8-Bit Microprocessor Family

SY6500

MICROPROCESSOR PRODUCTS

APRIL 1979

- Single 5 V ±5% power supply
- N channel, silicon gate, depletion load technology
- Eight bit parallel processing
- 56 Instructions
- Decimal and binary arithmetic
- Thirteen addressing modes
- True indexing capability
- Programmable stack pointer
- Variable length stack
- Interrupt capability
- Non-maskable interrupt
- Use with any type or speed memory
- Bi-directional Data Bus
- Instruction decoding and control
- Addressable memory range of up to 65 K bytes
- "Ready" input
- Direct memory access capability
- Bus compatible with MC6800
- Choice of external or on-board clocks
- 1 MHz, 2 MHz, and 3 MHz operation
- On-chip clock options
  * External single clock input
  * Crystal time base input
- 40 and 28 pin package versions
- Pipeline architecture

The SY6500 Series Microprocessors represent the first totally software compatible microprocessor family. This family of products includes a range of software compatible microprocessors which provide a selection of addressable memory range, interrupt input options and on-chip clock oscillators and drivers. All of the microprocessors in the SY6500 family are software compatible within the group and are bus compatible with the MC6800 product offering.

The family includes six microprocessors with on-board clock oscillators and drivers and four microprocessors driven by external clocks. The on-chip clock versions are aimed at high performance, low cost applications where single phase inputs or crystals provide the time base. The external clock versions are geared for the multi-processor system applications where maximum timing control is mandatory. All versions of the microprocessors are available in 1 MHz, 2 MHz, and 3 MHz maximum operating frequencies.

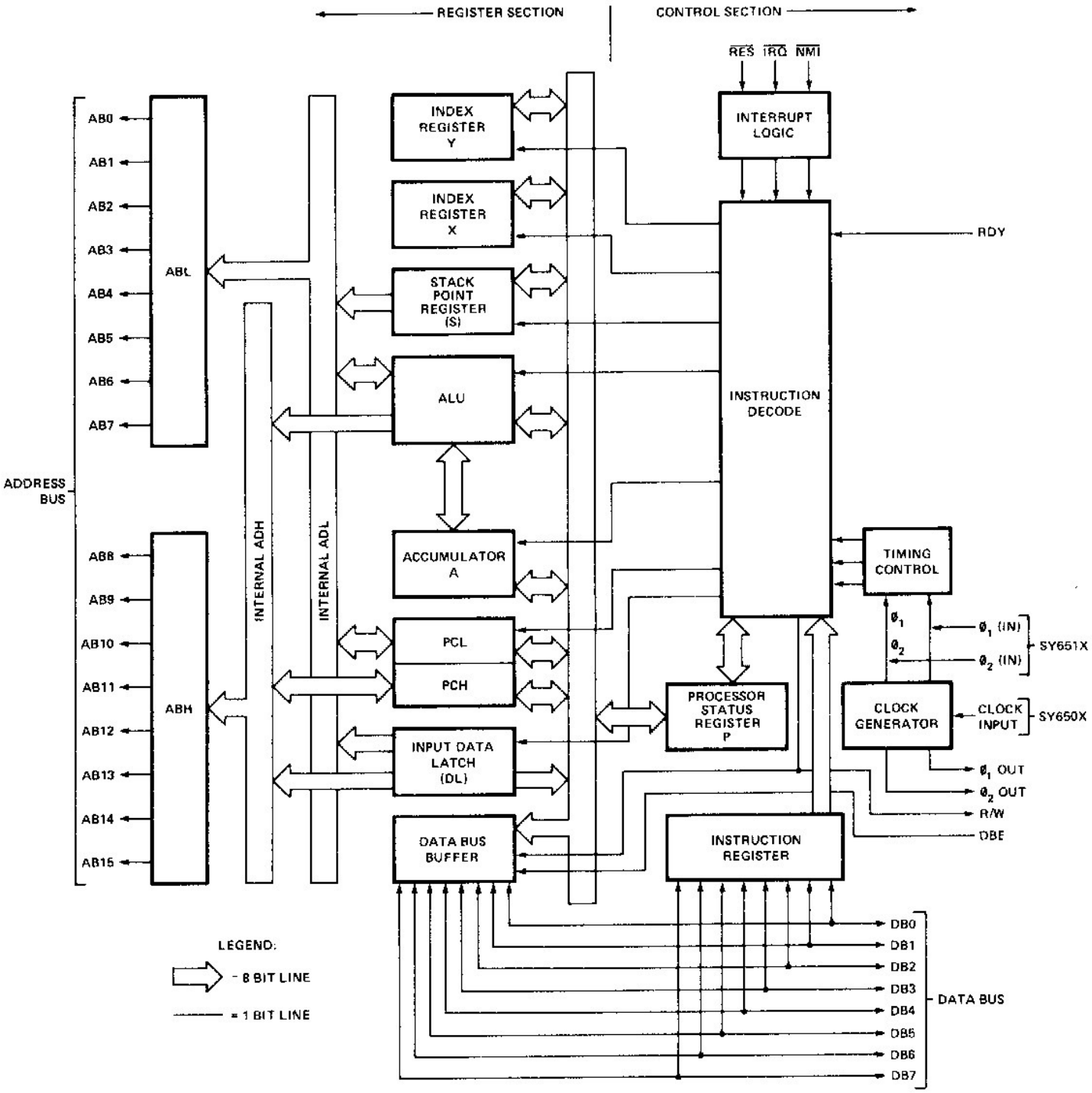
MEMBERS OF THE FAMILY

PART NUMBERS		CLOCKS	PINS	$\overline{IRQ}$	$\overline{NMI}$	RDY	ADDRESSING
Plastic	Ceramic						
SYP6502	SYC6502	On-Chip	40	√	√	√	16 (64 K)
SYP6503	SYC6503	"	28	√	√		12 (4 K)
SYP6504	SYC6504	"	28	√			13 (8 K)
SYP6505	SYC6505	"	28	√		√	12 (4 K)
SYP6506	SYC6506	"	28	√			12 (4 K)
SYP6507	SYC6507	"	28			√	13 (8 K)
SYP6512	SYC6512	External	40	√	√	√	16 (64 K)
SYP6513	SYC6513	"	28	√	√		12 (4 K)
SYP6514	SYC6514	"	28	√			13 (8 K)
SYP6515	SYC6515	"	28	√		√	12 (4 K)

COMMENTS ON THE DATA SHEET

The data sheet is constructed to review first the basic "Common Characteristics" — those features which are common to the general family of microprocessors. Subsequent to a review of the family characteristics will be sections devoted to each member of the group with specific features of each.

SY6500 INTERNAL ARCHITECTURE



NOTE:
1. CLOCK GENERATOR IS NOT INCLUDED ON SY651X.
2. ADDRESSING CAPABILITY AND CONTROL OPTIONS VARY WITH EACH OF THE SY6500 PRODUCTS.

