	Electronic Engine Control
EGO	Exhaust Gas Oxygen sensor (see HEGO)
EGR	Exhaust Gas Recirculation system
EGRC	EGR Control solenoid or system
EGRV	EGR Vent solenoid or system
EVP	EGR Position sensor
EVR	EGR Valve Regulator
FI	Fuel Injector or Fuel Injection
FP	Fuel Pump
FPM	Fuel Pump Monitor
GND or GRND	Ground
HEDF	High Speed Electro Drive Fan relay or circuit
HEGO	Heated EGO sensor
HEGOG	HEGO Ground circuit
HO	High Output
HSC	High Swirl Combustion, engine type
IDM	Ignition Diagnostic Module

IGN	Ignition system or circuit
INJ	Injector or Injection
ISC	Idle Speed Control
ITS	Idle Tracking Switch
KAM	Keep Alive Memory
KAPWR	Keep Alive Power
KOEO	Key On Engine Off
KOER	Key On Engine Running
KS	Knock Sensor
L	Liter(s)
LOS	Limited Operation Strategy (computer function)
LUS	Lock-Up Solenoid
MAF	Mass Air Flow sensor, meter or circuit
MA PFI	Mass Air Sequential Port Fuel Injection system
MCU	Microprocessor Control Unit
MIL	Malfunction Indicator Light
MPFI	Multi Port Fuel Injection
NDS	Neutral Drive Switch
NGS	Neutral Gear Switch
NPS	Neutral Pressure Switch
OCC	Output Circuit Check
OHC	Over Head Camshaft (engine type)
OSC	Output State Check
PFE	Pressure Feedback EGR sensor or circuit
PFI	Port Fuel Injection
PIP	Profile Ignition Pickup
PSPS	Power Steering Pressure Switch
PWR GND	Power Ground circuit
RWD	Rear Wheel Drive
SC	Super Charged (engine type)
SIG RTN	Signal Return circuit
SIL	Shift Indicator Light
SPOUT	Spark Output Signal from ECA
SS 3/4 - 4/3	Shift Solenoid circuit
STAR	Self Test Automatic Readout (test equipment)
STI	Self Test Input circuit
STO	Self Test Output circuit
TAB/TAD	Thermactor Air Bypass/Diverter Tandem solenoid valves
TAPS	Throttle Angle Position Sensor (see TP/TPS)
TFI	Thick Film Ignition system (see DIS, EDIS)
TGS	Top Gear Switch (cancels SIL operation in top gear)
THS	Transmission Hydraulic Switch
TP/TPS	Throttle Position Sensor
TTS	Transmission Temperature Switch
VAF	Vane Air Flow sensor or circuit
VAT	Vane Air Temperature
VBATT	Vehicle Battery Voltage
VM	Vane Meter
VOM	Analog Volt/Ohm Meter
VPWR	Vehicle Power supply voltage (regulated 10-14 volts)
VREF	Voltage Reference (ECA supplied reference voltage 4-6 volts)
VSC	Vehicle Speed Control sensor or signal
VSS	Vehicle Speed Sensor or signal
WAC	WOT A/C Cut-off switch or circuit
WOT	Wide Open Throttle

EEC APPLICATIONS

(sorted on CID and Code)

A9L is the most common 89-93 MAF 5-speed computer catch code
T4M0 is the most common 94-95 MAF 5-speed/E0D computer catch code
J4J1 is the catch code on 94-95 Cobra computers
ZA0 is the catch code used on the Cobra-R!!!

