

AT LAST!



A low-cost, fully professional ASCII KEYBOARD AND ENCODER you can build



Using only two IC's, this simple-to-build alphanumeric system can be your springboard to many sophisticated applications

BY DON LANCASTER

MANY advanced electronic projects start with an alphanumeric keyboard. The difficulty is in finding one that is reasonable in cost, reliable in use, and equipped with the proper 7- or 8-bit parallel ASCII code. (See box.) This is particularly true if it is

to be used with computer circuits, a calculator, ham RTTY equipment, video titling, etc. Commercial keyboards of this type are very expensive and hard to find. Surplus keyboards are limited in availability and usually have encoders and keytops that may

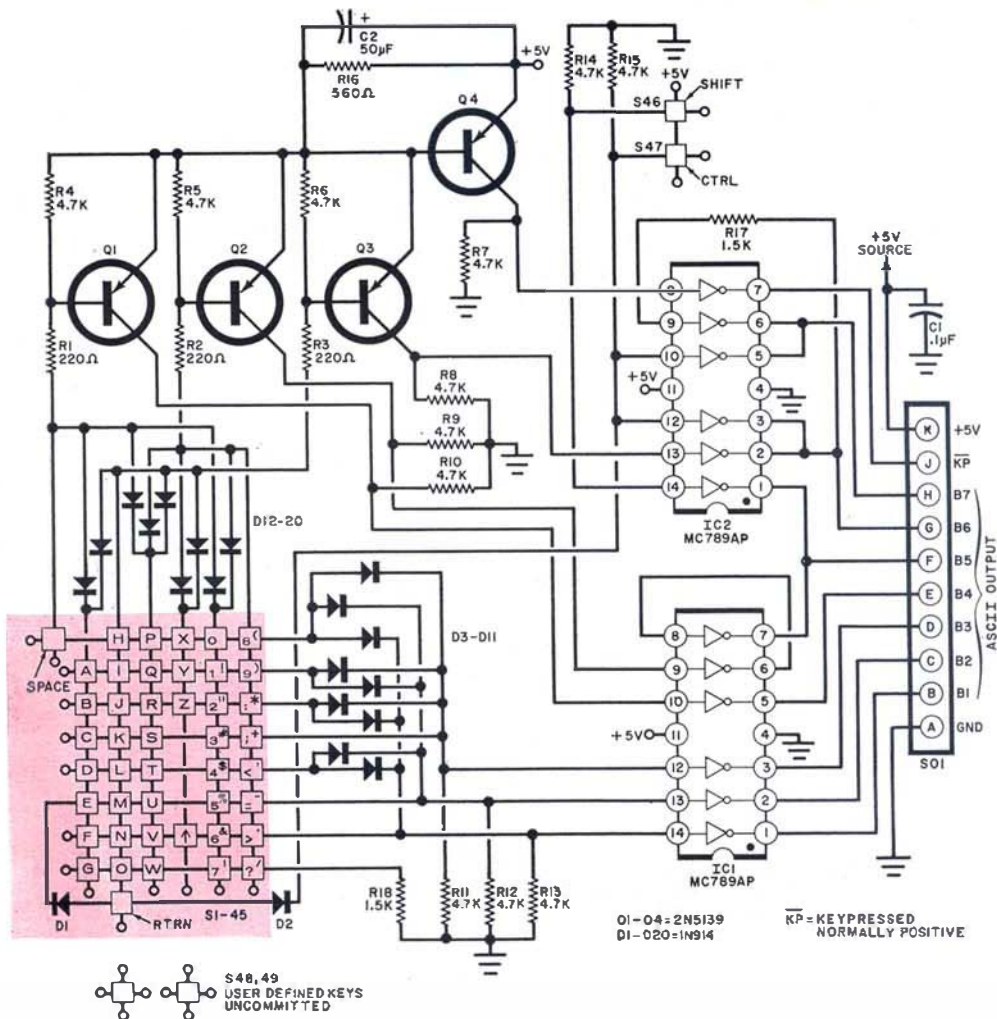


Fig. 1. The 48 keys are arranged in a 6-by-8 matrix as shown in block at lower left. The encoder, Q1 through Q4 and IC1 and IC2, provides the proper output.

