

**INSTRUCTION MANUAL**

**LOGIC ANALYZER**  
**LA 420**



**DOLCH**

**Logic Instruments GmbH**

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## Section 1 - GENERAL

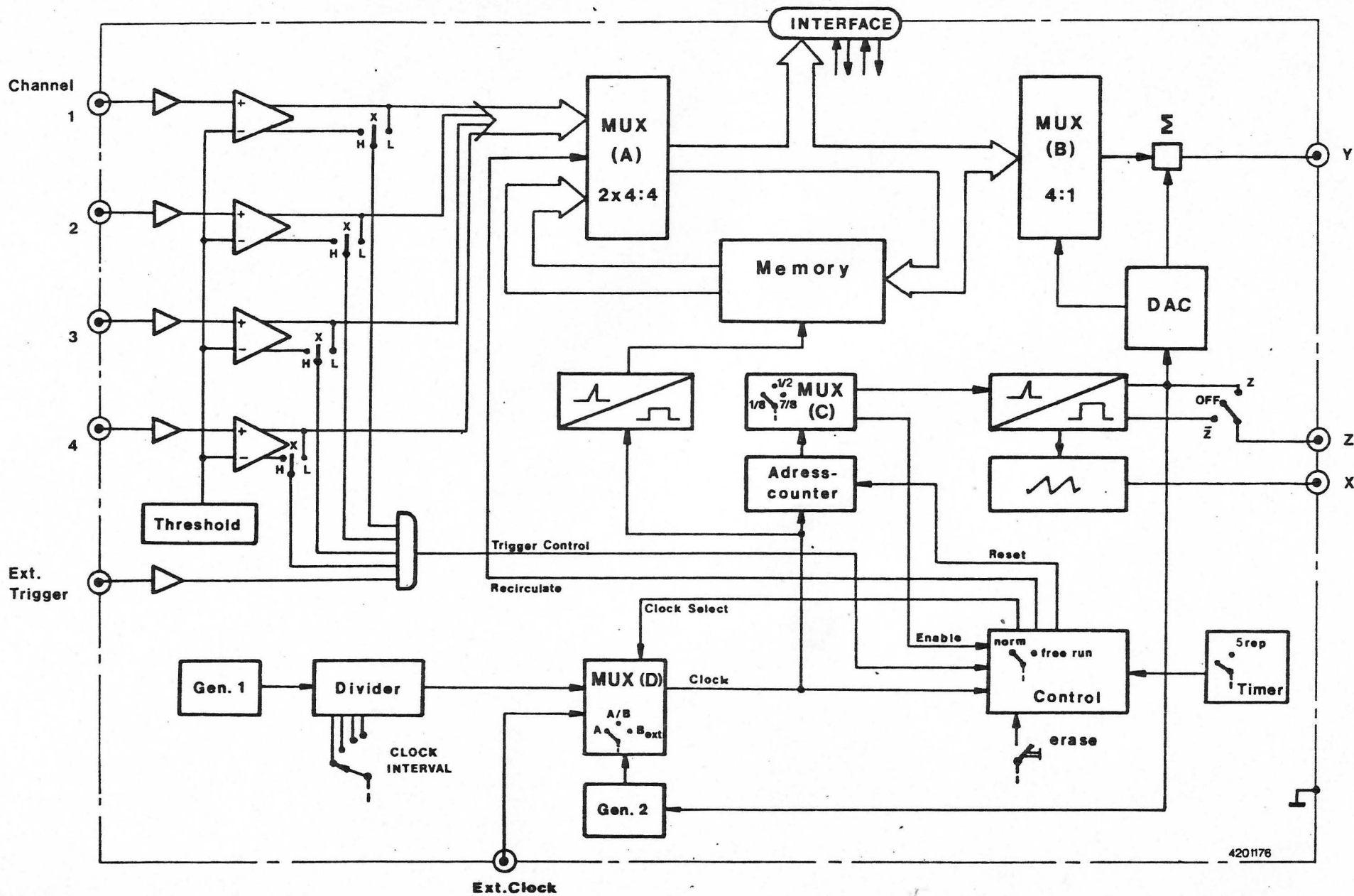
### 1.1 Introduction

The Logic Analyzer LA 420/LA820 is a Digital Logic Recorder that has proved to be a powerful diagnostic tool for digital designers and trouble-shooters. This new instrument captures up to 4 parallel (LA 420) or 8 parallel (LA 820) digital signals, stores them in IC memories and then presents them on a CRT or via an ordinary oscilloscope as a familiar timing diagram producing in effect a 4-trace resp. 8-trace storage display for logic signals. In addition, the versatile pre-trigger recording permits an ease of digital signal capture and analysis heretofore virtually impossible. Other features include combinatorial trigger detection, trigger delay selection, a wide range of internal clock rates or external clock input, and continuously variable threshold voltage.