D.C. CHARACTERISTICS

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Supply Voltage	V_{CC}	−0.3 to +7.0	V
Input Voltage	V_{in}	−0.3 to +7.0	V
Operating Temperature	T_A	0 to +70	°C
Storage Temperature	T_{STG}	−55 to +150	°C

COMMENT

This device contains input protection against damage due to high static voltages or electric fields; however, precautions should be taken to avoid application of voltages higher than the maximum rating.

ELECTRICAL CHARACTERISTICS (V_{CC} = 5.0V ± 5%, T_A = 0–70°C)

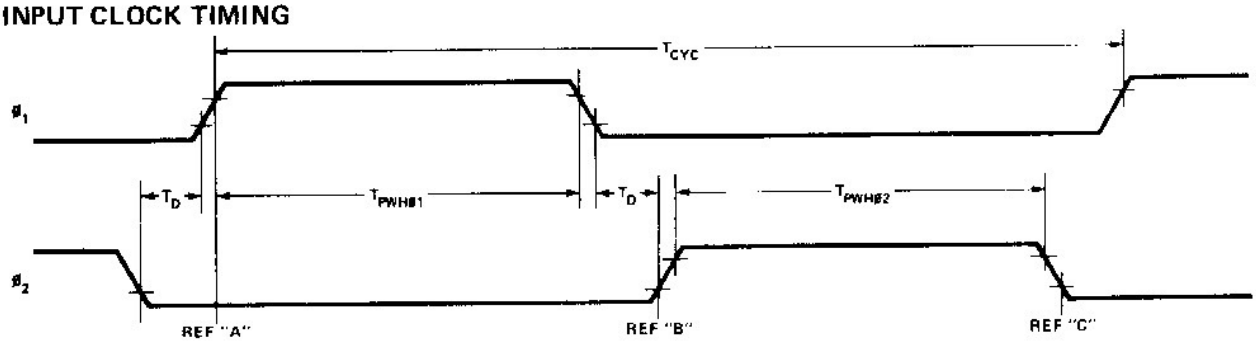
($\emptyset_1$, $\emptyset_2$ applies to SY651X, $\emptyset_{o\,(in)}$ applies to SY650X)

Symbol	Characteristic	Min.	Max.	Unit
V_{IH}	Input High Voltage			
	Logic, $\emptyset_{o\,(in)}$ (650X)	+2.4	V_{CC}	
	$\emptyset_1$, $\emptyset_2$ (651X)	V_{CC} − 0.5	V_{CC} + 0.25	V
V_{IL}	Input Low Voltage			
	Logic, $\emptyset_{o\,(in)}$ (650X)	−0.3	+0.4	
	$\emptyset_1$, $\emptyset_2$ (651X)	−0.3	+0.2	V
I_{IL}	Input Loading (V_{in} = 0 V, V_{CC} = 5.25 V) RDY, S.O.	−10	−300	μA
I_{in}	Input Leakage Current (V_{in} = 0 to 5.25 V, V_{CC} = 0)			
	Logic (Excl. RDY, S.O.)		2.5	μA
	$\emptyset_1$, $\emptyset_2$ (651X)	—	100	μA
	$\emptyset_{o\,(in)}$ (650X)	—	10.0	μA
I_{TSI}	Three-State (Off State) Input Current (V_{in} = 0.4 to 2.4 V, V_{CC} = 5.25 V) DB0-DB7	—	10	μA
V_{OH}	Output High Voltage (I_{LOAD} = −100μAdc, V_{CC} = 4.75 V) SYNC, DB0-DB7, A0-A15, R/W	2.4	—	V
V_{OL}	Output Low Voltage (I_{LOAD} = 1.6mAdc, V_{CC} = 4.75 V) SYNC, DB0-DB7, A0-A15, R/W	—	0.4	V
P_D	Power Dissipation			
	1 MHz and 2 MHz	—	700	mW
	3 MHz	—	800	mW
C	Capacitance (V_{in} = 0, T_A = 25°C, f = 1 MHz)			
C_{in}	$\overline{RES}$, $\overline{NMI}$, RDY, $\overline{IRQ}$, S.O., DBE	—	10	
	DB0-DB7	—	15	
C_{out}	A0-A15, R/W, SYNC	—	12	pF
$C_{\emptyset o(in)}$	$\emptyset_{o\,(in)}$ (650X)	—	15	
$C_{\emptyset_1}$	$\emptyset_1$ (651X)	—	50	
$C_{\emptyset_2}$	$\emptyset_2$ (651X)	—	80	

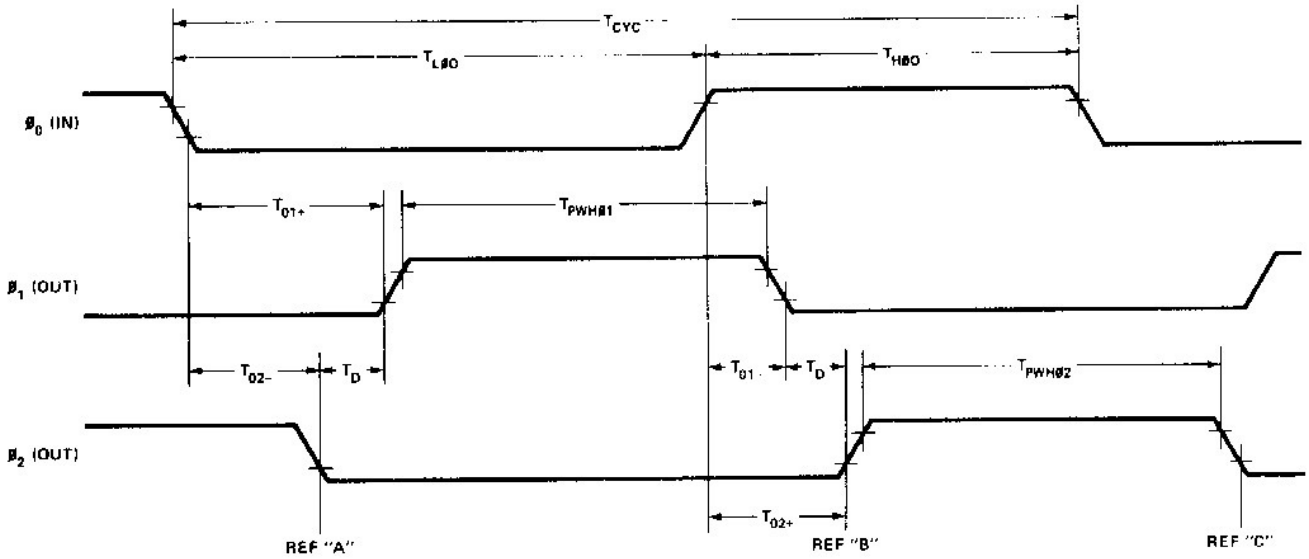
Note: $\overline{IRQ}$ and $\overline{NMI}$ require 3 K pull-up resistors.

