National Semiconductor

DIGITALKER™ Speech Synthesis

DT1050/DT1053 DIGITALKER™ Standard Vocabulary Kit

General Description

The DIGITALKER™ is a speech synthesis system consisting of several N-channel MOS integrated circuits. It contains a speech processor chip (SPC) and speech ROM and when used with external filter, amplifier, and speaker, produces a system which generates high quality speech including the natural inflection and emphasis of the original speech. Male, female, and children's voices can be synthesized.

The SPC communicates with the speech ROM, which contains the compressed speech data as well as the frequency and amplitude data required for speech output. Up to 128k bits of speech data can be directly accessed.

With the addition of an external resistor, on-chip debounce is provided for use with a switch interface.

An interrupt is generated at the end of each speech sequence so that several sequences or words can be cascaded to form different speech expressions.

The DT1050 is a standard DIGITALKER kit encoded with 137 separate and useful words, 2 tones, and 5 different silence durations. (See the Master Word List Table I). The words and tones have been assigned discrete addresses, making it possible to output single words or words concatenated into phrases or even sentences.

The "voice" output of the DT1050 is a highly intelligible male voice. The vocabulary is chosen so that it is applicable to many products and markets.
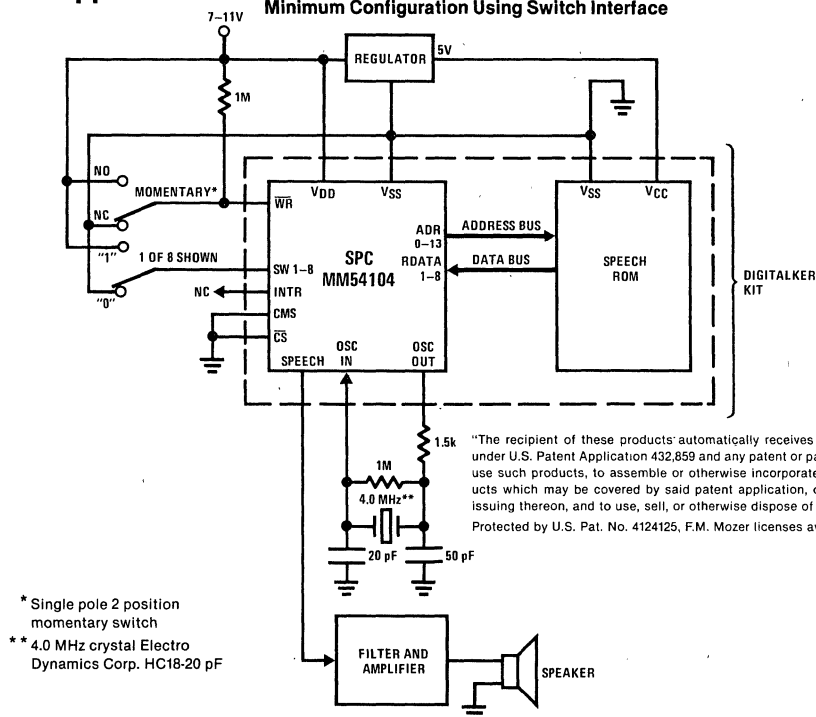
Features

- COPS™ and MICROBUS™ compatible
- Designed to be easily interfaced to other popular microprocessors
- 144 addressable expressions, including numbers
- Natural inflection and emphasis of original speech
- Addresses 128k of ROM directly
- TTL compatible
- On-chip switch debounce for interfacing to manual switches independent of a microprocessor
- Interrupt capability for cascading words or phrases
- Crystal controlled or externally driven oscillator
- Available in complete kit (DT1050) or speech ROM only (DT1053)

Applications

- Telecommunications
- Appliance
- Automotive
- Teaching aids
- Consumer products
- Clocks
- Language translation
- Annunciators

Typical Applications

Minimum Configuration Using Switch Interface

"The recipient of these products automatically receives a non-exclusive license under U.S. Patent Application 432,859 and any patent or patents issuing thereon to use such products, to assemble or otherwise incorporate them into further products which may be covered by said patent application, or any patent or patents issuing thereon, and to use, sell, or otherwise dispose of such products". Protected by U.S. Pat. No. 4124125, F.M. Mozer licenses available.

