17.0 THE RECEIVE SCOPE TRIGGER

Note: the timings shown are for the DMXter2 version of this code. Timings for the DMXter4 RDM version will be added soon.
The Receive Scope Trigger software is designed for detailed trouble shooting of DMX512 systems and for debugging of new designs. It is not generally needed by show electricians. With Scope Trigger it is possible to trigger an oscilloscope from certain important points within the DMX data stream. Proper use of this feature requires a detailed knowledge of DMX512 and the use of an oscilloscope. When executing Scope Trigger function, the DMXter cannot otherwise receive or analyze DMX512.

This feature consists of two parts, a software module and an optional external printed circuit card. (type number STC1A) Neither is of any use without the other.

17.0(1) Receive Scope Trigger Hardware

The STC1A card provides needed additional hardware to implement Scope Trigger.

Its features include:

* The TTL level trigger signal is on a BNC connector. It is switchable to either a hardware trigger circuit or the software 'arming' signal.
* The TTL level DMX512 data signal is on a BNC connector.
* A delay line in the data output allows viewing of the triggering event.
* EIA485 DMX512 repeater with the ability to optionally invert the data. This driver may be disabled to conserve battery life.
* A self contained, low drain, battery power supply with low battery warning LED.

Functionally the card converts the EIA485 DMX512 signal to a TTL signal. This signal is passed to one input of an 'exclusive or gate' where it is buffered or inverted, depending on the state of a control line from the DMXter. The control line from the DMXter is connected to the other input of the EXOR gate. The output of EXOR is connected to the clock input of a S latch. The S input of this latch is held high. The DMXter provides an 'Arm' signal which is connected to the reset line of the S latch. The DMXter sets the control line to the EXOR gate depending on whether the next trigger is to be on a rising or falling edge of the DMX line. The latch is held in reset until just before a triggering event is expected. It is then released; the next transition of the proper polarity on the DMX line will cause the trigger. After the DMXter software knows the trigger event has passed, it resets the S latch. The arm signal from the DMXter is sometimes also a useful Scope Trigger so it is selectable as the trigger output.

The triggering event to trigger out delay of this hardware is about 25nS. When enabled, the data delay line will add about 75nS of delay to the TTL data output. This should allow you to view the leading edge of the triggering event.

As well as the general resources of the microprocessor and its UART, the Scope Trigger uses certain hardware counters and timers available in this processor to produce highly accurate programmable delays.

17.0(2) Receive Scope Trigger Software

The behavior of Receive Scope Trigger is totally controlled by special software. The Scope Trigger user interface has fewer user warnings and error traps than the general DMXter code. This is because of both the nature of the code and the type of user we expect to use this code. Specifically there is no **'NO DIGITAL INPUT OR INPUT NOT DMX512'** message in Scope Trigger. Also if DMX data stops while the Scope Trigger is waiting for some important event to take place the software will patiently wait there until the event happens. Depending where in the code you are this may cause the user interface to freeze. To regain user interface control, restart the DMX data or exit by way of **<TOP>**.

17.1 TRIGGER ON THE START OF THE BREAK

OVERVIEW

This routine allows you to trigger a scope on the start of a DMX512 break. You will only get a stable trigger on DMX512 transmitters that send packets containing a consistent number of Frames. This routine should work on the vast majority of current production transmitters.

The DMXter arms the trigger card during the stop bits of the last slot of the previous packet. The Scope Trigger card produces a rising trigger when it detects the next falling edge. In a properly formatted DMX data stream that edge will be the beginning of the break. The trigger should be taken from the gated output of the card. This routine is equally useful with either analog or digital storage scopes.

INTERFACE

The entry point is | START OF BREAK? |. On entering you will see the following display

```
  START OF BREAK
UNSTABLE   SLT:
```

If no DMX512 is being received, this display will be steady. If you are receiving DMX512 the number of slots in the packet will appear in the DIM field, and if the number of dimmers in each packet is stable the UNSTABLE field changes to STABLE. Trigger generation starts after the DMXter determines that the number of slots is stable. A stable display of a console sending 504 slots is

```
START OF BREAK
STABLE   SLT: 504
```

If the transmitter should switch to a different packet size the STABLE field will momentarily change to **UNSTABLE**, the number in the **SLT** field will change and the display will change back to **STABLE**. The **UNSTABLE-STABLE** field is one shot so even a single packet with a different slot count should be observable. If the transmitter is intermingling packets of different lengths, the field will stay showing **UNSTABLE**. The algorithm used for this trigger mode does not work with changing packet lengths. Note: If you totally lose DMX512 the display will not change, it just acts as if the packet was being sent very slowly. But you should be able to figure it out, you do have a scope connected to the line, don't you?

