EXTERNAL SYNCHRONIZATION

March 30, 1985

CONTENTS OF THIS MANUAL

This manual contains information on the the basic operation of the
external synchronization function of the Synclavier (R). In it you
will find instructions for

- laying down a sync track on a tape recorder track;

- recording a memory recorder track onto a single track of a
  multitrack tape recorder;

- synchronizing the Synclavier (R) to another synthesizer or drum
  machine;

- replacing the timbre of a live drum with a Synclavier (R)
  timbre.

In addition you will find information on several hardware options
designed to solve common synchronization problems.

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INTRODUCTION

With the external synchronization function, you can synchronize
Synclavier (R) performances with live performances recorded on analog
tape recorders or performances created on drum machines and other
kinds of synthesizers. You can also synchronize the transfer of
individual tracks from the Synclavier (R) memory recorder to a
multitrack tape recorder or to enhance the timbre of a live drum
performance.

External synchronization can be used for either recording or playing
back.

When the Synclavier (R) is in the external synchronization mode and
you press START, the sequence in the memory recorder will not start
playing until a signal from an external source is fed into the
computer.

There are several types of synchronization signals:

Taped Signals

   Synchronization signals can be produced by the Synclavier
   (R), encoded by a signal conditioner and then recorded on
   tape. Once recorded, the signals, decoded by the conditioner
   and fed back into the Synclavier (R), will drive the memory
   recorder.

Signals From Another Synclavier (R)

   Two Synclaviers (R) can be connected together, with one
   Synclavier acting as the "master" and the other as the
   "slave." The master output signals, produced when the master
   memory recorder is running, will drive the slave memory
   recorder.

Signals From Other Synthesizers

   Drum machines and other manufacturers' synthesizers fed
   through a signal processing device into the Synclavier (R)
   can be used to drive the memory recorder.

Live Drum Beats

   Any percussive audio signal recorded on tape can be converted
   into digital pulses and then fed into the Synclavier to
   trigger notes in the memory recorder.

In future releases, SMPTE Time Code will also be available for
synchronization function.

HARDWARE OPTIONS

Under normal circumstances, there is an average delay of 2.5 milliseconds between the time when the external signal trigger occurs and the time when the Synclavier (R) "notices" the signal. The actual delay may be as little as 0 milliseconds or as much as 5 milliseconds. In cases of playing complex timbres or sequences, delays may be considerably longer.

Variations in delay from one pulse to the next sometimes results in an objectionable "jitter" in the meter of the music.

Two hardware options, the D16 Timer and the High Speed Processor, reduce this sync jitter. A third option, the Clock Interface Module, simplifies interfacing to other equipment and improves synchronization timing resolution.

D16 Scientific Timer

The D16 Scientific Timer measures time with high resolution. Systems equipped with a D16 Scientific Timer experience external sync delays of about 1.5 milliseconds with variations of only plus or minus 0.5 milliseconds.

High Speed Processor

The High Speed Processor replaces your current processor to increase overall system performance. For external synchronization functions, the High Speed Processor in conjunction with the D16 Timer reduces sync delays to about 0.5 milliseconds.

Clock Interface Module (CIM-1)

The CIM-1 is a signal processing device that was specially designed to interface the Synclavier (R) with tape recorders and other synthesizers. The CIM-1 incorporates four essential sync functions into a single unit:

1. FSK (frequency shift key) technology prints digital clock impulses onto recording tape.

2. Pulse divider circuitry makes the higher clock pulse rates used on many synthesizers and drum machines compatible with Synclavier (R) clock rates.

3. Conditioning circuitry conditions digital clock pulses to be compatible with Synclavier (R) requirements.

4. Analog signal conditioning circuitry converts audio signals such as live drum beats into Synclavier (R) compatible trigger pulses.

The manual "Clock Interface Module Operating Manual," available from New England Digital, gives detailed instructions on the use of the CIM-1. Basic instructions for its use are included in this manual.

SETTING UP EXTERNAL SYNCHRONIZATION

On the computer connector panel are two jacks labeled EXT. CLOCK.
The one labeled EXT. CLOCK INPUT is used to feed signals from an
external source into the Synclavier (R). The one labeled EXT. CLOCK
(under OUTPUTS) is used to feed signals emitted from the Synclavier
(R) to an external device.