* Single pole 2 position momentary switch

* * 4.0 MHz crystal Electro Dynamics Corp. HC18-20 pF

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

Absolute Maximum Ratings*

Storage Temperature Range	−65°C to +150°C	Voltage at Any Pin	12V
Operating Temperature Range	0°C to 70°C	Operating Voltage Range, V_{DD}-V_{SS}	7V to 11V
V_{DD}-V_{SS}	12V	Lead Temperature (Soldering, 10 seconds)	300°C

DC Electrical Characteristics* $T_A = 0°C$ to $70°C$, $V_{DD} = 7V$-$11V$, $V_{SS} = 0V$, unless otherwise specified.

Symbol	Parameter	Conditions	Min	Typ	Max	Units
V_{IL}	Input Low Voltage		−0.3		0.8	V
V_{IH}	Input High Voltage		2.0		V_{DD}	V
V_{OL}	Output Low Voltage	$I_{OL} = 1.6$ mA			0.4	V
V_{OH}	Output High Voltage	$I_{OH} = -100 \mu A$	2.4		5.0	V
V_{ILX}	Clock Input Low Voltage		−0.3		1.2	V
V_{IHX}	Clock Input High Voltage		5.5		V_{DD}	V
I_{DD}	Power Supply Current				45	mA
I_{IL}	Input Leakage				±10	μA
I_{ILX}	Clock Input Leakage				±10	μA
V_S	Silence Voltage			$0.45 V_{DD}$		V
V_{OUT}	Peak to Peak Speech Output	$V_{DD} = 11V$		2.0		V
R_{EXT}	External Load on Speech Output	R_{EXT} Connected Between Speech Output and V_{SS}	50			kΩ

AC Electrical Characteristics* $T_A = 0°C$ 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_{red}	$\overline{ROMEN}$ ON to Valid ROM Data		2	μs
t_{wss}	Write Strobe to Speech Output Delay		410	μs
f_t	External Clock Frequency	3.92	4.08	MHz

Note: Rise and fall times (10% to 90%) of MICROBUS signals should be 50 ns maximum.
*SPC characteristics only. ROM characteristics covered by separate data sheet for MM52164.

Timing Waveforms

Command Sequence
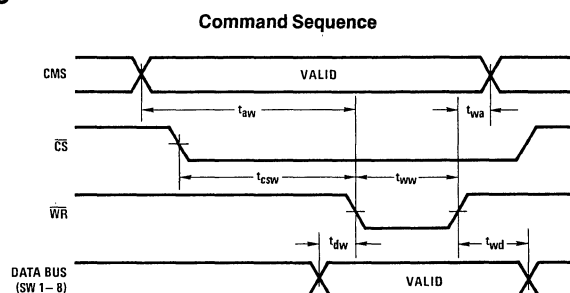
Timing Waveforms (Continued)

ROM Data Timing
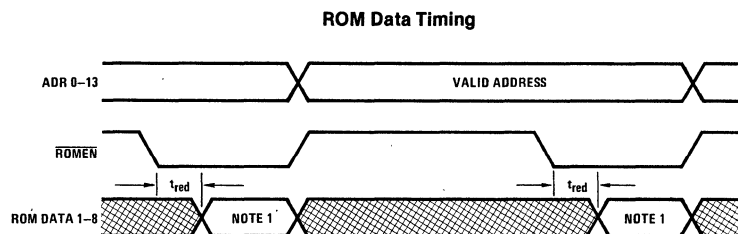
Note 1: ROM Data 1-8 can go valid any time after ADR 0-13 changes, however it must be valid within the t_{red} spec and remain valid until ROMEN goes high.

Functional Description

The following describes the function of all SPC input and output pins.

Note: In the following descriptions, a low represents a logic 0 (0.4V nominal), and a high represents a logic 1 (2.4V nominal).

INPUT SIGNALS

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.

Data Bus (SW 1-8): This is an 8-bit parallel data bus which contains the starting address of the speech data.

