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Speech! Speech!

Here's a talking repeater controller that you can build in no time at all. It gives a whole new meaning to the word "vox"!

This project began as a voice identifier for one of our local repeaters. We wanted the ability to have several voice ID messages given at proper times during repeater operation.

After the ID software had been written, I noticed that only a little additional hardware and software would be needed to completely replace the repeater timer

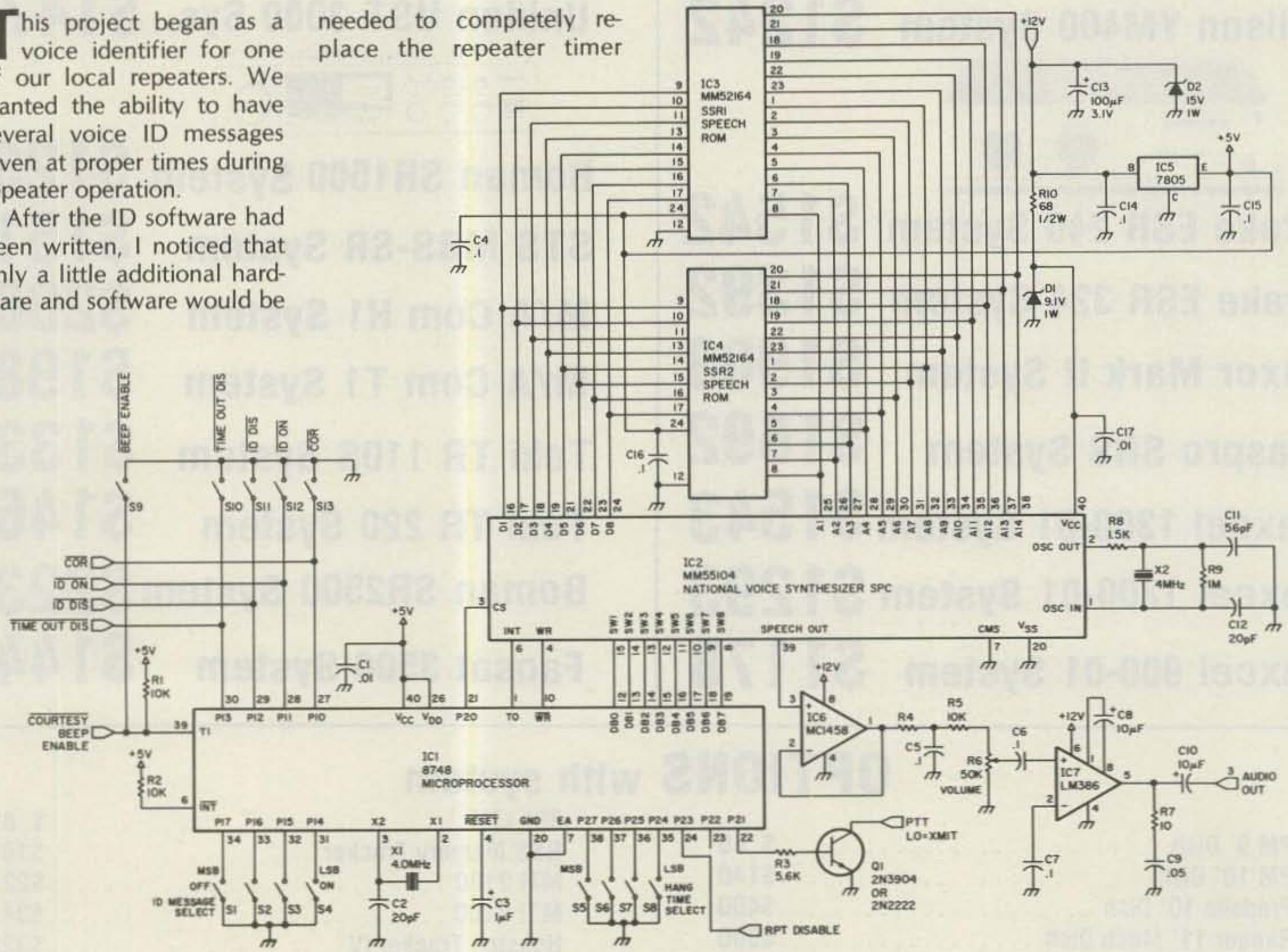

Fig. 1. Microprocessor repeater interface and identifier.

board in the all-Motorola repeater. I added what was needed to fully implement the repeater timer and squelch-tail timer functions, and the circuit ended up with the following features:

1) Voice ID with up to 15 switch-selectable messages. Each message can be individually selected or the messages will automatically cycle through, giving a different ID each ID period.

