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This paper is in response to discussion regarding the KA-B function for detecting and marking small wildfire hot spots.

The U.S. Forest Service has used a two color infrared sensor since 1969. This concept was developed with the prototype RS-7 line scanner designed by the Northern Forest Fire Laboratory (NFFL), Texas Instruments (TI), and Litton Industries. The primary product output from this unit was 5 inch wide, continuous strip, Mylar based film. This early system relied entirely upon the Infrared (IR) Image interpreter to find and annotate the fire signals found on the film and transpose this data onto topographic maps. This proved to be a very labor intensive process and dependant entirely upon the subjective skills of the individual IR image interpreter.

Because the film based product was capable of producing only 21 levels of grey, the medium temperature targets (solar heated rock outcroppings etc.) looked exactly like a wildfire. Without a superb knowledge of the area being scanned it was impossible to delineate wildfire from low temperature look alikes.

A method of thresholding on the short wavelength or hot channel IR signal was developed to aid the IR image interpretation. It was soon discovered that, with this method, many of the smaller hot spots were being skipped over and many of the low to medium temperature targets were being marked. This was totally unsatisfactory to the wildfire community and the IR development group.

It was determined that a small portion of earth emissions (medium temperature) signals were present in the short wavelength (3 to 5 micron) region. During daytime and early evening, these earth emissions are quite strong and mask the smaller hot spots. In the early morning hours, these earth emissions are minimal, but they still contribute to the detection problem. See Fig. 1.

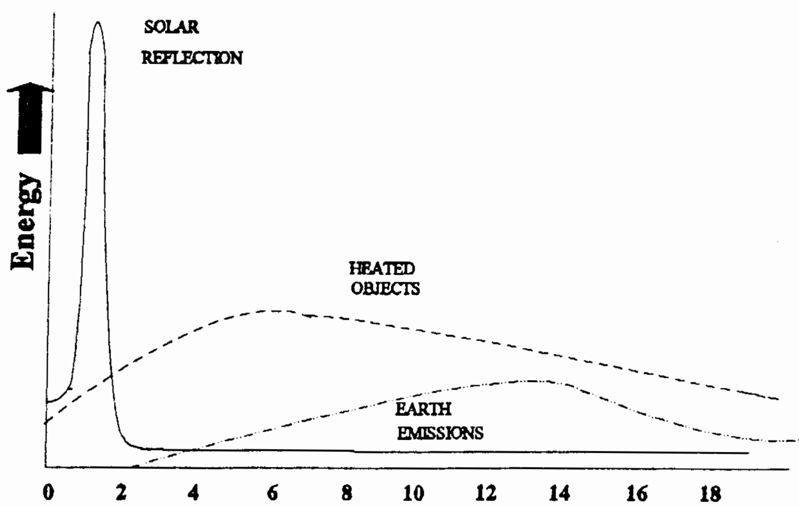


Fig. 1

TDM

A Target Discrimination Module (TDM) was developed which greatly improved the detection capability of the IR system to detect and mark small hot spots. AIRBORNE INFRARED FOREST FIRE DETECTION SYSTEM: FINAL REPORT (USDA Forest Service Research Paper INT-93, 1971) provides the research background for the development of the TDM.

HISTORICAL BACKGROUND

In 1971/72, Texas Instruments Inc. was commissioned to design and manufacture a state-of-the-art line scanning system. The Fire Scan group at the Northern Forest Fire Laboratory (NFFL) provided a full set of specifications written around the prototype RS-7 unit. This unit, the RS-25, is an analog/digital system. It is a two color system with a film product output. In 1975/76, this unit was modified to operate at 200 line scans per second vs 100 line scans.

In 1986, this unit was extensively modified to incorporate much of the analog circuitry of the FLAME and was renamed to RS-25(A).

In 1982, The Jet Propulsion Laboratory (JPL) was commissioned to design and manufacture a state-of-the-art line scanning system using available technology. Most of the usual budget constraints were in place. As much as possible, line replaceable units were to be used. And any practicable innovative measures were to be incorporated.

The result of this contract became the current FLAME line scanning unit.

The FLAME unit is a combination analog/digital system. The basic IR sensor system is still analog. The primary output is a film based image. Secondary output is RS-170 scrolling video format. It was desired to be able to transmit, via data link, 1024 X 1024 high resolution video, to a ground based system where a high resolution image could be displayed and manipulated. The ground based system was never fully developed.

Even though the FLAME unit was designed and constructed 13 years after the RS-7 and 10 years after the RS-25, the basic concepts used in the design of the FLAME are the same. It was not a requirement for JPL to utilize the same TDM module concept. They, however, found this concept to be very satisfactory to meet the Forest Service (FS) goals .

JPL did investigate the possibility of using a single detector in the 3 to 5 micron range or a single detector in the 8 to 12 micron range. This was done primarily for cost reduction purposes. It was determined by JPL engineering that a single detector sensor could not duplicate or exceed the small hot spot detection performance of the line scanning systems currently in use.

Around 1986, JPL was commissioned to develop a conceptual design for a system that would be able to geo-reference fire data, data link air-to-ground, and provide an enhanced fire map for ground personnel. This project was dubbed FFAST and met with an early demise because much of the technology described by this proposal was still a prototype in someone's lab and was not commercially available.

In 1989/90, JPL was again commissioned to design and manufacture a line scanning system similar to the FFAST requirements. This system is dubbed FIREFLY. There were several detector/optics systems looked at including single detector sensors. Because of availability and factory support, the Deadalus scanning system with two color spectral capability was chosen.

Even though the Deadalus/FIREFLY system is nearly 100% digital and incorporates 5 computers, the basic signal handling concepts are the same as the 1970 prototype unit. The geo-referencing capability is the new and innovative.

KA-B, TDM

The following discussion will be directed toward Fig. 2, a simplified block diagram of the overall TDM circuit.

A prerequisite for proper operation of the TDM function is:

To have the same rise and fall time constant for each channel.
To be 100% coincident with each other.

The 3 to 5 micron or 'HOT' channel will be referred to as channel 'A.'

The 8 to 12 micron or 'TERRAIN' channel will be referred to as channel 'B.'

The output from the two input buffer amps will be positive going for hot temperatures.

Theory

The full spectrum of 'A' channel thermal response is fed into the algebraic summation circuit at the KA-B SUM'R. (Waveform Fig. 3-a)

The full spectrum of 'B' channel thermal response (Waveform Fig 3-b) is fed through the KA-B, front panel control, then to the 'B' invert amplifier where it is inverted and then fed into the algebraic summation circuit at the KA-B SUM'R.. (Waveform Fig 3-c)

Since earth emissions from 'B' channel will be much stronger than those from 'A' channel, some form of amplitude control must be incorporated. Hence the KA-B control. In the analog systems, the summation output can be monitored (front panel test point). The KA-B control is adjusted to remove, as much as possible, earth emissions from the HOT channel signal.

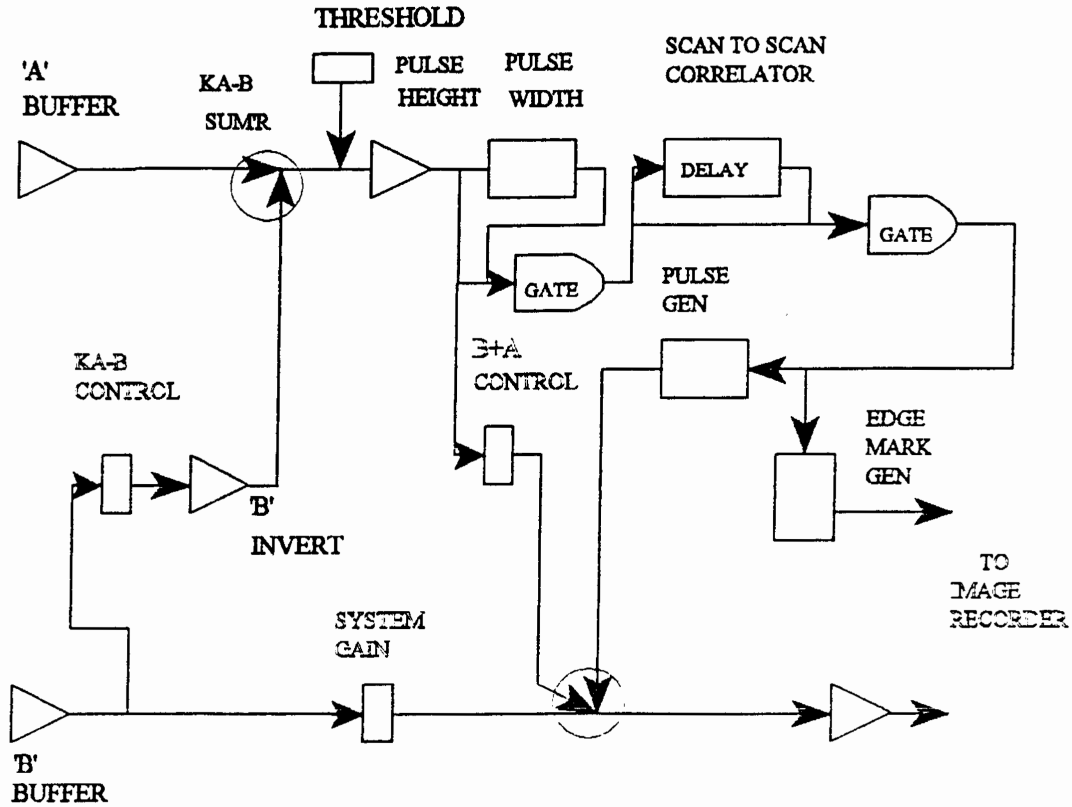


Fig. 2

The composite KA-B signal is then fed into the pulse height circuit which is nothing more than a voltage comparator. The operator controls this switching level with the front panel THRESHOLD control. (Waveform Fig 3-d)
Since 'A' and 'B' channel detectors are not perfectly matched, there will be some differences in the waveforms going into the KA-B SUMR and consequently there will still be some background low temperature signals present going into the PULSE HEIGHT circuit. This is most noticeable during daytime flights. Because the TERRAIN emissions have been removed, the THRESHOLD level may be set much lower or closer to the system noise level than could be accomplished without the summation circuit

This signal is now fed into a voltage comparator (pulse height) circuit. The threshold trip level control determines the comparator threshold point. Because we have removed most of the low temperature earth emissions, this level may be set much lower than we could without the summation circuitry. This is a key factor in increased small hot spot detection.