The jacks on the new computer control unit (designed for polyphonic
sampling and multichannel output) are labeled IN and OUT under
EXTERNAL CLOCK.

This manual will refer to the two jacks as EXTERNAL CLOCK IN and
EXTERNAL CLOCK OUT.
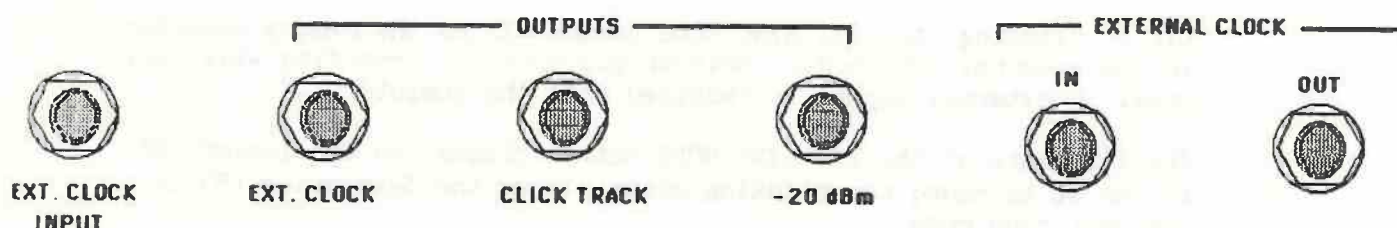
**OLD COMPUTER CONTROL UNIT**   **NEW COMPUTER CONTROL UNIT**

The EXTERNAL CLOCK OUT jack sends out signals produced on Synclavier
(R). Fed through a signal conditioner, the outgoing signals can be
recorded onto tape. Or they can be sent directly to drive other
equipment, including another Synclavier (R).

The EXTERNAL CLOCK IN jack receives signals from an external source
such as a tape recorder (through a signal conditioner) or from
another Synclavier (R) or other signal triggering device. On the new
computer control unit, a signal conditioner is built in to the
EXTERNAL CLOCK IN jack.

When the Synclavier (R) is in the external synchronization mode, the
memory recorder will operate only upon receiving signals from an
external source. When you press START, the sequence in the memory
recorder will not begin playing until the external signals are
received through the EXTERNAL CLOCK IN jack. In this way, a sequence
in the memory recorder can be precisely synchronized with live
performances recorded on tape or sequences created on other
synthesizers.

To place the Synclavier (R) into the external synchronization mode, press the EXT SYNC MODE button in the second panel once to make it light up or twice to make it blink.
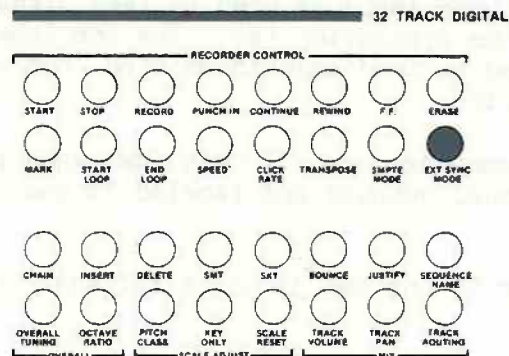

Lit or blinking, the EXT SYNC MODE button places the memory recorder in the external sync mode. Neither playback nor recording will begin until an external signal is received into the computer.

The lit state of the EXT SYNC MODE button places the Synclavier (R) in the 50 Hz mode; the blinking state places the Synclavier (R) in the beat sync mode.

50 Hz Mode

When the EXT SYNC MODE button is lit, the Synclavier (R) produces a steady 50 Hz signal with a 50% duty cycle. That is, its period of 20 milliseconds is divided equally between its high and low states.
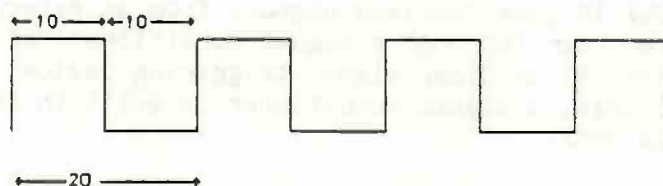
During each 20 millisecond period, the computer senses the state of the input signal. Each time the signal is high, the sequence moves forward.