2) ID interval set in software. Ours is set to 9 minutes 45 seconds, but the period can be set to any length up to 255 seconds in 1-second increments.

3) Repeater time-out timer. Time-out time set in software. We set ours to 2 minutes, but any length up to 255 minutes may be specified in 1-second increments.

4) Time-out messages. Ours says "Time out is near" at 15 seconds before time out. Then at 2 seconds before time out, it says "Over and out!" Times and messages may be changed in software.

5) Adjustable hang timer. DIP switches allow selection of hang times in 0.5-second increments from 0 to 7.5 seconds.

6) Courtesy beep at the end of the hang time.

7) Independent disable lines brought out for all functions.

8) Single-supply +12-volt operation.

The Circuit

The circuit shown in Fig. 1 is built around just two major components, the Intel 8748 microprocessor and the National Digitalker chip set. The microprocessor handles all the timing and message-storage jobs while the Digitalker does the actual voice synthesis.

The Digitalker chip set contains a voice-synthesizer chip, the MM55104, and two speech ROMS which contain the data necessary to generate 143 different words and phrases. A word list showing the words available in the basic chip set is shown in Fig. 2. Two op amps are connected to the output of the voice synthesizer to provide for speech filtering and audio amplification to speaker-level audio. Since speech is digitally constructed in the Digitalker, the output needs to be low-pass filtered to remove extraneous digital noise and high-frequency by-products. This filtering helps the speech to sound more natural. Without it, the speech tends to sound somewhat garbled.

The 8748 microprocessor has attached to it three sets of DIP switches. The first set, S1–S4, is used to select the ID message to be sent at ID time. The second set, S5–S8, is used to select the hang-time length. The last set, S9–S13, is used for function controls. The micro has internal pull-up resistors for most of the lines going to the switches, so only one line, pin 39, needs external pull-up, provided by resistor R1. All lines going to the micro are TTL-compatible, so standard negative-true logic was adopted. That is, grounding a line causes its function to occur.

The function lines out of the processor allow you to control what it does. The COR line is the most important. It connects, with proper interface, to your repeater receiver. Bringing it low triggers all functions done by this circuit. The ID ON line enables you to have the micro continuously send the ID message you have selected with DIP switches S1–S4. The ID DISABLE line prevents ID generation

Word	Hex Address
THIS IS DIGITALKER	00
ONE	01
TWO	02
THREE	03
FOUR	04
FIVE	05
SIX	06
SEVEN	07
EIGHT	08
NINE	09
TEN	0A
ELEVEN	0B
TWELVE	0C
THIRTEEN	0D
FOURTEEN	0E
FIFTEEN	0F
SIXTEEN	10
SEVENTEEN	11
EIGHTEEN	12
NINETEEN	13
TWENTY	14
THIRTY	15
FORTY	16
FIFTY	17
SIXTY	18
SEVENTY	19
EIGHTY	1A
NINETY	1B
HUNDRED	1C
THOUSAND	1D
MILLION	1E
ZERO	1F
A	20
B	21
C	22
D	23
E	24
F	25
G	26
H	27
I	28
J	29
K	2A
L	2B
M	2C
N	2D
O	2E
P	2F
Q	30
R	31
S	32
T	33
U	34
V	35
W	36
X	37
Y	38
Z	39
AGAIN	3A
AMPERE	3B
AND	3C
AT	3D
CANCEL	3E
CASE	3F
CENT	40
400 Hz TONE	41
80 Hz TONE	42
20 MS SILENCE	43
40 MS SILENCE	44
80 MS SILENCE	45
160 MS SILENCE	46
320 MS SILENCE	47
CENTI-	48
CHECK	49
COMMA	4A
CONTROL	4B
DANGER	4C
DEGREE	4D
DOLLAR	4E
DOWN	4F
EQUAL	50
ERROR	51
FEET	52
FLOW	53
FUEL	54
GALLON	55
GO	56
GRAM	57
GREAT	58
GREATER	59
HAVE	5A
HIGH	5B
HIGHER	5C
HOUR	5D
IN	5E
INCHES	5F
IS	60
IT	61
KILO	62
LEFT	63
LESS	64
LESSER	65
LIMIT	66
LOW	67
LOWER	68
MARK	69
METER	6A
MILE	6B
MILLI-	6C
MINUS	6D
MINUTE	6E
NEAR	6F
NUMBER	70
OF	71
OFF	72
ON	73
OUT	74
OVER	75
PARENTHESIS	76
PERCENT	77
PLEASE	78
PLUS	79
POINT	7A
POUND	7B
PULSES	7C
RATE	7D
RE-	7E
READY	7F
RIGHT	80
-SS (makes plurals)	81
SECOND	82
SET	83
SPACE	84
SPEED	85
STAR	86
START	87
STOP	88
THAN	89
THE	8A
TIME	8B
TRY	8C
UP	8D
VOLT	8E
WEIGHT	8F