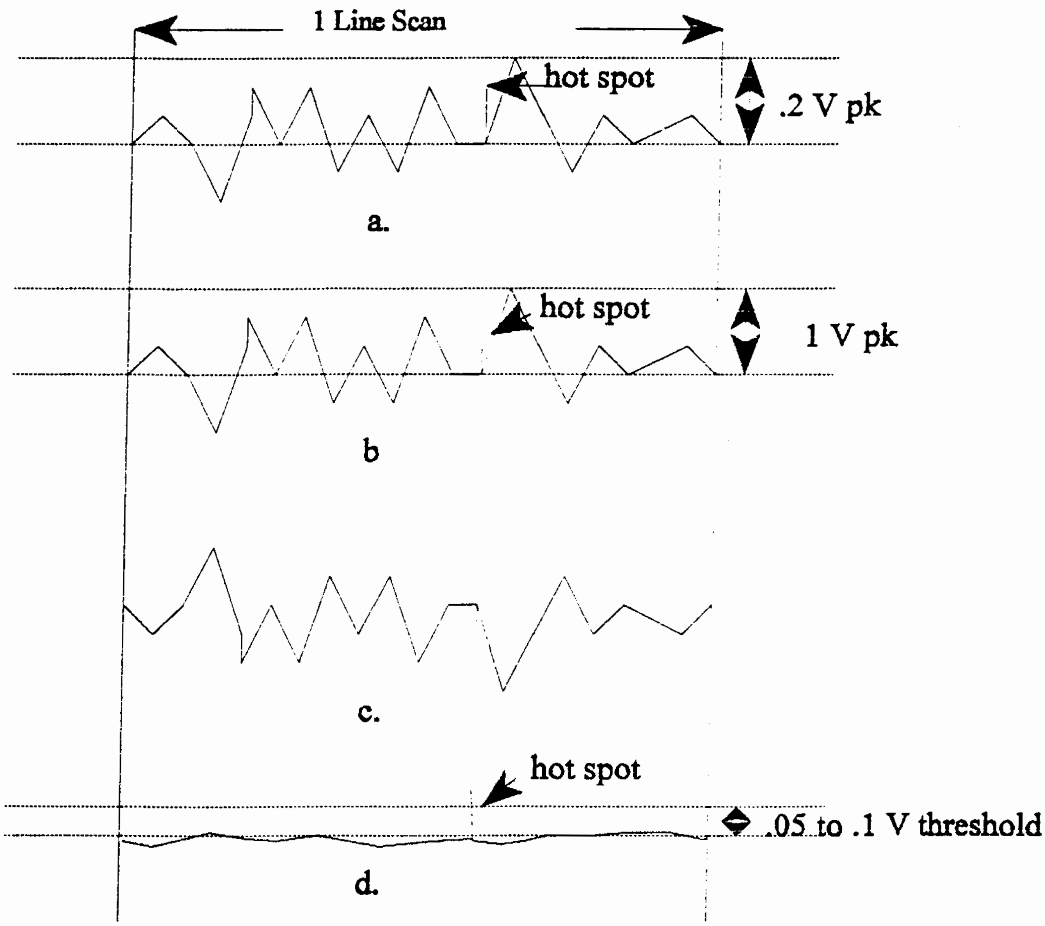


Fig. 3

NOTE: Because of the differences in the thermal response of the 2 detectors to very cold signals, (i.e. The very cold signal from a flat metal roof or trailer home roof during late evening and early morning.) the KA-B SUM'R and the pulse height circuit does not differentiate between the very cold signal and a fire signal.

Since 'A' channel is very unresponsive to the extremely cold targets, there will be a very small amplitude signal sent to the KA-B SUM'R. Since there is a much greater response from 'B', there will be a large amplitude signal sent to the KA-B SUM'R. Since there is no similar cold target in 'A' to be subtracted, the cold target shows up at the PULSE HEIGHT comparator as if it were a hot spot.

Usually, the cold target shows up in the imagery and the IR interpreter is able to identify the cold temperature source. The JPL, FIREFLY staff were able to develop a software algorithm to eliminate this cold target and many of the affects caused by snow on the ground.

The output of the pulse height circuit is then fed into a pulse width circuit.

The pulse width circuit has to parts. It eliminates any pulses less than .5 micro-seconds in length and passes all pulses .5 micro-seconds to 40 micro-seconds in length, thus creating a .5 to 40 micro-second window where a Target Discrimination Mark will be generated.

NOTE: Since the larger fires are very discernable on the film image, it has not been necessary to generate a target discrimination mark for the larger fire signals.

The output from the pulse width circuit is then fed into the scan to scan correlator
The scan to scan correlator is a 1 line scan delay (shift register).

> To generate a valid fire mark, the line scanner must 'see' the same fire signature in 2 adjacent line scans, plus/minus 2 pixels.

With a pulse from line scan 1 present at input to the delay circuit and the same pulse present at the input to the associated and gate, there will be no output.

As the 1 line delay is clocked, the pulse at the input to the delay is shifted through the shift register.

The pulse that was present at the gate input is now gone and there is no output.

Since the register is shifted at a predetermined start and stop time coincident with one line scan, then:

When the same fire signature is 'seen' by the line scanner during line scan 2, a new fire pulse is present at the input to the delay register and at the input to the gate---But now there is also a pulse from line scan 1 coming out of the shift register being applied to the gate circuit. With the gate inputs high, there will be an output to the pulse generator.

This process repeats itself as long as there is a fire signal of the proper pulse width (.5 to 40 micro-seconds) and amplitude in 2 adjacent line scans.

NOTE: There must be sufficient overscan to 'see' the same spot on the ground on 2 adjacent line scans. Three adjacent line scans give even greater opportunity for the system to 'see' and mark a hot spot.

The output from the gate circuit is fed to the TDM pulse generator and the EDGE mark circuit.

The output from the PULSE generator is mixed into the print video chain and sent to the image recorder to be displayed on the imagery in its proper location on the scan.

The EDGE mark circuit feeds a long time constant positive signal to the image recorder to place a TDM EDGE mark on the film.

SIMPLIFIED CIRCUIT ANALYSIS (FLAME)

(Much of this narrative is taken from the FLAME maintenance manual.)

The FLAME line scanning unit is an airborne infrared system with radiometric capabilities. It is currently mounted in a Forest Service owned, Beach King Air 200.

The FLAME line scanning unit uses two MerCadTelluride detectors operating in the 3 to 5 micron (A-channel)and the 8 to 12 micron (B-channel) region of the infrared spectrum. The detectors are mounted on the same plane with approximately .020 inch separation. The line scan data is clamped to a blackbody reference at the beginning or the end of each line scan (selectable, internal switching).

GENERAL PRINCIPLES OF OPERATION

The FLAME infrared scanner is a Kennedy scanner, which is a split image, high scanning rate optical system, used to collect energy in the spectral regions of interest. Liquid Nitrogen cooling is used for the mercury cadmium telluride detectors. A gyroscope enables the system to compensate for as much as +/- 10 degrees of aircraft roll.

DESCRIPTION OF MAJOR UNITS

Receiver

The FLAME infrared scanner incorporates two controllable thermal calibration sources (blackbodies). These are mounted just outside the active field-of -view of the scanner .

The detector-filter assembly is mounted in a liquid nitrogen cooled dewar assembly which is mounted on the scanner optical housing. The FLAME line scanning unit uses two MerCadTelluride detectors operating in the 3 to 5 micron (A-channel)and the 8 to 12 micron (B-channel) region of the infrared spectrum. The detector-filter assembly is mounted in a liquid nitrogen cooled dewar assembly which is mounted on the scanner optical housing. The detectors are mounted on the same plane with approximately .020 inch separation and are individually cold filtered to approx 2.75 to 4.7 and 8.3 to 12.7 micron respectively.. The line scan data is clamped to a blackbody reference at the beginning or the end of each line scan (selectable, internal switching).

Main Equipment Rack

The FLAME main equipment rack includes the analog electronics, the target discrimination circuitry, digital conversion for data transmission of high resolution television video, and video display and recording on a strip image recorder and a video cassette recorder.

Rack Analog electronics

The rack analog electronics is contained in two printed circuit boards mounted in a drawer in the equipment rack. Figures 4, 5, and 6 are simplified block diagrams of the electronics mounted on the scanner receiver and the analog electronics drawer.

The Channel A video (3 to 5 micron) is applied to a high gain, low noise, pre-amp. It is then fed to the unity gain post-amplifier where the video signal is clamped to the blackbody heat source to compensate for 1/f noise drift and long time constant high temperature drift. The signal is then fed to video buffer/gold spike gate which removes the spike created by the detector viewing itself. The cable buffer amplifier provides a gain of approximately 2 to compensate for the cable termination loss.

The output of the cable buffer drives a tapped delay line. The fixed 4.5 micro-second delay line is jumpered to the position on the tapped delay line which provides time coincidence between the A and B signals. The output of the 4.5 micro-second delay line is fed to the KA-B summing amplifier. In the KA-B amplifier the gain of 4 V/V to the channel A signal corrects for the loss caused by terminating the two delay lines.

The B video signal passes through a pre-amp, post-amp, and cold spike gate and buffer identical to the A channel. After buffering, the signal passes through the B-INVERT amplifier whose gain is controlled from the front panel by a potentiometer.

The B signal video then passes through the 1/K attenuator which is controlled from the front panel in 10db steps.

At this point, the delayed A signal and the attenuated B signal are summed in the KA-B summing amplifier. Since the two inputs to the KA-B summer are of opposite phases, the signals are differenced with the output polarity positive-going for larger A signals. When the B gain adjustment and the 1/K attenuator have been set properly, the changes in the A signal and the changes in the B signal will be equalized over the temperature range for normal terrain temperatures. Therefore the output of the KA-B summing amplifier will be approximately constant when viewing normal terrain temperatures. At higher temperatures (above 50 deg C) the A signal increases faster than the B signal so that hot objects can be detected.

NOTE: When extremely cold targets are sensed by B channel and the same cold target is poorly sensed by A channel a cold target appears at the output of the KA-B summing amplifier with the same characteristics as a fire signal.

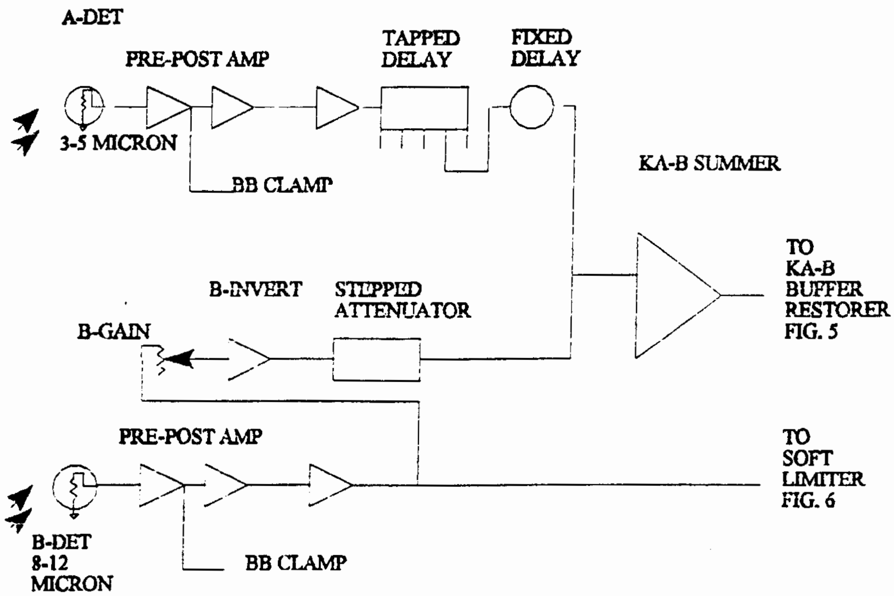


Fig. 4

The signal from the KA-B summer is baseline-restored during the blackbody viewing time and amplified before being fed into the threshold comparator.

KA-B Buffer/Restorer

The KA-B output is connected to the KA-B buffer/Restorer. The buffer/restorer references these KA-B Waveform to the selected blackbody during the time the blackbody is viewed. During this time, the BB switch is on and in this condition the amplifier functions as a unity gain amplifier forcing the output to 0 volts. As the scan moves off the blackbody disconnecting the feedback path resulting in sub-millivolt baseline drift at the output over a line cycle period. The buffer/restorer has a gain of about -30 V/V with the output negative-going for higher A temperatures.

