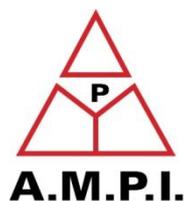# Master-9

Programmable
Pulse Stimulator

User Manual

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Thank you for purchasing **Master-9 - the best pulse stimulator!**

Master-9 is an advanced 9-channel pulse stimulator that offers many distinct and useful features.

Master-9 is user friendly, easy to learn, and simple to program using user-preprogrammed paradigms.

Please read this manual carefully and familiar yourself with all of **Master-9** unique and advanced options.

Table of Contents

1 General

Master-9 is a 9-channel pulse stimulator designed for nerve and muscle stimulation procedures and a broad range of neurophysiological stimulation requirements.

1.1 Outputs

Each channel delivers repetitive, single, train or twin outputs. The outputs can be set to monophasic and biphasic pulses and ramp outputs.

All channels can be operated independently of each other, or synchronized to produce simple and complex pulse patterns.

You can use some channels to stimulate your preparation, while using other channels to trigger other instruments (oscilloscope, PC, etc.) in synchronization with the stimulation.

1.2 Paradigms (chapter 11)

Master-9 stores nine user-preprogrammed experiments (paradigms). Each paradigm can use all nine channels. You can easily switch your setup to the selected paradigm.

This feature is very useful in the following cases:

- When the current protocol requires modifications during the course of the experiment. You can preset the modifications in different paradigms and then switch between the experiments easily.
- When several users of a setup run different experiments. Each user can retrieve his specific settings from the Master-9 memory.

All parameters of the 9 paradigms are stored in the memory even after the power is switched off.

1.3 Controlling the Master-9

You can control the Master-9 as follows:

1. As a standalone unit – via its touch screen

2. Via your PC – using our **MASTER-9 CONTROL** software

3. From within your own application – using the **Master-9 SDK**

1. **Controlling Master-9 via the touchscreen (chapter 3)**:
   The touchscreen (TS) on the front panel displays all modes of operation and time parameters, as well as a table of the internal connections between channels. You can set the channel parameters by touching the TS with your finger or any stylus pen or standard pen. Do not touch the screen with ink or sharp tools!

2. **Controlling Master-9 via your PC, using our MASTER-9 CONTROL software**:
   You can see and modify all the parameters directly on your PC monitor using the **MASTER-9 CONTROL** Software.
   Scheduler: The Scheduler is another powerful feature of this software. This tool allows you to set a series of events to occur at scheduled times, such as triggering channels, switching paradigms, modifying time parameters, etc.

3. **Controlling Master-9 from within your own application (Master-9 SDK)**:
   You can also program and control your experiment from within your own application or software (LabView, Matlab, VBScript, etc.). Using the **Master-9 SDK** (Software Development Kit) you can easily access all instructions of Master-9 in real-time from your application or software, providing real-time feedback from your preparation.

1.4   Firmware Upgrades

Master-9 can be upgraded at any time with our firmware upgrades.
From time to time, be sure to check our website for new upgrades. Downloading and upgrading your Master-9 is free of charge.

1.5   External Waveforms

Channel 9 can save external waveforms in two ways:

1. You can set an Excel file with the desired waveform and download it to channel 9 via the USB cable.

2. Channel 9 can record input waveforms (such as action potential, sine wave, etc.). The waveform can be recorded from an external source via the IN9 input. The waveform is saved in the memory of channel 9.

The saved waveform can be replayed in all the operational modes – FREE-RUN, TRIG, TRAIN, and TWIN modes.

1.6   Combined outputs: OUT A, B, and C

Using the connection table you can connect any combination of channels 1 - 9 to each other and to each of the outputs A, B, and C. This way you can have complex patterns through a single output.

1.7   External inputs: IN 1, 2, and 3 (chapter 8)

Channels 1, 2 and 3 can receive external trigger inputs through the IN 1, 2, 3 inputs. This enables the synchronization of channels with external devices.