Fig. 2. Digitalker master word list.

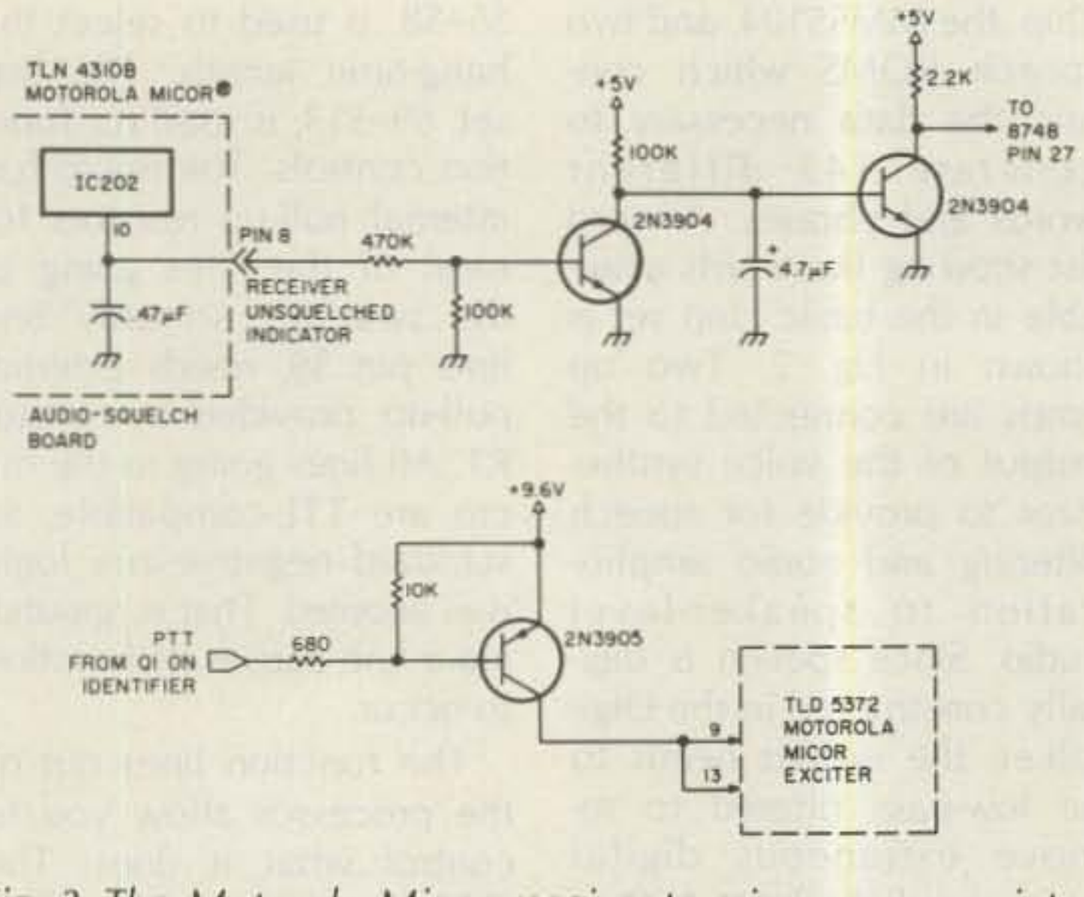

Fig. 3. The Motorola Micor receiver-to-microprocessor interface (top) and the identifier-exciter PTT interface.

