⚡ National
⚡ Semiconductor

DIGITALKER™ Speech Synthesis

DT1000 DIGITALKER™ Speech Synthesis Evaluation Board

General Description

The DIGITALKER™ (DT1000) speech synthesis evaluation board is an extremely easy to use device for understanding the operation and application of the DIGITALKER chip set in an end product.

The DT1000 contains all components required to output speech upon demand: a speech processor chip (SPC), 2 MAXI-ROMs® containing 138 individual words, linear filter, audio amplifier, keyboard, and a COPS™ microcontroller complete with stored data programmed to provide the various functions on the board. The only external hardware required for complete operation are a single 7V–11V power supply, a speaker of your choice for size and quality, and this instruction sheet.

The 2 speech MAXI-ROMs employed on the board contain a brief introductory phrase, 138 separate and individual words consisting of numbers and letters of the alphabet, assorted useful nouns, verbs and tones; and 5 different individual silence durations. (In constructing a phrase, different silence durations between different words significantly affect the overall quality of the phrase.)

A COPS program is provided which permits the user to: 1) sequentially output each word automatically; 2) repeat any desired word; 3) build and store several short phrases for outputting when desired; 4) output a "canned" phrase which permits insertions and changing of a word in the phrase; 5) play a simple game which requires some interaction between the keyboard and the user; and 6) output hex equivalent decimal number inputs.

Features

■ Only a single 7V–11V power supply and inexpensive loudspeaker required for total operation

■ 138 individually addressable words, applicable to many products

■ Programmed COPS processor permits 6 individual program modes

■ Demonstrates the extreme flexibility and ease of application of the DIGITALKER chip set

■ 1/2 watt audio amplifier on-board

■ Edge connector facilitates tying in to external processor system (3M Company connector part number #3415)

DT1000 Conceptual Drawing
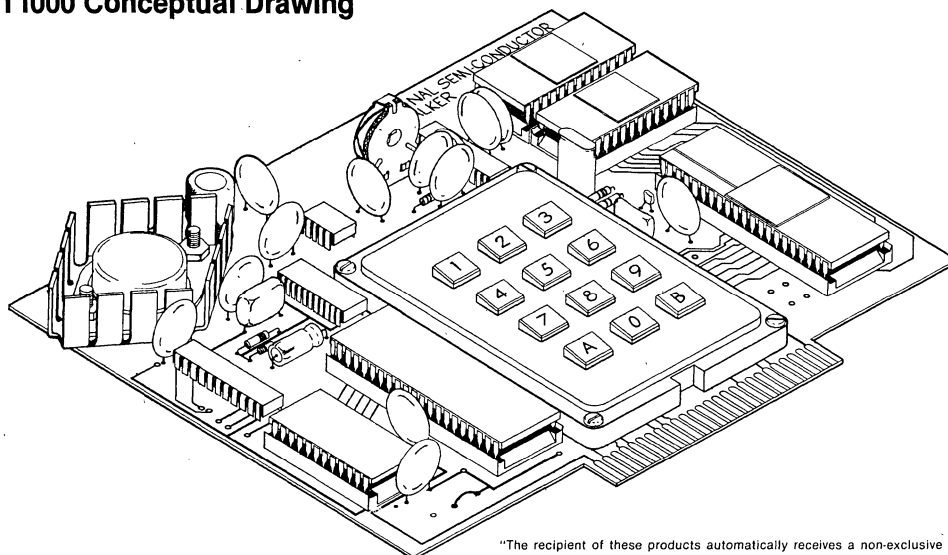
MAXI-ROM® is a registered trademark of National Semiconductor Corp.

DIGITALKER™ and COPS™ are trademarks of National Semiconductor Corp.

13

Absolute Maximum Ratings

Operating Temperature Range 0°C to 70°C

V_{DD} Supply Voltage 12V

Electrical Characteristics $T_A = 25°C$

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{DD}*	Supply Voltage	$V_{SS} = 0V$	7.0		11.0	V
I_{DD}	Supply Current	$V_{DD} = 11V$			0.6	A
	Amplifier Output	$V_{DD} = 11V, 8\Omega$	0.55			W
		$V_{DD} = 9V, 8\Omega$	0.50			W

*Important! V_{DD} must be regulated!