The 50 Hz signal is a steady signal. When it is received through the EXTERNAL CLOCK IN jack, the memory recorder will move forward at the steady rate. When the 50 Hz signal stops, the memory recorder will stop.

Beat Sync Mode

When the EXT SYNC MODE button is blinking, the Synclavier (R) sends
out a beat sync pulse with a frequency determined by the click rate
and click rate multiplier settings of the Synclavier (R).

The high level of a beat sync pulse lasts 15 milliseconds; the length
of the low level depends on the click rate.

For example, a beat sync pulse triggered by a click rate of 120 would
have a frequency of 2 Hz and thus a period of 500 milliseconds.

If the click rate were instead 60 beats per minute, the frequency of
this beat sync pulse would be 1 Hz and its period would be 1000
milliseconds.

If the click rate were 60 beats per minute with a click rate
multiplier of 4, the frequency of the pulse would be 4 Hz or four
times the 1 Hz frequency of the 60-beat-per-minute click rate.

The beat sync pulse for a sequence recorded at 120 clicks per minute
is illustrated below:
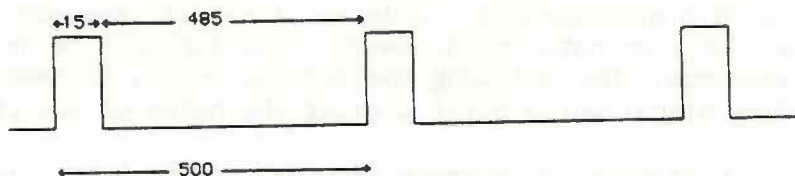
When the beat sync pulse is received back into the Synclavier (R) through EXTERNAL CLOCK IN, each beat sync pulse advances the Synclavier (R) sequence by a time equal to the current click period divided by the click rate multiplier. Thus, the playback or recording is triggered from the beginning of one beat up to immediately before following beat.

If the rate of the sync pulse matches the click rate used during recording, the sequence will play back in perfect synchronization with the external signals.

If the rate of the sync pulse is very different from the click rate used during recording, each incoming pulse may trigger several notes or perhaps none at all. In this case, you will want to use the sync delay feature.

Sync Delay*

When the incoming beat sync signal being fed into the computer is much faster than the click rate of the recorded sequence, some fast notes may not be in perfect synchrony. When this happens, use the sync delay feature to assure precise synchronization.

When you press EXT SYNC MODE, the current sync delay will be displayed in the display window. You can dial in any sync delay from 0.0 to 75.0 milliseconds. A delay of 50 milliseconds, for example, means that each note in the memory recorder will be held back by 50 milliseconds, thus allowing the Synclavier (R) to read the next incoming signal while still playing the notes of the preceding beat.

Take, for example, a sequence recorded on the Linn drum at 120 beats per minute and fed through the Clock Interface Module or signal conditioner into the EXTERNAL CLOCK IN input of the Synclavier (R). The sequence in the memory recorder is also recorded at 120 beats per minute.

If the Linn drum is played back at its recorded speed, then the Synclavier (R) sequence will be triggered with no problem.

However, if the playback of the Linn drum is speeded up to, say, 180 beats per minute, the Synclavier (R) may not "be ready" for the faster incoming signal. The memory recorder may still be playing the notes in between Beat 1 and Beat 2 when the external signal for Beat 2 is received and thus the signal will not be able to trigger the notes from Beat 2 to Beat 3.

If a sync delay of 50 milliseconds is dialed in, then all the notes in between Beat 2 and Beat 3 (and all other notes) will be delayed 50 milliseconds. Thus, when the external signal for Beat 2 is received, the Synclavier (R) playback will continue to be in perfect synchronization with the Linn drum sequence.

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* This feature will be available with Release J.

Signal Encoding

The CIM-1 is recommended when recording clock pulses to tape because analog tape recorders cannot record digital clock pulses without distorting them. The illustration below shows the type of distortion typically encountered when recording digital clock pulses directly.