1.8   Clocks (chapter 15)

In addition to its 9 channels, Master-9 features 2 internal clocks. The first counts the time in seconds up to 24 hours, while the other counts time in tenths of seconds, up to 1 hour.

2 Front & Rear Panel

Figure 1

2.1 Front panel

The front panel consists of the following sections (see Figure 1):

- Power Switch - located on the left side of the front panel.
- Touchscreen (TS) - where the Master-9 parameters can be viewed and modified (Chapter 3).
- Backlight switch - turns the TS backlight on & off..
- Stylus pen - located at the bottom of the Master-9, under the power switch.
- USB interface – used for:
  - Communicating and programming of the Master-9 by using a computer (Chapter 14).
  - Upgrading the Master-9 (firmware upgrades, Chapter 14).
- Input section. The input section has 4 BNC sockets:
  - IN 1, 2, 3 inputs are used to externally trigger channels 1, 2 and 3 (Chapter 9).
  - IN 9 is an analog input for the recording channel 9 (Chapter 13).
- Output Section:
  - a. **Enable/Disable Switch** - enables/disables all outputs of Master-9. This switch is useful for cases where immediate stop of the stimulation is required. *Make sure that this switch is set to ENABLE.*
  - b. **12 output BNC sockets and LEDs** - Each of the 9 channels has an output BNC socket and a LED that indicates the channel activity. There are 3 additional outputs A, B and C for output combinations of the 9 channels.

2.2 Rear panel

The rear panel contains a switch to connect or disconnect the ground to/from the chassis.

This switch can be used to reduce the noise level of the system.

3 The Touch-Screen

When the Master-9 is turned on, the following screen is displayed:

		#	1	2	3	4
P1	1 2 3 4 5 6 7 8	M	OFF	OFF	OFF	OFF
1	. . . .	D	1.0 m	1.0 m	1.0 m	1.0 m
2	. . . .	L	0 μ	0 μ	0 μ	0 μ
3	. . . .	I	200 m s	200 m s	200 m s	200 m s
4	. . . .	N	5	5	5	5
5	. . . .	V	10 V	10 V	10 V	10 V
6	. . . .	S	⊓	⊓	⊓	⊓
7	. . . .	v	0 V	0 V	0 V	0 V
8	. . . .					
9	. . . .	1 2 3	4 5	6 7	8 9	
VER						
CLOCK						

Figure 2

3.1 The parameters of the channels

The screen is divided vertically:

The right side of the screen displays the parameters of channels 1, 2, 3 and 4.

The **definition column** is displayed to the left of channel 1. This definition column defines the heading of each row, as follows:

1. **#** - The top row shows the channel number.
2. **M -Mode**: The 2nd row defines the channel operating mode (see Chapter 4).
3. **D - Duration**: The 3rd row defines the pulse duration (see Chapter 5, figure 3) - the time that elapses from the onset of the output pulse to its end.
4. **L – deLay**: The 4th row defines the delay time - the time that elapses from the beginning of the input trigger to the beginning of the output pulse.
5. **Interval**: The 5th row defines the Interval time - the time that elapses between the beginning of a pulse and the beginning of the following pulse (interval = 1/rate).
6. **N – Number**: The 6th row defines the number of pulses per train in the TRAIN mode.
7. **V – Volt**: The 7th row defines the pulse amplitude in volts.
8. **S – Shape**: The 8th row defines the shape of the pulse: Monopolar, Bipolar or Ramp.
9. **v – ΔV**: The 9th row defines the ΔV increment or decrement voltage steps, if applied.

Example: In Figure 2 above you see that each of the channels (1, 2, 3, 4) is in its default values as follows: Set to OFF mode, duration time is set to D=1.0 msec. Delay time is set to L=0 μsec,

Interval time I=200 msec, N=5 pulses per TRAIN, V=10V, S=monophasic pulses, and v=0 - meaning there are no voltage steps.

The screen displays 4 channels at a time, although all channels are operational as set. You can choose which channels to display (Chapter 9).

3.2   The Manual Trig keys

The bottom line of the touch-screen contains the "1","2","3","4","5","6","7","8","9" keys.