The LA 420/LA 820 offers a number of very useful features usually only found in very sophisticated and, therefore, expensive instruments. A wide range of operation modes are available. Single event storage, automatically refreshing storage/display cycles, and external remote control capability make the LA 420/LA 82/ a very flexible system serving a wide range of logic analysis problems. Its capability to operate in a Master-Slave configuration allows easy cascading of several LA 420 or LA 820 units to form 8, 12, 16 etc. channel systems. The LA 420/LA 820 is capable of performing a dual delayed time base operation using an external clock as second time base which is a unique feature for an instrument of this kind.

### 1.2 Principle of Operation

The LA 420/LA 820 compares up to four resp. eight digital signals against a present threshold, updating the input comparators with an internal or external clock and storing 256 such simultaneous decisions from each of the 4 resp. 8 input signals. Once recording is complete the LA 420/LA 820 produces a repetitive display output reconstructing 256 bit/line in a 4 resp. 8 line timing diagram on a conventional oscilloscope or CRT display.



### 1.3 Specifications

Channels :	4 with 256 bits memory capacity
Signal Inputs:	1 M $\Omega$ //20pF Voltages greater than 15V are clamped through 1 K $\Omega$ to 15V. Overvoltage permitted for a short time 250V.
Threshold:	Continuously adjustable from -10V to +10V Resolution of the decimal dial 10mV; accuracy 3%
Memory:	1024 bit - 4 x 256 format Max. internal clock rate 10 MHz in 1, 2, 5 steps from 0, 5 ms to 100ns
Modes:	Store: with manual erase Rep.: repetition rate 0.5 or 5 seconds External: erase, store, display is implemented through an external interface connector
Timebase:	A: Internal clock A/B: Internal clock up to triggering event, external clock from triggering event to memory termination B: External clock Trigger delay of 1/8 = 224 bits, 1/2 = 128 bits, 7/8 = 32 bits 5 bits combinatorial triggering - 4 data inputs plus 1 external trigger input; free run : with external triggering
Display Output:	X-output: ramp - 5Vpp approx. Y-output: 500mV amplitude per channel at 750mV DC interval Z-output: 15V on 200 $\Omega$ inverted or non-inverted, used to trigger the oscilloscope

Interface: Parallel output of the four memory channels at TTL levels

Operating Temperature Range: 0 - 50° C

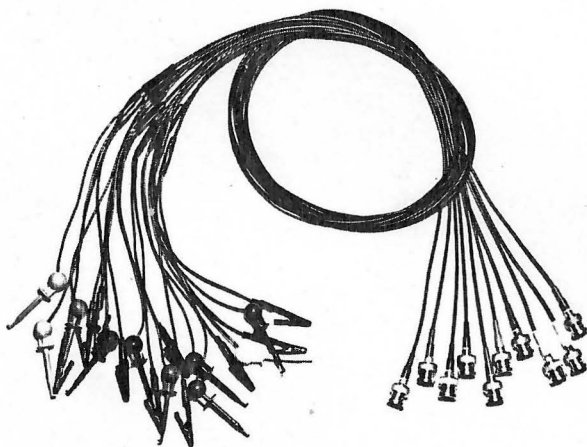
Power Consumption: 15VA 110/220V/50 - 60Hz

