AN ATARI TAPE INTERFACE

A simple FSK interface permits loading and storing programs on a conventional cassette recorder

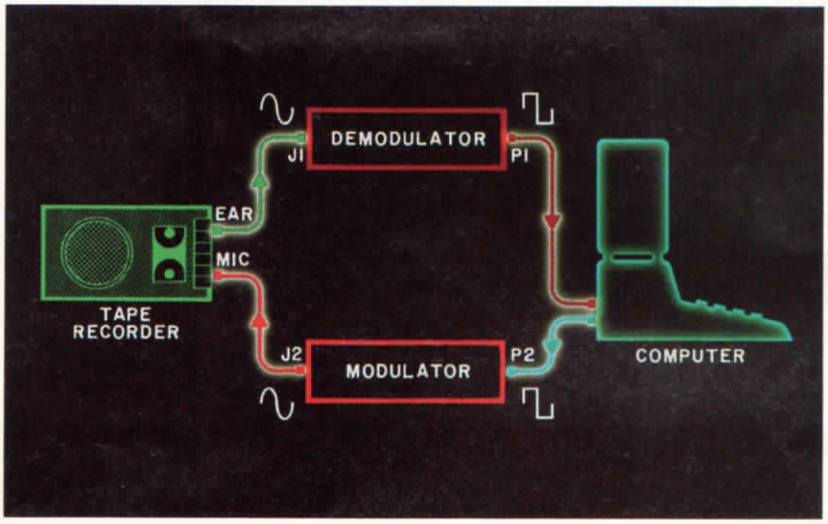

Fig. 1. Basic setup of the tape interface.

By Randy Carlstrom

ONE thing you learn quickly when you become a member of the computer revolution is that, while your computer's initial purchase price may have been dirt-cheap, the other things you need to make it useful—like a cassette recorder or disk drive, printer, and other peripheral devices—generally cost far more than you'd expect. The computer itself may turn out to be the least expensive part of your system, and it becomes a case of the tail wagging the dog.

It is difficult to justify purchasing a peripheral that costs more than the computer with which it was designed to operate. Having purchased an Atari 400 computer for less than $80 (including an Atari rebate) from a local hobby-and-toy store, I couldn't quite bring myself to pay more for the data recorder than I had for the computer. If you belong in the same category and own a standard cassette player/recorder of decent quality, or if you already own an Atari recorder and find that it's not quite as reliable as you'd like it to be, read on—for less than $20 you now have access to the wealth of Atari cassette programs.

Circuit Description. The Atari data recorder differs from a conventional audio cassette recorder because the frequency-shift keyed (FSK) modulator circuit is incorporated into its design, rather than being an integral part of the computer, as is usually the case. This article describes a simple single-chip FSK interface, designed to operate with the Atari computers, based on the Exar XR-2211 integrated circuit. This interface will permit loading and storing programs using a conventional cassette tape recorder.

Basic operation of the FSK tape interface is shown in Fig. 1. The modulator section accepts digital pulses from the computer (representing the program or data in the computer that is in the process of being stored) and converts them into audio tones, which are readily "stored" by a tape recorder. In the case of the Atari computers, a logic 1 is represented by a 5327-Hz tone and a logic 0 by a 3995-Hz tone. The demodulator section performs the reverse operation. It accepts the recorded data tones from the tape player and translates them back into their original binary format. The resulting pulses are then sent on to the computer for final processing. (If this sounds strangely similar to a modem, it's because the two are almost identical in operation. The only difference is that the tones are sent between a computer and tape deck via a cable, rather than back and forth over telephone lines.)