PARTS LIST

C1—0.1- μ F, 10-volt disc ceramic capacitor
 C2—50- μ F, 10-volt electrolytic capacitor
 D1-D20—1N914 diode
 IC1, IC2—MC789AP hex inverter (no substitute)
 Q1-Q4—2N5139 transistor
 R1-R3—220-ohm, $\frac{1}{4}$ -watt resistor
 R4-R15—4700-ohm, $\frac{1}{2}$ -watt resistor
 R16—560-ohm, $\frac{1}{2}$ -watt resistor
 R17, R18—1500-ohm, $\frac{1}{2}$ -watt resistor
 S1-S49—Keyswitches (Mechanical Enterprises LFW-CT)
 S01—Socket (Molex #9-52-3103)

Misc.—Keypops (two-shot molded) (shift and return are $1\frac{1}{2}$ width); spacebar with equalizer and #2-56 mounting hardware; pc board (see text); #6 mounting hardware; solder; etc.

Note—The following are available from Southwest Technical Products, 219 W. Rhapsody, San Antonio, TX 78216: actual-size pc foil patterns and component installation diagram (see on request); pc board, etched and drilled #Kb at \$17.50; complete kit of all parts #KBC at \$39.50 plus postage for 3 lb.

not be compatible with modern circuits.

Here is a brand-new, fully professional, alphanumeric typewriter-style keyboard that you can build yourself for less than \$40 and uses only two IC's (readily available) for its integral ASCII encoder and debouncer. Thus, it's both simple to build and inexpensive. The output is directly compatible with TTL, DTL, RTL, CMOS, and PMOS integrated circuits.

The 49 keys provide all the upper-case alphabet, numbers, punctuation, spacing, and transparent or control commands. Two of the keys are uncommitted, which means they can be used for any purpose, either with or without the rest of the encoder circuit. Except for some punctuation which is seldom used, the design follows very closely the ANSI keyboard. It is easily made compatible with such popular industrial equipment as the ASR-33 Teletype®.

High-reliability modular keyswitches duplicate the full typewriter travel and tactile feedback. The two-shot molded keytops are identical to those found on quality office typewriters. The spacebar has an equalizer so that it travels smoothly, regardless of where it is depressed. Power needs are +5 volts at under 100 mA.

About the Circuit. The 48 single-contact, normally open keys are arranged in a matrix 8 keys high by 6 keys wide (Fig. 1). Some of the little-used keys are omitted from the matrix. When a key is depressed, it shorts the wires beneath it.

The "8" side of the matrix goes to a diode encoder (D3-D11) and an integrated circuit (½ of IC1) that generates the least significant three bits of the ASCII code (B1, B2, and B3).

The "6" side of the matrix goes to a diode encoder (D12-D20) and transistors (Q1-Q4) that sense which section of the matrix has been selected by a key. When any key is pressed, the signal is sensed by Q4 and passed on to IC2 as a key-pressed output, while Q1 through Q3 set up the upper, or most significant, four bits of the code, producing B4, B5, B6, and B7. Key actuation is logically combined with a shift key and a control key to handle the machine commands and the punctuation-numeral shifts.

The spacebar and carriage return key do two things at once. Space is a "shifted zero," while carriage return is a "control M." The spacebar is electrically the same as any other key. The eighth ASCII bit can be optionally

picked up with an external IC parity generator (such as a 74180); but this feature is seldom used in experimental or small-scale circuits. Capacitor C2 provides a delay of a few milliseconds so that the code is up and valid before the key-pressed common signal is sent.

Construction. The complete keyboard is assembled on a single, double-sided pc board. Since the two foil patterns are too large to be reproduced here, they are available free from the source given in the Parts List.

Adequate mechanical support for the board is essential. It should be backed with a similar-size blank board (or an insulating layer) mounted on a metal plate. The best operation angle is with a slight slope down from the top—about 10 or 15 degrees. If more response is needed on the spacebar, booster springs can be added to each equalizer post.

Testing. Ground terminal A of SO1 and connect a 100-mA meter to the +5-volt line. Briefly connect the metered 5-volt line to terminal K of SO1 and note that there is a current of about 30 mA.

Connect a dc voltmeter (5-volt range) to terminal J of SO1 and note that there is a high level there. If it is low, recheck the key matrix for shorts.