Size: Height 67 cm, width 209 cm, depth 220 cm

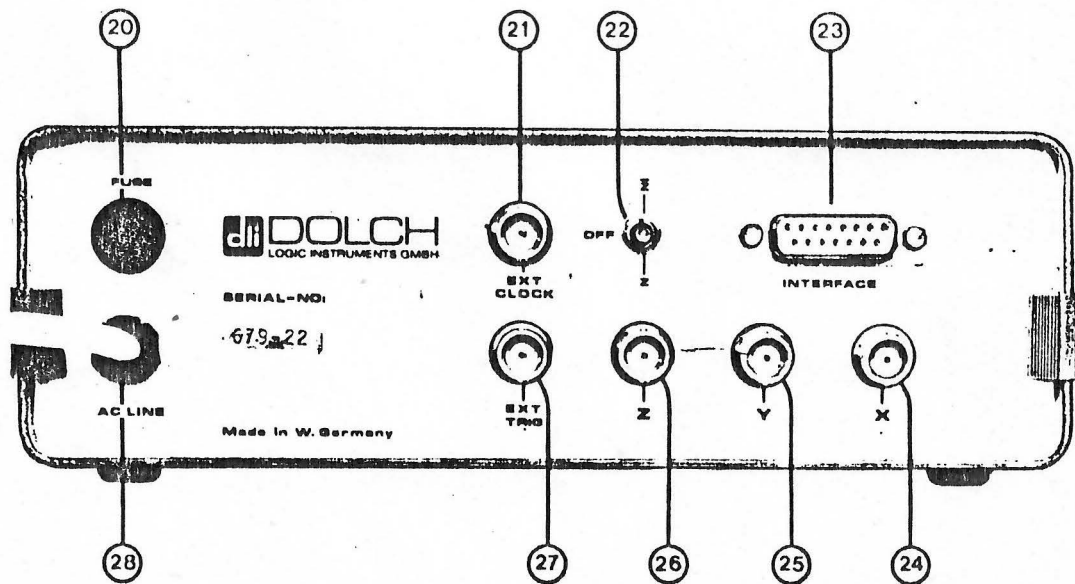
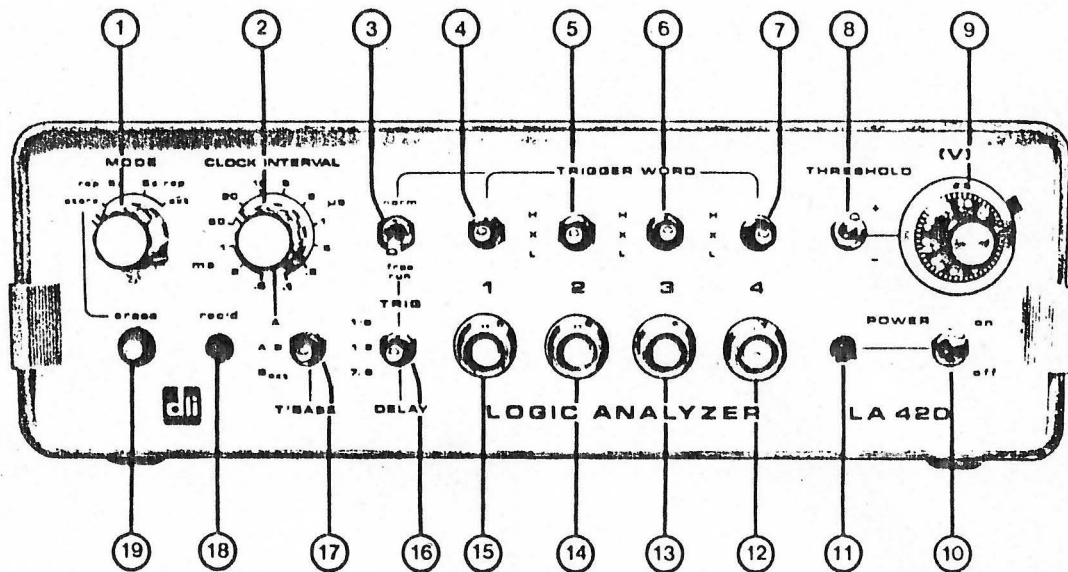
Weight: Approx. 2, 3 kg

#### 1.4 Accessories Available

Available are special logic probes providing a 1:1 coupling using BNC connectors and a special set of clips that connect easily to ICs. A color coding both on the BNC connector and on the IC hook allow easy channel identification.



Section 2 - OPERATING INSTRUCTIONS





## 2.1 Front Panel Controls; Connectors

### ① ①⑨ MODE - Operational mode Selection

Position store: Single event storage with indefinite display of captured date. With the erase ①⑨ push button the memory can be erased at any time and the unit enters a new record cycle at the same time awaiting a trigger signal which terminates the recording after counting down a previously selected ①⑥ delay and then enters automatically a display phase.

Position rep 5s; rep 0, 5s: A record and display cycle is automatically repeated once every 5 or 0, 5 seconds.

Position ext: All major operation functions can be externally controlled via the interface connector ②③. This mode facilitates a Master-Slave-Operation or processor integration.

② CLOCK INTERVAL - The internal clock rate is selectable from 0, 5ms to 0, 1  $\mu$ s. This clock rate determines the date sampling period.

③ Trigger Mode -  
Position norm: The trigger is generated by tying together the input signals via a word selector ④ - ⑦.

Position free run: The trigger is originated from the internal clock thus enforcing triggering irrespective of any input signal condition.

④ - ⑦ These switches serve to preset the trigger word. The trigger word can be expanded to 5 bits with an external trigger signal applied via ②⑦.

There is a tristate choice:

H - high - input threshold ⑨  
L - low - input threshold ⑨  
X - don't care

⑧ Threshold-Polarity-Selection: The threshold voltage ranges from -10V to +10V. ⑧ selects either polarity.

⑨ Threshold Control: A calibrated high precision 10-turn potentiometer with a digital dial serves to set the threshold voltage. This voltage ranges from -10 to +10V to serve all

logic families within a power supply range of -20 to +20V, assuming a 50% threshold point.

Since all inputs have an impedance equivalent of regular oscilloscopes ( $1\text{ M}\Omega // 20\text{pF}$ ) compensated probes can be used to reduce signal loading and expanding the threshold voltage range according to the probe attenuation.

- ⑩ ⑪ Power switch and ON condition LED
- ⑫ - ⑮ The four inputs are overvoltage protected and can shortly withstand - 250V. Input voltages greater than 15V are shunted to + 15V through a  $1\text{ K}\Omega$  resistor. Input impedance  $1\text{ M}\Omega // 20\text{pF}$ . Storage of 256 bits per channel. The four signals are displayed with channel 1 on top and channel 4 on bottom.
- ⑯ TRIG DELAY - This switch determines the delay following a trigger event that terminates the recording.  
  