All pin connections, except for speaker out, and power supply, are TTL compatible.

Functional Description

INSTRUCTIONS FOR USE

In any case, plus 7V to 11V direct current and ground must be brought to the respective pins on the edge connector of the DT1000 board. See *Figure 1*.

BASIC MODE OPERATIONS

1. **Power Up Mode.** At power up, the DT1000 will say "This is DIGITALKER". You can make it repeat this phrase by depressing [A] . Further depressions of [A] will repeat the same phrase until a new word address is entered. From the DT1000 master word list (Table I) select the 3-digit address of the next word desired. The new word can be outputted simply by keying in its 3-digit address and ending with an [A] key depression. For example, the word "pound" will be spoken as a result of key sequence [1] , [2] , [3] , [A] . Additional depressions of A will repeat the word "pound". To output a new word, repeat the above sequence.

   If a mistake is made in the address entry of the desired word, simply continue to key in the correct address. The DT1000 only remembers the last 3 address digits keyed prior to depression of the [A] key. For example, if the desired word is "pound" and keys [1] , [2] , [2] were depressed, simply rekey the proper address followed by the [A] key as shown [1] , [2] , [3] , [A] .

   In this Power Up Mode the [B] key will advance to the next sequential word in the DT1000 master word list, one word per depression, starting with the next sequential word after the word selected by the entry sequence shown above. Continued depressions of [B] will manually sequence through the complete word list, wrapping around from address 143 to address 000 and ending up at the first word in the sequence. Depressions of the [A] key will take the DT1000 back to the starting word and address inputted via the entry sequence shown above. Additional depressions of the [B] key would then sequence from that address again. Should a different start word be desired, you must enter the respective address of that word as is shown in the above sequence.

The DT1000 has 144 legal address locations, these are shown in the Master Word List as being addresses 000 through 143. If an address of 144 through 199 is inadvertently keyed in, a response of "Please Try Again" will be outputted. Addresses 200 and up will put the DT1000 into various operating modes as explained in paragraphs 2 through 7.

2. **Auto Repeat/Auto Cycle Mode.** The Auto Repeat/Cycle Mode is entered by depressing [2] [0] [0] and either the [A] or [B] key. An additional depression of [A] will start an automatic repeating cycle of some word and address, until the [A] key is depressed and held momentarily. Depression of the [B] key will start the automatic sequential cycling through the complete word list, beginning with the last word that was outputted in either the Auto Repeat or Auto Cycle Mode. The sequential cycling will automatically continue through the entire word list, wrapping around from address 143 to address 000 each time until the [A] or [B] key is depressed and held momentarily. When in this mode you can choose a new starting word by entering its respective address and keying either the [A] or [B] keys.

3. **Decimal to Hex Conversion Mode.** Key sequence [3] [0] [0] [A] (or [B]) will put the DT1000 into a mode where it will automatically convert a decimal address into its hexadecimal equivalent. Once in this mode, key in the decimal address desired from the master word list, and depress the [A] key twice. The respective word will be spoken on the first depression of [A] , a further depression of [A] will cause its hexadecimal equivalent address to be spoken.

   A [B] key activation stand alone will set the DT1000 into the Power Up Manual Control Mode.

Functional Description (Continued)

4. Phrase Construct Mode. In this mode, it is possible to string respective word addresses together to create up to 3 phrases or short sentences and play them back upon demand. The phrase modes are [4] [0] [0] , [5] [0] [0] , and [6] [0] [0] . The 400 mode will store up to twelve word addresses, the 500 and 600 modes will store up to six addresses each. Initial phrase construction should begin with key sequence [4] [0] [0] [B] where the [B] depression clears out any addresses previously stored. (In either the [4] [0] [0] , [5] [0] [0] , [6] [0] [0] sequence, the B key will "clear" out any previous addresses stored in those respective modes.) You are then ready to string addresses together to construct a phrase. To construct the phrase, simply enter each address of the words desired in the phrase and in the sequence in which the words are to be outputted. Each word address keyed in must be followed by two depressions of the [B] key. The first depression of the [B] key will speak the word at that respective address to give you a chance to "hear" the word before its address is "loaded" into the DT1000 RAM. A second depression of the [B] key will store that address into the DT1000 RAM and that word is then in position in the desired phrase. If upon the first depression of the [B] key the word outputted is not the desired word, simply key in the correct address and depress the [B] key again, and again finally to store into the RAM. In the construction of a phrase a "beep" will occur during the addressing of the last possible address that will fit into that particular phrase mode. (If additional addresses are still keyed in, they will replace the first addresses loaded in that same phrase.)