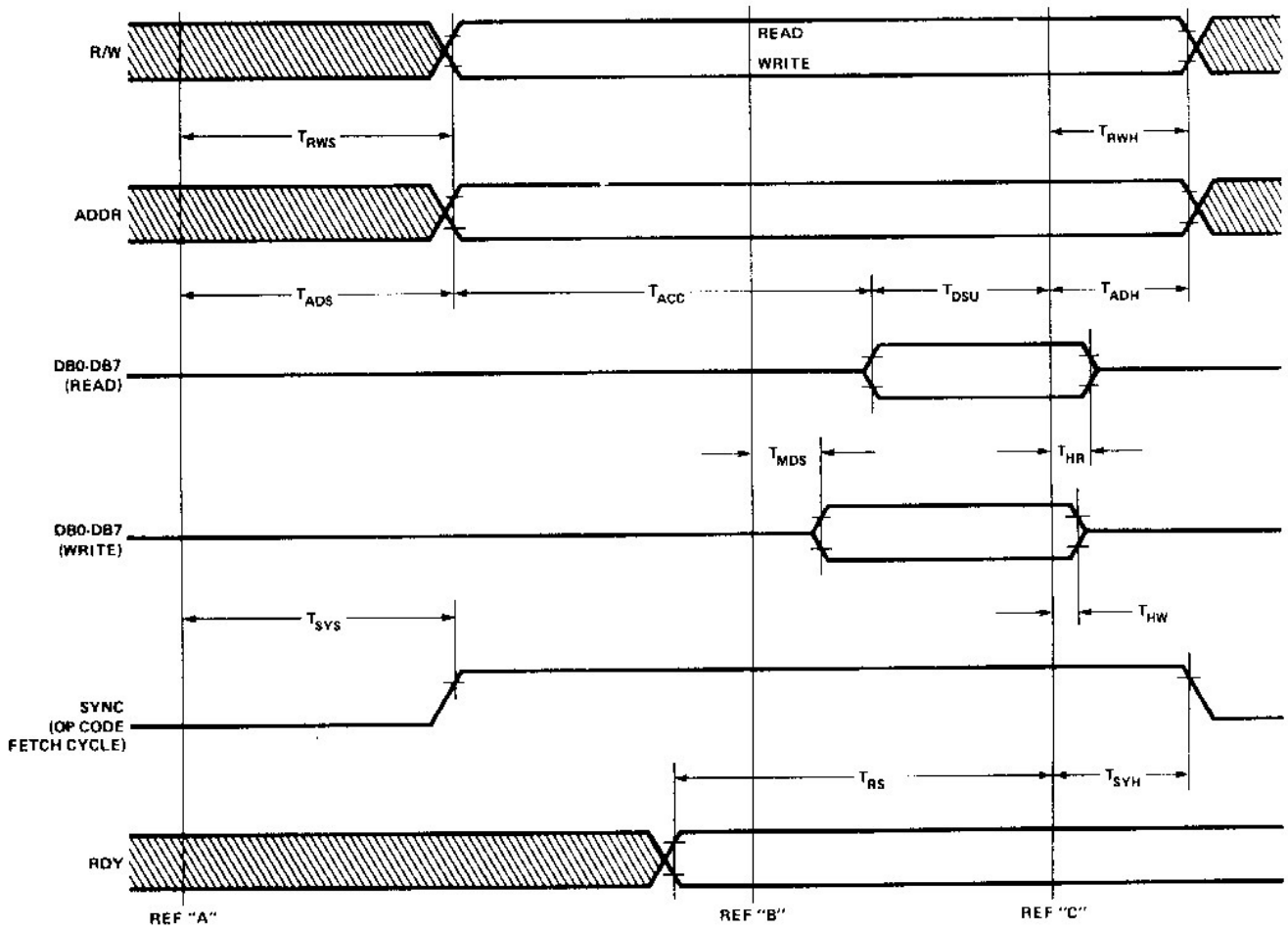
TIMING DEFINITIONS

SY651X INPUT CLOCK TIMING



SY650X INPUT CLOCK TIMING





DYNAMIC OPERATING CHARACTERISTICS

(V_{CC} = 5.0 ± 5%, T_A = 0° to 70°C)

Device Type	Parameter	Note	Symbol	1 MHz		2 MHz ⑥		3 MHz ⑦		Unit
				Min.	Max.	Min.	Max.	Min.	Max.	
651X	Cycle Time		T_{CYC}	1.00	40	0.50	40	0.33	40	µs
	$\emptyset_1$ Pulse Width		$T_{PWH\emptyset_1}$	430	–	215	–	150	–	ns
	$\emptyset_2$ Pulse Width		$T_{PWH\emptyset_2}$	470	–	235	–	160	–	ns
	Delay Between $\emptyset_1$ and $\emptyset_2$		T_D	0	–	0	–	0	–	ns
	$\emptyset_1$ and $\emptyset_2$ Rise and Fall Times	①	T_R, T_F	0	25	0	20	0	15	ns
650X	Cycle Time		T_{CYC}	1.00	40	0.50	40	0.33	40	µs
	$\emptyset_{o(IN)}$ Low Time	②	$T_{L\emptyset_o}$	480	–	240	–	160	–	ns
	$\emptyset_{o(IN)}$ High Time	②	$T_{H\emptyset_o}$	460	–	240	–	160	–	ns
	$\emptyset_o$ Neg to $\emptyset_1$ Pos Delay	⑤	T_{01+}	10	70	10	70	10	70	ns
	$\emptyset_o$ Neg to $\emptyset_2$ Neg Delay	⑤	T_{02-}	5	65	5	65	5	65	ns
	$\emptyset_o$ Pos to $\emptyset_1$ Neg Delay	⑤	T_{01-}	5	65	5	65	5	65	ns
	$\emptyset_o$ Pos to $\emptyset_2$ Pos Delay	⑤	T_{02+}	15	75	15	75	15	75	ns
	$\emptyset_{o(IN)}$ Rise and Fall Time	①	T_{RO}, T_{FO}	0	10	0	10	0	10	ns
	$\emptyset_{1(OUT)}$ Pulse Width		$T_{PWH\emptyset_1}$	$T_{L\emptyset_o}$-20	$T_{L\emptyset_o}$	$T_{L\emptyset_o}$-20	$T_{L\emptyset_o}$	$T_{L\emptyset_o}$-20	$T_{L\emptyset_o}$	ns
	$\emptyset_{2(OUT)}$ Pulse Width		$T_{PWH\emptyset_2}$	$T_{L\emptyset_o}$-40	$T_{L\emptyset_o}$-10	$T_{L\emptyset_o}$-40	$T_{L\emptyset_o}$-10	$T_{L\emptyset_o}$-40	$T_{L\emptyset_o}$-10	ns
	Delay Between $\emptyset_1$ and $\emptyset_2$		T_D	5	–	5	–	5	–	ns
	$\emptyset_1$ and $\emptyset_2$ Rise and Fall Times	① ③	T_R, T_F	–	25	–	25	–	15	ns
650X 651X	R/W Setup Time		T_{RWS}	–	225	–	140	–	110	ns
	R/W Hold Time		T_{RWH}	30	–	30	–	15	–	ns
	Address Setup Time		T_{ADS}	–	225	–	140	–	110	ns
	Address Hold Time		T_{ADH}	30	–	30	–	15	–	ns
	Read Access Time		T_{ACC}	–	650	–	310	–	170	ns
	Read Data Setup Time		T_{DSU}	100	–	50	–	50	–	ns
	Read Data Hold Time		T_{HR}	10	–	10	–	10	–	ns
	Write Data Setup Time		T_{MDS}	–	175	–	100	–	75	ns
	Write Data Hold Time		T_{HW}	60	–	60	–	30	–	ns
	Sync Setup Time		T_{SYS}	–	350	–	175	–	100	ns
	Sync Hold Time		T_{SYH}	30	–	30	–	15	–	ns
	RDY Setup Time	④	T_{RS}	200	–	200	–	150	–	ns