Data bus inputs SW 1-SW 8 accept an 8-bit binary address which is the address of the word which is to be "spoken" from the DIGITALKER output. See the Master Word List (Table I) for the complete listing of words and their respective addresses. If the entire word list is not used, unused inputs must be connected to V_SS.

Command Select (CMS): This line specifies the two commands to the SPC.

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

Write Strobe (WR): This line latches the starting address (SW 1-SW 8) 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. When connecting WR to a switch, it must be a single pole 2 position switch as shown on page 1.

ROM Data (RDATA 1-8): This is an 8-bit parallel data bus which contains the speech data from the speech ROM.

OUTPUT SIGNALS

Interrupt (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.

ROM Address (ADR 0-ADR 13): This is a 14-bit parallel bus that supplies the address of the speech data to the speech ROM.

ROM Enable (ROMEN): For low power applications, this line can be used to drive a transistor that switches the supply for static speech ROMs. See ROM data timing.

Speech Output (Speech Out): This is the analog output that represents the speech data. See frequency response section.

INPUT/OUTPUT SIGNALS

Clock Input/Output (OSC IN, OSC OUT): These two pins connect the main timing reference (crystal) to the SPC.

PHRASE QUALITY

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 any 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. 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.

Functional Description (Continued)

TABLE I. DT1050 MASTER WORD LIST*

| Word	8-Bit Binary Address SW8 SW1		8-Bit Binary Address SW8 SW1		8-Bit Binary Address SW8 SW1
THIS IS DIGITALKER	0 0 0 0 0 0 0 0	Q	0 0 1 1 0 0 0 0	IS	0 1 1 0 0 0 0 0
ONE	0 0 0 0 0 0 0 1	R	0 0 1 1 0 0 0 1	IT	0 1 1 0 0 0 0 1
TWO	0 0 0 0 0 0 1 0	S	0 0 1 1 0 0 1 0	KILO	0 1 1 0 0 0 1 0
THREE	0 0 0 0 0 0 1 1	T	0 0 1 1 0 0 1 1	LEFT	0 1 1 0 0 0 1 1
FOUR	0 0 0 0 0 1 0 0	U	0 0 1 1 0 1 0 0	LESS	0 1 1 0 0 1 0 0
FIVE	0 0 0 0 0 1 0 1	V	0 0 1 1 0 1 0 1	LESSER	0 1 1 0 0 1 0 1
SIX	0 0 0 0 0 1 1 0	W	0 0 1 1 0 1 1 0	LIMIT	0 1 1 0 0 1 1 0
SEVEN	0 0 0 0 0 1 1 1	X	0 0 1 1 0 1 1 1	LOW	0 1 1 0 0 1 1 1
EIGHT	0 0 0 0 1 0 0 0	Y	0 0 1 1 1 0 0 0	LOWER	0 1 1 0 1 0 0 0
NINE	0 0 0 0 1 0 0 1	Z	0 0 1 1 1 0 0 1	MARK	0 1 1 0 1 0 0 1
TEN	0 0 0 0 1 0 1 0	AGAIN	0 0 1 1 1 0 1 0	METER	0 1 1 0 1 0 1 0