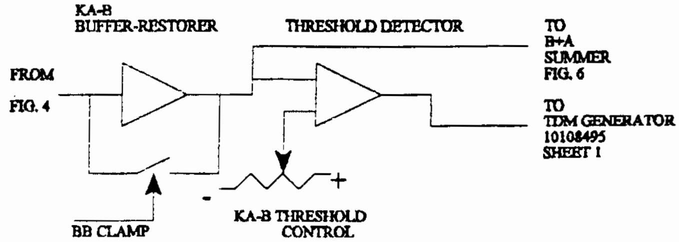


Fig. 5

The output is fed to the B+A Summer (Figure 6) and to the threshold detector.

Threshold Detector

One input to the threshold detector is the output from the KA-B buffer/restorer. The second input to the detector is the threshold level itself. The threshold level is controlled from a potentiometer located on the front control panel. When the restored KA-B signal is more negative than the setting of the control panel potentiometer, the output goes to ground indicating that a signal above threshold has been detected. This signal is processed by the digital electronics to determine if a valid signal has been detected.

Soft Limiter

The second use of the B channel signal is to develop an image of the terrain and fire so that the fire location can be determined. For this purpose the channel B buffer signal is connected to the soft limiter (Figure 6). The soft limiter is adjusted such that terrain temperatures (0-50 deg C) are processed in a linear fashion. Voltages corresponding to temperatures above this range are progressively compressed so that most of the system resolution can be retained in the terrain temperature range.

The output voltage range of the soft limiter is normally approximately 0 - +4 V.

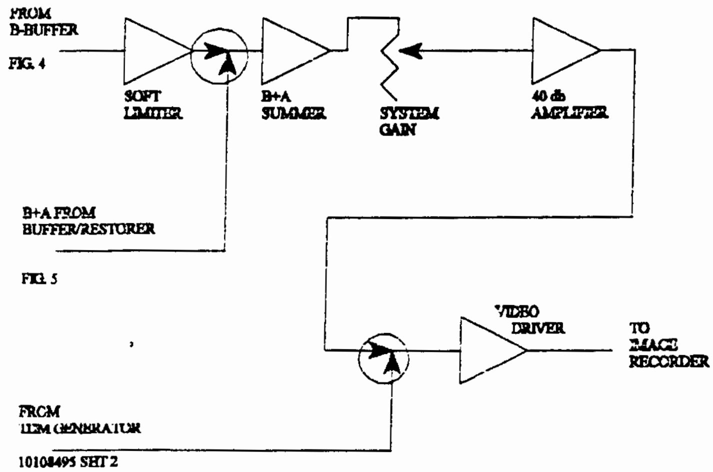


Fig.6

B+A Summer

The output of the soft limiter is fed into the B+A summer which sums in a portion of restored KA-B signal (Fig. 5) as determined by the A+B control panel potentiometer.

The output of the B+A summer is fed to the front panel system gain control and then fed to the 40 db video amplifier and then to the marker mixer/print video buffer.

Marker Mixer/Print Video Buffer

In the marker mixer/print video buffer the black and white TDM marks (from the digital electronics) are added to the B+A output to form the signal for the dry film processor.

Roll Correction

The active line scan video is roll corrected up to +/- 10 degrees to provide a stable ground image viewed +/- 60 degrees from nadir.

DIGITAL ELECTRONICS DESCRIPTION

The purpose of the digital electronics is the orchestration of data collection and processing events for the FLAME line scanner. This task utilizes inputs from the scan mirror sync, roll gyro, and control panel to provide the required timing and control signals to the analog electronics, frame buffer, and film recorder. Additionally, the digital electronics perform a test for the presence of hot targets in the video data and generate the appropriate visual and aural alarms when such an event occurs.

Digital Block Diagram

The digital electronics functional block diagram is shown in Figure 3.2.1. The system operates from a 20Mhz crystal controlled master clock and is synchronized to the scan mirror motion via SYS SYN. Timing elements solely dependent upon the scan mirror position are generated by the fixed sync generator. These signals include black-body 1 and 2 syncs and RAMP used in the roll correction process.

The roll correction sync generator creates timing elements used to acquire and process ground track video. As the name implies this circuit provides a system sync signal (RC Sync) that has been modified by input from the roll gyro. Synchronized to RC Sync the Digital Video Timing Generator provides the signal chain with the necessary timing and control signals to enable the video data to be rectilinearized and digitized.

The PROM based V/H decoder operates upon velocity and altitude data supplied by control panel inputs to create SCAN ENBL, a signal which controls the acquisition of only critical sampled scan lines.
Digital video data passes from the signal chain to the frame buffer interface where line and pixel strobes are added to complete the input requirements to the frame buffer.

The TDM generator analyzes the pulse width of detected targets and generates audio and visual alarms when the requisite parameters are met.

Circuit Descriptions

Master Clock

The Master Clock is a crystal controlled oscillator operating at 20 MHZ. It's outputs, 20 MHZ CK and 20 MHz CK' serve as the system clock throughout the analog and digital electronics.

Scan Mirror Optical Sync Interface

SYS SYN, the output of the scan mirror optical sync interface, synchronizes the operation of the FLAME electronics to the rotation of the scan mirror. The interface is divided into two sections. The optical pickoff pulse resides on the receiver near the scan mirror while the system sync interface is located in the rack electronics drawer (Figure 3.3.2-1

The optical pickoff pulse shaper consists of the electro-mechanical scan mirror interface and Waveform modification electronics that enable the signal to be transmitted to the rack electronics. the optical switch is composed of an optically aligned LED/photo transistor pair with a notched wheel rotating between them. The photo transistor remains off as long as light from the LED is blocked by the wheel. When a notch passes between the pair, however, light from the LED turns the photo transistor on. The pulse shaper senses this change of state and outputs a pulse with a much faster rise time than can be achieved by the transistor alone. The pulse shaper output is buffered by the line driver which transmits the signal to the system sync interface via the receiver rack cabling.

The notched wheel has been precisely machined and attached to the shaft of the scan mirror in a way that places the leading edge of each of its three notches (mirror has 3 flats) between the LED/photo transistor pair prior to the start of each mirror scan. The wheel has been indexed by machining one notch wider than the remaining two. This creates one sync pulse 400 micro-second in duration and two pulses 240 micro-second long (SYNC B', Figure 3.3.2-2).

The system sync interface receives the transmitted sync signal and deskews the pulse eliminating any timing aberrations caused by the scan mirror and notched wheel. The line receiver converts the transmitted sync into the TTL compatible signal SYNC B'. The skew controller provides the capability to fine tune out small differences in the timing of three sync pulses occurring each revolution of the mirror. (Refer to Figures 3.3.2-2 and 3.3.2-3 during the following discussion.)

The sync selector generates three enable signals (Aen, Ben, and Cen) synchronized to the 400 micro-second index pulse on SYNC B'. The selector is composed of a one-shot and a quad-d latch wired as a serial shift register. The one-shot is designed to provide a 300 micro-second pulse triggered by the high-to-low transition of SYNC B'. The low-to-high transition of SYNC B' then clocks the state of the one-shot output into the first stage of the shift register. If the SYNC B' pulse is 400 micro-second in duration, the one-shot times out and a logic 1 is clocked into the register. If SYNC B' is 240 micro-second long, the one-shot output is low and a logic 0 is clocked into the register. Arbitrarily, the 400 micro-second pulse is labeled C and its associated enable Cen. The next SYNC B' pulse is A and the remaining pulse B. Figure 3.3.2-2 illustrates the relationship of these pulses to their enables.

The sync selector enable signals each control a delay one-shot. When a one-shot's enable is high the one-shot will trigger on the next high-to-low transition of SYNC B'. If the enable is low, the one-shot will not trigger. Only the delay time of one-shot A has been fixed. The delays of B and C are variable and can be tuned to remove any skew in the SYS SYN signal generated by the output one shot by adjusting the associated trimpots. The output one-shot is triggered by the end of each delay pulse providing a SYS SYN signal with a constant pulse width of 140 micro-seconds.

Fixed Sync Generator (Figure 3.3.3-1)

The fixed sync generator is a PROM based timing generator capable of generating eight separate, synchronous signals. The basic components of the generator are:

Start/Stop Gate
Gated Divide-by 20 counter
Address Register
PROM 4K x 8
Output Latch

In the reset state the start/stop gate output GO1 remains low holding both the gated divide-by 20 counter and the address register off. The address register points to PROM address 000 Hex, and the data stored at this location is present at the PROM output.

As seen in Figure 3.3.3-2, when SYS SYN' goes low GO1 goes high releasing both the divide-by 20 counter and address register for operation. The divide-by 20 counter is preset to allow its output G1.0 MHz to go high on the next low-to-high transition of the 20 MHz CK. When this occurs, the PROM output data is strobed into the output latch and the address register is incremented to 001 Hex placing a new set of data at the PROM output. The process of strobing data into the output latch and incrementing the address register is repeated with each lot-to-high transition of G1.0 MHz until STOP1 sets GO1 low and returns the sync generator to its reset state until the next occurrence of SYS SYN'.

Definition of the fixed sync generator output signals is as follows:

BB1 SYNC	Is a 100 micro-second pulse occurring when Blackbody 1 is in full view of the detectors. BB1 SYNC is used by the analog electronics.
BB2 SYNC	is a 100 micro-second pulse occurring when Blackbody 2 is in full view of the detectors. BB2 SYNC is used by the analog electronics.
RAMP	is a 630 micro-second signal used by the video sync roll corrector to produce a ramp required for generation of the roll corrected sync.
ALIGN	is a test point signal used in the alignment of the scan mirror optical sync.
ROLL>15	is a 2 micro-second pulse occurring after the effective roll correction window has passed. This signal allows the roll sync generator to function when the aircraft has exceeded a 15 degree roll angle.
STOP1	having been set low at the start of the fixed sync generator cycle transitions low-to-high at the end of the cycle returning the generator to its reset state. When inverted, STOP1 becomes COLD SPIKE a signal used by the analog electronics.

Roll Correction Circuit Description (Figure 3.3.5-1

The roll sync generator is a PROM based timing generator capable of generating eight separate, synchronous signals. As illustrated in Figure 3.3.5-1, the basic components of the generator are:

Start/Stop Gate
Gated Divide-by 24 Counter
Address Register
PROM 4K x 8
Output Latch

In the reset state the start/stop gate output GO2 remains low holding both the gated divide-24 counter and the address register off. The address register points to PROM address 000 hex, and the data stored at this location is present at the PROM output.

As seen in figure 3.3.5-2, when either ROLLD goes low or ROLL>15 goes high GO2 goes high releasing both the divide-by 24 counter and address register for operation. The divide-24 counter is designed to allow its output G833.3 KHZ to go high on the sixth high-to-low transition of the 20 MHz CK'. When this occurs the PROM output data is strobed into the output latch and the address register is incremented to 001 Hex placing a new set of data at the PROM output. The process of strobing data into the output latch and incrementing the address register is repeated with each low-to-high transition of G833.3 KHz until STOP2, a PROM generated signal, goes high. The low-to-high transition of STOP2 sets GO2 low and returns the sync generator to its reset state until the next occurrence of ROLLD or ROLL>15. Definition of the roll sync generator output signals is as follows:

FILM SYNC is a 1.2 micro-second pulse occurring 9.6 micro-second before the start of each active scan (+/- 60 deg of nadir) which synchronizes the film recorder to the analog video signal.