Three positions can be selected:  
  
1/8: 32 clock periods prior to trigger are retained in memory  
1/2: 128 clock periods are retained  
7/8: 224 clock periods are retained
- ⑰ T-BASE - Time base selection with a choice of:  
  
A - - internal clock is used throughout the recording  
A/B - internal clock is used up to triggering and an external clock proceeds to the end of the recording  
B - external clock via ⑳ is used exclusively
- ⑱ Rec'd LED: Illuminates to indicate recording in process
- ⑲ ERASE - Pressing erase clears the memory at any time and the unit enters a new record cycle. Mainly used in STORE ① mode this push button serves as recording initiation and single shot arming control.

## 2.2 Rear Panel Controls; Connectors

- (20) Fuse: 0,1A for 220V  
0,2A for 110V  
slow blow
- (21) External clock input: Designated as B-time base in conjunction with switch (17) TTL-level requirement.
- (22) Z-out inverting switch: Inverts signal of connector (26) .
- (23) The interface connector allows access to all major control functions when the unit is set with (1) to ext. used for Master-Slave-operation or for processor system integration.
- (24) X-output: Analog ramp  $+5V$  pp for display deflection when X-Y display mode is used.
- (25) Y-output: Serial output of stored data.  
Repetitive stair-step ramp, each step equally spaced in amplitude. Data from each channel modulates each respective step level
- (26) Z-output: Nominal 0 to +15V pulse. Synchronous with X and Y output. Used for flyback blanking in X-Y display configurations or used as trigger pulse fed to the external Trigger input of an oscilloscope. Can be inverted with switch (2) .
- (27) External Trigger Input - Expands the trigger word to a 5-bit combination. Designated as inverting input. A low level enables, a high level prevents triggering.  
Input requirements:  
Low < 1V  
High > .2 - 50V
- (28) AC-Line: Power line connection, 15VA consumption

### 2.3 Preparation for Use

The LA 420 is calibrated and ready for use when received. Inspect the instrument for physical damage and check its operation as soon as possible after delivery. If physical damage is evident, or the instrument does not meet specifications when received, notify the carrier and the nearest DLI sales/service office.

#### 2.3.1 Initial Warm-Up

Although the LA 420 is a solid state instrument, a brief warm-up period of approximately 5 minutes is required for the input amplifiers and comparators to reach thermal stabilization.

#### 2.3.2 Signal Inputs

The input impedance of each channel into the LA 420 is 1M shunted by 25pF. This allows the use of passive X 1 and X 10 scope probes for connecting the unit to the circuit of interest. Circuit loading is minimal. Input voltages above -15V are clamped at these levels through 1 K resistors. When working with logic signals whose voltage levels exceed the clamp voltages, X 10 probes may be used. The selectable threshold will then be multiplied by a factor of 10. A combination of X 1 and X 10 probes permit the LA 420 to record both high and low level logic signals.

#### 2.3.3 Connections to Oscilloscope

The BNC X, Y, Z are the connector outputs for the oscilloscope. The LA 420 generates the data twice so that the output channels can be displayed also on a two-channel scope in alternate mode taking into consideration the internal channel switching of the scope. Connection to the scope can be seen on Fig. 6. The scope can be triggered from the rising edge of the Z pulse or from the falling edge of the inverted Z pulse.

**CAUTION:** Some older "tube type" scopes have a high voltage on the Z axis inputs. This could damage the Z or Z-output of the LA 420. Please check before connecting the units together. When displaying the four channels on the scope, it would be advisable to set the vertical sensitivity at 0.5V/div. and 20 us/div. deflection rate.

## Section 3 - OPERATING CONSIDERATIONS

### 3.1 Input and Threshold

All inputs are  $1\text{ M}\Omega$  with  $20\text{pF}$  input capacitance. This permits the use of common compensated probes for wide bandwidth and high impedance performance. The threshold can be expanded using attenuating probes. The LA 420 uses a calibrated high precision 10-turn potentiometer with a digital dial to set the threshold voltage. This voltage ranges from  $-10$  to  $+10\text{V}$  to serve all logic families within a power supply range of  $-20$  to  $+20\text{V}$ , assuming a 50% threshold point.

### 3.2 Combinatorial Trigger

The unit can be triggered from a combination of the input signals selectable to trigger when the four inputs match the "High-Don't care - Low" combination set on the combinatorial switches on the front panel. It will also accept an external triggering pulse via a rear panel connector which in fact expands the trigger combination to a 5 bit word.

### 3.3 Free Run Trigger

This mode uses the sampling clock pulse as trigger information. Free Run aids in troubleshooting of digital systems by clearly displaying active (superimposed ones and zeros) and inactive (unchanging ones and zeros) data lines. This mode is used to simply capture a display when a suitable trigger word is unknown. After viewing such captured data and selecting a suitable trigger word paging through of a data stream will be straight forward.