A block diagram of the XR-2211 integrated circuit is shown in Fig. 2. The small, numbered circles are the package pin leads. This versatile device contains an input preamplifier, a voltage-controlled oscillator (VCO), two phase detectors, two voltage comparators, and a reference voltage source. These functional blocks are internally connected to

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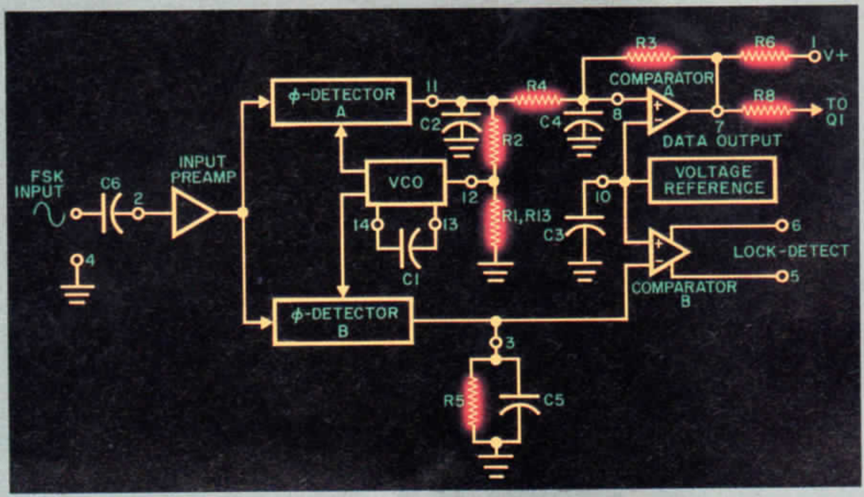


Fig. 2. Block diagram of the XR-2211 integrated circuit.

form a phase-locked loop (PLL).

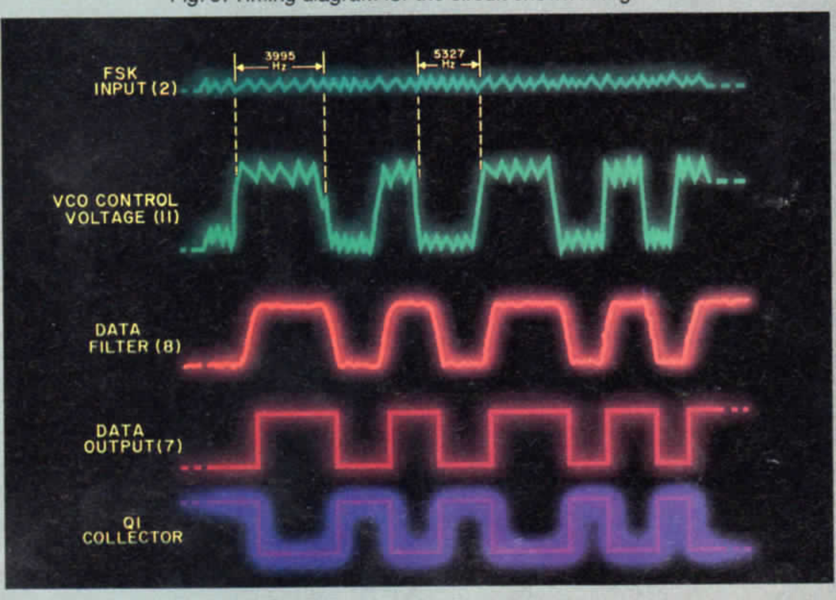
When a signal of sufficient amplitude is present at the FSK input (pin 2), the loop formed by phase detector A, *R2*, and the VCO attempts to track the input frequency. If the input signal is within the capture range of the PLL (the range of frequencies over which the loop can lock in), the VCO will track any small changes in the input frequency. The resulting changes in the VCO control voltage at the output of the phase detector (pin 11) are filtered by *C2* and the data filter, *C4* and *R4*. This signal is a facsimile of the original data and is amplified and shaped by comparator A. Inverter *Q1* provides the proper data polarity for the computer. Typical waveforms are shown in Fig. 3.

Phase detector B, filter *C5* and *R5*, and comparator B form a lock-detection circuit. Any time the input signal falls outside the PLL's capture range (or if the input signal is lost), pin 6 of comparator B is low. This pin is usually connected directly to the FSK demodulator's output (pin 7) to prevent chatter, should the PLL become unlocked.

The input preamplifier is actually a limiting amplifier that is able to accommodate a wide range of input signal levels. Ten millivolts rms is sufficient to cause limiting, but signals as large as 3 V rms can be used. This makes the PLL relatively immune to the volume (gain) setting of the tape recorder.