An example of constructing a phrase is as follows for the desired word sequence "To start the time set the meter and go", key sequence: [4] [0] [0] [B] / [0] [0] [2] [B] [B] / [1] [3] [5] [B] [B] / [1] [3] [8] [B] [B] / [1] [3] [9] [B] [B] / [1] [3] [1] [B] [B] / [1] [3] [8] [B] [B] / [1] [0] [6] [B] [B] / [0] [6] [0] [B] [B] / [0] [8] [6] [B] [B] /. To output this same phrase, depress the [A] key. The above phrase should automatically be spoken from the DT1000. Additional keyings of [A] will output the same phrase until it is cleared out by a [4] [0] [0] [B] sequence.

Registers 500 and 600 can be loaded in exactly the same way as shown above, except that the [5] [0] [0] [B] and/or the [6] [0] [0] [B] keys must be addressed to load those respective registers. Remember that registers 500 and 600 are each only 6 addresses long.

If you chose to construct the exact phrase as shown above, you may have noticed that the spoken output was rather a mechanical output. This is primarily due to the fact that the words were butted against each other. In normal human speech, the brain puts durations of silence between the words to make the sentence flow smoothly. Since several durations of silence are provided in the Master Word List, the actual quality of the same phrase can be significantly improved by adding durations of silence (also assigned addresses) between the words. As one thinks about how the phrase is actually spoken, one might assume the approximate duration of silence between each word, and insert the closest duration of silence from the word list. It is found that some experimentation in this area can significantly enhance the quality of the desired phrase. A hint in this area would be that for words beginning with the letters K, T, P, B, D, and G insert 80 milliseconds silence prior to the words, and for words ending in the same letters as above, 40 milliseconds silence following the word is recommended. It is also possible in this mode to make any singular word plural by the addition of "SS" (Address 129) to the word. In this case no silence should be inserted between the word and the "SS".

4A. Phrase Output Mode. As stated in (4) any phrase can be outputted by being in the 400, 500 or 600 modes and depressing the [A] key. It is also possible to output all 3 phrases in any sequence. To "string" these phrases together, simply key in the phrase sequence desired concluded with two depressions of the [A] key. Key sequence [4] [5] [6] [A] [A] would output phrases at 400-500 and 600 respectively. (This would indicate that a sentence 24 addresses long might be constructed.) Any phrase sequence might actually be chosen, 546, 645, etc. For an interesting effect the same phrase could be outputted twice or even three times such as 455. 444. 664. etc.

5. Canned Phrase Mode. Key sequence [7] [0] [0] [A] (or [B]) will output a fixed phrase "The time is ____ P.M.". This gives you the ability to insert the desired word(s) in the blank location. In this case "twelve OH one" might be appropriate. While in the [7] [0] [0] [A] mode simply key in the respective addresses of the words desired, inserting silences if required, exactly the same as constructing a phrase in the 400-500 or 600 modes. To output the completed phrase, simply depress the [A] key. To insert a new word sequence into the blank, key [7] [0] [0] [B] to erase the original contents. Then enter the new word addresses as required.

This mode demonstrates how a talking clock or a trip computer might work. Changing data can be inserted at the required time as a part of a fixed message.