RC SYNC is a 1.2 micro-second pulse occurring at the start of each active scan. RC SYNC is used throughout the electronics.

TEST is a 38.4 micro-second pulse occurring at the nadir time in each scan. It is utilized by the TDM generator electronics to provide a test capability for the TDM generator.

STOP2 having been set low at the start of the roll sync generator cycle transitions low-to-high at the end of the cycle returning the generator to its reset state.

TDM Generator (Figure 3.3.6-1)

The TDM generator is organized into three task groups. The first, responsible for target detection, consists of the following blocks:

Minimum target Discriminator
IFOV Clock Generator
Maximum target Filter
One Line Delay
Target Comparator

The second group generates the various aural and visual alarms in response to a detected target. This group is composed of the following blocks:

Black/White Generator

Edge Mark Generator
Aural Alarm Generator

The final group, the test target generator, simulates a target to facilitate testing of the TDM generator for proper operation.

Minimum target Discriminator (Drawing 10108495 sheet 1)

The minimum target discriminator consists of a two-stage binary down counter (4-58, 4-59), two flip-flops (4-57, and a control input (4-56) composed of three signals (ASCAN, GTHRSH1, AND TEST TARGET'). ASCAN enables operation of the discriminator only during the actual scan period. Although TEST TARGET' is not controlled by ASCAN, it is independently timed to occur during the actual scan period.

As illustrated in Figure 3.3.6-2, the absence of a threshold detector output (GTHRSH1=0V) presets the down counter to a count of 16 Hex. When GTHRH1 goes high the counter will decrement on each lot-to-high transition of the 20 MHz CK. At terminal count (00Hex) MIN+ goes low for one half of a 20MHz clock cycle. Its low-to-high transition resets LF' causing the Target signal to go high. Should GTHRSH1 go low at any time prior to terminal count the operation of the discriminator is reset. The minimum target discriminator is presently set to reject threshold signals with widths less than 1.1 micro-send. This time may be modified by rewiring the parallel inputs to the down counters.

IFOV Clock Generator (Drawing 10108495 sheet 1)

The IFOV clock generator (4-55) creates a 50% duty cycle, 833.3KHz clock during active scan time. This clock defines one IFOV time per cycle and is used throughout the TDM generator.

Maximum Target Filter (Drawing 10108495 sheet 1)

The maximum target filter disables the TDM function for lengthy targets and edge marks. The length of target signals screened is selected by the on board switch at location 4-66. Table 3.3.6-1 defines the switch settings.

The filter is composed of a 16-bit serial/parallel shift register (4-60 through 4-63), an 8 channel gate structure (4-67 through 4-69, 4-71 through 4-73), and a mode control counter (4-70). Target signals not exceeding the selected length criterion are shifted through the filter in a serial fashion on the high-to-low transition of IFOV CK' and continue on to the one line delay circuit.

The operation of the filter when the target signal exceeds the length criterion is best shown by an example. refer to the timing diagram in Figure 3.3.6-3 during the following discussion.

In this example the maximum length select switch is set to six. Prior to the target signal going high the mode control counter is preset to the count value six. When the target signal goes high, it is loaded into the shift register and begins to propagate on each low-to-high transition of IFOV CK'. Simultaneously, the mode control counter is enabled and decrements once for each shift of the register. The mode control counter reaches its terminal count (00Hex) as the leading edge of the target signal reaches stage S6. At terminal count the operation of the register changes from serial to parallel.

Parallel operation of the register still advances data in a serial fashion with one major difference. The data must now pass through the 8 channel gate structure between stages. This structure determines whether the target signal is allowed to pass or is reset by decoding the length select information. In this example. all target signals located in stages S7 and above are passed while signals in stages S6 and below are reset to zero. Therefore, in the example the target information is deleted. It should also be noted that parallel operation is continued until the target signal returns low.

One Line Delay (Drawing 10108495 Sheet 1)

The purpose of the one line delay circuit is to store one scan line worth of target data for comparison with the next scan line. a TDM alarm may be generated only when two targets compare within +/- 1 IFOV on two successive scan lines. One scan line is comprised of 2084 IFOV's. Therefore, the one line delay circuit coupled with the 16-bit register in the maximum target filter must store 2084 bits. The 2068-bit serial shift register (4-74 through 4-77, 4-82) is clocked by IFOV CK, it should be noted, is gated to contain exactly 2984 clock transitions/scan to achieve proper registration.

The output of the target comparator (4-80, 4-81) TDM' goes low only when the comparison criterion above is met and only when the TDM circuitry has been enabled (TDM ON=3.2v).

Black White Generator (Drawing 10108495 Sheet 2)

The black/white generator creates a TDM flag that is injected into the film recorder video signal. the flag consists of a delay followed by a white bar followed by a black bar each N IFOV's in length. The length N may range from 0 to 15 and is selected by the Flag Length TDM switch found at location 3-32.

Operation of the generator is best illustrated by example. Refer to the timing diagram in figure 3.3.6-4 during the following discussion.

In this example the Flag Length TDM switch is set to five. In the reset state the delay counter (3-29), the white bar counter (3-30), and the black bar counter (3-31) are each preset to count of five. The output of the control flip-flip (3-42 pins) is low holding both WHITE' and BLACK' high which is their off state.

When TDM' goes low, the control flip-flop changes state enabling the delay counter to decrement on each low-to-high transition of IFOV CK. When the delay count reaches zero its output (3-29 pin 12) goes high which disables the delay counter, enables the white bar counter, and causes WHITE' to go low on the next low-to-high transition of IFOV CK. Similarly when the white bar count reaches zero, the white bar counter is disabled, the black bar counter is enabled, and WHITE' goes high on the next IFOV CK clock cycle while BLACK' goes low. When the black bar count reaches zero, the black bar counter is disabled and BL;ACK' goes high on the next IFOV CK clock cycle causing the output of the control flip-flop to return to its low state.

The output of the edge mark generator (3-35) is set high whenever TDM' goes low. EDGE MARK causes a mark to occur on the edge of the film recorder data product. The signal is reset by the next RC SYNC.

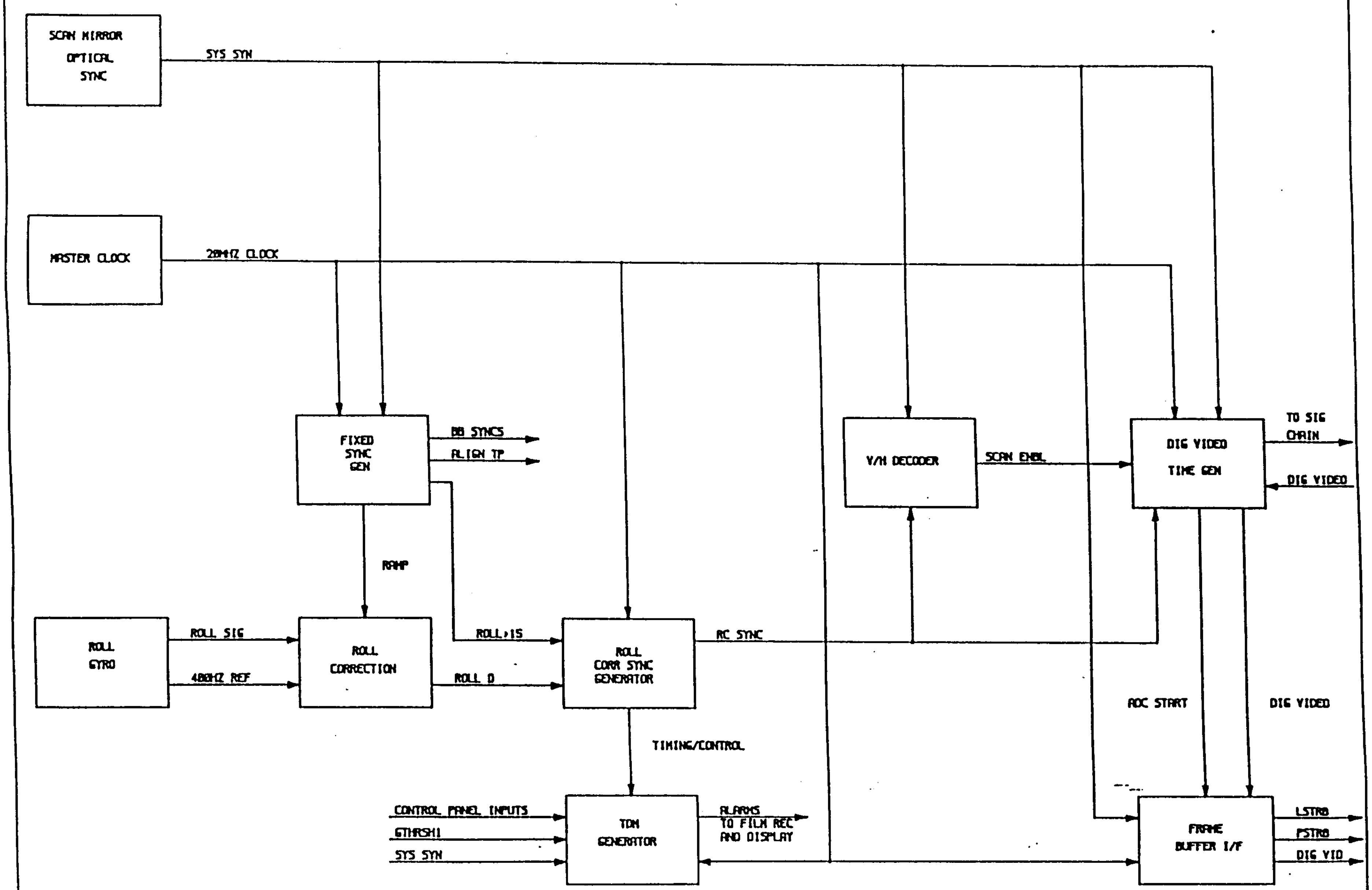
the aural alarm generator (3-35, 3-36, 3-37) creates an approximate one half second pulse to drive a sonalert each time TDM' goes low. The ALARM' signal is se thigh by TDM' enabling a two stage down counter which decrements on the rising edge of SYS SYN'. The counter is set to count 100 pulses before resetting ALARM'.