Using the ASCII code as a guide, depress

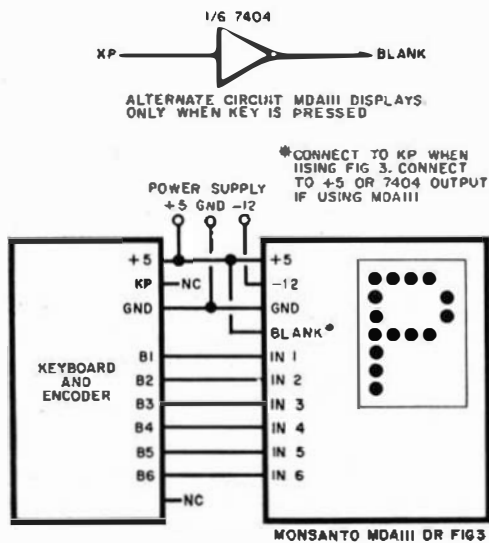


Fig. 2. One possible output display for the keyboard uses a Monsanto MDA111 readout

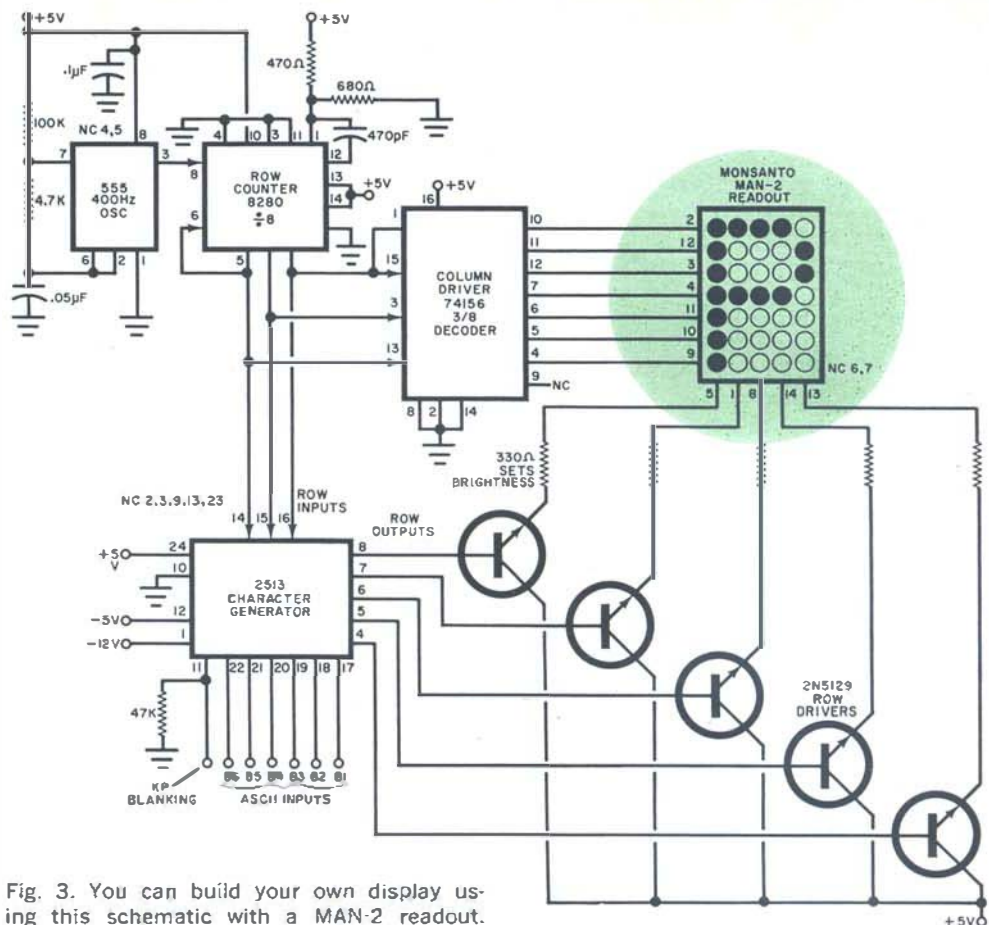


Fig. 3. You can build your own display using this schematic with a MAN-2 readout.

one key at a time and check for the correct output code at the B1 through B7 outputs of SQ1. If you have access to an instrument that "speaks" ASCII, you can make an actual use test.