These are the manual trig keys, which are used to manually trigger each individual channel.

3.3   The Connection Table

The left side of the screen displays the connection table. At the moment (as seen in figure 2 above), there are no connections between channels (see Chapter 7).

3.4   The Paradigm key

The Paradigm key is located above the connection table. It displays "P1", meaning that paradigm #1 is currently running. Switch paradigms by pressing this key (Chapter 10).

3.5   The VER key

The VER key is located under the connection table. Pressing the VER key shows the current version of the Master-9 (see Chapter 14). The VER key is also used for touchscreen calibration.

3.6   The Clock key

The Clock key is located under the VER key. Press this key to view and set the clock or stopwatch (see Chapter 15).

4   Operating Modes

Each of the 9 channels can operate in any of the following operating modes:

FREE-RUN - The channel delivers pulses continuously according to the programmed *Duration* and *Interval* times. The channel is independent of the other channels.

TRAIN - Following a trigger, the channel delivers a train of N pulses according to the programmed *Delay*, *Duration* and *Interval* times and the N parameter.

TRIG - Following a trigger, the channel delivers a single pulse according to the programmed *Delay* and *Duration* times.

TWIN - Following a trigger, the channel delivers a pair of pulses according to the programmed *Delay, Duration* and *Interval* times**.**

GATE - The channel delivers pulses continuously while it is gated (externally or internally from the other channels). When the input stops, the channel deactivates. A new input reactivates the channel.

DC - The channel is time-independent and can be turned on and off manually by pressing its Manual Trig key.

4.1   Setting the operating modes

To set the mode of operation of a channel, first press the selected mode key and then choose the desired mode.

Example 1: Setting channel #1 to the FREE-RUN mode:

1.   Press M1 – (Row M Column 1 **-** This is the MODE of channel 1 - now **OFF**).

2.   A new menu appears. You can choose any mode of operation for channel #1.

3.   Press "FREE". Channel #1 now delivers pulses continuously according to the set duration (now 1 msec.) and interval times (now 200 msec).

Example 2: Setting channel #2 to TRAIN mode:

1.   Press M2 – (the mode of channel 2 - now OFF). Press "TRAIN".

2.   Channel #2 is now in the TRAIN mode. You can trigger it externally, manually or internally by the other channels (see Chapter 9).

3.   Trigger it manually by pressing the "2" manual trigger key (at the bottom of the screen).

4.   Channel #2 delivers a TRAIN of N=5 pulses.

Example 3: Setting channel #3 to DC mode:

Press M3, and then press "DC". Channel #3 is now in the DC mode. It is time-independent and delivers a continuous DC output. You can manually stop and start the output by pressing the "3" manual trig key.

Example 4: Turning channel # 3 off: Press M3 (now DC) then press "OFF".

5 Setting Parameters

5.1 The parameters

The following parameters can be set for each channel:

- **D** (duration) - Defines the time elapsing from the onset of the output pulse to its end (see Figure 3).
- **L** (delay) - Defines the time elapsing from the beginning of the input trigger to the beginning of the output pulse.
- **I** (interval) - Defines the time elapsing between the beginning of a pulse and the beginning of the following pulse (interval = 1/rate).
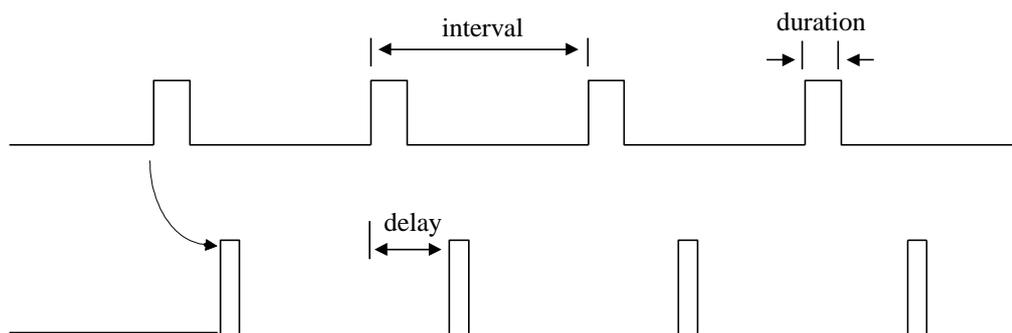
Figure 3