Test Target Generator (Drawing 10108495 Sheet 3)

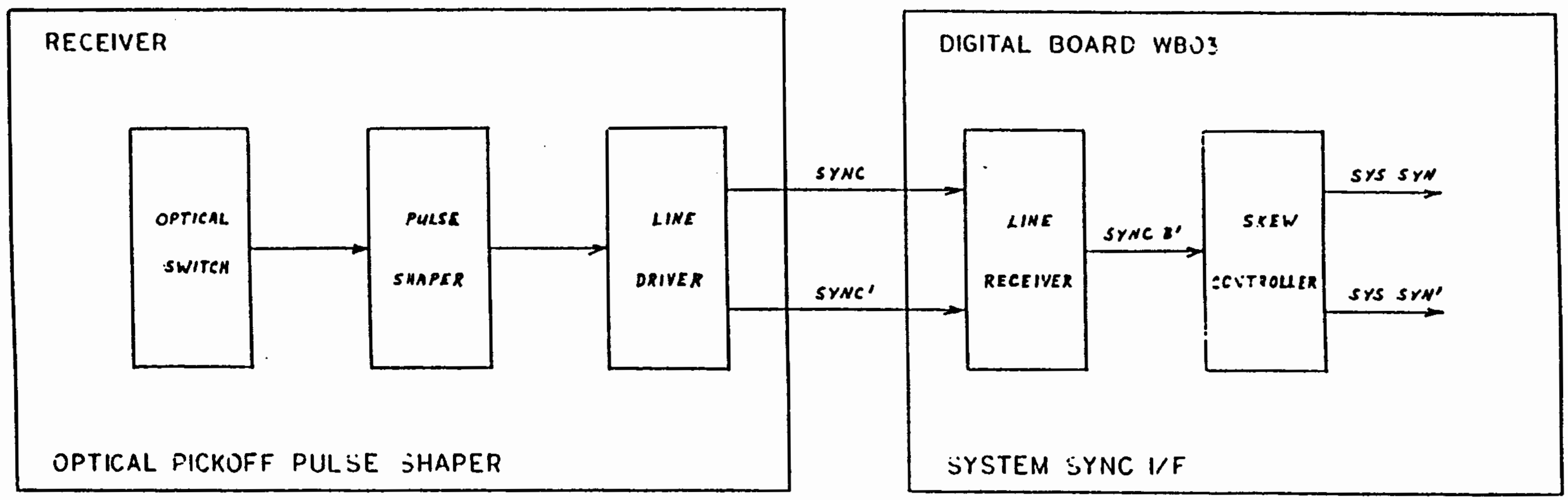
The test target generator provides the capability to test the operation of the TDM generator by simulating a target signal from the threshold detector. The test target width and skew are defined by two on-board switches as shown in Figure 3.3.6-5.

Activation of the test target generator occurs on the low-to-high transition of TEST STRB which occurs when the control panel switch labeled 'TEST' is momentarily depressed. Operation occurs over two successive scan lines creating a target signal N micro-second wide at the midpoint of the first scan line and another N microsecond wide signal delayed M micro-second from the midpoint of the second scan line. By varying the width and skew controls operation of all aspects of the TDM generator can be tested.

The remainder of the digital circuitry associated with the video display will not be addressed at this time.

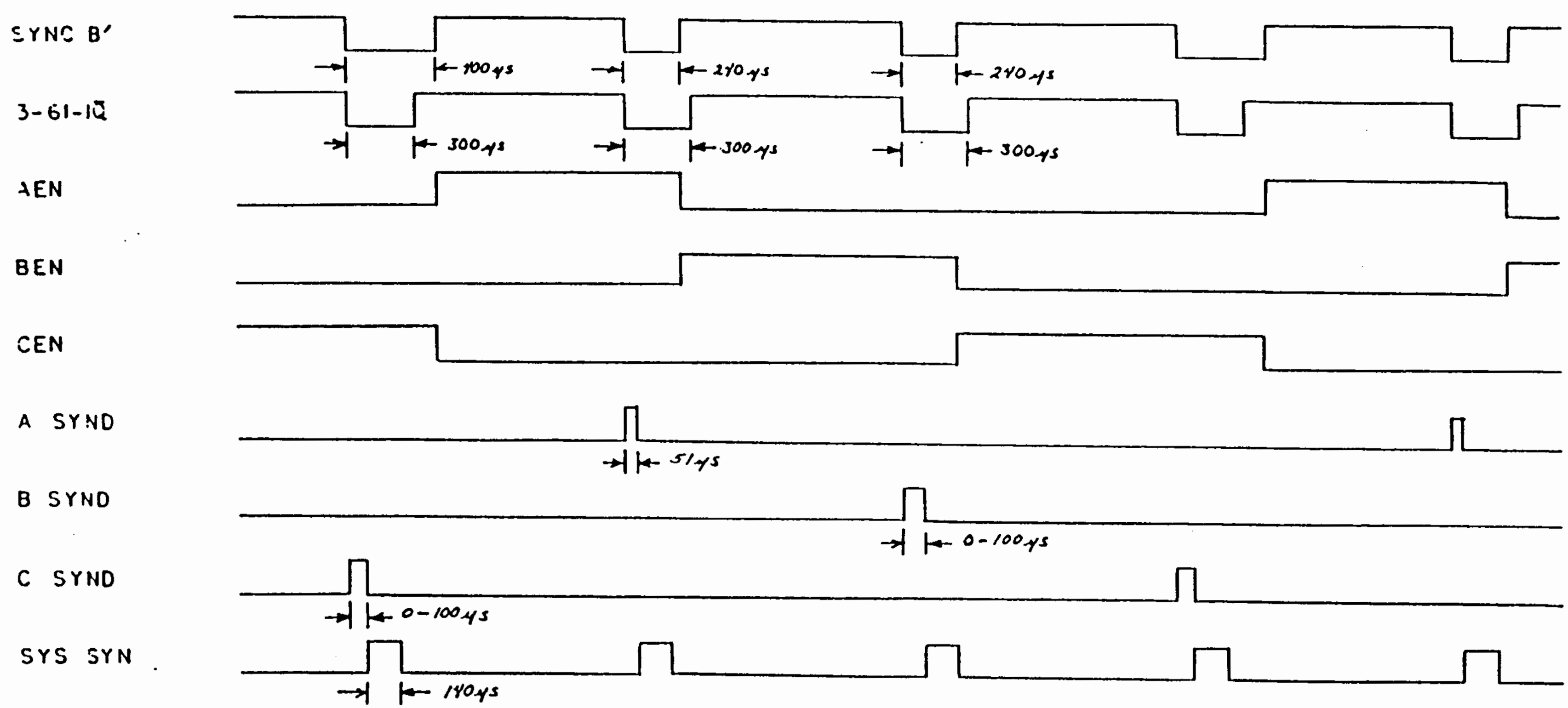


FLAME DIGITAL BLOCK DIAGRAM
FIGURE 3.2-1



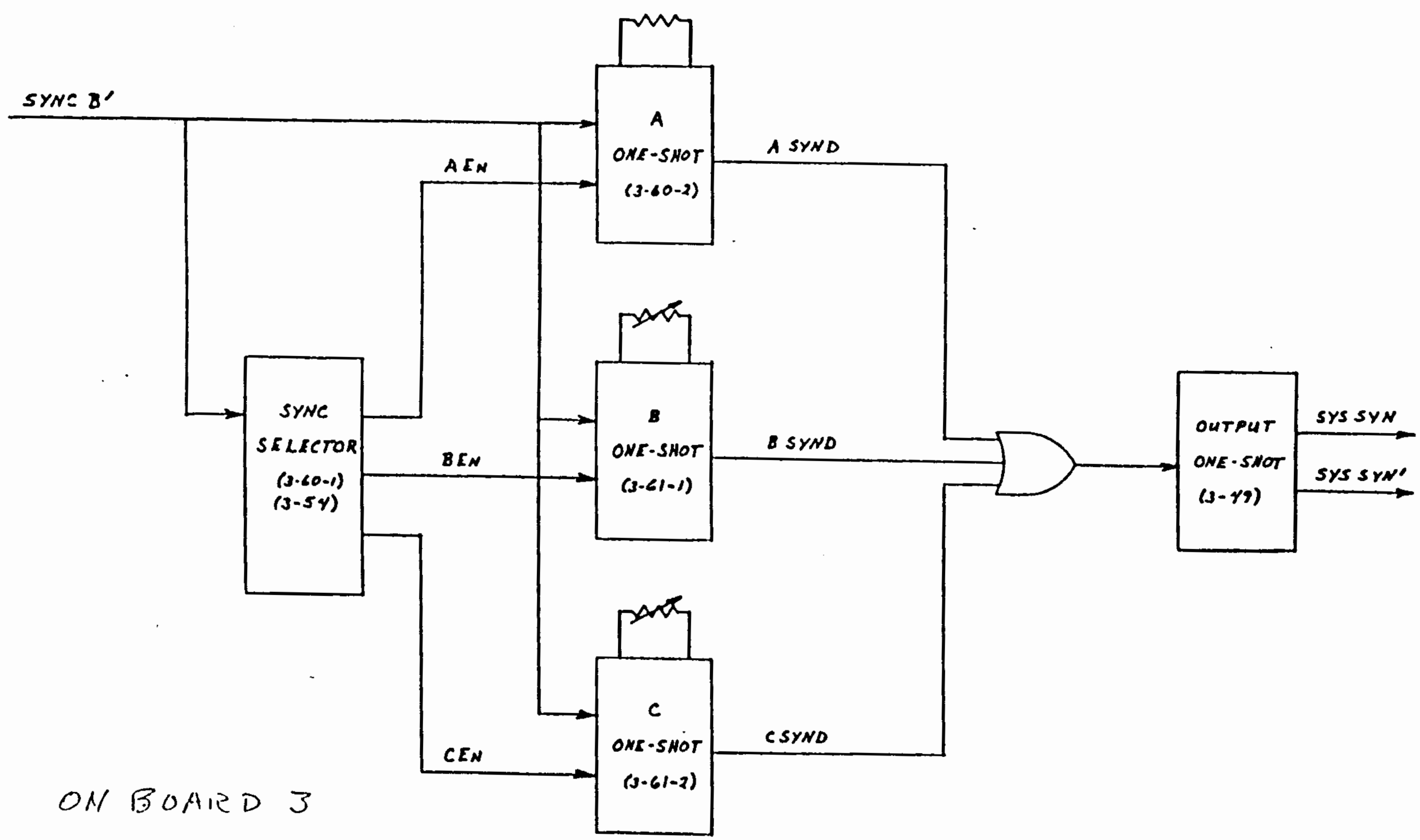
SCAN MIRROR OPTICAL SYNC INTERFACE BLOCK DIAGRAM