engine	vehicle	year	type	xmsn	diff	Code	Part Number
	MK7					D9S	
	Probe V6					KLO7	
	MK7					M1L1	
	MK8					W3Z2	
	XR7					X2P	
	MK8					Z4H0	
1.9	Escort					8AM	
1.9	Escort					8BB	
1.9	Escort					AA2	
1.9	Escort					AB2	
1.9	Escort					AB3	
1.9	Escort					AF1	
1.9	Escort					AH1	
1.9	Escort					F1X	
1.9	Escort					L1X	
1.9	Escort					M2Z	
1.9	Escort					UB	
1.9	Escort					W1E	
2.0	Probe 16V					T	
2.3	Mustang					8CC	
2.3	Tempo					8DN	
2.3	T'Bird Turbo					8UA	
2.3	Mustang					FB2	
2.3	Mustang SVO					FB2	
2.3	T'Bird Turbo					LA	
2.3	T'Bird Turbo					LA2	
2.3	T'Bird Turbo					LA3	
2.3	T'Bird Turbo					LB2	
2.3	T'Bird Turbo					LB3	
2.3	Mustang SVO					PC1	
2.3	Mustang SVO					PE	
2.3	Merkur Turbo					PF2	
2.3	Merkur Turbo					PF3	
2.3	Mustang SVO					PJ	
2.3	Mustang SVO					PK	
2.3	Mustang SVO					PK1	
2.3	T'Bird Turbo					TA	
2.3	T'Bird Turbo					TE	
2.3	Mustang SVO					TE	
2.3	T'Bird Turbo					TF	
2.3	Mustang SVO					VJ1	
2.3	T'Bird Turbo					ZAA	
2.3	Mustang SVO					ZBA	
2.3	T'Bird Turbo					ZGA	
2.8	Ranger					C9B	
2.9	Scorpio					7GYA	
2.9	Ranger					8DR	
2.9	Scorpio					8GHB	
2.9	Ranger					8ML	
2.9	Ranger					C9E1	
2.9	Ranger					C9M	

2.9	Ranger	87	SD	5-spd		HD	
2.9	Ranger					LDP1	
2.9	Ranger					RM2	
2.9	Bronco II	86	SD	A4LD		RP	
3.0	Taurus	88				8NC	E9AF-14A624-AA
3.0	Ranger					ACE1	
3.0	Taurus SHO					B9B	
3.0	Taurus SHO					B9B1	
3.0	Cougar					CE	
3.0	Taurus					D9C	
3.0	Taurus					D9C1	
3.0	Ranger					J2Z	
3.0	Taurus SHO					L0S	
3.0	Ranger					M2T	
3.0	Ranger					MOM2	
3.0	Taurus SHO					W2Z	
3.0	Taurus SHO					X2J	
3.2	Taurus SHO					H3Z	
3.8	T'Bird SC					B9A1	
3.8	Cougar					B9L1	
3.8	T'Bird					B9L2	
3.8	T'Bird SC					C0S	
3.8	T'Bird SC					LOE1	
3.8	T'Bird SC					M2Y	
3.8	T'Bird					MP	
3.8	LTD					SX	
3.8	T'Bird SC					U2Y	
3.8	T'Bird SC					W1M	
3.8	T'Bird SC					W4D2	
3.8	T'Bird					X1A2	
3.8	T'Bird SC					X1A2	
3.8	T'Bird SC					Z1Z2	
3.8	T'Bird					Z2U2	
4.0	Ranger/Explr					A1S	
4.0	Ranger/Explr					ADZ1	
4.0	Ranger/Explr					ANY1	
4.0	Ranger/Explr					BAT1	
4.0	Ranger/Explr					C1J	
4.0	Ranger/Explr					COW1	
4.0	Ranger/Explr					E0E	
4.0	Ranger/Explr					E0L	
4.0	Ranger/Explr					HAG0	
4.0	Ranger/Explr					K1P0	
4.0	Ranger/Explr					L0D	
4.0	Ranger/Explr					NAP2	
4.0	Ranger/Explr					OLD2	
4.0	Ranger/Explr					P0X0	
4.0	Ranger/Explr					PAN1	
4.0	Ranger/Explr					RAT1	
4.0	Ranger/Explr					UMP1	
4.0	Ranger/Explr					VAN	
4.0	Ranger/Explr					VET1	
4.0	Ranger/Explr					X0A	
4.0	Ranger/Explr					X2T2	
4.0	Ranger/Explr					YAM1	
4.0	Ranger/Explr					Z2C2	
4.6	Crown Vic					A2J1	
4.6	Crown Vic					C2Z3	
4.6	Crown Vic					C3N3	