6. Reaction Timer Game. Key sequence [8] [0] [0] [A] (or [B]) enters you into a simple game which could conceptually be a real product. In this mode, the DT1000 speaks ten random numbers from zero to nine, with a pause between each number output. The game is to hit the respective key as fast as possible after the number has been called out. After the tenth and last number has been depressed, a tone is outputted and the total reaction time is spoken as "seven point three two five seconds". Obviously, the game is to have the lowest possible total reaction time. *Note that it is necessary to eventually hit the correct key for the number called out.* If the wrong key is depressed, the DT1000 will not output another number until the correct key is depressed—meanwhile, time is accruing. It should also be noted that the random pauses between word outputs is not part of total elapsed time.

To continue playing the game, keying the [A] key will output a new set of numbers. To exit the game mode, depress the [B] key.

7. Back to Power Up Mode. Key sequence [9] [0] [0] [A] (or [B]) will put the DT1000 back into the Power Up Mode. Refer to mode (1.) explained in the earlier section of this data sheet for all operations covered by this mode.

13

Functional Description (Continued)

GENERAL COMMENTS

1. The DT1000 is always in one of the modes. To exit a mode, simply key in the control code of the next desired mode.
2. "SS" (located at address 129) can make singular words plural.
3. "Centi", "milli", "re" are prefixes to make words like "centimeter", "reset", etc. Some prefixes do not blend well directly with some words such as "milli ampere". In these cases, insert an appropriate amount of silence between the words.
4. High output volume can be obtained by supplying 11V to power supply input (pin 50).

SPEECH QUALITY

The actual speech quality of the DT1000 is affected by many factors. Certainly the quality is affected most significantly by the actual speaker and baffle chosen to output the final speech data. Although the DT1000 will drive most any size of "common" PM speakers, care ought to be made in the actual selection of the speaker, AND its respective baffle or enclosure. An unbaffled speaker will not give a true response, small speakers typically do not reproduce low frequencies. Truly, the most desirable com-bination for best quality would be a medium size speaker 6 inches to 12 inches in diameter, and housed in a solid wood enclosed baffle.

One can actually "experiment" with the quality by trying various speaker and baffle combinations.

APPLICATION WITH EXTERNAL PROCESSOR

The DT1000 is designed so that it is possible to access on-ly the DIGITALKER portion of the board. *Important: it is necessary to remove the COP402 from the DT1000 in this mode.* The DIGITALKER portion is defined as the speech processor chip (SPC) and the speech ROM(s) which contain the actual vocabulary (see Table I). The inputs required to connect the DIGITALKER (and the vocabulary of the DT1000 board) to an external processor have been made available on the pin edge connector (refer to Figure 3).

The following describes the function of all speech processor chip (SPC) inputs and outputs, and all other inputs and outputs required for operation in this external processor mode. Note: in the following descriptions and Table I, a low represents a logic zero (0.4V nominal) and a high represents a logic one (2.4V nominal).

CONNECTION REQUIREMENTS FOR EXTERNAL PROCESSOR APPLICATIONS

Edge Connector Pin Number	Function	Edge Connector Pin Number	Function
8	**Chip Select (CS).** The SPC is selected when CS is low. It is only necessary to have CS low during a command to the SPC. It is not necessary to hold CS low for the duration of the speech data.	37	**Write Strobe (WR).** This line latches the starting address (A0–A7) into a register. On the rising edge of the WR, the SPC starts execution of the command specified by CMS. The command sequence is shown in the timing waveform section. If a command to start a new speech sequence is issued during a speech sequence, the new speech sequence will be started immediately.
3, 43, 45, 40, 13, 9, 16, 11	**Data Bus (SW1–SW8).** SW1 (LSB) This is an 8-bit parallel binary data bus which accepts the binary address of the desired word. The binary addresses are available from Table I and are the same as the decimal address from the word list. Unused inputs must be connected to ground when used with external logic.	50	**Power Supply Voltage (V_DD).** Plus 7V to 11V maximum, direct current, to SPC, filter and amplifier sections. **Important!** V_DD *must* be regulated!
		47	**Ground (V_SS).**
		7	**Interrupt Output (INTR).** This signal goes high at the completion of any speech sequence. It is reset by the next valid command. It is also reset at power up.
34	**Command Select (CMS).** This line is used to specify the two commands to the SPC.	10	**Speaker Output.** 4Ω–8Ω 1/2W at V_DD, 11.0V