### 3.4 Pre and Delayed Trigger

The unique pretrigger recording feature, not possible with an oscilloscope, allows to record the signals preceding the trigger event. This is accomplished by having the unit recording continuously until the trigger is received, then using the trigger to stop the recording process, freezing the data in memory that was received in the period preceding the trigger. A precise

variable delay allows control of the stop point, so the trigger may be near the beginning, middle or end of the stores information. Thus the events leading up to or around some definable trigger event can be saved. These versatile trigger capabilities make the LA 420 a powerful diagnostic tool since it is able of displaying the data sequence preceding a system's fault. The choice of pretrigger, center-trigger, or post-triggering makes it easier to capture one of a kind faults and analyse large blocks of data before or after the fault.

### 3.5 Dual Delayed Time Base Operation

The LA 420 offers a choice of 3 time base modes: A; A/B; B whereby "A" represents the exclusive use of the internal sampling clock; in mode "B" an external clock is used; the "A/B" position allows a mixed time base operation. This "A/B" mode is in fact a Dual Delayed Time Base operation, which is a unique feature of the LA 420 not found in any other instrument of this kind. This mode allows to use two different sampling rates during one single record cycle. The changing from time base A to time base B is in synchronism with the delayed trigger event. If such a trigger event represents a fault, it can be extremely powerful to sample data up to such an event, for example with a relatively slow rate, in order to capture a large time span, but by the time a fault (trigger event) has occurred, increasing the sample rate resulting in an increased resolution which allows an improved analysis. There are also applications where it is advantageous to select a high speed sampling up to the trigger capturing pretrigger data with increased resolution but by the time the fault (trigger) has occurred expanding the time span of recording by reducing the sample rate taking into account a reduction of resolution.

### 3.6 Master-Slave Operation

LA 420 units can be cascaded via a rear interface connector to perform a Master-Slave operation, in fact forming 8, 12, 16 etc. channel systems which work fully synchronous. The great advantage of such configurations is the fact that

the system's flexibility is enhanced. The internal time base of the Slave unit is automatically assigned to be the time base B of the system allowing a convenient two time base operation. Each unit of the system can be set individually for its threshold, in fact serving different logic families, if necessary.

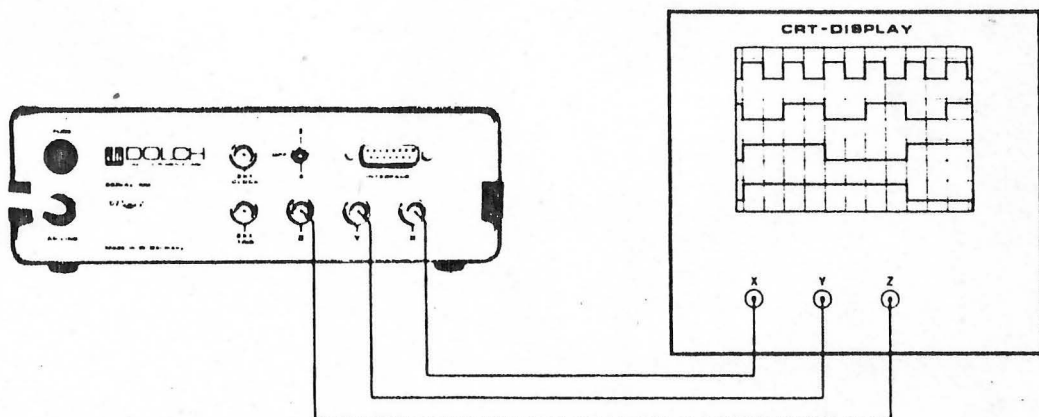
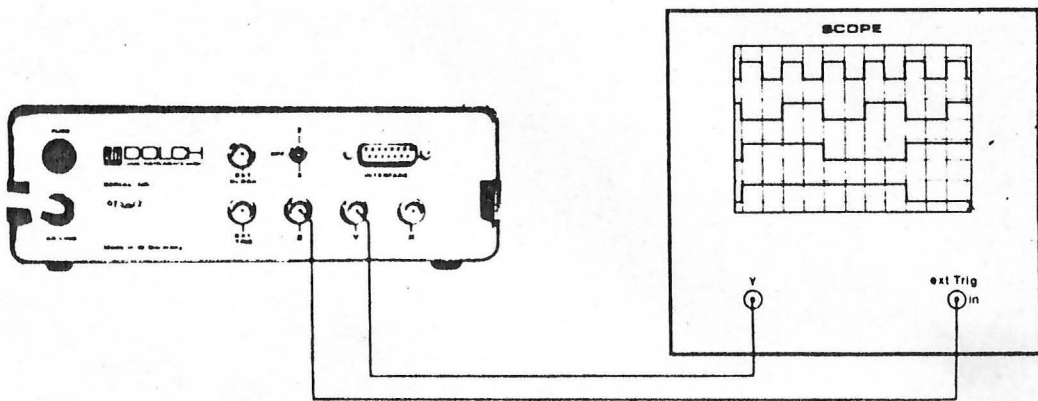
### 3.7 Microprocessor Applications

The LA 420 is equipped with an interface socket on the rear easily connecting to any computer or microprocessor. A mode of operation labelled "ext." allows an LA 420 to be remotely controlled e. g. by a Master LA 420 or by a processor system. This remote control gives access to all principal functions, such as initiating or recording, triggering and delaying, time base changing, as well as reading out and displaying stored data. This mode of operation, which is a unique feature of the LA 420 not found in any other instrument of this kind, makes the unit a most valuable tool for microprocessor troubleshooting and design, since it allows a full system integration of an LA 420.