The source of the distortion lies in the DC nature of a digital clock pulse. The upper waveform in the figure is the 50 Hz waveform. Note that the wave has a 50% duty cycle, remaining in its high state for 10 milliseconds and in its low state for 10 milliseconds.

The tape recorder, however, is only capable of recording changes in voltage levels and cannot register DC voltage, which is how the high and low states of the digital pulse appear to the tape recorder. Thus, the tape recorder distorts the original square wave into the lower waveform, as illustrated below.
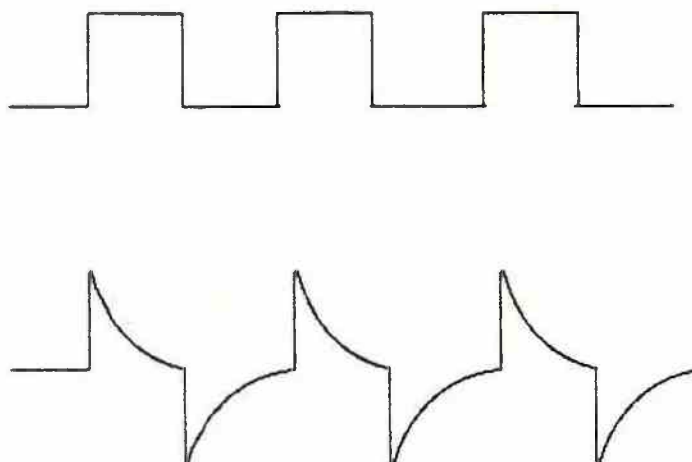
That is, the rising edge of the digital pulse is recorded faithfully. But as soon as the high level of the digital pulse is received, the signal in the tape recorder starts falling off to zero. When the falling edge of the digital pulse is received, the tape recorder reads it as a negative change in voltage level. But the signal on the tape recorder has already fallen to zero, so the falling edge is registered as a further decrease to a negative peak. As soon as the low level of the digital pulse is received, the signal in the tape recorder begins to rise to zero.

For this reason, a signal encoder, such as the Clock Interface Module (CIM-1) described above, is recommended for recording Synclavier (R) pulses to tape.

SYNCHRONIZATION THE SYNCLAVIER (R) TO TAPE

Recording Signals Onto Tape ·

When recording Synclavier (R) synchronization signals onto tape, set up the Synclavier (R), CIM-1 and tape recorder as follows:

- Synclavier (R) EXTERNAL CLOCK OUT to CIM-1 CLOCK IN.

- CIM-1 SEND to tape recorder sync channel input.
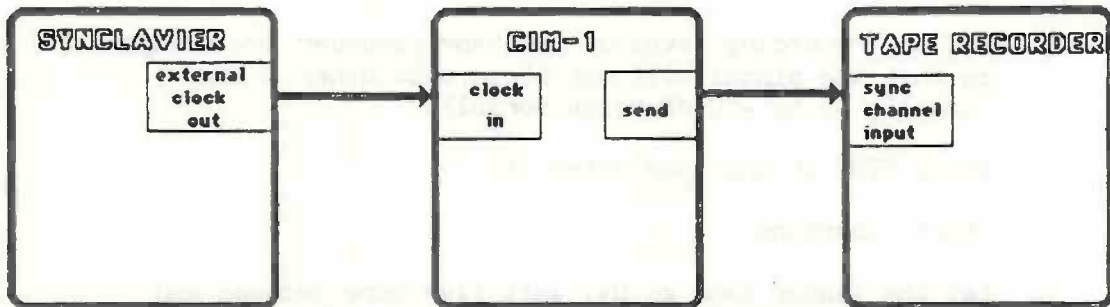
Set up the CIM-1 and tape recorder as follows:

1. Set the FUNCTION switch to DECODE.

2. Turn the HOLDOFF control to 15 ms.

3. Place the tape recorder into the "sync" mode and the sync track channel of the tape recorder into the "input" mode.

4. Adjust the SEND LEVEL control of the CIM-1 to obtain a reading of -10dB on the VU meter of the tape recorder. This reading is of the FSK signal coming from the CIM-1, not the signal coming from the Synclavier (R).

The basic procedure for recording either kind of Synclavier (R) pulse is the same. However, since recording beat sync pulses onto tape is somewhat more complex, we will treat the two kinds of recording separately.