- **N** - Defines the number of pulses per train in the TRAIN mode.
  N also defines the number of ΔV steps if applied ($\Delta V \neq 0$) when in the TRAIN, FREE or TRIG modes.
- **V** (Voltage) - Defines the voltage amplitude of the pulses.
- **S** (shape) - Defines if the pulses are monopolar or bipolar pulses, or ramps.
- **v** (ΔV steps) - Defines the voltage increment (decrement) steps if applied.

5.2 Setting the time parameters

To set the time parameters (DURATION, DELAY or INTERVAL), first press the selected parameter key and then the desired time.

Example: To set the interval time of channel 1 to 1 sec:

1. Press I1 – (now 200 msec).

2. A new menu appears. The present interval time is displayed on the top of the new menu.

3. Press: "1" then "sec".

> **Notes**:

1. While setting parameters you can use the "DEL", the decimal point and the "ESC" keys.

2. You can also use the "▲" and "▼" keys.

The interval time defines the time elapsing between the beginning of a pulse and the beginning of the following pulse (interval = 1/rate, Figure 3).

> **Important**: When a channel is set to the FREE-RUN, TRAIN, TWIN or GATE mode, it must be set so that INTERVAL > DURATION.

5.3   Setting the "N" parameter

Example: To set N=80 pulses per train for channel 1:

Press N1 (now 5), then press "80", "ENTER".

5.4   Setting the "V" and "v" (ΔV steps) Parameters

Example: To set V1= -5.02 V

Press V1 then press -5.02, Volt.

N defines the number of ΔV steps if applied ($\Delta V \neq 0$) when in the TRAIN, FREE or TRIG modes.

The minimal step is $\Delta V = 0.01V$ (10 mV).

Table 1 - Parameters

Parameter	Min	Max
DURATION	4 μsec	3600 sec
DELAY	4 μsec	3999 sec
INTERVAL	40 μsec Interval> Duration	3999 sec
Ramp Duration	5 msec	60 sec
N	1	60,000
V, v	-10V	+10V

Output current – 20 mA.