whenever it is grounded. The TIME-OUT DISABLE line will defeat the internal time-out countdown and enable Q1 to stay enabled for as long as the COR line is held low.

The RPT DISABLE line is really powerful, as it should be. Whenever it is brought low, Q1 is immediately turned off and all functions are disabled. This line may also be used as a system reset. The BEEP ENABLE line, when grounded, allows the courtesy beep to occur at the end of the hang-time period.

Remember that with exception of the PTT line from Q1, all of these lines are limited to a maximum voltage of 5 volts, so be careful when interfacing this circuit into your repeater system. Although all of these lines are connected to on-board DIP switches for local control, they may also be connected to external, open-collector, TTL-level devices for remote control. When using external control, make sure that all on-board DIP switches are set to their open, or off, positions.

Construction and Operation

Our prototype circuit was built on a Vector 3677-2 DIP plugboard for ease of mounting in our repeater. I highly recommend building the circuit on plug-in boards. It surely makes debugging easier! Sockets were provided for all ICs. Since the circuit draws about 200 mA at 12 volts, a small TO-220-style heat sink was provided for the 5-volt regulator, IC7. Also note the 15-volt, 1-Watt zener across the 12-volt bus. That little diode, placed on each board in the repeater system, has saved my backside several times when lightning hit or when the main-supply pass transistor in the repeater shorted out. I highly recommend its use.

After the circuit is wired, check it over carefully several times. If possible, have a friend check it too. There isn't much to it, but the ICs are expensive, so don't take a chance.

After checking the wiring and before you insert the ICs in their sockets, check the power-supply voltages. Once you're satisfied that all is in readiness, set all DIP switches to their open position, plug in the ICs, attach a speaker, and apply power. The circuit should wake up with a short burst of unintelligible speech followed by silence.

Next, close all of the ID MESSAGE SELECT switches. Then close the ID ON switch. The circuit should then cycle through the ID messages that have been preprogrammed into the processor. If all is OK thus far, congratulations! The rest of the functions should now also work as advertised. You're ready to interface the circuit into your repeater.

Obviously, I can't show you how to interface to all equipment, but Fig. 3 shows the interface we used between the circuit and the Motorola Micor® audio-squelch and transmitter-exciter boards in our system.

Once interfaced into your system, all you'll need to do now is set the HANG-TIME SELECT switches. They are set in binary. First, determine the number of half-seconds of time desired. Then consult the chart in Fig. 4 for the proper switches to close. If all switches are open, there will be no squelch tail. The PTT will follow the COR signal immediately.

Here's how the system operates once successfully interfaced. When the receiver senses an incoming signal, it pulls the COR line low. Two events then occur. First, the PTT transistor is turned on to enable the repeater transmitter. Second, the ID interval timer is started and will continue to run until it times out. Voice ID is then certain to occur unless disabled by the ID DISABLE line, regardless of the state of the COR line.

When the COR line is released, or brought high again, the hang-time countdown is begun. When this countdown is complete (at a time set by the HANG-TIME SELECT switches), the processor turns off Q1, thereby turning off the transmitter. If the courtesy-beep line has been tied low, the processor will also command the voice synthesizer to send a short beep of 400-Hz tone. If the COR line is held low, about 15 seconds before