ELEVEN	0 0 0 0 1 0 1 1	AMPERE	0 0 1 1 1 0 1 1	MILE	0 1 1 0 1 0 1 1
TWELVE	0 0 0 0 1 1 0 0	AND	0 0 1 1 1 1 0 0	MILLI	0 1 1 0 1 1 0 0
THIRTEEN	0 0 0 0 1 1 0 1	AT	0 0 1 1 1 1 0 1	MINUS	0 1 1 0 1 1 0 1
FOURTEEN	0 0 0 0 1 1 1 0	CANCEL	0 0 1 1 1 1 1 0	MINUTE	0 1 1 0 1 1 1 0
FIFTEEN	0 0 0 0 1 1 1 1	CASE	0 0 1 1 1 1 1 1	NEAR	0 1 1 0 1 1 1 1
SIXTEEN	0 0 0 1 0 0 0 0	CENT	0 1 0 0 0 0 0 0	NUMBER	0 1 1 1 0 0 0 0
SEVENTEEN	0 0 0 1 0 0 0 1	400HERTZ TONE	0 1 0 0 0 0 0 1	OF	0 1 1 1 0 0 0 1
EIGHTEEN	0 0 0 1 0 0 1 0	80HERTZ TONE	0 1 0 0 0 0 1 0	OFF	0 1 1 1 0 0 1 0
NINETEEN	0 0 0 1 0 0 1 1	20MS SILENCE	0 1 0 0 0 0 1 1	ON	0 1 1 1 0 0 1 1
TWENTY	0 0 0 1 0 1 0 0	40MS SILENCE	0 1 0 0 0 1 0 0	OUT	0 1 1 1 0 1 0 0
THIRTY	0 0 0 1 0 1 0 1	80MS SILENCE	0 1 0 0 0 1 0 1	OVER	0 1 1 1 0 1 0 1
FORTY	0 0 0 1 0 1 1 0	160MS SILENCE	0 1 0 0 0 1 1 0	PARENTHESIS	0 1 1 1 0 1 1 0
FIFTY	0 0 0 1 0 1 1 1	320MS SILENCE	0 1 0 0 0 1 1 1	PERCENT	0 1 1 1 0 1 1 1
SIXTY	0 0 0 1 1 0 0 0	CENTI	0 1 0 0 1 0 0 0	PLEASE	0 1 1 1 1 0 0 0
SEVENTY	0 0 0 1 1 0 0 1	CHECK	0 1 0 0 1 0 0 1	PLUS	0 1 1 1 1 0 0 1
EIGHTY	0 0 0 1 1 0 1 0	COMMA	0 1 0 0 1 0 1 0	POINT	0 1 1 1 1 0 1 0
NINETY	0 0 0 1 1 0 1 1	CONTROL	0 1 0 0 1 0 1 1	POUND	0 1 1 1 1 0 1 1
HUNDRED	0 0 0 1 1 1 0 0	DANGER	0 1 0 0 1 1 0 0	PULSES	0 1 1 1 1 1 0 0
THOUSAND	0 0 0 1 1 1 0 1	DEGREE	0 1 0 0 1 1 0 1	RATE	0 1 1 1 1 1 0 1
MILLION	0 0 0 1 1 1 1 0	DOLLAR	0 1 0 0 1 1 1 0	RE	0 1 1 1 1 1 1 0
ZERO	0 0 0 1 1 1 1 1	DOWN	0 1 0 0 1 1 1 1	READY	0 1 1 1 1 1 1 1
A	0 0 1 0 0 0 0 0	EQUAL	0 1 0 1 0 0 0 0	RIGHT	1 0 0 0 0 0 0 0
B	0 0 1 0 0 0 0 1	ERROR	0 1 0 1 0 0 0 1	SS (Note 1)	1 0 0 0 0 0 0 1
C	0 0 1 0 0 0 1 0	FEET	0 1 0 1 0 0 1 0	SECOND	1 0 0 0 0 0 1 0
D	0 0 1 0 0 0 1 1	FLOW	0 1 0 1 0 0 1 1	SET	1 0 0 0 0 0 1 1
E	0 0 1 0 0 1 0 0	FUEL	0 1 0 1 0 1 0 0	SPACE	1 0 0 0 0 1 0 0
F	0 0 1 0 0 1 0 1	GALLON	0 1 0 1 0 1 0 1	SPEED	1 0 0 0 0 1 0 1
G	0 0 1 0 0 1 1 0	GO	0 1 0 1 0 1 1 0	STAR	1 0 0 0 0 1 1 0
H	0 0 1 0 0 1 1 1	GRAM	0 1 0 1 0 1 1 1	START	1 0 0 0 0 1 1 1
I	0 0 1 0 1 0 0 0	GREAT	0 1 0 1 1 0 0 0	STOP	1 0 0 0 1 0 0 0
J	0 0 1 0 1 0 0 1	GREATER	0 1 0 1 1 0 0 1	THAN	1 0 0 0 1 0 0 1
K	0 0 1 0 1 0 1 0	HAVE	0 1 0 1 1 0 1 0	THE	1 0 0 0 1 0 1 0
L	0 0 1 0 1 0 1 1	HIGH	0 1 0 1 1 0 1 1	TIME	1 0 0 0 1 0 1 1
M	0 0 1 0 1 1 0 0	HIGHER	0 1 0 1 1 1 0 0	TRY	1 0 0 0 1 1 0 0
N	0 0 1 0 1 1 0 1	HOUR	0 1 0 1 1 1 0 1	UP	1 0 0 0 1 1 0 1
O	0 0 1 0 1 1 1 0	IN	0 1 0 1 1 1 1 0	VOLT	1 0 0 0 1 1 1 0
P	0 0 1 0 1 1 1 1	INCHES	0 1 0 1 1 1 1 1	WEIGHT (Note 2)	1 0 0 0 1 1 1 1