Use. The keyswitches are inherently low in noise and, combined with the delay in C2, provide enough debouncing for the majority of experimental applications. Only the leading edge of the key-pressed command is debounced. This leading edge should be used to enter data into the system. A more sophisticated system might use an 8-bit latch to store the entire code word until the rest of the circuit could use it.

The key-pressed output is normally high and drops to ground if one or more keys are pressed. Codes other than ASCII can be created by rewiring the pc board. The parallel code output can be converted to

serial form by using a shift register such as a 74165 or 2536 UART.

The two uncommitted keys (S48 and S49) can be tied to the encoder for extra commands or used separately for local or remote controlling.

Obviously, the keyboard has to be connected to something else to make it useful. For example, a Monsanto MDA111 alphanumeric display can be connected to the keyboard as shown in Fig. 2. To make your own single-character display (at lower cost), build the circuit shown in Fig. 3.

Some immediate and obvious applications of this one-character computer terminal are as a touch-typing teaching aide; as a means of communication for a deaf or handicapped person; as a pre-school lettering and spelling machine; for keyboard monitoring; for film annotation; as a secure communications loop (with bits of the ASCII code scrambled and

BIT NUMBERS								0	0	0	0	1	1	1	1
b7	b6	b5	b4	b3	b2	b1	COLUMN	0	1	2	3	4	5	6	7
↓	↓	↓	↓	↓	↓	↓	ROW ↓	0	1	2	3	4	5	6	7
			0	0	0	0	0	NUL	DLE	SP	0	@	P	\	p
			0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
			0	0	1	0	2	STX	DC2	"	2	B	R	b	r
			0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
			0	1	0	0	4	EDT	DC4	\$	4	D	T	d	t
			0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
			0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
			0	1	1	1	7	BEL	ETB	/	7	G	W	g	w
			1	0	0	0	8	BS	CAN	(	8	H	X	h	x
			1	0	0	1	9	HT	EM	)	9	I	Y	i	y
			1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
			1	0	1	1	11	VT	ESC	+	;	K	[	k	{
			1	1	0	0	12	FF	FS	,	<	L	\	l	|
			1	1	0	1	13	CR	GS	-	=	M	]	m	}
			1	1	1	0	14	SO	RS	.	>	N	^	n	~
			1	1	1	1	15	SI	US	✓	?	0	-	o	DEL

WHAT IS ASCII?

ASCII is a standard 8-bit information interchange code, which is used with virtually every computer and data base system. It is essential as an input to such integrated-circuit character-generation systems as the Signetics 2513. ASCII is a machine language. It should not be confused with such programming languages as "Basic," "Fortran," "PLI," "APL," etc. All of the alphanumeric communications between machines using any of these programming languages are really nothing but a group of ASCII coded commands.

The eighth bit of the code is often a 1 all the time, though some systems use the eighth bit for parity or error testing. The remaining seven bits provide 128 possible different codes or characters. Of these, 32 are allocated for the upper-case alphabet and some are often used for punctuation. Another 32 are used for numbers, spacing, and other punctuation. Assigned but very rarely used is a third group of 32 for lower-case alphabet

and little-used punctuation. Finally, the remaining 32 possible codes are "transparent" or machine commands, called control or CTRL commands. They never appear in print, but they handle the sequencing of machinery at both ends. A carriage return (CR) is a typical machine command. If only upper case alphanumerics are needed, only six of the eight bits of the code are used. This is called the ASCII-6 code.

The complete code is shown above. The first four bits are read from the left—the remaining three from the top. For instance "H" is 100-1000. A carriage return command is 000-1101, and a 7 is 011-0111. Note that the bottom four number bits are identical to the four-bit binary (BCD) code. By the same token, if the serial form of the ASCII is used with a start bit and two stop bits added, the result is the 11-bit Teletype code such as that used on an ASR-33.

ASCII can be used in parallel form (all bits at once) or serial form (one bit at a time, least, or B1 significant bit first.)

inverted on either end); or as an annunciator or electronic catalog.

On a more ambitious scale, the keyboard can be used as a computer timesharing terminal, either in commercial service or for home or school. The keyboard, with a simple parallel-to-series converter, forms half of

an ASR-33 Teletype at a very reasonable cost.

Other applications include programmable calculators, ham RTTY transmission, videotape and TV titling and annotation, electronic editing and page composition, and data search and retrieval systems. ♦