NOTES:

① Measured between 10% and 90% points on waveform.

② Measured at 50% points.

③ Load = 1 TTL load +30 pF.

④ RDY must never switch states within T_{RS} to end of $\emptyset_2$.

⑤ Load = 100 pF.

⑥ The 2 MHz devices are identified by an "A" suffix.

⑦ The 3 MHz devices are identified by a "B" suffix.

PIN FUNCTIONS

Clocks (ϕ_1, ϕ_2)

The SY651X requires a two phase non-overlapping clock that runs at the V_{CC} voltage level.

The SY650X clocks are supplied with an internal clock generator. The frequency of these clocks is externally controlled. Clock generator circuits are shown elsewhere in this data sheet.

Address Bus (A_0-A_{15}) (See sections on each micro for respective address lines on those devices.)

These outputs are TTL compatible, capable of driving one standard TTL load and 130 pF.

Data Bus (DB_0-DB_7)

Eight pins are used for the data bus. This is a bi-directional bus, transferring data to and from the device and peripherals. The outputs are three-state buffers, capable of driving one standard TTL load and 130 pF.

Data Bus Enable (DBE)

This TTL compatible input allows external control of the three-state data output buffers and will enable the microprocessor bus driver when in the high state. In normal operation DBE would be driven by the phase two (ϕ_2) clock, thus allowing data output from microprocessor only during ϕ_2. During the read cycle, the data bus drivers are internally disabled, becoming essentially an open circuit. To disable data bus drivers externally, DBE should be held low. This signal is available on the SY6512, only.

Ready (RDY)

This input signal allows the user to halt the microprocessor on all cycles except write cycles. A negative transition to the low state during or coincident with phase one (ϕ_1) will halt the microprocessor with the output address lines reflecting the current address being fetched. This condition will remain through a subsequent phase two (ϕ_2) in which the Ready signal is low. This feature allows microprocessor interfacing with low speed PROMS as well as fast (max. 2 cycle) Direct Memory Access (DMA). If ready is low during a write cycle, it is ignored until the following read operation. Ready transitions must not be permitted during ϕ_2 time.

Interrupt Request ($\overline{IRQ}$)

This TTL level input requests that an interrupt sequence begin within the microprocessor. The microprocessor will complete the current instruction being executed before recognizing the request. At that time, the interrupt mask bit in the Status Code Register will be examined. If the interrupt mask flag is not set, the microprocessor will begin an interrupt sequence. The Program Counter and Processor Status Register are stored in the stack. The microprocessor will then set the interrupt mask flag high so that no further interrupts may occur. At the end of this cycle, the program counter low will be loaded from address FFFE, and program counter high from location FFFF, therefore transferring program control to the memory vector located at these addresses. The RDY signal must be in the high state for any interrupt to be recognized. A 3KΩ external resistor should be used for proper wire-OR operation.

Non-Maskable Interrupt ($\overline{NMI}$)

A negative going transition on this input requests that a non-maskable interrupt sequence be generated within the microprocessor.

$\overline{NMI}$ is an unconditional interrupt. Following completion of the current instruction, the sequence of operations defined for $\overline{IRQ}$ will be performed, regardless of the state interrupt mask flag. The vestor address loaded into the program counter, low and high, are locations FFFA and FFFB respectively, thereby transferring program control to the memory vector located at these addresses. The instructions loaded at these locations cause the microprocessor to branch to a non-maskable interrupt routine in memory.

$\overline{NMI}$ also requires an external 3KΩ resistor to V_{CC} for proper wire-OR operations.

Inputs $\overline{IRQ}$ and $\overline{NMI}$ are hardware interrupts lines that are sampled during ϕ_2 (phase 2) and will begin the appropriate interrupt routine on the ϕ_1 (phase 1) following the completion of the current instruction.

Set Overflow Flag (S.O.)

A NEGATIVE going edge on this input sets the overflow bit in the Status Code Register. This signal is sampled on the trailing edge of ϕ_1.

SYNC

This output line is provided to identify those cycles in which the microprocessor is doing an OP CODE fetch. The SYNC line goes high during ϕ_1 of an OP CODE fetch and stays high for the remainder of that cycle. If the RDY line is pulled low during the ϕ_1 clock pulse in which SYNC went high, the processor will stop in its current state and will remain in the state until the RDY line goes high. In this manner, the SYNC signal can be used to control RDY to cause single instruction execution.

Reset ($\overline{RES}$)

This input is used to reset or start the microprocessor from a power down condition. During the time that this line is held low, writing to or from the microprocessor is inhibited. When a positive edge is detected on the input, the microprocessor will immediately begin the reset sequence.

After a system initialization time of six clock cycles, the mask interrupt flag will be set and the microprocessor will load the program counter from the memory vector locations FFFC and FFFD. This is the start location for program control.

After V_{CC} reaches 4.75 volts in a power up routine, reset must be held low for at least two clock cycles. At this time the R/W and SYNC signal will become valid.

When the reset signal goes high following these two clock cycles, the microprocessor will proceed with the normal reset procedure detailed above.

Read/Write (R/W)

This output signal is used to control the direction of data transfers between the processor and other circuits on the data bus. A high level on R/W signifies data into the processor; a low is for data transfer out of the processor.