* DT1050 is a complete kit including MM54104 SPC; DT1053 is SSR1 and SSR2 speech ROMs only.

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 will produce pieces of unintelligible invalid speech data.
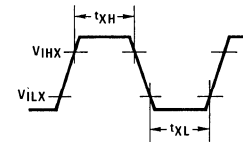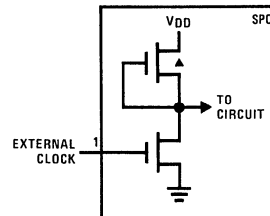
13

Crystal Circuit Information
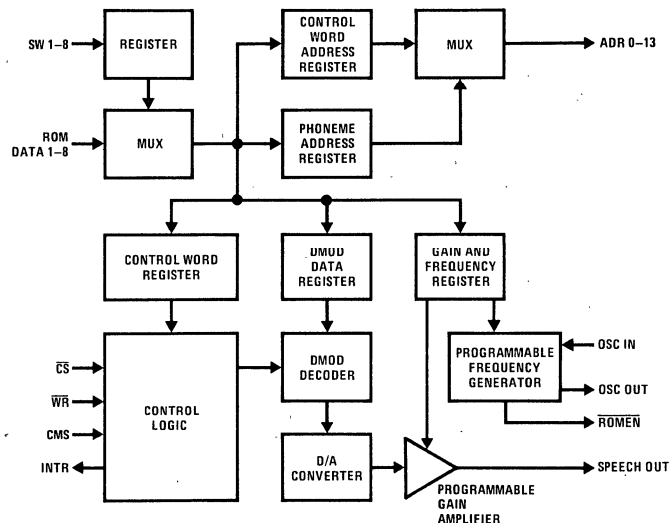
Typical Crystal Oscillator Network

Crystal	R1	R2	C1	C2
4.0 MHz	1M	1.5k	10–30 pF	40–60 pF
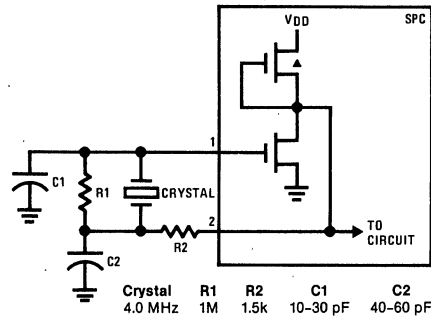
(4.0 MHz crystal manufactured by Electro Dynamics Corp. P/N HC18-20 pF)

External Clock Input (4.0 MHz)

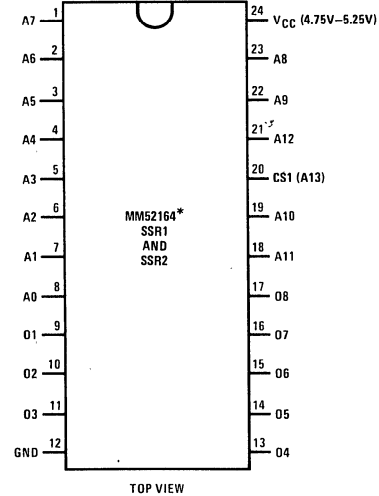| Timing	Min	Units
t_{XH}	100	ns
t_{XL}	100	ns

SPC Block and Connection Diagrams

Dual-In-Line Package

SPC (MM54104)