## Section 4 - SETUP AND OPERATION

This section describes the connection of a Model LA 420 with a CRT display or oscilloscope and the steps to record and display digital signals.

### 4.1 System Connection





## 4.2 Trigger Operati on

In this mode the scope has to be switched to external triggering and the Z-output of the LA 420 is connected to the external trigger input of the oscilloscope (see Fig. 6). The Z out of the LA 420 delivers a sync pulse to the oscilloscope. The oscilloscope has to be triggered with the trailing edge of the Z pulse and, therefore, the right polarity should be provided. The Z pulse can be set positive or negative with a toggle switch on the rear panel which is off in normal position.

The automatic triggering has to be turned off and the trigger level has to be set on the corresponding leading or trailing edge.

To finally display the four channels on the CRT, the Y out of the LA 420 is connected to the Y input of the scope. The vertical input amplifier of the scope should be switched to DC with 0,5V/div. sensitivity. Set the time base to 20 us/div.

The setup on the LA 420 is as follows:

- (1) Set mode switch on 0.5 rep.
- (2) Switch to free run
- (3) Switch T' BASE to A

If the selected time base of 20 us/div. does not exactly correspond with the one of the LA 420, it can be finely adjusted on the time base vernier.

## 4.3 X-Y Mode

In X-Y mode the LA 420 has to be connected as shown in Fig 7. The Z pulse is used as beam blanking on the CRT. The X-output furnishes a 5V deflecting ramp. This is the setup procedure for the LA 420 in X-Y mode:

- (1) Set MODE switch on 0.5 rep.
- (2) Switch to free run
- (3) Switch T' BASE to A

Four channels are then displayed on the CRT. The flyback on the CRT can be blanked with the Z pulse. The four channels can be displayed full width on the scope with the help of the horizontal deflection adjustment.

#### 4.4 Typical Adjustment Problems

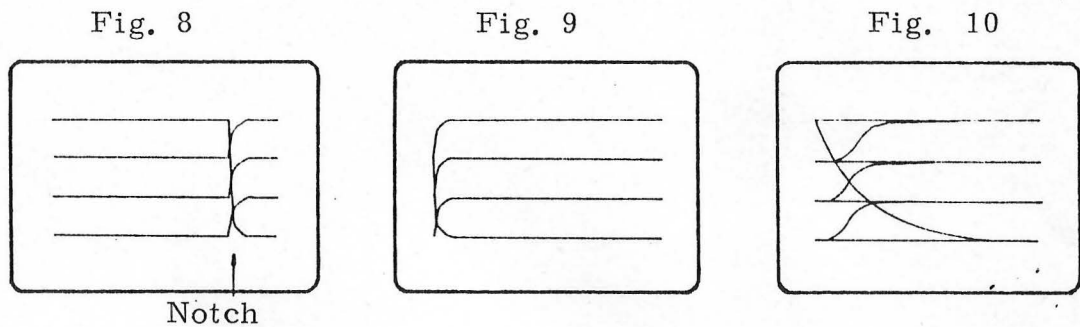


Fig. 8 shows a typical misadjustment of the time base of the oscilloscope. The time fine-control has to be set so that the notches disappear on the right hand side of the screen. These notches represent the end of the register (256 bit).

Fig. 9: The wrong trigger slope is used. Select either the opposite polarity of the Z pulse or use the opposite trigger slope on the scope.

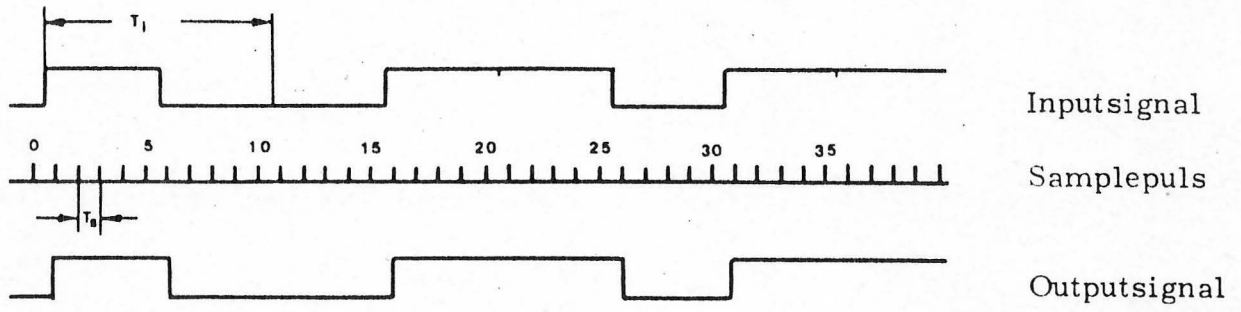
Fig. 10: This situation occurs when X-Y mode is used without a CRT flyback blanking.