A schematic of the complete project is shown in Fig. 4. Resistors *R9* and *R11* form a 40-dB attenuator betweeen the computer's FSK output and *J2*, which connects to the microphone input of the recorder. Approximately 10 mV rms is delivered to *J2* during program save operations, providing the proper recording level for most recorders. The value of *R9* can be changed (or it can be removed) if necessary to suit the requirements of your tape recorder.

Fig. 3. Timing diagram for the circuit shown in Fig. 4.



Construction. The cassette interface can be built using any convenient construction technique and can be housed in its own enclosure or mounted inside the computer's case. If the latter method is chosen, two holes must be drilled in the case for mounting *J1* and *J2*. The five power and I/O connections from the interface board can be soldered directly to the mounting pins of the computer's serial I/O connector. (This eliminates *P1*, and the serial I/O connector is left free for use with other peripherals.) However, this method is recommended only for the skilled and/or dauntless since the computer's warranty is automatically voided.

Alignment and Operation. One adjustment is necessary to ensure reliable operation of the interface. It involves setting the free-running frequency of the PLL's VCO. The following steps outline the procedure:

1. Connect an ohmmeter between pin 12 of *IC1* and ground. Adjust *R13* until the ohmmeter indicates approximately 21 kilohms, then disconnect the ohmmeter.

2. Connect a shielded cable from the earphone or speaker jack of a cassette recorder to *J1* (EAR) of the interface. Place a program tape in the recorder and rewind it completely. If the interface wasn't installed inside the computer, make certain plug *P1* is plugged into the computer's serial I/O connector at this time. Turn on the computer power.

3. Press the PLAY button on the recorder. The first 10 seconds or so of the tape should consist of a steady 5327-Hz tone, which can be verified by listening to the television speaker. During this period, adjust *R13* so that pin 11 of *IC1* is −2.6 V with respect to pin 10. If you don't have access to an ohmmeter or voltmeter, you can center *R13* and slowly adjust it until the program loads suc-

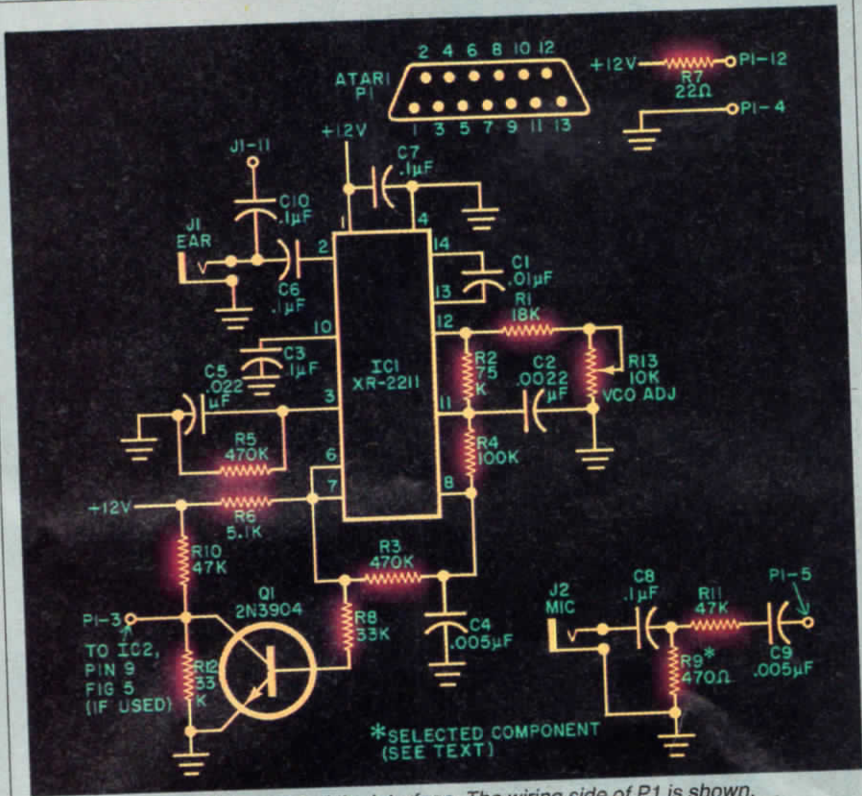


Fig. 4. Schematic of the interface. The wiring side of P1 is shown.