OSC IN — 1	40 — VDD
OSC OUT — 2	39 — SPEECH OUT
CS — 3	38 — ADR 13 (MSB)
WR — 4	37 — ADR 12
ROMEN — 5	36 — ADR 11
INTR — 6	35 — ADR 10
CMS — 7	34 — ADR 9
SW 8 (MSB) — 8	33 — ADR 8
SW 7 — 9	32 — ADR 7
SW 6 — 10	31 — ADR 6
SW 5 — 11	30 — ADR 5
SW 4 — 12	29 — ADR 4
SW 3 — 13	28 — ADR 3
SW 2 — 14	27 — ADR 2
SW 1 (LSB) — 15	26 — ADR 1
RDATA 0 (LSB) — 16	25 — ADR 0 (LSB)
RDATA 1 — 17	24 — RDATA 7 (MSB)
RDATA 2 — 18	23 — RDATA 6
RDATA 3 — 19	22 — RDATA 5
VSS — 20	21 — RDATA 4

TOP VIEW

Dual-In-Line Package

MM52164* SSR1 AND SSR2

A7 — 1	24 — VCC (4.75V–5.25V)
A6 — 2	23 — A8
A5 — 3	22 — A9
A4 — 4	21 — A12
A3 — 5	20 — CS1 (A13)
A2 — 6	19 — A10
A1 — 7	18 — A11
A0 — 8	17 — 08
01 — 9	16 — 07
02 — 10	15 — 06
03 — 11	14 — 05
GND — 12	13 — 04

TOP VIEW

* For specific ROM device information, see MM52164 data sheet.