CMS 0: Reset interrupt and start speech sequence
CMS 1: Reset interrupt only

Functional Description (Continued)

TABLE I. DT1000 MASTER WORD LIST

Word	Keyboard Address	8-Bit Binary Address SW8 ⟶ SW1	Word	Keyboard Address	8-Bit Binary Address SW8 ⟶ SW1	Word	Keyboard Address	8-Bit Binary Address SW8 ⟶ SW1
THIS IS DIGITALKER	000	0 0 0 0 0 0 0 0	W	054	0 0 1 1 0 1 1 0	MILLI	108	0 1 1 0 1 1 0 0
ONE	001	0 0 0 0 0 0 0 1	X	055	0 0 1 1 0 1 1 1	MINUS	109	0 1 1 0 1 1 0 1
TWO	002	0 0 0 0 0 0 1 0	Y	056	0 0 1 1 1 0 0 0	MINUTE	110	0 1 1 0 1 1 1 0
THREE	003	0 0 0 0 0 0 1 1	Z	057	0 0 1 1 1 0 0 1	NEAR	111	0 1 1 0 1 1 1 1
FOUR	004	0 0 0 0 0 1 0 0	AGAIN	058	0 0 1 1 1 0 1 0	NUMBER	112	0 1 1 1 0 0 0 0
FIVE	005	0 0 0 0 0 1 0 1	AMPERE	059	0 0 1 1 1 0 1 1	OF	113	0 1 1 1 0 0 0 1
SIX	006	0 0 0 0 0 1 1 0	AND	060	0 0 1 1 1 1 0 0	OFF	114	0 1 1 1 0 0 1 0
SEVEN	007	0 0 0 0 0 1 1 1	AT	061	0 0 1 1 1 1 0 1	ON	115	0 1 1 1 0 0 1 1
EIGHT	008	0 0 0 0 1 0 0 0	CANCEL	062	0 0 1 1 1 1 1 0	OUT	116	0 1 1 1 0 1 0 0
NINE	009	0 0 0 0 1 0 0 1	CASE	063	0 0 1 1 1 1 1 1	OVER	117	0 1 1 1 0 1 0 1
TEN	010	0 0 0 0 1 0 1 0	CENT	064	0 1 0 0 0 0 0 0	PARENTHESIS	118	0 1 1 1 0 1 1 0
ELEVEN	011	0 0 0 0 1 0 1 1	400HERTZ TONE	065	0 1 0 0 0 0 0 1	PERCENT	119	0 1 1 1 0 1 1 1
TWELVE	012	0 0 0 0 1 1 0 0	80HERTZ TONE	066	0 1 0 0 0 0 1 0	PLEASE	120	0 1 1 1 1 0 0 0
THIRTEEN	013	0 0 0 0 1 1 0 1	20MS SILENCE	067	0 1 0 0 0 0 1 1	PLUS	121	0 1 1 1 1 0 0 1
FOURTEEN	014	0 0 0 0 1 1 1 0	40MS SILENCE	068	0 1 0 0 0 1 0 0	POINT	122	0 1 1 1 1 0 1 0
FIFTEEN	015	0 0 0 0 1 1 1 1	80MS SILENCE	069	0 1 0 0 0 1 0 1	POUND	123	0 1 1 1 1 0 1 1
SIXTEEN	016	0 0 0 1 0 0 0 0	160MS SILENCE	070	0 1 0 0 0 1 1 0	PULSES	124	0 1 1 1 1 1 0 0
SEVENTEEN	017	0 0 0 1 0 0 0 1	320MS SILENCE	071	0 1 0 0 0 1 1 1	RATE	125	0 1 1 1 1 1 0 1
EIGHTEEN	018	0 0 0 1 0 0 1 0	CENTI	072	0 1 0 0 1 0 0 0	RE	126	0 1 1 1 1 1 1 0
NINETEEN	019	0 0 0 1 0 0 1 1	CHECK	073	0 1 0 0 1 0 0 1	READY	127	0 1 1 1 1 1 1 1
TWENTY	020	0 0 0 1 0 1 0 0	COMMA	074	0 1 0 0 1 0 1 0	RIGHT	128	1 0 0 0 0 0 0 0