FIGURE 3.3.2 -1



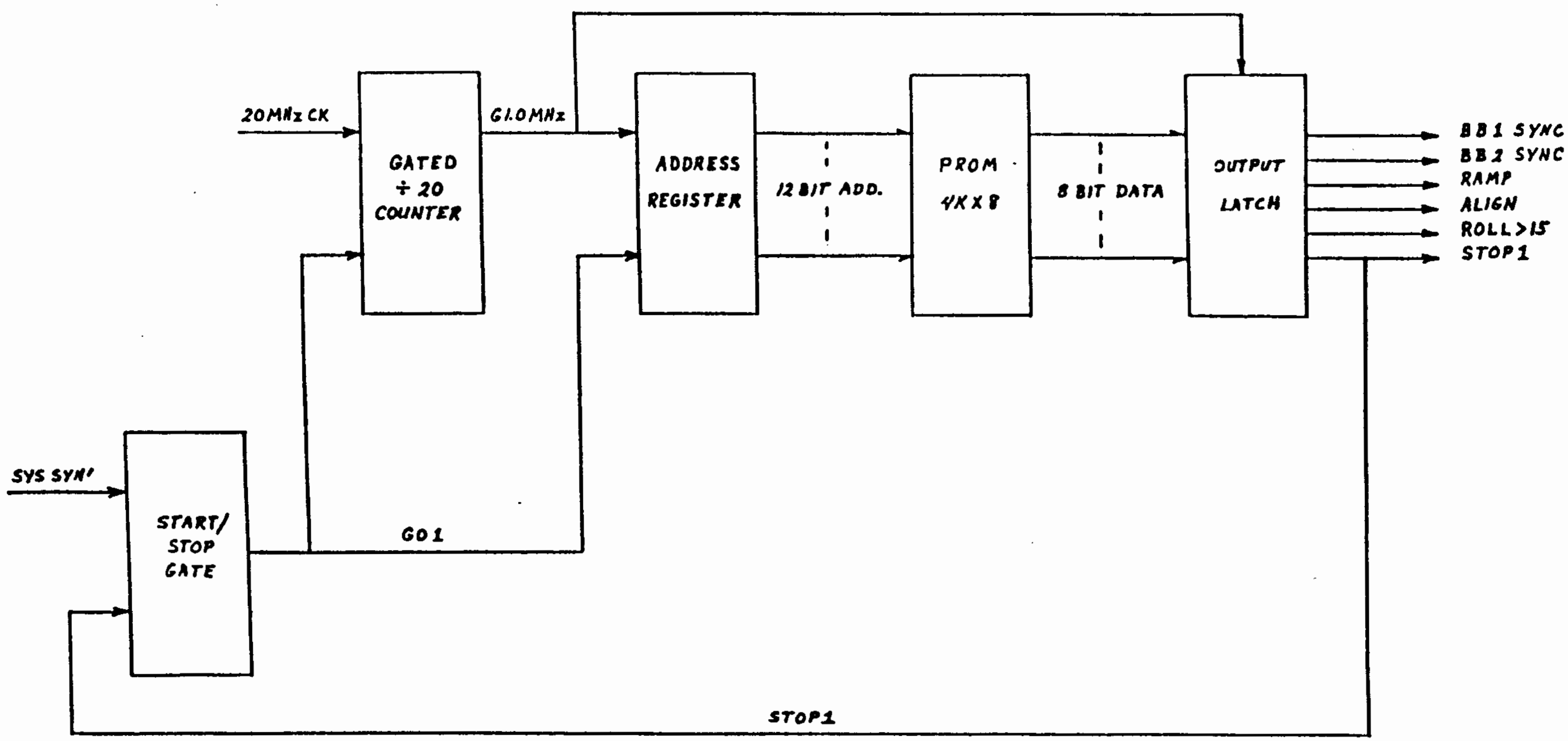
SYSTEM SYNC I/F TIMING

FIGURE 3.3.2-2



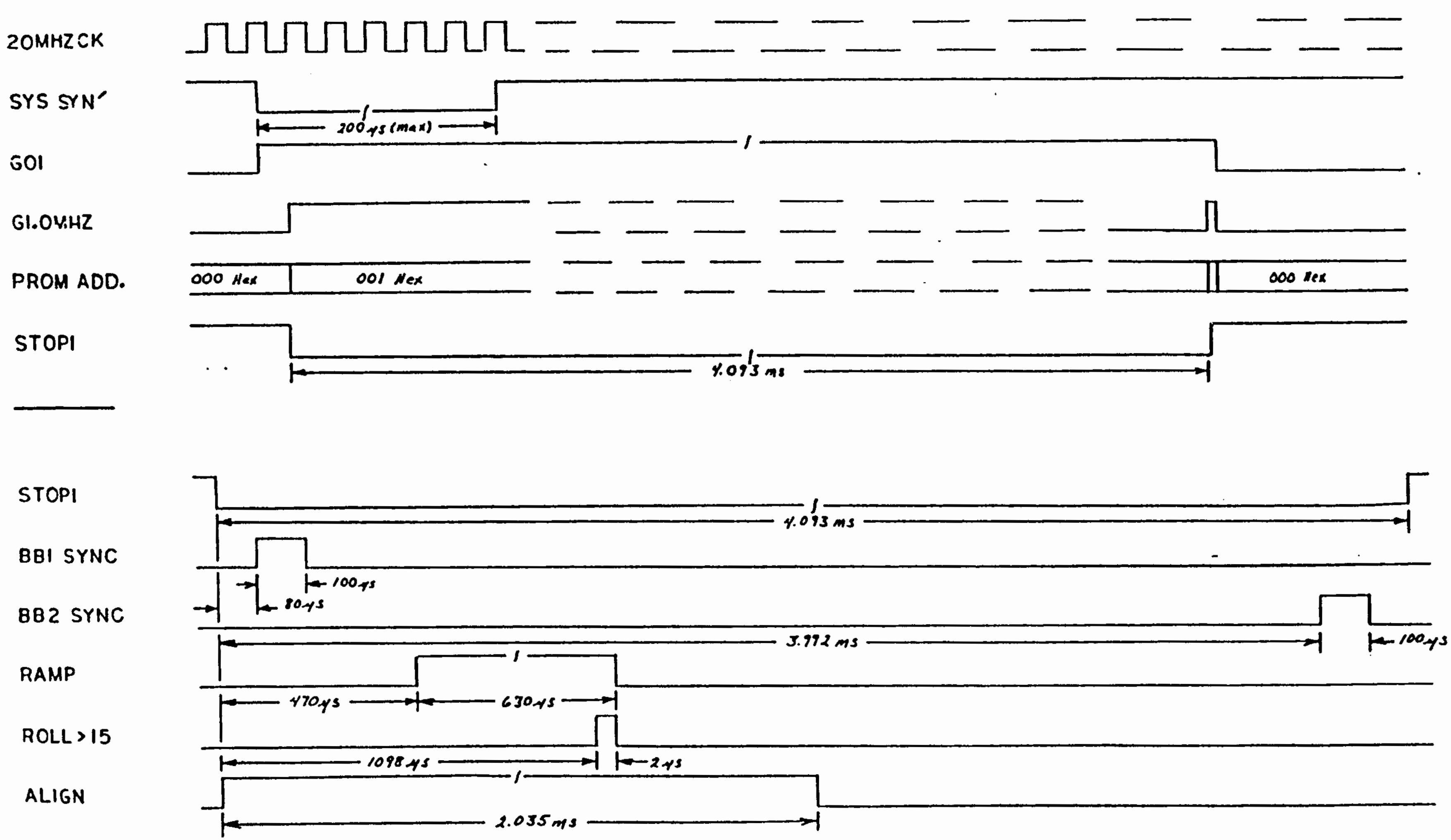
SKEW CONTROLLER

FIGURE 3.3.2-3



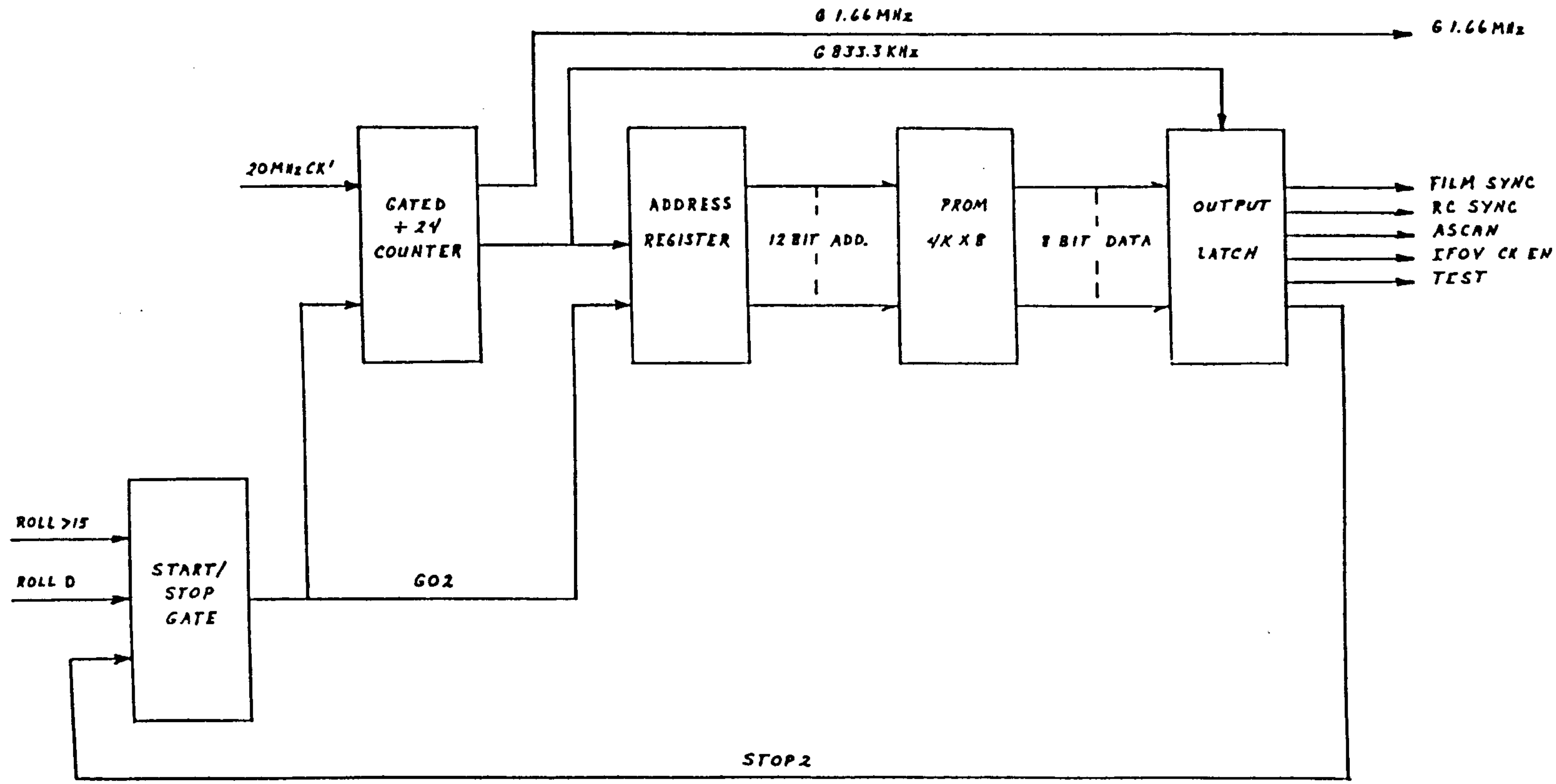
FIXED SYNC GENERATOR BLOCK DIAGRAM

FIGURE 3.3.3 -1



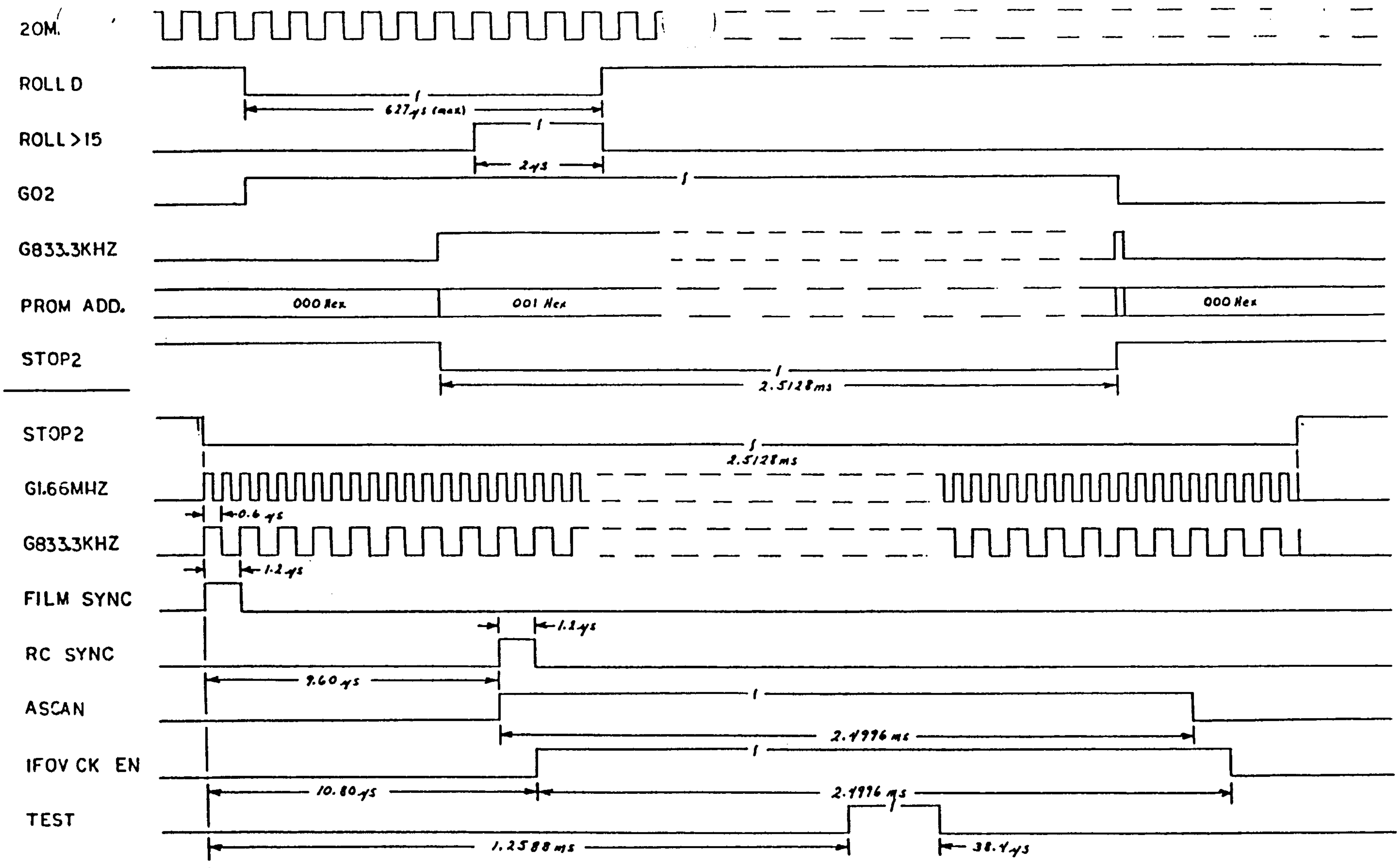
FIXED SYNC GENERATOR TIMING

FIGURE 3.3.3-2



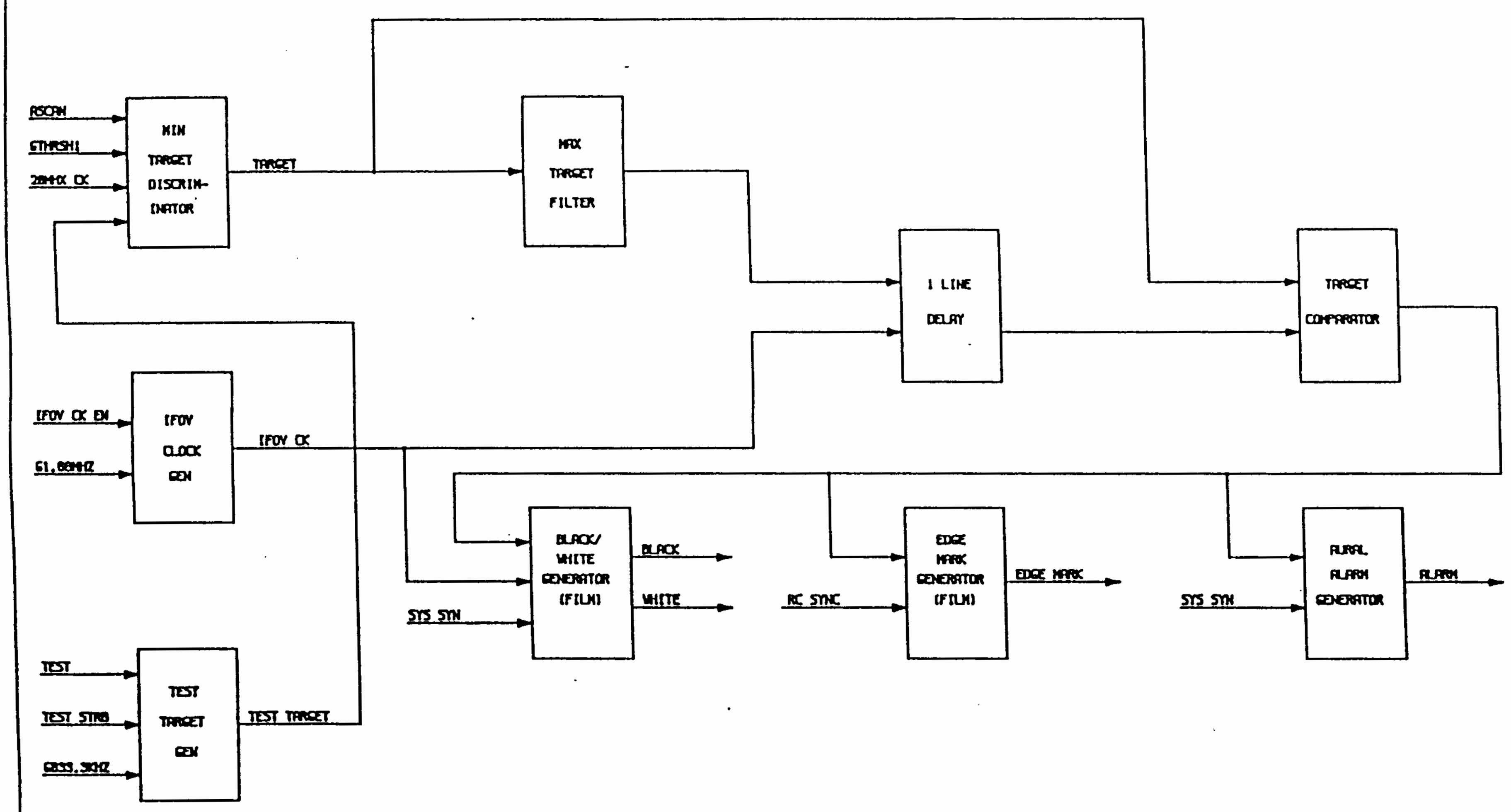
ROLL SYNC GENERATOR BLOCK DIAGRAM

FIGURE 3.3.5-1

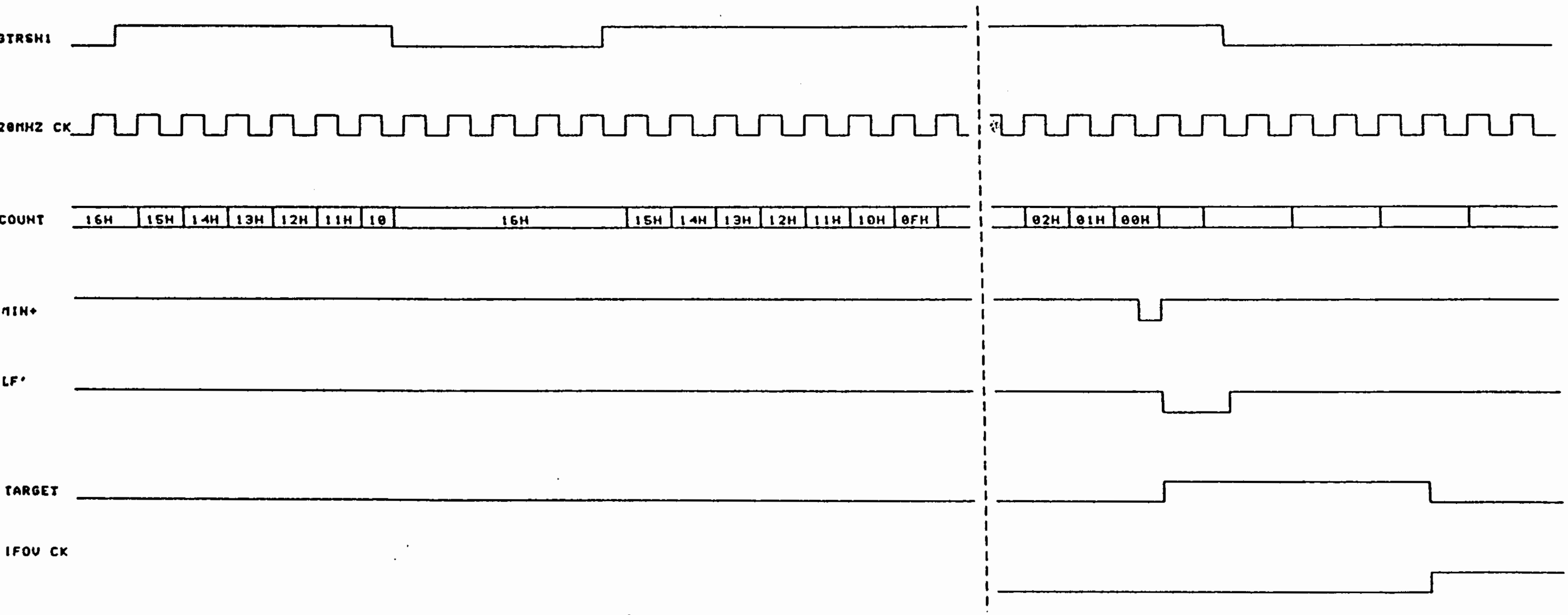