Recommended Schematic Diagram
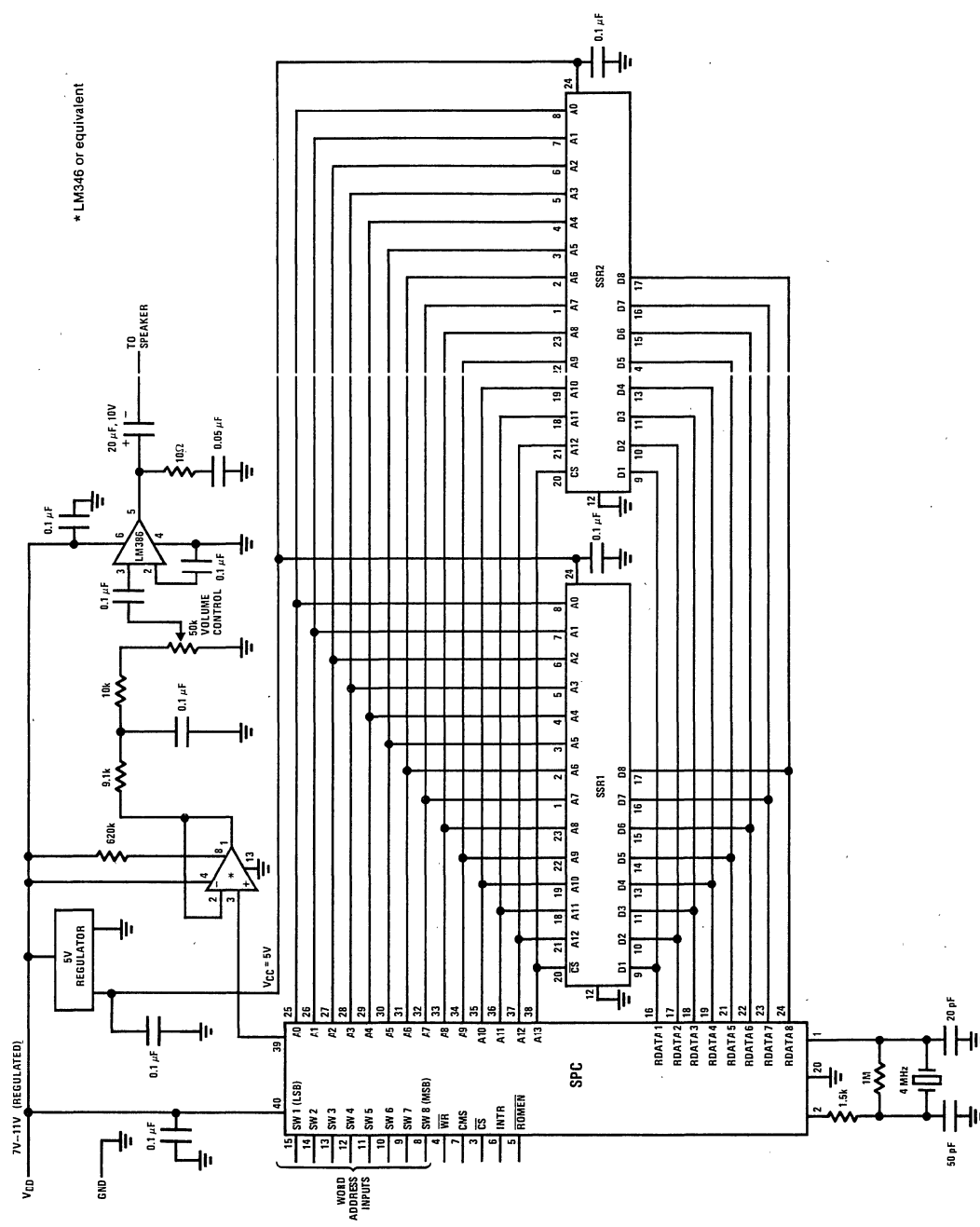
13

Applications Information

### Frequency Response of Combined Amplifier and Speaker
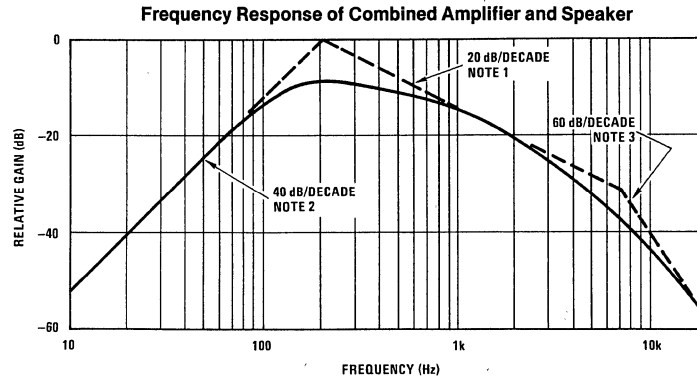
Note 1: This curve is the desired response of the entire audio system including speaker. Minimum response is a low pass filter with a cutoff frequency of 200 Hz. For an audio system with a natural cutoff frequency around 200 Hz, this filter can be eliminated. This cutoff frequency may be tuned for the particular voice being synthesized. For a low pitched male voice it may be 100 Hz, while for a high pitched female or child's voice it might be 300 Hz.

Note 2: This is optional filtering that can be eliminated by proper selection of the speaker. If this 2 pole response is electronically produced, it should be adjusted as described in Note 1.
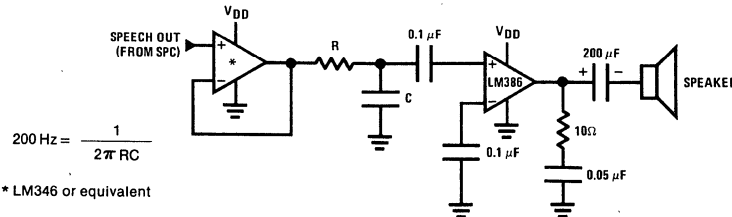
Note 3: This is optional filtering that can be eliminated for simpler systems. The acceptable range for this cutoff frequency is 6000 Hz–8000 Hz.