ALGORITHM DETAILS

The software requires that three packets have the same number of frames for the packet length to be considered stable. The arm signal goes high 2.5µs - 2.9µs into the first stop bit of the last frame of the packet. The trigger will be generated on the next falling edge. Obviously no break qualification is possible.

17.2 TRIGGER ON THE END OF THE BREAK

OVERVIEW

This routine is designed to trigger a scope at the end of a break that lasted at least as long as a minimum time set by the user. When the DMXter detects a frame with a framing error that it believes to be a break, it times from the leading edge of that frame: if when the amount of time set by the user has passed we are still in break, the trigger card is armed. The next rising edge of the DMX line will produce a rising trigger on the BNC connector. On analog scopes this is useful for observing the Mark After Break. Additionally on DSO's you may use this routine to observe breaks that cannot be reliably viewed with the routine of 17.1 above. This routine should be reasonably well behaved on most transmitters with either type of scope.

INTERFACE

The entry point is |END BREAK/START MAB?|. On entering you will see the following display

```
END BREAK/START MAB
TRIG ARM AT    65 uS
```

Note the cursor under the 6; you may move it using the **<RIGHT>** and **<LEFT>** keys. Whichever number or space the cursor is under may be edited using the **<UP>** and **<DOWN>** keys. If the cursor is under the one's place the **<UP>** key will increment the number by one with a carry to the ten's place if needed. If the cursor is under the ten's place the **<UP>** key will increment the number by ten with a carry to the hundred's place if needed. Pressing the **<DOWN>** key will decrement the proper place; if an underflow occurs the number will be set to 65µs . The default value for the arm delay is 65µs. Any value up to 16383µs may be selected. Once you have selected a value it will be saved as long as battery power is maintained. All trigger modes other than TRIGGER ON THE START OF THE BREAK use the arm delay and share the same value for it.

ALGORITHM DETAILS

To be considered a possible break a frame must be missing both stop bits, and the data slot must be zero. The line must stay low until the time set by the user has passed. Then the break is considered valid and the arm signal is set. The time is measured from the falling edge at the start of the break. The trigger will be generated by the rising edge. To allow for worst case latency in the break time the timer is offset by a small amount. This latency has a certain amount of jitter. On most packets if the trigger is set to arm at 65µs the arm signal will actually go high 63.5µs after the leading edge of the break. Generally this will mean that the break is one micro second shorter than the maximum setting that gives a break trigger. If the break starts to be displayed as the delay is decreased from 90 to 89 µs the true break length is 88µs.

17.3 TRIGGER ON THE BEGINNING OF THE START CODE

OVERVIEW

This routine is designed to trigger a scope at the beginning of the START Code if the break has lasted at least as long as a minimum set by the user. When the DMXter detects a break, it times from the leading edge of that break; when the amount of time set by the user has passed, the trigger card is armed. The next falling edge of the DMX line will produce a rising trigger on the BNC connector. This is useful for observing the START Code and as a general trigger at the beginning of a packet.

INTERFACE

The entry point is |BEGIN OF START CODE?|. On entering you will see the following display

```
BEGIN OF START CODE
TRIG ARM AT    65 uS
```

The interface behavior is identical to that for **END BREAK/START MAB**.

ALGORITHM DETAILS

Other than generating a trigger on the falling edge this routine is identical to the **Trigger on the End of the Break.**

17.4 SLOT TRIGGER

OVERVIEW

The SLOT TRIGGER routine is actually a number of powerful trigger routines selectable from a bar menu. The main thrust of these routines is to allow you to trigger on any slot in a DMX512 packet. The trigger is generated when the 'AND' of three conditionals is true. An important thing to keep in mind is that the trigger is generated only AFTER a slot in the DMX packet has satisfied all of the conditions.