PROGRAMMING CHARACTERISTICS

INSTRUCTION SET – ALPHABETIC SEQUENCE

ADC	Add Memory to Accumulator with Carry	DEC	Decrement Memory by One	PHA	Push Accumulator on Stack
AND	"AND" Memory with Accumulator	DEX	Decrement Index X by One	PHP	Push Processor Status on Stack
ASL	Shift left One Bit (Memory or Accumulator)	DEY	Decrement Index Y by One	PLA	Pull Accumulator from Stack
				PLP	Pull Processor Status from Stack
BCC	Branch on Carry Clear	EOR	"Exclusive-or" Memory with Accumulator		
BCS	Branch on Carry Set			ROL	Rotate One Bit Left (Memory or Accumulator)
BEQ	Branch on Result Zero	INC	Increment Memory by One	ROR	Rotate One Bit Right (Memory or Accumulator)
BIT	Test Bits in Memory with Accumulator	INX	Increment Index X by One	RTI	Return from Interrupt
BMI	Branch on Result Minus	INY	Increment Index Y by One	RTS	Return from Subroutine
BNE	Branch on Result not Zero				
BPL	Branch on Result Plus	JMP	Jump to New Location	SBC	Subtract Memory from Accumulator with Borrow
BRK	Force Break	JSR	Jump to New Location Saving Return Address	SEC	Set Carry Flag
BVC	Branch on Overflow Clear			SED	Set Decimal Mode
BVS	Branch on Overflow Set	LDA	Load Accumulator with Memory	SEI	Set Interrupt Disable Status
		LDX	Load Index X with Memory	STA	Store Accumulator in Memory
CLC	Clear Carry Flag	LDY	Load Index Y with Memory	STX	Store Index X in Memory
CLD	Clear Decimal Mode	LSR	Shift One Bit Right (Memory or Accumulator)	STY	Store Index Y in Memory
CLI	Clear Interrupt Disable Bit				
CLV	Clear Overflow Flag	NOP	No Operation	TAX	Transfer Accumulator to Index X
CMP	Compare Memory and Accumulator			TAY	Transfer Accumulator to Index Y
CPX	Compare Memory and Index X	ORA	"OR" Memory with Accumulator	TSX	Transfer Stack Pointer to Index X
CPY	Compare Memory and Index Y			TXA	Transfer Index X to Accumulator
				TXS	Transfer Index X to Stack Pointer
				TYA	Transfer Index Y to Accumulator

ADDRESSING MODES

Accumulator Addressing

This form of addressing is represented with a one byte instruction, implying an operation on the accumulator.

Immediate Addressing

In immediate addressing, the operand is contained in the second byte of the instruction, with no further memory addressing required.

Absolute Addressing

In absolute addressing, the second byte of the instruction specifies the eight low order bits of the effective address while the third byte specifies the eight high order bits. Thus, the absolute addressing mode allows access to the entire 65K bytes of addressable memory.

Zero Page Addressing

The zero page instructions allow for shorter code and execution times by only fetching the second byte of the instruction and assuming a zero high address byte. Careful use of the zero page can result in significant increase in code efficiency.

Indexed Zero Page Addressing – (X, Y indexing)

This form of addressing is used in conjunction with the index register and is referred to as "Zero Page, X" or "Zero Page, Y." The effective address is calcuated by adding the second byte to the contents of the index register. Since this is a form of "Zero Page" addressing, the content of the second byte references a location in page zero. Additionally due to the "Zero Page" addressing nature of this mode, no carry is added to the high order 8 bits of memory and crossing of page boundaries does not occur.

Indexed Absolute Addressing – (X, Y indexing)

This form of addressing is used in conjunction with X and Y index register and is referred to as "Absolute, X," and "Absolute, Y." The effective address is formed by adding the contents of X or Y to the address contained in the second and third bytes of the instruction. This mode allows the index register to contain the index or count value and the instruction to contain the base address. This type of indexing allows any location referencing and the index to modify multiple fields resulting in reduced coding and execution time.

Implied Addressing

In the implied addressing mode, the address containing the operand is implicitly stated in the operation code of the instruction.

Relative Addressing

Relative addressing is used only with branch instructions and establishes a destination for the conditional branch.

The second byte of the instruction becomes the operand which is an "Offset" added to the contents of the lower eight bits of the program counter when the counter is set at the next instruction. The range of the offset is −128 to +127 bytes from the next instruction.

Indexed Indirect Addressing

In indexed indirect addressing (referred to as (Indirect,X)), the second byte of the instruction is added to the contents of the X index register, discarding the carry. The result of this addition points to a memory location on page zero whose contents is the low order eight bits of the effective address. The next memory location in page zero contains the high order eight bits of the effective address. Both memory locations specifying the high and low order bytes of the effective address must be in page zero.

Indirect Indexed Addressing

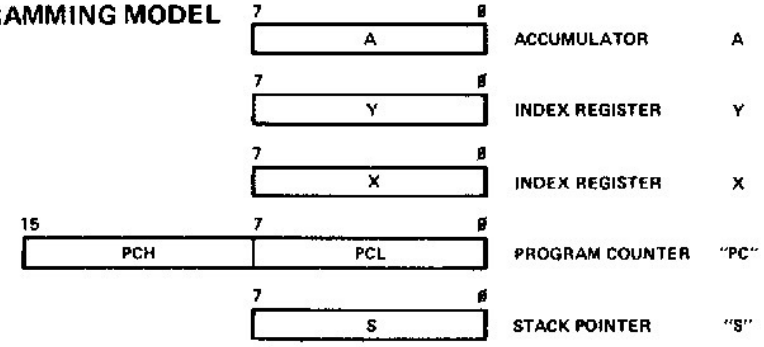
In indirect indexed addressing (referred to as (Indirect),Y), the second byte of the instruction points to a memory location in page zero. The contents of this memory location is added to the contents of the Y index register, the result being the low order eight bits of the effective address. The carry from this addition is added to the contents of the next page zero memory location, the result being the high order eight bits of the effective address.

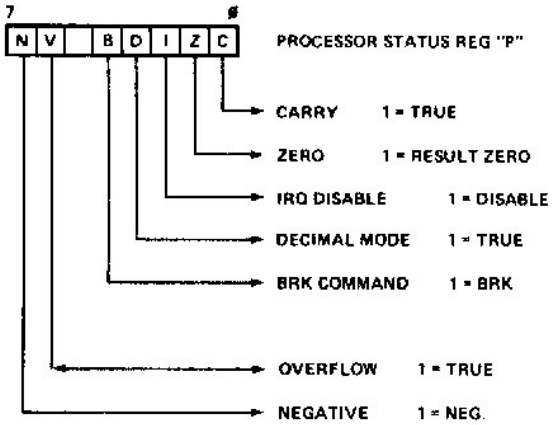
Absolute Indirect

The second byte of the instruction contains the low order eight bits of a memory location. The high order eight bits of that memory location is contained in the third byte of the instruction. The contents of the fully specified memory location is the low order byte of the effective address. The next memory location contains the high order byte of the effective address which is loaded into the sixteen bits of the program counter.