PARTS LIST

C1,C12—0.01-µF, 5% polyester capacitor
C2—0.0022-µF ceramic capacitor
C3,C6,C7,C8,C10,C14—0.1-µF ceramic capacitor
C4,C9—0.005-µF ceramic capacitor
C5—0.022-µF ceramic capacitor
C11,C15—1-µF electrolytic or tantalum capacitor
C13—10-µF electrolytic or tantalum capacitor
IC1—XR-2211 FSK demodulator/tone decoder (Exar)
IC2—XR-2206 function generator (Exar)
J1,J2,J3—Miniature phone jack
P1—13-pin Atari mating plug
Q1—2N3904 npn transistor
The following are ¼-W, 5% carbon resistors unless otherwise specified:
R1—18 kilohms
R2—75 kilohms
R3,R5—470 kilohms
R4—100 kilohms
R6,R21,R22—5.1 kilohms
R7—22 ohms
R8,R12,R15,R23—33 kilohms
R9,R16—470 ohms (selected, see text)
R10,R11—47 kilohms
R13,R18,R20—10-kilohm trimmer potentiometer
R14—200 ohms
R17—20 kilohms
R19—15 kilohms
Misc.—Suitably etched and drilled pc board or perf board; IC sockets; 5-conductor cable; solder; enclosure; etc.

Note: The following are available from RC Systems Inc., 121 W. Winesap Rd., Bothell, WA 98012: Kit of parts for cassette interface/duplicator, including etched and drilled pc board, No. AK-1, for $29.95. Also available separately from the same source: Kit of parts for cassette interface only, No. AK-2, for $19.95; etched and drilled pc board for interface/duplicator, No. AB-1, for $5.00; etched and drilled pc board for cassette interface, No. AB-2, for $4.00; XR-2211 IC for $5.25; XR-2206 IC for $5.00; Atari 13-pin mating plug, No. AP-1, for $6.50. Please include $1.75 shipping and handling on all orders. Washington state residents, add 7.8% sales tax.

cessfully through the interface.

Operation of the cassette interface is similar to that of the Atari data recorder. Programs can be loaded by following the instructions that accompany the program cassette. As a program is loaded, you will hear a buzzing sound from the television speaker. This is normal and indicates that the Atari is happy with the data it is receiving from the tape recorder. When saving programs on tape, follow the instructions given with the programming language used. Remember to press the RECORD button on the recorder.

If the interface was aligned properly as outlined above, programs should load very reliably, since this interface has proven to be more reliable than the Atari 410 data recorder. If you experience any problems, adjust the recorder's volume and/or tone controls. If that doesn't help, the recorder may not be quite up to par, in which case a good tape-head cleaning may be in order.

Errors occurring at the beginning of a loading sequence can often be attributed to leaving an insufficient amount of tape leader before the actual data began on the tape. (The computer doesn't really begin accepting data from the recorder until approximately 5 to 10 seconds after the computer's RETURN key has been pressed.) A tape that refuses to load past a certain point (usually at the same point and somewhere in the middle) is a classic example of the "bargain-tape syndrome." Some cheaper tapes often contain "dead spots" where the FSK signal drops out momentarily—a phenomenon almost certain to succeed in confusing your computer.

Bit-Copying Tapes. It is a simple matter to make backup copies of any of your tapes using the cassette interface and the circuit shown in Fig. 5. This circuit simply remodulates the serial data stream from the demodulator, bit by bit, and consequently doesn't care if the program is BASIC, machine language, or even copy-protected. A second tape recorder "listens in" on *J3* while the first recorder is playing the original program tape through *J1* (Fig. 6).

"So," you say, "why not just patch two recorders together to duplicate tapes?" This method will work, in general, if you use a good quality recording to start with. However, it has been the author's experience that many of the commercially available cassettes tend to degrade with time, especially those that are favorites of the family and are constantly being used and abused. You can be sure that a "patched" duplicate made from such marginal tapes will be even more marginal!