The qualifiers for the START Code are: equal(**=**), not equal (**≠**), or don't care (**----**).
For slot number they are: equal (**=**), or don't care, (**----**).
For slot level they are: equal (**=**), greater than (**>**), less than (**<**), not equal(**≠**), or don't care (**----**).

Getting these routines to do what you want will require careful understanding of what they do. Unlike the other trigger routines all of these routines cause the receiver to read the DMX data and store it in the slot table. All of these routines will run in either a continuous mode or a single shot mode. In the continuous mode a trigger is generated every time the condition is met; in the single shot mode only one trigger is generated. In the continuous mode all packets are written to the slot table; in the single shot mode, reception stops at the end of the first packet that satisfies the conditional trigger.

INTERFACE

The entry point is SLOT TRIGGER? |. On entering you will see the following display

```
MIN BREAK IS    65uS
  CHANGE IT?
```

This allows you to set the shortest break that may be received for a packet to be further analyzed. After you have changed the break or bypassed doing so you will enter the main bar menu.

```
STCD SLT  LEV  CAPT
-___ =  1 ____  CONT
```

17.4(1) Triggering after a Slot

These are the default settings and this is the most common mode of operation. These settings cause a trigger to be generated on every packet, regardless of START Code, after slot 1. On an analog scope or DSO set to view post trigger you will see the start bit of slot **2**.

The slot number may be set from 0 to 512. To set the slot number, move the underline cursor with the **<RIGHT>** and **<LEFT>** keys. Place the cursor under the digit you wish to change. If the cursor is under the one's place the **<UP>** key will increment the number by one with a carry to the ten's place if needed. If the cursor is under the tens place, the **<UP>** key will increment the number by ten with a carry to the hundred's place if needed. Pressing the **<DOWN>** key will decrement the proper place; if an underflow occurs the number will roll over to the highest allowed number, in the case of slot 512.

If you want to view slot 1, set the number to 0. Setting the number equal to the number of slots sent will cause a trigger on the start of the break of the next packet. The reason we display the slot that causes the trigger and not the slot that will be viewed is so that we may have consistency with the rest of the slot trigger modes. If one is looking at the next slot the trigger will almost always be taken from the gated trigger signal from the BNC connector. If you are using a DSO to look backward in time at the slot that caused the trigger you may find that the arm signal gives less jitter. The difference between these two signals is that the Arm signal is precisely delayed from the start bit of the arming slot, while the gated trigger is synchronous with an edge in the next slot.

TIMING DETAILS

With the START Code and the level entries set to 'don't care' the delay from the rising edge of the stop bit of the triggering frame to the generation of the arm signal is 3µs.

17.4(2) Trigger on Packets with START Code 'x'

STCD stands for START Code. Setting the cursor under any one of the STCD spaces and pressing **<UP>** will cause the START Code to come out of 'don't care'. On entry the START Code will be set to the DMXter present START Code setting, generally

```
STCD SLT  LEV  CAPT
=  0 =  1  ---- CONT
```

Now the trigger will be generated only for packets that have a zero START Code. Any slot number may be selected, but there are timing limitations on triggering on slot zero in this mode, meaning that for general viewing it is better to start with slot 1. See the timing details below.

The allowed qualifiers for a START Code are equal and not equal. The latter may be used with the single shot mode (**ARM**) to capture suspect corruptions of the START Code.

Try placing the **SLT** field into the 'don't care' state. Do this by placing the cursor under the = sign and pressing either **<UP>** or **<DOWN>** keys. You will note that **LEV** field comes out of 'don't care'. Only one of the SLT or LEV fields may be in 'don't care' at the same time.

TIMING DETAILS

The delay from the rising edge of the stop bit of the triggering frame to the generation of the arm signal depends on which slot generates the trigger. If we are triggering on slot 1 through 512, the delay is 3µs.

If the trigger is set to SLT the delay is 11.6µs. On an analog scope you may lose part of the first slot after the trigger depending on the amount of interslot time in the packet. You will lose less if you switch to triggering on the arm signal.

17.4(3) Triggering If Any Slot Is at Level 'X'

Leave the **SLT** field in the 'don't care' state, select the START Code value you want, including 'don't care'. The setting of the START Code will determine which packets will be checked for levels. This mode is novel in that multiple triggers may be generated by a single DMX packet. Each slot is evaluated and a trigger is generated whenever the qualified level is matched. The qualifiers for levels are: equal (**=**), not equal (**≠**), level greater than (**>**), and level less than (**<**).