THIRTY	021	0 0 0 1 0 1 0 1	CONTROL	075	0 1 0 0 1 0 1 1	SS (Note 1)	129	1 0 0 0 0 0 0 1
FORTY	022	0 0 0 1 0 1 1 0	DANGER	076	0 1 0 0 1 1 0 0	SECOND	130	1 0 0 0 0 0 1 0
FIFTY	023	0 0 0 1 0 1 1 1	DEGREE	077	0 1 0 0 1 1 0 1	SET	131	1 0 0 0 0 0 1 1
SIXTY	024	0 0 0 1 1 0 0 0	DOLLAR	078	0 1 0 0 1 1 1 0	SPACE	132	1 0 0 0 0 1 0 0
SEVENTY	025	0 0 0 1 1 0 0 1	DOWN	079	0 1 0 0 1 1 1 1	SPEED	133	1 0 0 0 0 1 0 1
EIGHTY	026	0 0 0 1 1 0 1 0	EQUAL	080	0 1 0 1 0 0 0 0	STAR	134	1 0 0 0 0 1 1 0
NINETY	027	0 0 0 1 1 0 1 1	ERROR	081	0 1 0 1 0 0 0 1	START	135	1 0 0 0 0 1 1 1
HUNDRED	028	0 0 0 1 1 1 0 0	FEET	082	0 1 0 1 0 0 1 0	STOP	136	1 0 0 0 1 0 0 0
THOUSAND	029	0 0 0 1 1 1 0 1	FLOW	083	0 1 0 1 0 0 1 1	THAN	137	1 0 0 0 1 0 0 1
MILLION	030	0 0 0 1 1 1 1 0	FUEL	084	0 1 0 1 0 1 0 0	THE	138	1 0 0 0 1 0 1 0
ZERO	031	0 0 0 1 1 1 1 1	GALLON	085	0 1 0 1 0 1 0 1	TIME	139	1 0 0 0 1 0 1 1
A	032	0 0 1 0 0 0 0 0	GO	086	0 1 0 1 0 1 1 0	TRY	140	1 0 0 0 1 1 0 0
B	033	0 0 1 0 0 0 0 1	GRAM	087	0 1 0 1 0 1 1 1	UP	141	1 0 0 0 1 1 0 1
C	034	0 0 1 0 0 0 1 0	GREAT	088	0 1 0 1 1 0 0 0	VOLT	142	1 0 0 0 1 1 1 0
D	035	0 0 1 0 0 0 1 1	GREATER	089	0 1 0 1 1 0 0 1	WEIGHT (Note 2)	143	1 0 0 0 1 1 1 1
E	036	0 0 1 0 0 1 0 0	HAVE	090	0 1 0 1 1 0 1 0			
F	037	0 0 1 0 0 1 0 1	HIGH	091	0 1 0 1 1 0 1 1			
G	038	0 0 1 0 0 1 1 0	HIGHER	092	0 1 0 1 1 1 0 0			
H	039	0 0 1 0 0 1 1 1	HOUR	093	0 1 0 1 1 1 0 1			
I	040	0 0 1 0 1 0 0 0	IN	094	0 1 0 1 1 1 1 0			
J	041	0 0 1 0 1 0 0 1	INCHES	095	0 1 0 1 1 1 1 1			
K	042	0 0 1 0 1 0 1 0	IS	096	0 1 1 0 0 0 0 0			
L	043	0 0 1 0 1 0 1 1	IT	097	0 1 1 0 0 0 0 1			
M	044	0 0 1 0 1 1 0 0	KILO	098	0 1 1 0 0 0 1 0			
N	045	0 0 1 0 1 1 0 1	LEFT	099	0 1 1 0 0 0 1 1			
O	046	0 0 1 0 1 1 1 0	LESS	100	0 1 1 0 0 1 0 0			
P	047	0 0 1 0 1 1 1 1	LESSER	101	0 1 1 0 0 1 0 1			
Q	048	0 0 1 1 0 0 0 0	LIMIT	102	0 1 1 0 0 1 1 0			
R	049	0 0 1 1 0 0 0 1	LOW	103	0 1 1 0 0 1 1 1			
S	050	0 0 1 1 0 0 1 0	LOWER	104	0 1 1 0 1 0 0 0			
T	051	0 0 1 1 0 0 1 1	MARK	105	0 1 1 0 1 0 0 1			
U	052	0 0 1 1 0 1 0 0	METER	106	0 1 1 0 1 0 1 0			
V	053	0 0 1 1 0 1 0 1	MILE	107	0 1 1 0 1 0 1 1			