Recording a 50 Hz Signal Onto Tape

1. Press the EXT SYNC MODE button once so that it is lit.

2. Press START on the Synclavier (R). A steady 50 Hz signal will be sent out from the EXTERNAL CLOCK OUT through the CIM-1 to the sync channel input on the tape recorder. If there is a sequence in the memory recorder, it will not start to play (unless the signal is simultaneously being fed back in to the EXTERNAL CLOCK IN jack).

3. Set the recording level on the tape recorder low enough so that the signal will not bleed onto other tracks (usually -5 to -10 dB below normal).

4. Press STOP on the Synclavier (R).

5. Start recording.

6. Let the leader tape go by, wait five more seconds and then press START on the Synclavier (R). The 50 Hz pulse will be recorded on the tape track so long as the memory recorder is running. Continue the recording until sufficient pulse is recorded for the entire Synclavier (R) sequence to be synchronized.

7. Press STOP on the Synclavier (R).

8. Stop the tape recorder and rewind the tape to the zero point.

Recording a Beat Sync Pulse Onto Tape

1. Recall a sequence to the memory recorder. Or set a click
   rate and click rate multiplier and record a sequence
   using the justified mode of recording. Make sure the
   SPEED is set at 1.000.

2. Press EXT SYNC MODE twice so that it is blinking.

3. Press START on the Synclavier (R).

   Beat sync pulses with a frequency equal to the click rate
   of the sequence (or the click rate times the click rate
   multiplier, if used) will be emitted from the EXTERNAL
   CLOCK OUT through the CIM-1 to the sync channel input of
   the tape recorder.

   The sequence in the memory recorder will not be played
   back (unless you are simultaneously feeding the signals
   back through the EXTERNAL CLOCK IN).

4. Set the recording level on the tape recorder low enough
   so that the signal will not bleed onto other tracks
   (usually -5 to -10 dB below normal).

5. Press STOP on the Synclavier (R).

6. Start recording.

7. Let the leader tape go by, wait five more seconds and
   then press START on the Synclavier (R). The beat sync
   pulses will be recorded on tape so long as the memory
   recorder is running. Record enough tape for the entire
   composition to be synchronized.

8. Press STOP on the Synclavier (R).

9. Stop the tape recorder and rewind the tape.

Triggering the Memory Recorder From Taped Signals

At this point, you have either a 50 Hz or a beat sync signal recorded on the sync track of the tape recorder.

Set up the Synclavier (R), CIM-1 and tape recorder as follows:

- Tape recorder sync channel output CIM-1 RETURN.

- CIM-1 CLOCK OUT to Synclavier (R) EXTERNAL CLOCK IN.
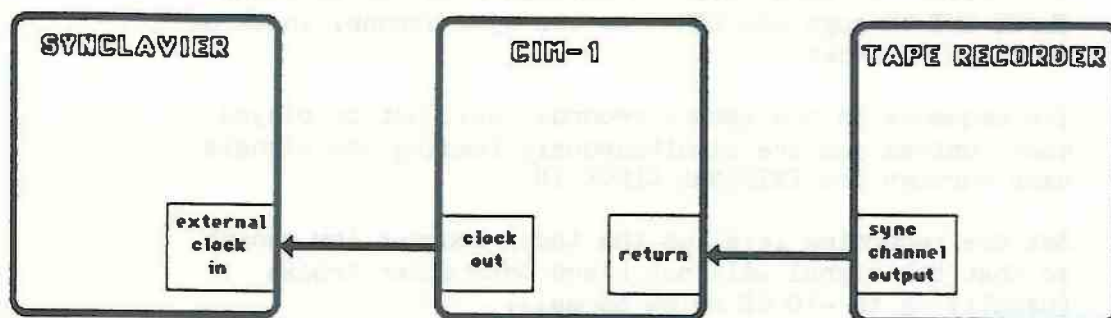
The basic procedure for triggering a sequence in the memory recorder from the either signal recorded on tape is as follows:

1. Place the tape recorder in the "sync" mode, with the sync track of the tape recorder in "sync playback."

2. Turn the RETURN LEVEL control of the CIM-1 to the maximum level.

3. Adjust the output level of the sync track of the tape recorder.

4. Start the tape recorder.

5. Watch the CIM-1 control panel. When the RETURN LEVEL LED lights, press START on the Synclavier (R).

   When the first pulse is received through the EXTERNAL CLOCK IN, the memory recorder will start. In the 50 Hz mode, the signals make the recorder move forward at a steady rate. In the beat sync mode, each individual beat pulse triggers the next beat. At the end of the recorded signal, the memory recorder will stop.