This is a mode where the fact that a trigger occurred may be all you wish to know, so consider using the single shot mode. If multiple triggers occurred you may be more interested in where they were than what the data was. You might consider viewing the trigger signals directly. Certain timing restrictions also must be pointed out. (Yeah, we wish we didn't have them too.)

TIMING DETAILS

The delay from rising edge of the stop bit of the triggering frame to the generation of the arm signal with the level check set for = or ≠ is 16.8µs. If the level check is set for < or > the delay is 17.6µs.

17.4(4) Triggering Slot'X' Is at Level 'Y'

If you enable both the **SLT** and the **LEV** fields at once the trigger will be generated after the indicated slot if it meets the level restrictions.

17.4(5) Using the One Shot Mode

The single shot mode is controlled by the last field. Placing the cursor under any one of the bottom line spaces beneath **CAPT** and pressing either **<UP>** or **<DOWN>** will change the **CONT** flag to **ARM**. This flag will stay showing **ARM** until the trigger conditions are met, then it changes to **TRIP**. At that time a single trigger is generated and the packet containing the trigger is preserved in the slot table. At this point you may wish to temporarily leave the **SLOT TRIGGER** to view the captured levels. You may do this by pressing **<YES/Q> <DOWN> <YES/Q>**. You may return to the **SLOT TRIGGER** without losing your setup with the one exception that the **TRIP** flag will be replaced by the **CONT** flag.

17.4(6) USING HEX NUMBERS IN RECEIVE SCOPE TRIGGER

If the DMXter is set to display in hexadecimal, the START Code and slot levels will be displayed as a two-digit hex number followed by a lowercase 'h'.

17.5 VIEW CAPTURED LEVELS

OVERVIEW

This routine allows you to view data stored in memory by the SLOT TRIGGER software above. The data that will be displayed is the last packet received. If you have not run SLOT TRIGGER since you entered the Receive Scope Trigger menu, the data in the slot table will be whatever was left from the last time transmit or receive functions of the DMXter were used. The only Scope Trigger routine that writes slot level to the slot table is SLOT TRIGGER.

INTERFACE

The entry point is |VIEW CAPTURED LEVEL?|. The interface for this routine is the same as VIEW LEVELS.

17.6 FRAMING ERROR TRIGGER

OVERVIEW

The **FRAMING ERROR TRIGGER** has a dual nature. If either or both of the two stop bits are missing from a frame and the data slot is not zero, a trigger is generated. No further time qualification is required. If both of the stop bits are missing, the data slot is zero, and the line goes high (marking) before the time set by the user, a trigger is generated. The trigger pulse is generated when the time delay expires. In many ways this is the inverse of the minimum break qualification routines (above) that require that a break lasts at least as long as the time set by the user for a trigger to be generated.

INTERFACE

The entry point is |FRAME ERROR TRIGGER? |. On entering you will see the following display