#### 4.5 Recording Considerations

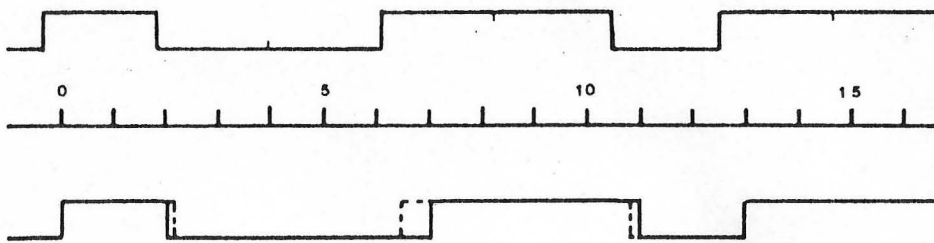
As the LA 420 can record as a function of either the internal clock or an external clock, care must be taken of some basic differences in these two methods.

When the internal clock is used for recording, no particular phase relationship will exist between this clock and any synchronous information rate in the signals being recorded. Therefore, a "beat" frequency can exist between these two basic rates. If the LA 420 internal clock is 5 times or more higher in frequency than the "signal" rate, very little effect will be noted in the recorded data. For higher "signal" rates (with respect to the record clock) a "beat rate" effect can be seen by varying widths in the recorded "pulses" and even periodic "dropped" bits when these rates approach the limiting ratio of two to one.

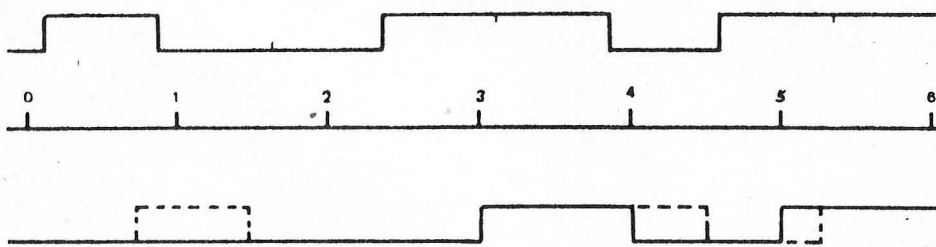
When the synchronous clock used for the generation of the input signals to the LA 420 is used as the record clock in the LA 420, no phase errors exist and no beat frequencies will be evident; i. e. the beat note is zero frequency. In this case, signals with information rates up to and including  $1/2$  the clock frequency can be recorded without distortion. This is called synchronous recording.



$$T_i/T_s = 10$$



$$T_i/T_s \approx 5$$



$$T_i/T_s = 1,5$$

#### 4.6 Dual Time Base Mode

In dual time base mode the input signals are recorded and displayed at two different frequencies, respectively one before and the other after the trigger event. This means that up to the trigger event data is recorded at the internal frequency rate and when trigger occurs this clock frequency will be furnished from an external source. Recalling the recording delay operation, i. e. if a delay of 1/8 is selected the unit will count down for 224 clock periods after trigger and stop recording, if the delay is 1/2 the time out count is 128, and 7/8 delay will cause 7/8 of the memory length to contain prior trigger data by counting for 32 clock periods after the detected trigger point - from a display point of view logic signals that happened before trigger can be seen on the CRT with a higher or lower time span than the ones that occurred after trigger. The internal clock frequency range is 2 KHz - 10 MHz and the external can go up to 14 MHz.

#### 4.7 Operating a Unit in Dual Time Base Mode

- (1) Choose the sample rate with the CLOCK INTERVAL switch
- (2) Set T' BASE switch on A/B
- (3) Set TRIG DELAY on 1/2
- (4) Connect external clock to EXT CLOCK BNC - TTL level
- (5) Select trigger mode, external, word, or free run
- (6) Set MODE switch on store or rep
- (7) Set input polarity and threshold
- (8) Connect to oscilloscope (see Section 4.1)

## Section 5 - THEORY OF OPERATION

### 5.1 Functional Description

The model LA 420 Digital Logic Analyzer is a very simple instrument. It simultaneously measures whether the input signals are above or below the selected threshold voltage and writes a corresponding 1 or 0 in a semi-conductor memory. The memory used is of the shift register configuration, such that new data is put into the input end of the memory, shifted throughout the length of the memory and discarded at the output end. The recording process may continue for an extended period of time. However, the memory is a finite length (256 data points), so that at any point in time only the previous 256 data points are remembered.

When data storage is halted by means of a trigger, the data contents of the memory can then be used either visually or by means of the digital output. When the LA 420 receives a trigger instructing it to stop data storage, a delay is started. If a delay of 128 (1/2) data points is selected, then new data will continue to be inserted into the memory for 128 clock intervals. Since the memory contains 256 data points, the result will be that 128 points of information prior to the trigger plus 128 points after the trigger will be stored in the memory for use by the operator. This feature allows the operator to look both forward and backward in time relative to his trigger signal.