When playing back a sequence synchronized to a 50 Hz signal, you can make tempo changes by pressing the SPEED button and dialing in a new speed. A sequence synchronized to a beat sync pulse, however, can only have tempo changes made by changing the click rate.

Recording Synclavier (R) Tracks to Tape

At this point you have already recorded a sync track and verified it, as outlined in the preceding two sections. Set up the Synclavier (R), CIM-1 and tape recorder as follows:

● Synclavier audio output to tape recorder selected channel input.

● Tape recorder sync track output to CIM-1 RETURN.

● CIM-1 CLOCK OUT to Synclavier (R) EXTERNAL CLOCK IN.
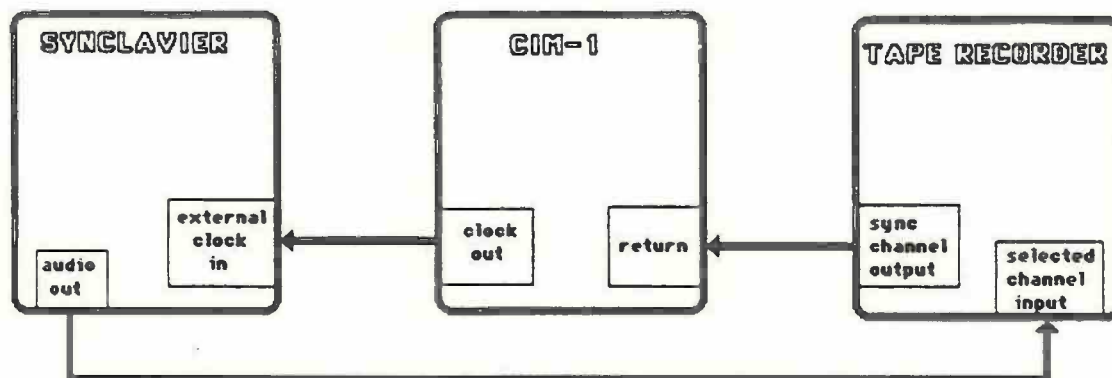
1. Place the tape recorder in "sync" mode and the track where you are going to record in the "input" mode. Make sure the tape is rewound to the leader tape.

2. Make sure the EXT SYNC MODE button is unlit.

3. Solo the Synclavier (R) track to be recorded, press START on the Synclavier (R) and set the recording level on the tape recorder.*

4. Press STOP on the Synclavier (R).

5. Press EXT SYNC MODE once or twice to place it in the lit or blinking state.

6. Start recording on the selected channel.

7. Watch the CIM-1. When the RETURN LEVEL LED comes on, press START on the Synclavier (R).

8. When finished recording, press STOP on the Synclavier (R)

* This procedure will change for future systems equipped with multichannel output.

SYNCHRONIZING TWO SYNCLAVIERS (R)

When synchronizing two Synclaviers (R), one Synclavier (R) acts as a "master" and one as a "slave." For example, if you recorded a drum track on Synclavier (R) #1 that you wanted to play back synchronized to a melody recorded on Synclavier (R) #2, Synclavier (R) #1 would be the master and Synclavier (R) #2 the slave.

A 50 Hz signal would be best for this application.