PROGRAMMING CHARACTERISTICS

PROGRAMMING MODEL





INSTRUCTION SET – OP CODES, EXECUTION TIME, MEMORY REQUIREMENTS

INSTRUCTIONS		IMMEDIATE			ABSOLUTE			ZERO PAGE			ACCUM			IMPLIED			(IND, X)			(IND), Y			Z PAGE, X			ABS, X			ABS, Y			RELATIVE			INDIRECT			Z PAGE, Y			CONDITION CODES					
MNEMONIC	OPERATION	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	N	Z	C	I	D	V
ADC	A + M + C → A (4) (1)	69	2	2	6D	4	3	65	3	2							61	6	2	71	5	2	75	4	2	7D	4	3	79	4	3										✓	✓	✓	–	–	✓
AND	A ∧ M → A (1)	29	2	2	2D	4	3	25	3	2							21	6	2	31	5	2	35	4	2	3D	4	3	39	4	3										✓	✓	–	–	–	–
ASL	C ← [7 0] ← 0				0E	6	3	06	5	2	0A	2	1										16	6	2	1E	7	3													✓	✓	✓	–	–	–
BCC	BRANCH ON C=0 (2)																															90	2	2							–	–	–	–	–	–
BCS	BRANCH ON C=1 (2)																															B0	2	2							–	–	–	–	–	–
BEQ	BRANCH ON Z=1 (2)																															F0	2	2							–	–	–	–	–	–
BIT	A ∧ M				2C	4	3	24	3	2																															M_7	✓	–	–	–	M_6
BMI	BRANCH ON N=1 (2)																															30	2	2							–	–	–	–	–	–
BNE	BRANCH ON Z=0 (2)																															D0	2	2							–	–	–	–	–	–
BPL	BRANCH ON N=0 (2)																															10	2	2							–	–	–	–	–	–
BRK	(See Fig. 1)													00	7	1																									–	–	–	1	–	–
BVC	BRANCH ON V=0 (2)																															50	2	2							–	–	–	–	–	–
BVS	BRANCH ON V=1 (2)																															70	2	2							–	–	–	–	–	–
CLC	0 → C													18	2	1																									–	–	0	–	–	–
CLD	0 → D													D8	2	1																									–	–	–	–	0	–
CLI	0 → I													58	2	1																									–	–	–	0	–	–
CLV	0 → V													B8	2	1																									–	–	–	–	–	0
CMP	A–M (1)	C9	2	2	CD	4	3	C5	3	2							C1	6	2	D1	5	2	D5	4	2	DD	4	3	D9	4	3										✓	✓	✓	–	–	–
CPX	X–M	E0	2	2	EC	4	3	E4	3	2																															✓	✓	✓	–	–	–
CPY	Y–M	C0	2	2	CC	4	3	C4	3	2																															✓	✓	✓	–	–	–
DEC	M – 1 → M				CE	6	3	C6	5	2													D6	6	2	DE	7	3													✓	✓	–			
DEX	X–1 → X													CA	2	1																									✓	✓	–	–	–	–
DEY	Y–1 → Y													88	2	1																									✓	✓	–	–	–	–
EOR	A ⊻ M → A (1)	49	2	2	4D	4	3	45	3	2							41	6	2	51	5	2	55	4	2	5D	4	3	59	4	3										✓	✓	–	–	–	–
INC	M + 1 → M				EE	6	3	E6	5	2													F6	6	2	FE	7	3													✓	✓	–			
INX	X + 1 → X													E8	2	1																									✓	✓	–	–	–	–
INY	Y + 1 → Y													C8	2	1																									✓	✓	–	–	–	–
JMP	JUMP TO NEW LOC				4C	3	3																												6C	5	3				–	–	–	–	–	–
JSR	(See Fig. 2) JUMP SUB				20	6	3																																		–	–	–	–	–	–
LDA	M → A (1)	A9	2	2	AD	4	3	A5	3	2							A1	6	2	B1	5	2	B5	4	2	BD	4	3	B9	4	3										✓	✓	–	–	–	–

MNEMONIC	OPERATION	IMMEDIATE			ABSOLUTE			ZERO PAGE			ACCUM			IMPLIED			(IND, X)			(IND), Y			Z PAGE, X			ABS, X			ABS, Y			RELATIVE			INDIRECT			Z PAGE, Y			CONDITION CODES					
		OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	OP	N	#	N	Z	C	I	D	V
LDX	M → X (1)	A2	2	2	AE	4	3	A6	3	2																			BE	4	3										✓	✓	–	–	–	–
LDY	M → Y (1)	A0	2	2	AC	4	3	A4	3	2													94	4	2	BC	4	3													✓	✓	–	–	–	–
LSR	0 → [7 0] → C				4E	6	3	46	5	2	4A	2	1										56	6	2	5E	7	3													0	✓	✓	–	–	–
NOP	NO OPERATION													EA	2	1																									–	–	–	–	–	–
ORA	A ∨ M → A	09	2	2	0D	4	3	05	3	2							01	6	2	11	5	2	15	4	2	1D	4	3	19	4	3										✓	✓	–	–	–	–
PHA	A → M_S S–1 → S													48	3	1																									–	–	–	–	–	–
PHP	P → M_S S–1 → S													08	3	1																									–	–	–	–	–	–
PLA	S + 1 → S M_S → A													68	4	1																									✓	✓	–	–	–	–
PLP	S + 1 → S M_S → P													28	4	1																									(RESTORED)					
ROL	[C 7 0] ←				2E	6	3	26	5	2	2A	2	1										36	6	2	3E	7	3													✓	✓	✓	–	–	–
ROR	→ [C 7 0]				6E	6	3	66	5	2	6A	2	1										76	6	2	7E	7	3													✓	✓	✓	–	–	–
RTI	(See Fig. 1) RTRN INT													40	6	1																									(RESTORED)					
RTS	(See Fig. 2) RTRN SUB													60	6	1																									–	–	–	–	–	–
SBC	A–M–$\bar{C}$ → A (1)	E9	2	2	ED	4	3	E5	3	2							E1	6	2	F1	5	2	F5	4	2	FD	4	3	F9	4	3										✓	✓	✓ (3)			✓
SEC	1 → C													38	2	1																									–	–	1	–	–	–
SED	1 → D													F8	2	1																													1	–
SEI	1 → I													78	2	1																									–	–	–	1	–	–
STA	A → M				8D	4	3	85	3	2							81	6	2	91	6	2	95	4	2	9D	5	3	99	5	3										–	–	–	–	–	–
STX	X → M				8E	4	3	86	3	2																															96	4	2	–	–	–	–	–	–
STY	Y → M				8C	4	3	84	3	2													94	4	2																	–	–	–	–	–	–
TAX	A → X													AA	2	1																									✓	✓	–	–	–	–
TAY	A → Y													A8	2	1																									✓	✓	–	–	–	–
TSX	S → X													BA	2	1																									✓	✓	–	–	–	–
TXA	X → A													8A	2	1																									✓	✓	–	–	–	–
TXS	X → S													9A	2	1																									–	–	–	–	–	–
TYA	Y → A													98	2	1																									✓	✓	–	–	–	–