When data storage ceases, the instrument normally goes into what is called the "display mode" of operation. In this mode, the contents of the memory are continuously recirculated and made available at the output port of the memory. With the memory outputs being updated at a high rate, it is relatively easy to achieve a non-flickering CRT display of the memory contents. By this technique, an X-Y CRT display unit or any conventional oscilloscope can be used to display the timing relationships between logic signals on the 4 input lines. The logic waveforms displayed will be identical to those shown by component manufacturers or in the timing diagram provided for a system if the operator of the LA 420 has chosen the clock interval sufficiently high.

An alternative to the display mode is the digital output mode. This mode allows the LA 420 to be used with a suitable interface to output the stored information to a computer system. Once the computer via its interface requests output data from the LA 420 via the interface to the computer, the data is supplied one word at a time sequentially, beginning with the first word in memory through the final word in memory. Each word is available at the output connector (4 bits in parallel) with a Flag signal indicating to the computer that the data is valid and ready to be clocked into the computer.

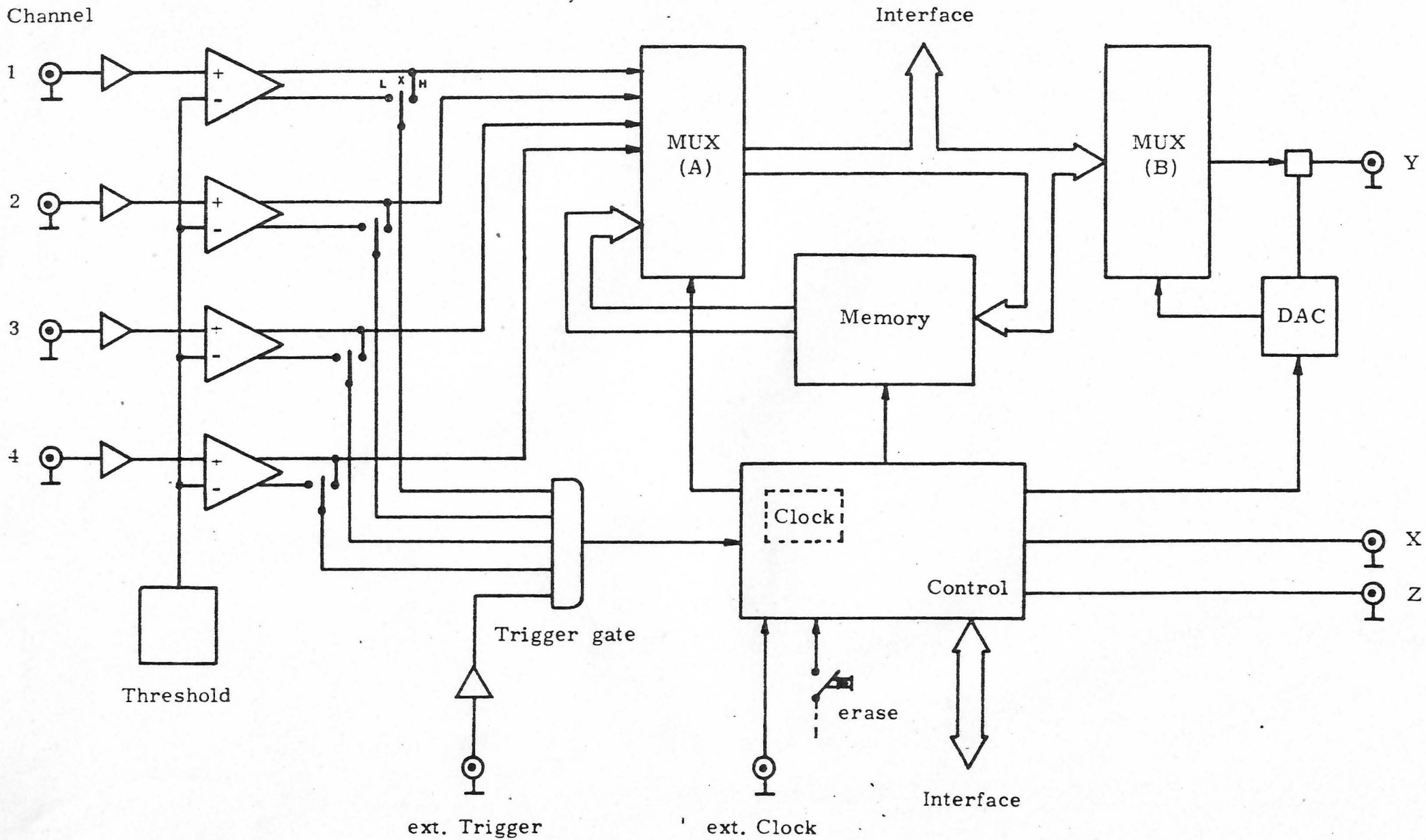


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