Note 1: "SS" makes any singular word plural.

Note 2: Address 143 is the last legal address in this particular word list. Exceeding address 143 in an external processor application will produce pieces of unintelligible invalid speech data.

13

DT1000 Schematic Diagram

FIGURE 1. DT1000 DIGITALKER™ Evaluation Board Circuit Diagram
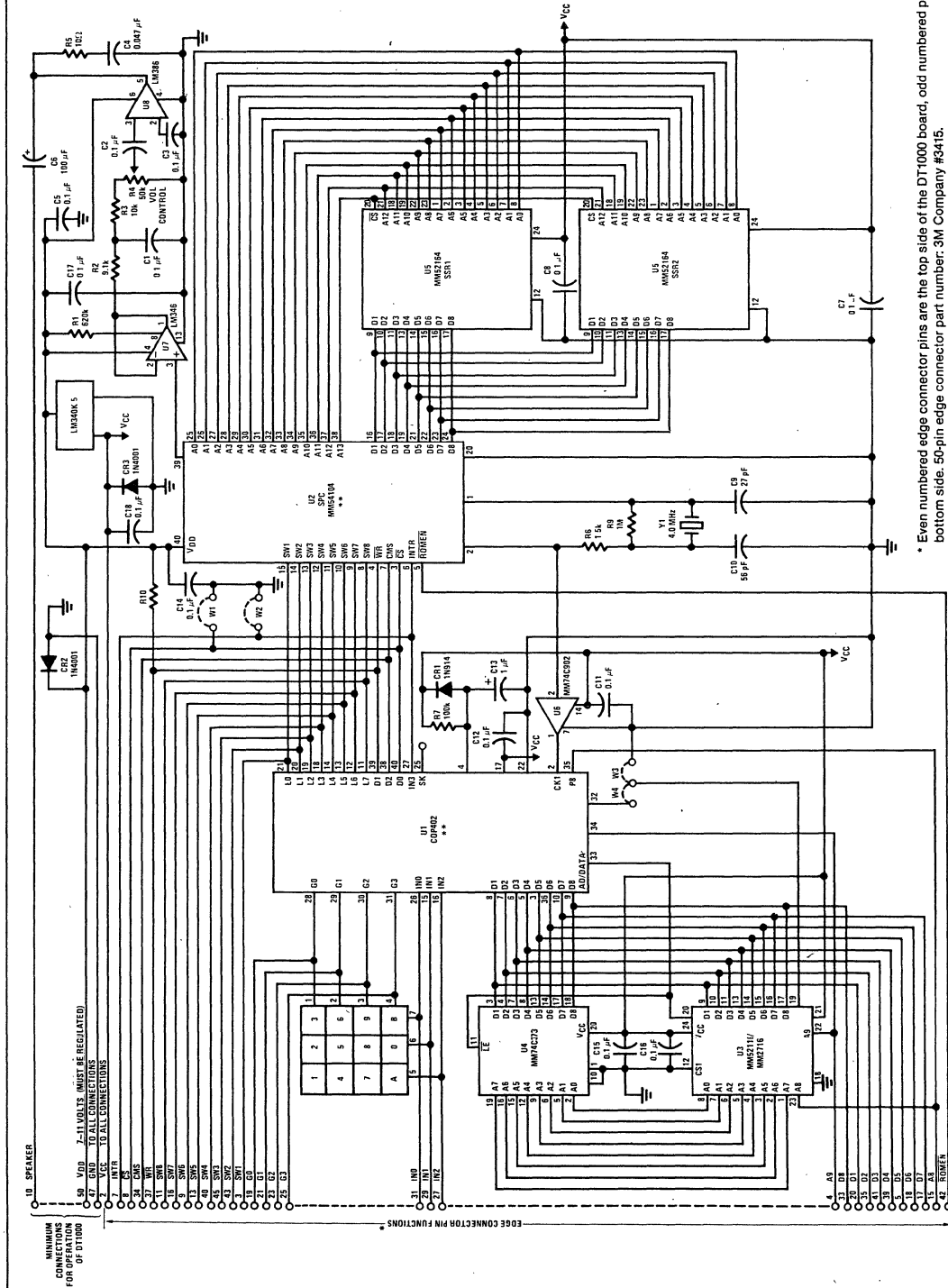
* Even numbered edge connector pins are the top side of the DT1000 board, odd numbered pins are on bottom side. 50-pin edge connector part number: 3M Company #3415.