6 Applications

Figure 4 shows how Master-9 works. Do not try to follow the programming just yet; Chapter 11 will enable you to practice programming of the Master-9.
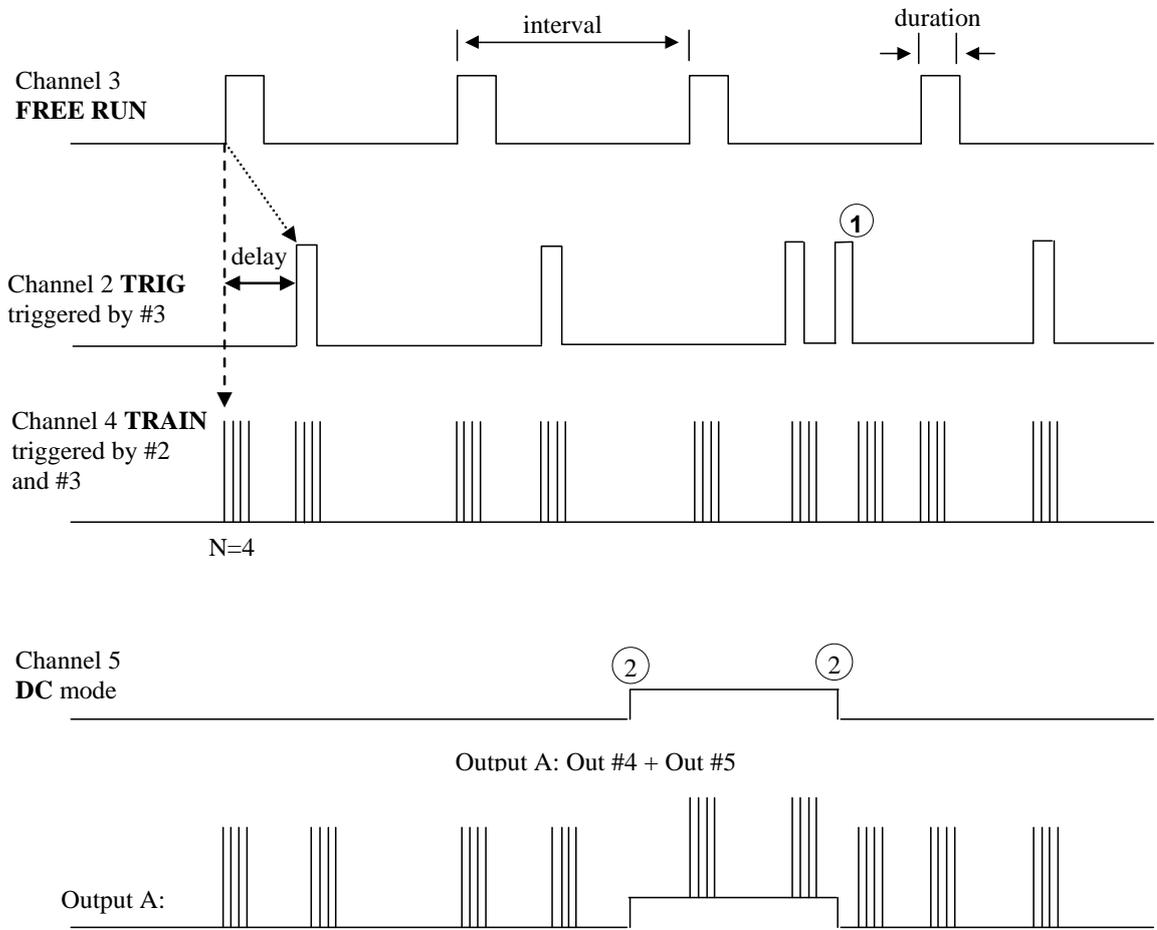

Figure 4

① Triggered externally or manually

② Turned on and off manually

7 The Connection Table


```
P1
    1 2 3 4 5 6 7 8 9 A B C
1   · · · · · · · · · · · ■
2   · · · · · · · · · · · ·
3   · · · · ■ · · · · · · ·
4   · · · · · · · · · · · ■
5   · · · · · · · · · · · ·
6   · · · · · · · · · · · ·
7   · · · · · · · · · · · ■
8   · · · · x x x · · · · ·
9   · · · · · · · · · · · ·
```

Figure 5: The connection table

The connection table displays all internal connections between channels and connections to outputs A, B and C. The numbers that appear in the left column are the source channels, and the numbers that appear on the top row are the target channels.

"·" Symbolizes that there is no connection between the channels.
The connection table (Figure 5) shows no connections from channels 2, 5, 6, and 9.

"■" Symbolizes that there is an operational connection between the two channels, i.e. there is a connection between them and it fulfills the following conditions:
a. The source channel is not in the OFF mode and thus may send a trigger.
b. The target channel is in mode TRIG, TWIN, TRAIN or GATE (the modes in which the channel expects a trigger input).

The table in figure 5 represents an operational connection from channel 3 to channel 6.

If you turn off channel 3 or channel 6 or if you set channel 6 to the FREE-RUN mode, this connection will switch to a non-operational connection.

"**x**" Symbolizes that there is a connection between the two channels but it is a non-operational connection. In the above table, all the internal outputs of channel 8 are non-operational (maybe because channel 8 is OFF).

Each of the 9 channels can be connected to any number of other channels and to outputs A, B and C. In the above example, output C outputs the summation/combination of channels 1, 4 and 7.

➢ When you have a complex experiment in which many channels are involved, a simple glance at the connection table gives you an instantaneous indication to what is being conducted in the experiment.

8 Triggering

In TRAIN, TWIN, TRIG or DC modes you can trigger the channel as follows:

1. Manual triggering.

2. Via the internal connections.

3. Via the external inputs 1, 2 and 3.

8.1 Manual triggering

In the TRAIN, TWIN, TRIG or DC modes you can trigger the channel manually.