Typical Applications (Continued)
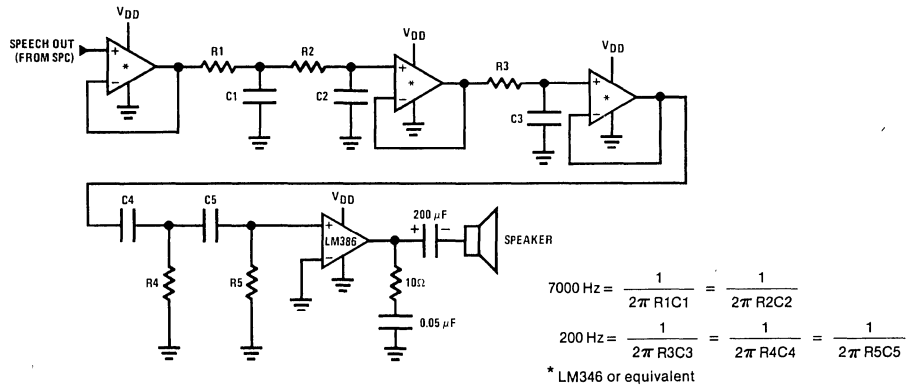
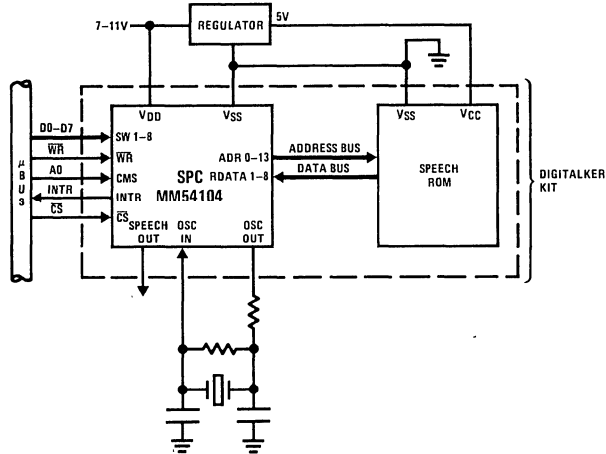### DIGITALKER System Using COP420 Interface

Minimum Filter Circuit

$$200\,Hz = \frac{1}{2\pi\,RC}$$
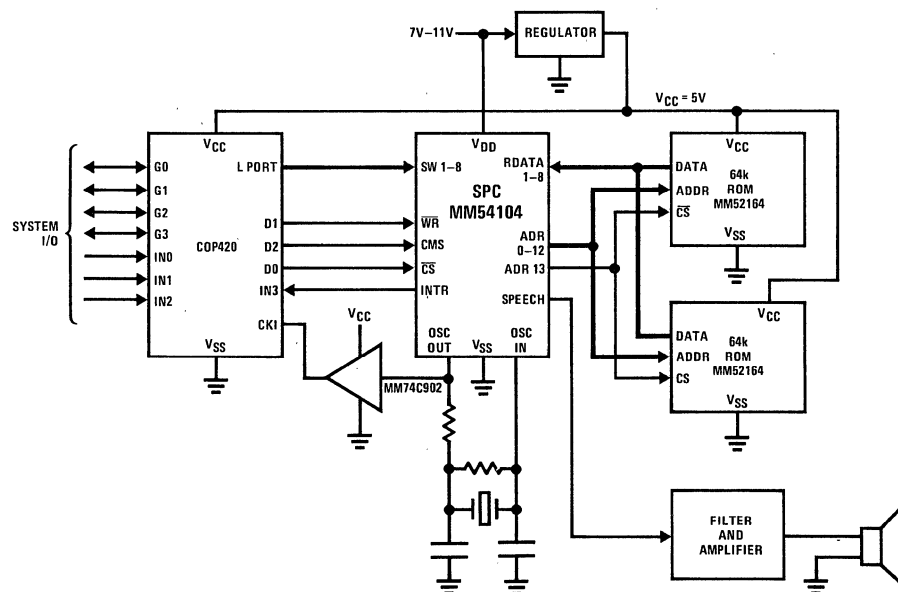
* LM346 or equivalent

Typical Applications (Continued)

Filter Circuit to Produce Maximum Frequency Response

$$7000\,Hz = \frac{1}{2\pi\,R1C1} = \frac{1}{2\pi\,R2C2}$$

$$200\,Hz = \frac{1}{2\pi\,R3C3} = \frac{1}{2\pi\,R4C4} = \frac{1}{2\pi\,R5C5}$$

*LM346 or equivalent

DIGITALKER System Utilizing MICROBUS™ Interface

Low Power Configuration Using Static ROM

13