Set up the two Synclaviers (R) as follows:

● Synclavier #1 EXT. CLOCK OUTPUT to Synclavier #2 EXT. CLOCK INPUT
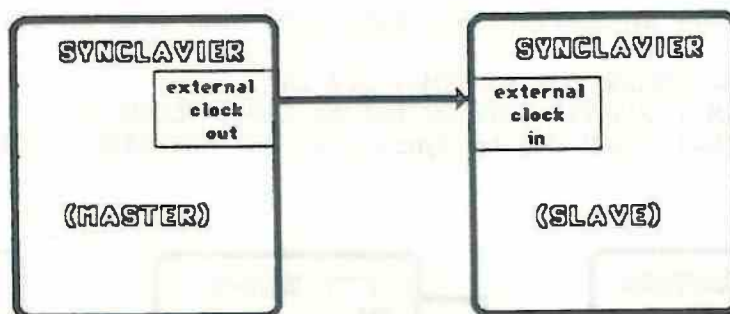
Then follow these directions:

1. Press EXT SYNC MODE on the slave Synclavier once so that it is lit.

2. Press START on the slave Synclavier.

3. Press START on the master Synclavier.

When you press START on the slave Synclavier, the memory recorder will wait for an external signal. When you press START on the master Synclavier, it will begin emitting a 50 Hz signal through its EXTERNAL CLOCK OUT jack to the slave Synclavier through its EXTERNAL CLOCK IN jack. Both systems will play in perfect synchronization.

This method can be used to record synchronized tracks on two Synclaviers (R) as well or to record on one while playing back on the other.

NOTE: If you place both systems in the external synchronization mode, they will eventually drift out of phase.

## SYNCHRONIZING THE SYNCLAVIER (R) TO A LINN DRUM

You can synchronize the Synclavier (R) to other manufacturers' synthesizers and drum machines by feeding the signal through the Clock Interface Module (CIM-1) or other signal processing device.

Many synthesizers and drum machines use a high speed clock signal at the clock out jack, such as 24, 48 or 96 pulses per quarter note beat. Since the Synclavier (R) synchronizes to slower pulses (quarter, eighth, sixteenth notes, etc.), the faster pulses of the synthesizer or drum machine must be fed through a circuit divider in the Clock Interface Module.

The following instructions are specific to a Linn Drum, which uses a pulse rate of 48 pulses per quarter note.

Set up the Synclavier (R), CIM-1 and Linn Drum as follows:

- LM-1 CLOCK OUT to CIM-1 DIV IN
- CIM-1 QUARTER NOTE OUTPUT to CIM-1 CLOCK IN
- CIM-1 CLOCK OUT to Synclavier (R) EXTERNAL CLOCK IN
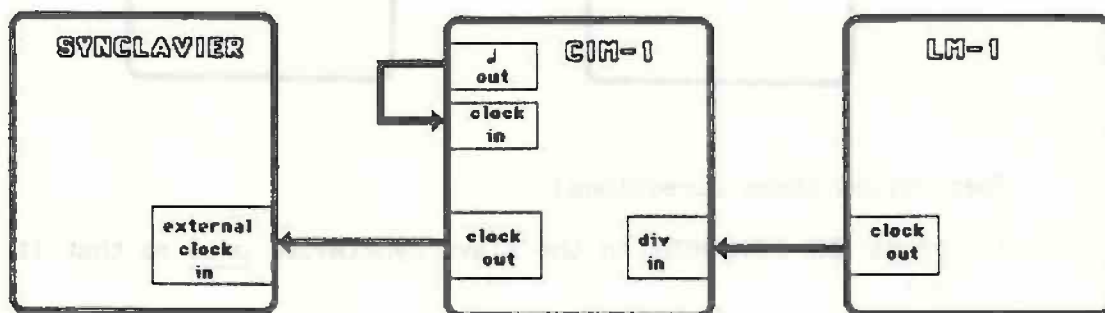
Set up the CIM-1 as follows:

- Set the FUNCTION switch to CONDITION.

- Set HOLDOFF control to the minimum setting (15 ms).

Once the connections are made and the CIM-1 controls set, follow these instructions:

1. Place the Synclavier into the beat sync mode by pressing EXT SYNC MODE twice to make it blink.

2. Press START.

3. Start the Linn Drum. Each beat of the Linn Drum will trigger a beat in the Synclavier (R) memory recorder.

DRUM REPLACEMENT

Any percussive audio signal, conditioned through the Clock Interface Module and fed into EXTERNAL CLOCK IN of the computer, will drive the memory recorder. You can, for example, record a live drum on tape and feed it into the CIM-1 so that each drum hit is converted into a digital clock pulse.