The bottom line of the touch screen contains the "1", "2", "3", "4", "5", "6", "7", "8", "9" keys.

These are the manual trigger keys.

Example 1: When channel 3 is in the TRAIN mode, pressing manual trigger key "3" triggers the channel.

Example 2: When channel 4 is in the DC mode, one press on the **manual trigger key** "4" turns the channel on, and a second press turns it off.

When a channel is not in the TRAIN, TWIN, TRIG or DC modes, pressing its manual trigger key does not affect the channel.

8.2 Setting the internal connections

In the TRAIN, TWIN, TRIG or GATE modes, you can trigger or gate the channel internally by other channels. The proper connection should be set in the connection table as follows:

1. Press anywhere inside the connection table. A new screen with a larger connection table appears.

2. The channels that appear on the left column are the source channels, and the channels that appear on the top row are the target channels.

3. **Example:** To connect channel 2 to trigger channel 3, press the point that connects channel 2 (left column) to channel 3 (top row).

   Note: The level or polarity of the output of the source channel does not affect the triggering.

4. To disconnect an existing connection, press the connection symbol.

5. Press the "RETURN" key to return to the main screen.

9 The External Trigger Inputs

In TRAIN, TWIN, TRIG or GATE modes, channels 1, 2 and 3 can be triggered or gated externally through the BNC inputs IN 1, 2, or 3. Channels 1, 2 and 3 can activate the other channels internally.

The external input must be in the range of 3V to 10V.

10 Displaying Other Channels

10.1 Displaying other channels

4 channels are displayed at a time. You can choose which channels to display.

Example: Right now channels 1, 2, 3 and 4 are displayed. To switch channel 3 with channel 8:

1. Press on the channel number "3". A new menu appears.

2. Press "8". The screen will now display channels 1, 2, 8 and 4.

Note: Channel 3 continues operating as before.

10.2 Eliminating channels from the screen view

If you are using less than 4 channels, you can set the screen to display only those channels, which would be more convenient.

Example: The screen displays channels 1, 2, 8 and 4.

3. To eliminate channel 4 from view press on the channel number "4".

4. A new menu appears. Press "0".

5. Now the screen displays three channels only: 1, 2 and 8.

Channel 4 no longer appears on the screen but continues to operate as set.

10.3 Erasing all parameters of a channel

Example: Erasing all current parameters of channel 2:

1. Press the channel number "2" then press "Clr".

Channel 2 erases all its parameters and restores the default parameters.

11 Nine Stored Paradigms

 A paradigm specifies the modes and parameters of all the channels and their internal connections. Master-9 stores nine different programmed paradigms.

11.1 Switching to another paradigm

Example 1: To switch to paradigm number 7:

Press the key "Px" (x=1,2..9 – x is the present paradigm number), then "switch to", "7".

You don't have to worry about saving the previous paradigm, each instruction is saved the moment you enter it.

Example 2: To switch to paradigm 1:

Press key "P7" then "switch to", "1".

11.2 Copying Paradigms

Copying paradigms is very useful when you want to save a backup paradigm or to create a new paradigm by modifying an existing one. Instead of programming a complete new paradigm, you can copy the desired paradigm and modify it.

Example: To copy the present paradigm to paradigm 6:

Press key "P1" then "copy to", "6".

Paradigm 1 is not affected by this instruction.

11.3 Clearing Paradigms

Example: To clear the present paradigm:

Press key "P1" then "clear par".

This will turn off all channels, disconnect all internal connections and change all parameters of all the channels to their default values.

Note: Clearing the present paradigm does not affect the other paradigms.

12 Demonstration of Programming Master-9

This chapter demonstrates how to program the Master-9.

➢ **Note**: Each instruction is followed by a reference enabling you to find more information on similar instructions.