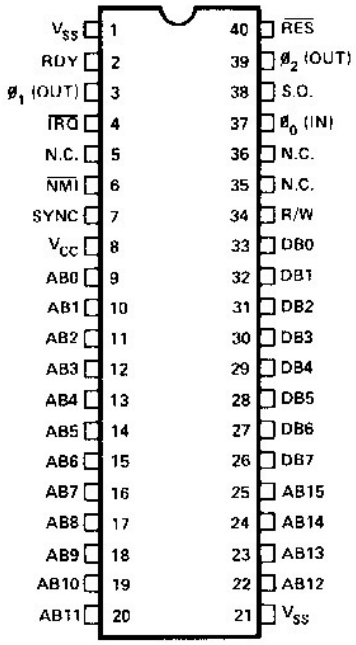
(1) ADD 1 TO "N" IF PAGE BOUNDARY IS CROSSED
(2) ADD 1 TO "N" IF BRANCH OCCURS TO SAME PAGE
ADD 2 TO "N" IF BRANCH OCCURS TO DIFFERENT PAGE
(3) CARRY NOT - BELOW
(4) IF IN DECIMAL MODE Z FLAG IS INVALID
ACCUMULATOR MUST BE CHECKED FOR ZERO RESULT

X INDEX X
Y INDEX Y
A ACCUMULATOR
M MEMORY PER EFFECTIVE ADDRESS
M_S MEMORY PER STACK POINTER

+ ADD
– SUBTRACT
∧ AND
∨ OR
⊻ EXCLUSIVE OR
✓ MODIFIED

– NOT MODIFIED
M_7 MEMORY BIT 7
M_6 MEMORY BIT 6
N NO CYCLES
NO BYTES

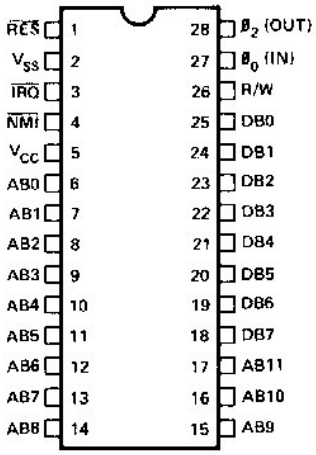
SY6502 — 40 Pin Package



Features

- 65K Addressable Bytes of Memory
- $\overline{IRQ}$ Interrupt
- $\overline{NMI}$ Interrupt
- On-the-chip Clock
  - √ TTL Level Single Phase Input
  - √ Crystal Time Base Input
- SYNC Signal
  (can be used for single instruction execution)
- RDY Signal
  (can be used for single cycle execution)
- Two Phase Output Clock for Timing of Support Chips

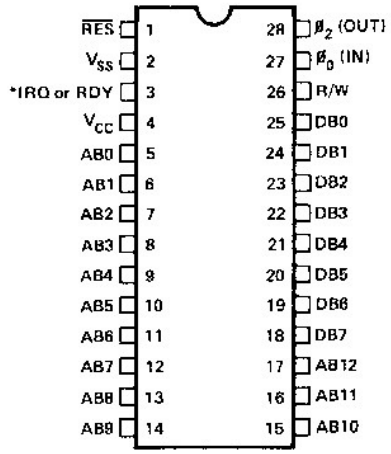
SY6503 — 28 Pin Package



Features

- 4K Addressable Bytes of Memory (AB00-AB11)
- On-the-chip Clock
- $\overline{IRQ}$ Interrupt
- $\overline{NMI}$ Interrupt
- 8 Bit Bi-Directional Data Bus

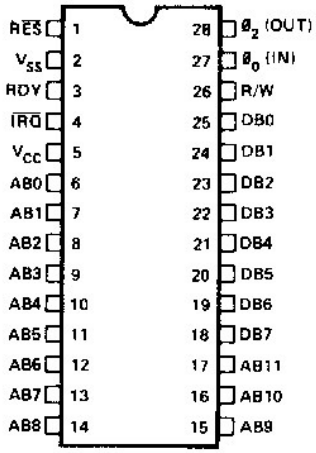
SY6504 & SY6507 — 28 Pin Package



Features

- $\overline{IRQ}$ Interrupt (6504 only)
- RDY Signal (6507 only)
- 8K Addressable Bytes of Memory (AB00-AB12)
- On-the-chip Clock
- 8 Bit Bi-Directional Data Bus

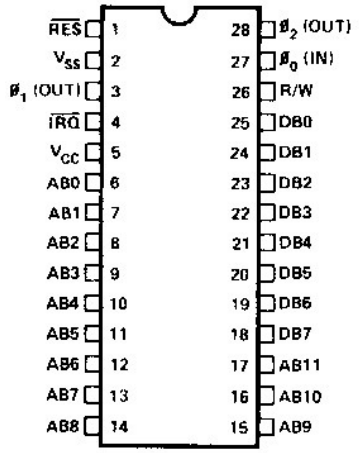
SY6505 — 28 Pin Package



Features

- 4K Addressable Bytes of Memory (AB00-AB11)
- On-the-chip Clock
- $\overline{IRQ}$ Interrupt
- RDY Signal
- 8 Bit Bi-Directional Data Bus

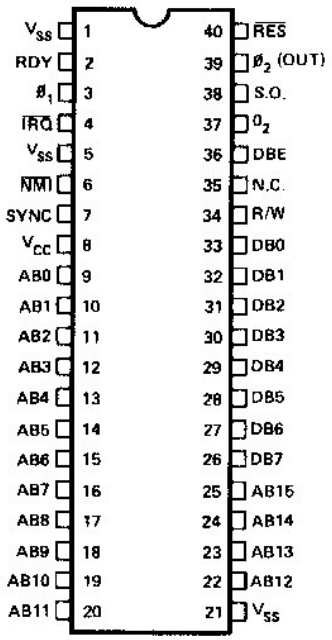
SY6506 — 28 Pin Package



Features

- 4K Addressable Bytes of Memory (AB00-AB11)
- On-the-chip Clock
- $\overline{IRQ}$ Interrupt
- Two phases off
- 8 Bit Bi-Directional Data Bus

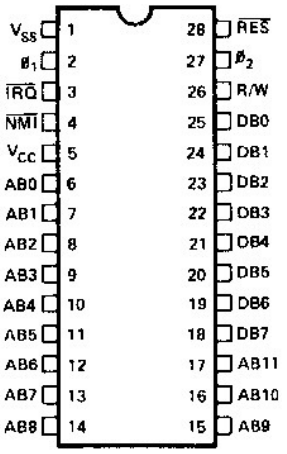
SY6512 — 40 Pin Package



Features

- 65K Addressable Bytes of Memory
- $\overline{IRQ}$ Interrupt
- $\overline{NMI}$ Interrupt
- RDY Signal
- 8 Bit Bi-Directional Data Bus
- SYNC Signal
- Two phase input
- Data Bus Enable