** The COP402 device must be removed from the socket for external processor applications.

AC Electrical Characteristics

(For Use in External Processor Application) $T_A = 0°C$ to $70°C$, $V_{DD} = 7V-11V$, $V_{SS} = 0V$, unless otherwise specified.

Symbol	Parameter	Min	Max	Units
t_{aw}	CMS Valid to Write Strobe	350		ns
t_{csw}	Chip Select ON to Write Strobe	310		ns
t_{dw}	Data Bus Valid to Write Strobe	50		ns
t_{wa}	CMS Hold Time after Write Strobe	50		ns
t_{wd}	Data Bus Hold Time after Write Strobe	100		ns
t_{ww}	Write Strobe Width (50% Point)	430		ns
t_{wss}	Write Strobe to Speech Output Delay		410	μS

Note: Rise and fall times (10% to 90%) of MICROBUS™ signals should be 50 ns maximum.

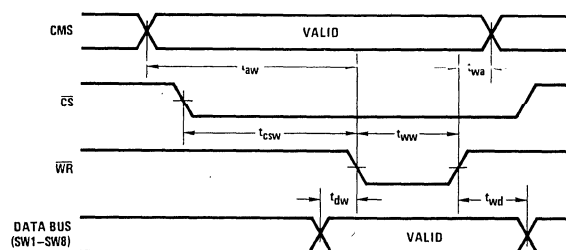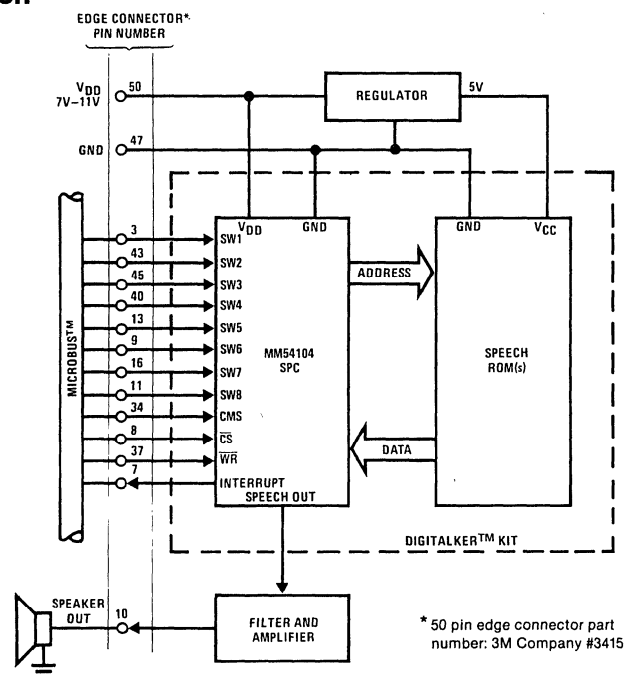## Timing Waveforms (Required in external processor applications)

FIGURE 2. Command Sequence

Typical Application

* 50 pin edge connector part number: 3M Company #3415

Note: COP402 must be removed from DT1000 in this configuration.

FIGURE 3. DIGITALKER™ Connections to External MICROBUS™ Processor

MICROBUS™ is a trademark of National Semiconductor Corp.

13