ROLL SYNC GENERATOR TIMING

FIGURE 3.3.5-2

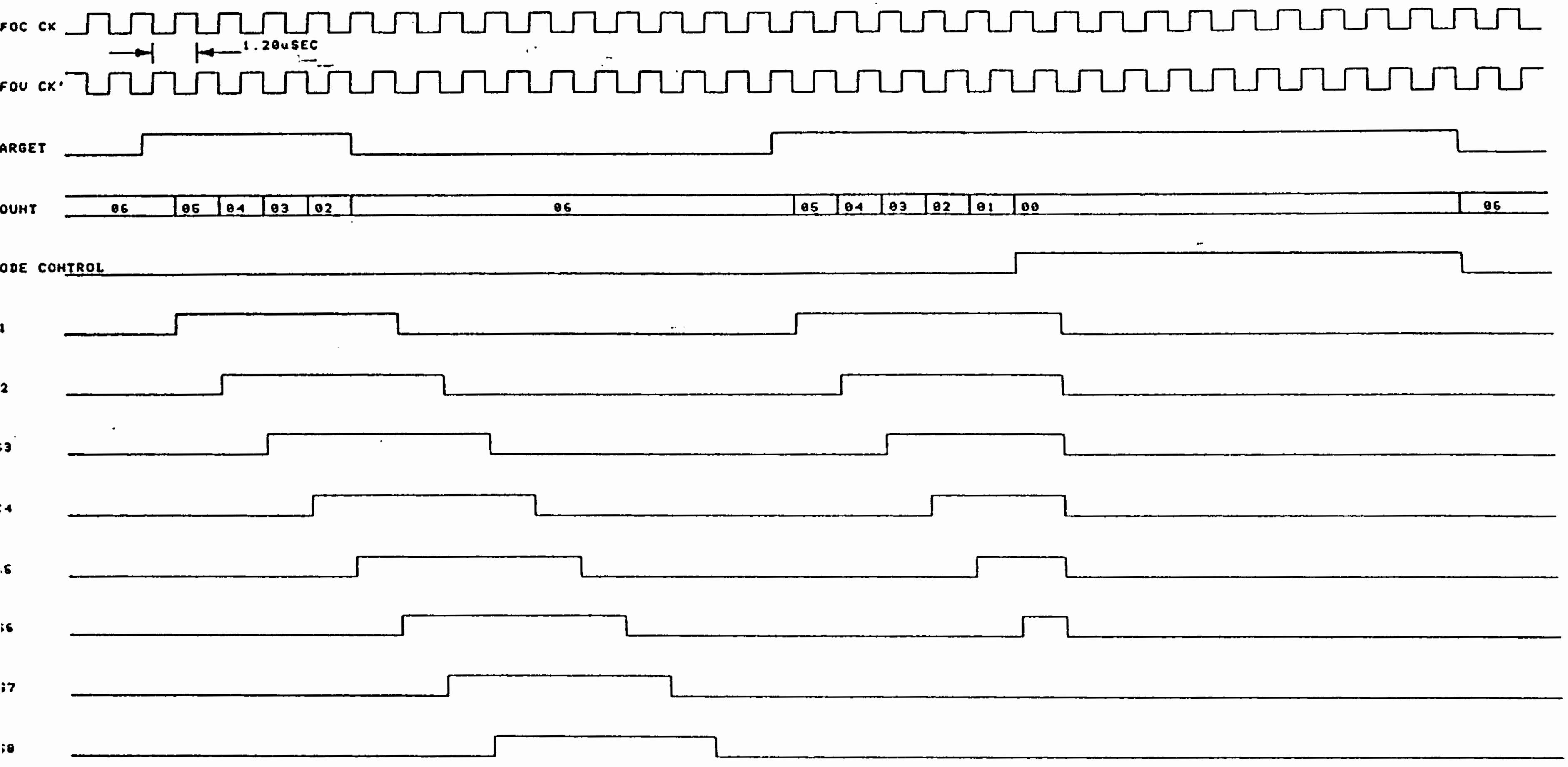


TDM GENERATOR BLOCK DIAGRAM
FIGURE 3.3.6-1



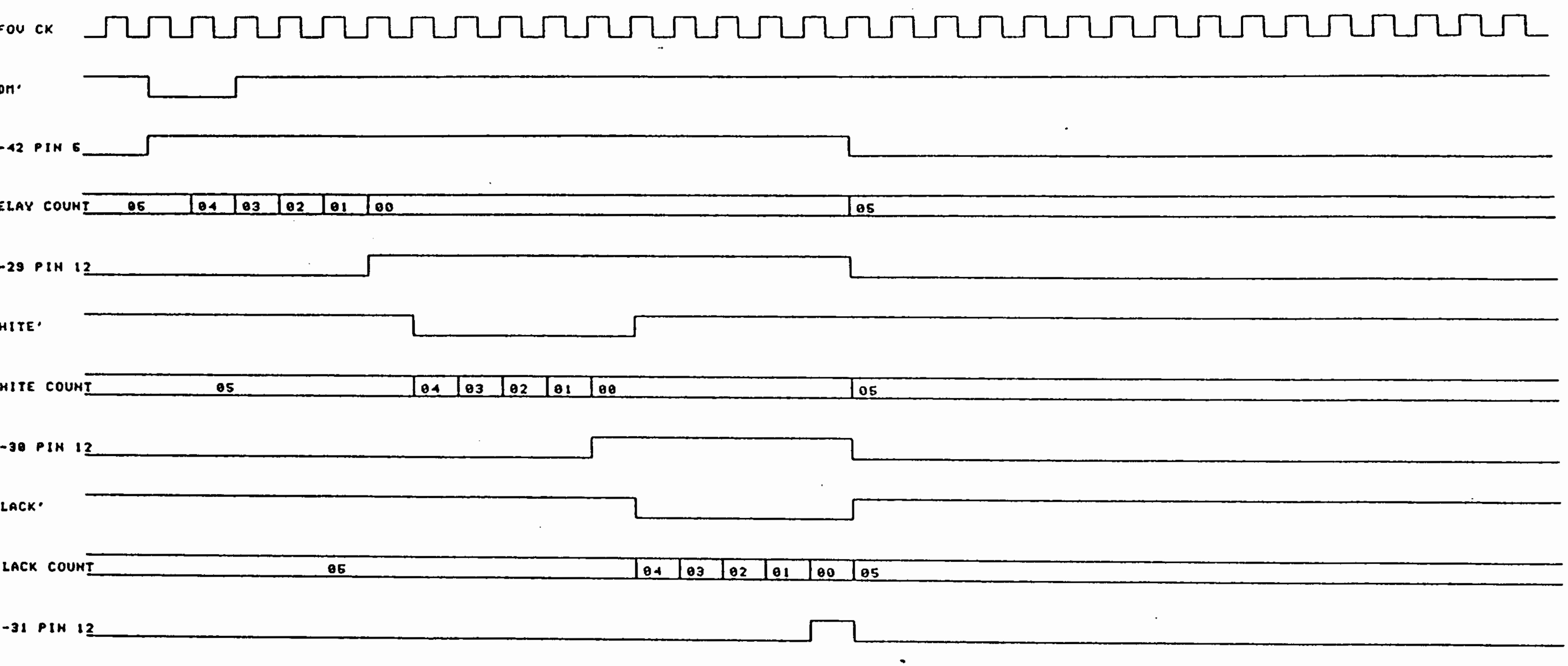
MINIMUM TARGET DISCRIMINATOR TIMING

FIGURE 3.3.6-2



MAXIMUM TARGET FILTER TIMING

FIGURE 3.3.6-3

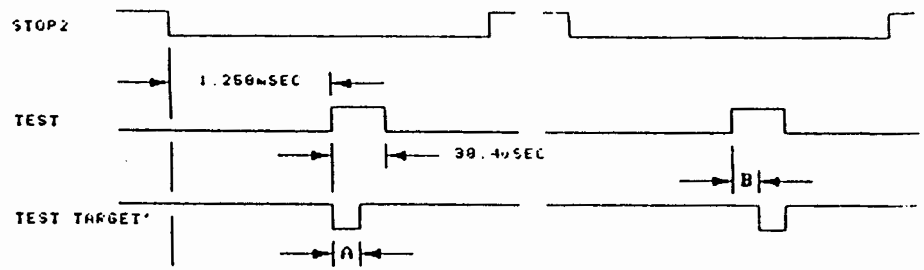


BLACK/WHITE GENERATOR TIMING

FIGURE 3.3.6-4

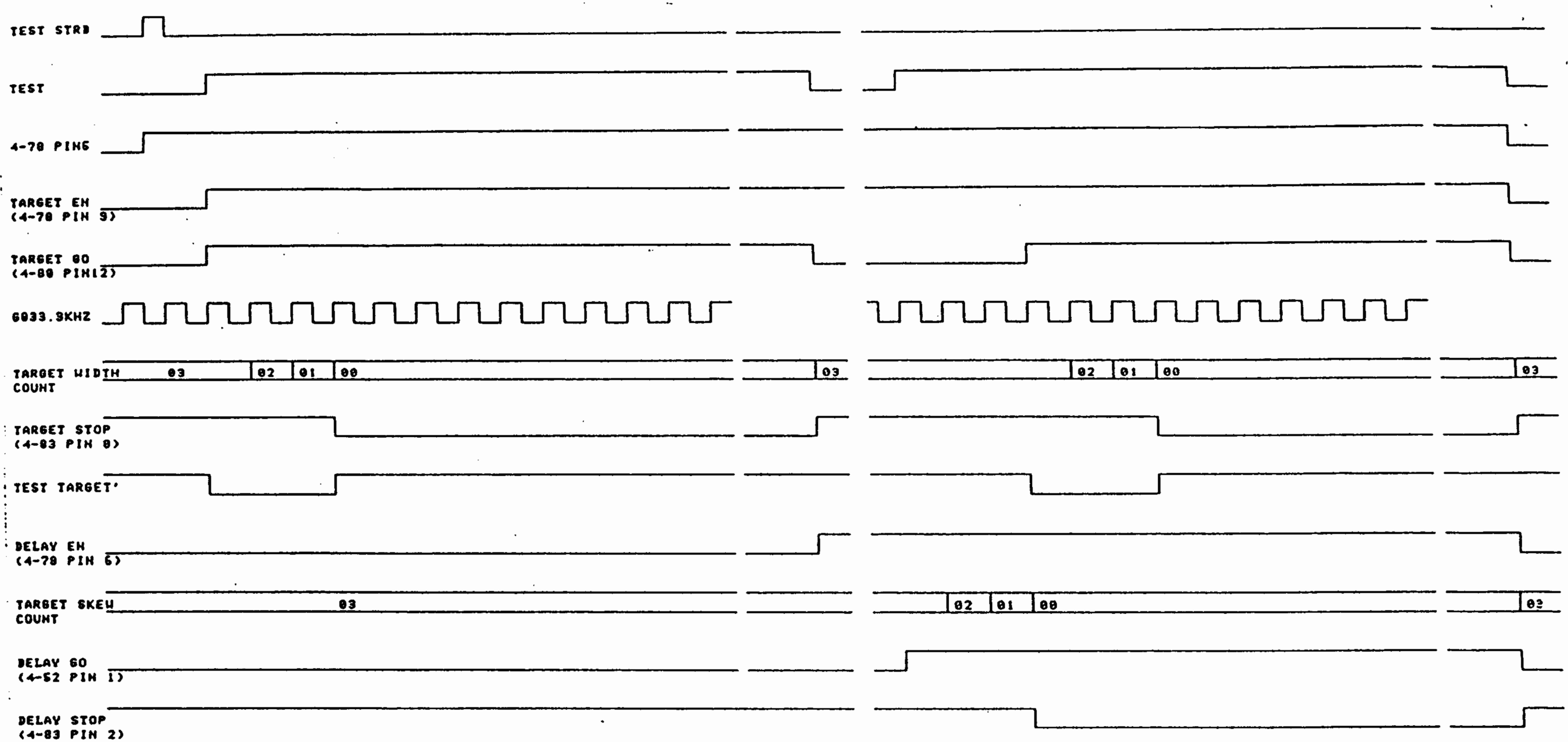
WIDTH CONTROL (4-64)	A µSEC
0	0
1	1.2
2	2.4
3	3.6
4	4.8
5	6.0
6	7.2
7	8.4
8	9.6
9	10.8
A	12.0
B	13.2
C	14.4
D	15.6
E	16.8
F	18.0

DELAY CONTROL (4-86)	B µSEC
0	0
1	1.2
2	2.4
3	3.6
4	4.8
5	6.0
6	7.2
7	8.4
8	9.6
9	10.8
A	12.0
B	13.2
C	14.4
D	15.6
E	16.8
F	18.0



TEST TARGET WIDTH AND SKEW CONTROL

FIGURE 3.3.6-5



TEST TARGET GENERATOR TIMING

FIGURE 3.3.6-6

TABLE 3.3.6-1

Maximum Length Select Switch	Deleted Target Length (IFOV)
0	None
1	None
2	None
3	None
4	None
5	>4
6	>5
7	>6
8	>7
9	>8
A	>9
B	>10
C	>11
D	None
E	None
F	None