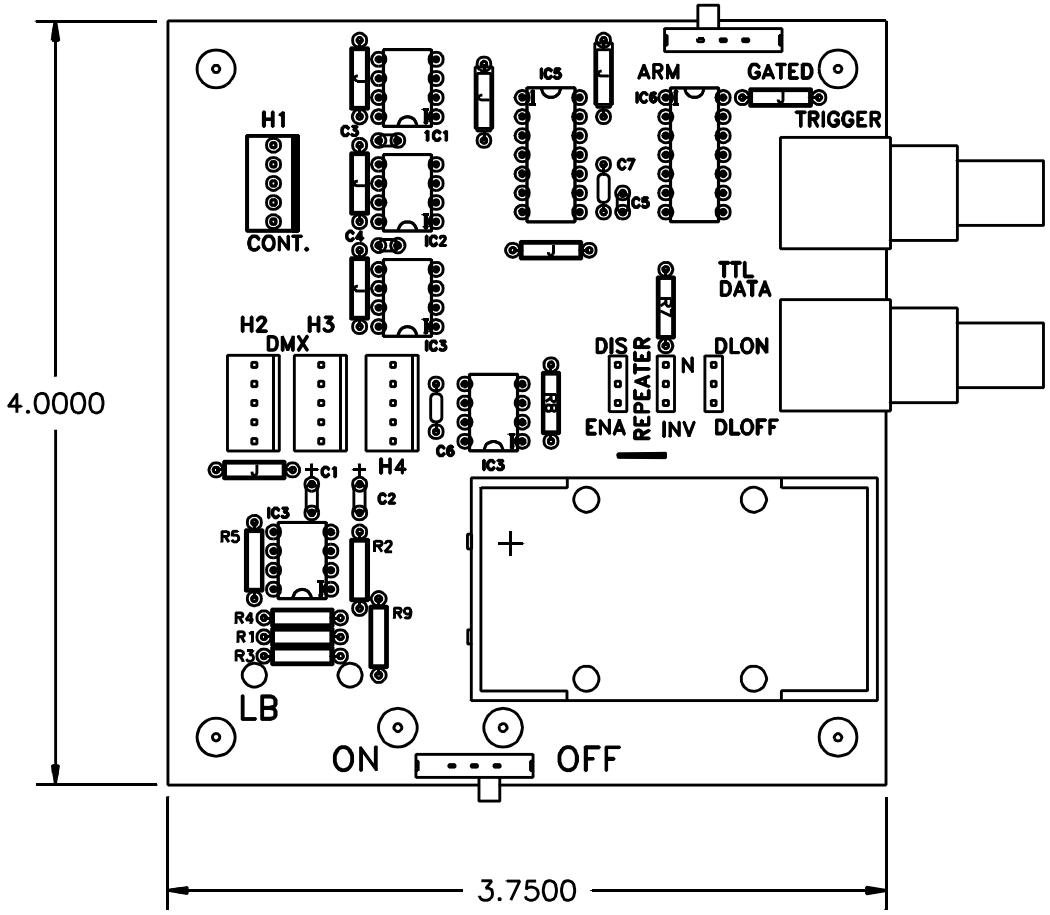
```
FRAME ERROR TRIGGER
  ERROR <       65 uS
```

This routine has a number of uses in tracking down glitches on a DMX512 line. Another use is to generate a trigger signal a precise time after the start of a DMX packet.

For normal use the gated trigger output produces a pulse with the needed accuracy. Using the arm signal may produce slightly more predictable timing. The framing error trigger is output about 4µs after the timer runs out. The trigger output is a short positive going pulse lasting approximately 2.5µs.

17.7 FURTHER HARDWARE DETAILS

Header Connections:



H1, Control: This header carries the Scope Trigger control signals from the DMXter to the STC1A card. It should be wired to an A5M connector plugged into the **DMX-512 OUT** connector on the Scope Trigger equipped DMXter. All header to 5 pin cables should be wired one for one.

1	Shield
2	- Arm
3	+ Arm
4	- Phase
5	+ Phase

H2 - H3, DMX512 Data: Headers H2 and H3 are wired in parallel. H2 should be wired to the DMX source under test. H3 should be wired to an A5F connector plugged into the **DMX-512 IN** connector on the Scope Trigger equipped DMXter.

1	Shield
2	- DMX
3	+DMX
4	- Aux.
5	+ Aux.

H4 Repeater: This connector is the output of the DMX repeater. In Scope Trigger mode the DMXter always terminates the DMX512 line. Hence if you need to simultaneously use the DMX signal under test and cannot tolerate double line termination you will need to use the built in repeater. The repeater is controlled by two sets of programming jumpers. The **DIS**able - **ENA**ble jumper block controls whether the repeater is enabled or tri-stated. The **N**ormal - **IN**verted jumper block controls whether the data is passed normally or inverted. This repeater is shipped disabled since its use shortens battery life. The scope card draws only about three to 4 MA. Driving a terminated DMX line draws about 25 MA additional.

1	Shield
2	Repeater out -
3	Repeater out +
4	Aux. - (jumped to H3-4)
5	Aux. + (jumped to H3-5)

The Delay line: The jumper block marked **DLON - DLOFF** controls whether a deliberate delay of about 75nS is introduced into the DMX data output on the BNC connector. Units are shipped with this delay enabled.

Getting The ARM Signal:
On the current version of the Scope Trigger card (STC1A R2)a switch on the edge of the card near the trigger BNC connector selects whether the **GATED** trigger or the **ARM** signal is available on the BNC connector.