It is recommended that the alignment of the modulator circuit in Fig. 5 be performed with a frequency counter. With the counter connected to pin 2 of *IC2*, short pin 9 to ground and adjust *R18* for 3995 Hz. Remove the short from pin 9 and adjust *R20* for 5327 Hz. (Note that the computer must be turned on to make these adjustments.) If you don't have access to a frequency counter, you can use the following alternate procedure:

1. With a jumper wire or shielded cable, connect *J3* of the modulator to *J1* of the demodulator.

2. Short pin 9 of *IC2* to ground and adjust *R18* until pin 11 of *IC1* is +2.6 V

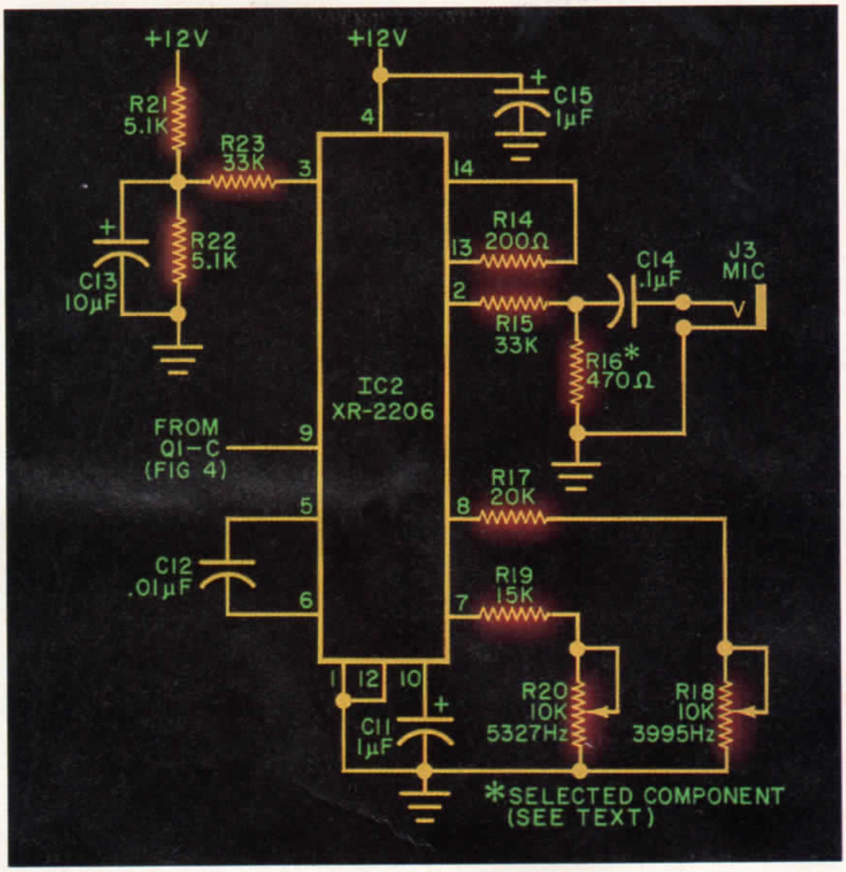


Fig. 5. Schematic of a circuit to remodulate the serial data.

with respect to pin 10.

3. Remove the short from pin 9 and short the base of *Q1* (the lead that connnects to *R8*) to ground.

4. Adjust *R20* until pin 11 of *IC1* is −2.6 V with respect to pin 10. Remove the short from *Q1* and the connection between *J1* and *J3*.

Since *IC1* is acting as a frequency discriminator during these adjustments, the accuracy of these adjustments will depend on how accurately *R13* was set. The value of *R16* sets the recording level at *J3*, which may need to be selected to suit the drive requirements of the second recorder.

The operation of the demodulator is not affected in any way by the modulator and can remain connected permanently. In fact, it's a good idea to have the computer load the original tape during the duplication process. If the original tape loads successfully, you can be reasonably certain the duplicate copy is accurate.

The remodulation process does a marvelous "cleanup" job of marginal tapes. In fact, I use my duplicates all the time, saving the originals for backups. Also, I don't get so upset now if my recorder gets hungry and chews up a $40 game cassette! ◇

Fig. 6. Modulator and demodulator interconnections.