Parts List

Resistors		
R1, R2, R4, R5	10k, ¼ W, 10%	$ .24
R3	5.6k, ¼ W, 10%	.06
R6	Potentiometer, 50k	.59
R7	10 Ohm, ¼ W, 10%	.06
R8	1.5k, ¼ W, 10%	.06
R9	1 M, ¼ W, 10%	.06
R10	68 Ohm, ½ W, 10%	.06
Capacitors		
C1, C17	.01 uF, disc ceramic, 50 V	.40
C2, C12	20 pF, disc ceramic, 50 V	.40
C3	1.0 uF, electrolytic, 15 V	.59
C4–7, C14–16	0.1 uF, disc ceramic, 50 V	1.40
C8, C10	10 uF, electrolytic, 15 V	1.18
C9	.05 uF, disc ceramic, 50 V	.20
C11	56 pF, disc ceramic, 50 V	.20
C13	100 uF, electrolytic, 15 V	.69
IC1	Microprocessor, Intel 8748	*
IC2–4	National Digitalker chip set	35.00
IC5	LM7805 voltage regulator, 5 V	.79
IC6	MC1458 dual op amp	.59
IC7	LM386 power op amp	.89
D1	Zener diode, 9.1 V, 1 W	.25
D2	Zener diode, 15 V, 1 W	.25
Q1	Transistor, NPN 2N3904 or equivalent	.25
X1, X2	Crystal, 4.0 MHz	7.90
S1–S4, S5–S8	DIP switch, SPST, 4 position	2.38
S9–S13	DIP switch, SPST, 8 position	1.49
	PC board	*
	Socket, 40-pin DIP (two)	.98
	Socket, 24-pin DIP (two)	.66
	Socket, 8-pin DIP (two)	.32
	Heat sink, TO-220 style	.25

* Available from author

S5	S6	S7	S8	Hang Time
0	0	0	0	0.0 sec.
0	0	0	1	0.5
0	0	1	0	1.0
0	0	1	1	1.5
0	1	0	0	2.0
0	1	0	1	2.5
0	1	1	0	3.0
0	1	1	1	3.5
1	0	0	0	4.0
1	0	0	1	4.5
1	0	1	0	5.0
1	0	1	1	5.5
1	1	0	0	6.0
1	1	0	1	6.5
1	1	1	0	7.0
1	1	1	1	7.5

Fig. 4 Hang-time switch settings.

time out a warning message will be sent by the voice synthesizer: *Time out is near*. At two seconds before time out, a second, final warning will be given: *Over and out!* The PTT output will then be deactivated until either the COR line is released and brought low again or the ID cycle is completed, at which time a voice ID message will be given and the PTT output deactivated again.

Holding the COR line low past time out will keep the transmitter off, but automatic ID with PTT activation will still occur at the end of every succeeding ID interval. If the synthesizer is speaking when the ID message is due, the ID message will immediately follow.

Messages

Although the word list seems at first glance to be somewhat limited, a little applied ingenuity can work wonders. For example, a sound-alike to the word "repeater" can be made by splicing the word "meter" (hex 6A) onto the utterance "re-" (hex 7E) to form "remeter." The difference is hardly noticeable on the air, especially if your users' minds are listening for the word "repeater"!

When we wanted to put in the phrase "high over East Tennessee," we used two splices. "East" was made up of the letter "E" spliced with the sound "SS" (hex 81). "Tennessee" was formed with "ten," "SS," and "C." Sneaky, huh?

Also, don't forget that many words can serve double duty such as "weight" and "wait," "one" and "won," "hour" and "our," "C" and "sea," "I" and "eye," etc. I am sure you can come up with many more.

Software

I thought long and hard about publishing the software I used, but decided not to do it. Since messages and times must be customized for each repeater owner's wishes, various addresses, pointers, and constants must be precisely programmed. How to determine them would be beyond the scope of this article. I will, however, furnish preprogrammed and customized microprocessors for a modest sum.

A version of software is also available for ID-only operation with no timers except those needed for identifier operation.

Conclusion

Voice synthesizers are becoming increasingly popular on repeaters across the country. This circuit provides an inexpensive way to add voice to your repeater, to demonstrate the claim that your repeater is "microprocessor controlled," and to eliminate those old and sometimes unreliable 555 timer circuits. For those who are interested, PC boards and microprocessors are available from the author.

I would like to thank Sam Kirby WB4HAP for building the prototype of this circuit and offering his repeater as the proving ground for its operation. ■