It is possible to use this feature to replace or augment a recording of an acoustic percussion instrument with any of the timbres of the Synclavier (R).

Once you have recorded the live percussion line onto one track of the tape recorder, set up the Synclavier (R), CIM-1 and tape recorder as follows:

- Drum track output of tape recorder to CIM-1 RETURN.

- CIM-1 CLOCK OUT to Synclavier (R) EXTERNAL CLOCK IN.

- Synclavier (R) audio output to selected track of tape recorder.
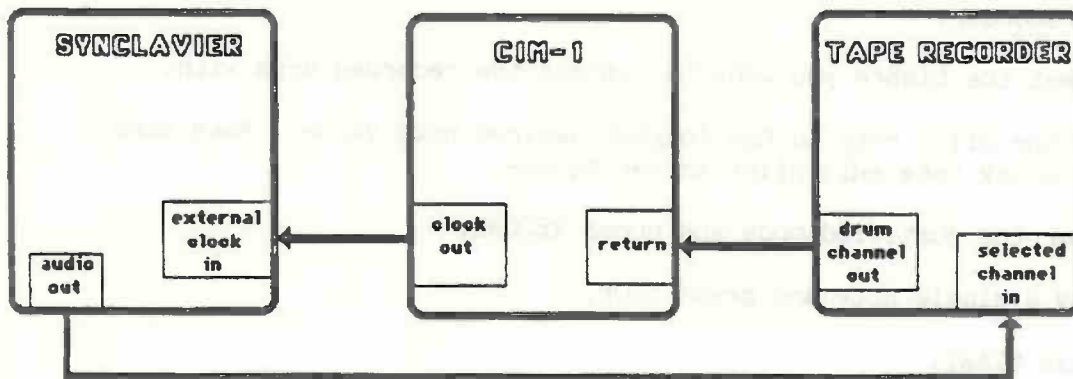
Set up the CIM-1 as follows:

- Set the FUNCTION switch to LIVE TRACK.

Once the connections are made and the CIM-1 controls set, you are
ready to convert the drum hits into digital clock pulses.

1. Reconnect CIM-1 RETURN to the output of the tape track with the
   recorded drum sound.

2. Start the playback of the recorded drum track.

3. Turn the CIM-1 RETURN LEVEL control all the way counterclockwise
   and then bring it back up slowly until the RETURN LEVEL LED
   lights on each drum hit.

   If the OUTPUT STATE LED flashes do not correlate exactly with the
   drum hits, adjust the HOLDOFF control. If the LED lights more
   than once for a single hit, decrease the HOLDOFF; if it misses
   some hits, increase the HOLDOFF.

   You may need an external noise gate or, for tracks with a wide
   dynamic range, an external gate with a limiter.

When you have ascertained that each drum hit will reliably trigger a
digital clock pulse, record a one-note loop in the Synclavier (R)
memory recorder.

1. Select the timbre you want to replace the recorded drum with.

2. Set the click rate to the longest desired note value. Make sure
   the click rate multiplier is set to one.

3. Enter the justified mode and press RECORD.

4. Play a single note and press STOP.

5. Press START.

6. After the single note sounds, press ENDLOOP to set up a justified
   loop.

7. Press STOP.

Now you can use the converted percussion sounds from the drum track
to drive the memory recorder. Each converted pulse will trigger the
single note of the sequence.

1. Press EXT SYNC MODE twice to select the beat sync mode.

2. Press START. The memory recorder will wait for the external
   signal.

3. Start the playback of the drum track. Since each drum hit is
   triggering the single note of the loop, the rhythmic line of the
   original percussion recording will sound with the Synclavier (R)
   timbre.

If you have patched the audio output of the Synclavier (R) to an empty track on the tape recorder, the rhythmic line with the new timbre will be recorded on another track of the tape recorder. You can simultaneously record the conditioned drum pulses on the tape recorder. To do this, add the following patches to the set up described above:

- Use a Y-connector to split the CIM-1 CLOCK OUT, one output going to EXTERNAL CLOCK IN of the computer and one to CIM-1 CLOCK IN.

- Connect CIM-1 SEND to the selected tape track input.