4.6	Crown Vic					DH	
4.6	Crown Vic					E3Y2	
4.6	Crown Vic					L2W	
4.6	Crown Vic					M2C	
460	Van					DAD	
460CI	F350					8SE	
460CI	F350					J2C1	
460CI	F350					W2T	
5.?	truck CA		MAF	E4OD	3.55		F5TF-12A650-GB
5.0	truck CA	95	MAF	E4OD	4.10		F5TF-12A650-HB
5.0	T'Bird					8KC	
5.0	Mustang		MAF			8LD	
5.0	Bronco					8PZ	
5.0	Bronco					8PZ	
5.0	Bronco	88	SD	5-spd	3.55	8TP	
5.0	Mustang					A3M	
5.0	Mustang		MAF			A3M1	
5.0	Mustang	89-93	MAF			A9L	
5.0	Mustang		MAF			A9M	
5.0	Mustang		MAF			A9P	
5.0	Mustang		MAF			A9S	
5.0	T'Bird					AB2	
5.0	Bronco					C2M1	
5.0	Mustang					C3W	
5.0	Mustang		MAF			C3W1	
5.0	T'Bird					D2L	
5.0	Mustang					D3D	
5.0	Mustang	87	SD/SFI			DA1	E7SF-12A650-A1B
5.0	Mustang					DC	
5.0	Mustang					DE	
5.0	T'Bird					DG1	
5.0	Mustang					DX3	
5.0	T'Bird					E1X	
5.0	Mustang					GJ1	
5.0	T'Bird					H2M	
5.0	T'Bird					H2M1	
5.0	T'Bird					KF	
5.0	Bronco					L12D	
5.0	T'Bird					MC2	
5.0	G.Marquis					MN	
5.0	T'Bird					P3M	
5.0	Econoline					T2T	
5.0	Mustang	94-95	MAF	EOD		T4MO	
5.0	Mustang					U4PO	
5.0	Mustang	86	SFI			VH2	E6SF-12A650-H1C
5.0	Mustang					VJ1	
5.0	Mustang					VM1	
5.0	Mustang					VR1	
5.0	Bronco					W2J	
5.0	Cobra					X3Z	
5.8	truck CA		MAF	E4OD	4.10		F5TF-12A650-BYA
5.8	Bronco,F-x50					39D1	
5.8	Bronco,F-x50					A0C3	
5.8	Bronco,F-x50					A2Z	
5.8	Bronco,F-x50					A2Z1	
5.8	Bronco,F-x50					BTQ	
5.8	Bronco,F-x50					C1Z	
5.8	Bronco,F-x50					C2M1	
5.8	Lightning			E4OD		C3P1	

5.8	Lightning			E4OD		C3P2	
5.8	Bronco,F-x50					D1X	
5.8	Bronco,F-x50					D9D1	
5.8	Bronco,F-x50					D9L1	
5.8	Bronco,F-x50					E0D	
5.8	Bronco,F-x50					FK1	
5.8	Bronco,F-x50					GT	
5.8	Bronco,F-x50					U2U1	
5.8	Bronco,F-x50					W2J	
5.8	Bronco,F-x50					X0P	
5.8	Bronco,F-x50					Z2D1	
5.8	Cobra-R					ZA0	

EEC-IV REFERENCE SOURCES:

The Engine/Emissions Diagnosis manual (a.k.a. the "H" manual) for your car's model year covers all emissions related maintenance procedures for the entire model year's production. It is available from Helm, Inc., (800) 782-4356.

"How to Understand, Service, and Modify Ford Fuel Injection and Electronic Engine Control", by Charles O. Probst, published by Robert Bentley of Cambridge, MA, USA, ISBN 0-8376-0301-3. It is available from a number of sources, including the publisher, Ford Motorsports dealers, and Classic Motorbooks at (800) 826-6600. For about $30, you get a complete overview of the sensors, actuators, and control algorithms used by the EEC-IV, step-by-step diagnostic procedures, wiring diagrams, plus tips on hot-rodding EEC-IV cars.

SAE paper #820900, "EEC-IV Tomorrow's Electronic Engine Controls Today", David Hagen & Dennis Wilkie, Ford Motor Co., Dearborn, MI

AFTER-MARKET SUPPLIERS:

Connectors for the EEC are apparently proprietary also, though some have said they are available through Amp, Farnell and DigiKey.

There seem to be two channels of ECM availability:

1 - OEMs and the companies they authorize, who together provide remanufactured ECMs through dealer channels;

2 - and those involved in the remanufacturing of ECMs for the true automotive aftermarket.

- A1 Cardone
- Echlin
- Micro-Tech Automotive
- Standard Motor Parts

Some of these companies catalog and offer product (or repair service) on almost 800 different ECM configurations for Ford-made vehicles in the model years from 1977-1993. Some of these are consolidations of applications, where units have proven and tested to be comparable. Foreign made vehicles sold under the Ford nameplate would add to this population of ECMs, since the above count is only Ford units.

For an idea of what the EEC does, and what can be done with it, get a demo of Mike Wesley's calibrator for the EEC-IV at:
http://www.tiac.net/users/goape/index.htm