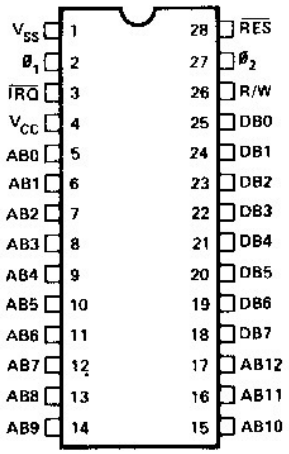
SY6513 — 28 Pin Package



Features

- 4K Addressable Bytes of Memory (AB00-AB11)
- Two phase clock input
- $\overline{IRQ}$ Interrupt
- $\overline{NMI}$ Interrupt
- 8 Bit Bi-Directional Data Bus

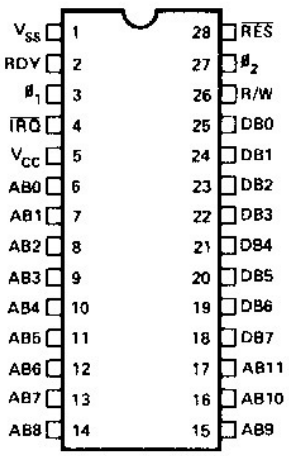
SY6514 — 28 Pin Package



Features

- 8K Addressable Bytes of Memory (AB00-AB12)
- Two phase clock input
- $\overline{IRQ}$ Interrupt
- 8 Bit Bi-Directional Data Bus

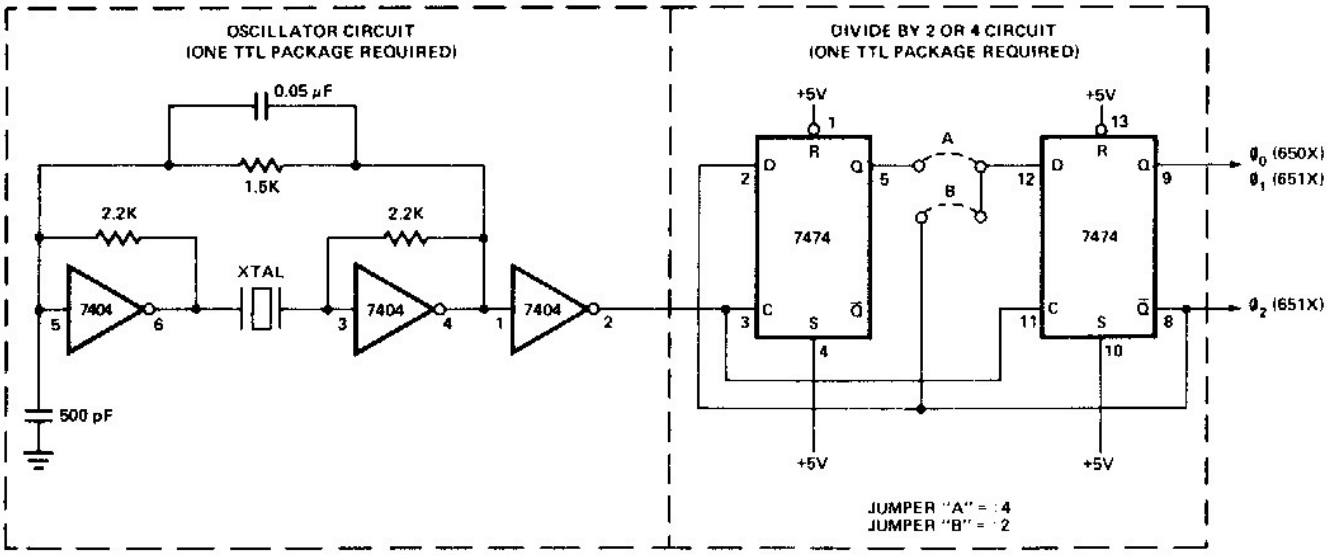
SY6515 — 28 Pin Package



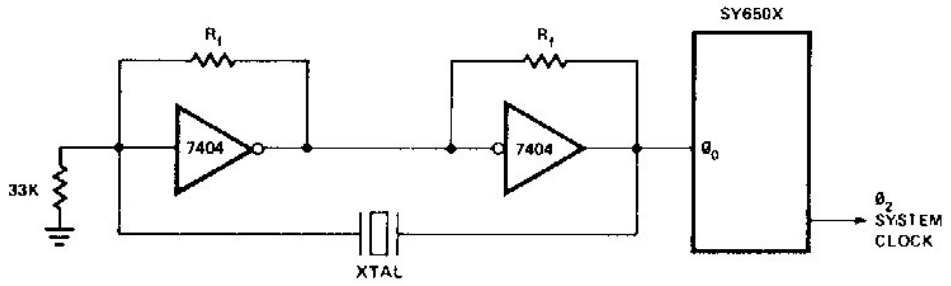
Features

- 4K Addressable Bytes of Memory (AB00-AB11)
- Two phase clock input
- IRQ Interrupt
- 8 Bit Bi-Directional Data Bus

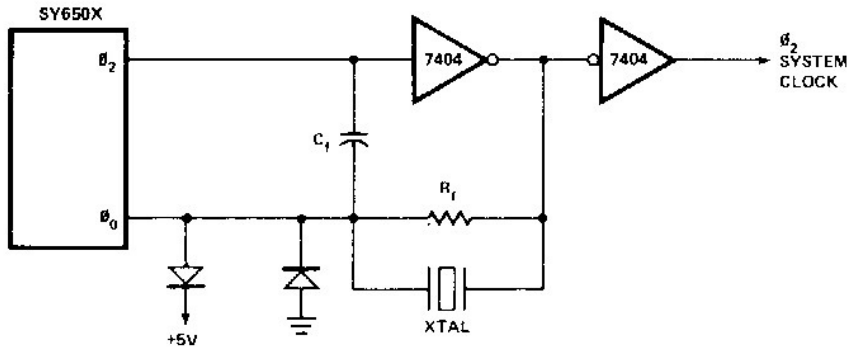
CLOCK GENERATION CIRCUITS



CRYSTAL FREQUENCY	OUTPUT FREQUENCY	
	÷2	÷4
3.579545 MHz	1.7897 MHz	0.894886 MHz
4.194304 MHz	2.097152 MHz	1.048576 MHz



R_f = 1.8K ohms
XTAL = 1 MHz – 5 MHz
(CTS KNIGHT MP SERIES
OR EQUIVALENT)



R_f = 330K ohms
C_f = 10 pF
XTAL – CTS KNIGHT MP SERIES
OR EQUIVALENT