Before you begin to program, the present paradigm must be cleared as follows:

1. Press the paradigm switch "P1" (paradigm #1, see Chapter 10) on the top line of the screen, a new keyboard appears.

2. Press: "CLEAR PAR". This instruction clears the present paradigm and resets all channels to their default values.

Now you are ready to start programming:

1. Setting channel #1 to the FREE-RUN mode (see Chapter 4):

    a. Press M1 – (Row M column 1, this is the mode of channel 1, now OFF). A new menu appears. You can choose any mode of operation for the channel.

    b. Press "FREE".

    c. Channel #1 now delivers pulses continuously. Since you have not set the time parameters yet, the channel is running with its default times: duration of 1.0 msec, and interval time of 200 msec.

2. Setting the interval time of channel #1 to 2 sec. (see Chapter 5):

    a. Press I1 – (now 200 msec). The present interval time is displayed at the top of the new menu.

    b. Press "2" then "sec".

➢ **Notes**: While setting parameters you can use the "DEL", decimal point and "ESC" keys. You can also use the " ▲ " and " ▼ " keys.

Now channel #1 runs in the FREE-RUN mode. Its duration time is 1.0 msec. and its interval time is 2 sec.

3. Setting channel #2 to the TRIG mode:

    a. Press M2. You can choose any mode of operation for the channel.

    b. Press "TRIG". Channel #2 is now in the TRIG mode, but is waiting to receive a trigger.

    c. You can trigger it in 3 ways (see Chapter 8):

        i. **Manual triggering**:
        The bottom line of the touch-screen contains the "1","2", "3","4","5", "6","7", "8","9" keys. These are the manual trig keys.

Press the "2" manual trig key. ("2" is the channel number.)
Note that each press on "2" delivers the triggered pulse.

ii. **External triggering**:
Whenever there is an input pulse in the "IN 2" input, it triggers channel #2.

iii. **Internal triggering**: You can internally connect each channel to any number of the other channels.

4. Connect channel #1 internally to channel #2:

   a. Press anywhere inside the connection table. A new screen with a larger connection table appears.

   b. Press the point that connects channel 1 (left column) to channel 2 (top row). The channels are now connected. Each output pulse of channel #1 triggers channel #2.

   c. Return to the main screen by pressing the "RETURN" key.

5. Setting the delay of channel #2 to be 200 msec:

   a. Press L2, then press 200 ms.

   b. Check the new delay.

➢ **Notes**:

   ▪ There is no need to connect wires between channels.
   ▪ You don't have to worry about the amplitude or polarity of the trigger source.
   ▪ You can add manual pulses by pressing "2".
   ▪ You can connect many channels to/from a single channel and get complex patterns.

6. Setting channel #3 to the TRAIN mode:

   a. Press M3, and then press "TRAIN".

   b. Channel #3 is now in the TRAIN mode and is waiting for a trigger. Manually trigger the channel several times by pressing the "3" manual trig key (see Chapter 9). Channel 3 delivers the trains of pulses.

7. Connecting channel #1 to trigger #3:

   a. Press anywhere inside the connection table.

   b. Press the point that connects channel 1 (left column) to channel 3 (top row).

   c. Channel #1 now triggers both channels #2 & #3.

   d. Return to the main screen by pressing the "RETURN" key.

9. **Setting the delay of channel #3 to be 500 msec**:

   a. Press L3, and then press 500 msec.

10. **Connecting channel #1, 2 and 3 to the "C" output (see Chapter 7)**:

   a. Press the points that connect channel 1, 2 and 3 (left column) to "C" (top row).

   b. Now all 3 outputs are visible from the "C" output.

9. Disconnecting channel 2 from the "C" output:

    a. Press the point that connects channel 2 to "C".

    b. The output of channel #2 does not appear on the "C" output any more.

    c. Return to the main screen by pressing the "RETURN" key. The connection table displays all the current connections.

Now you are ready to program the Master-9. Before you start programming, you must clear the current paradigm:

Press keys "P1" and "CLEAR PAR".

This instruction clears the present paradigm.

13 Channel 9: Replaying External Waveforms

Channel 9 can save external waveforms in two ways:

1. You can set an Excel file with the desired waveform and download it to channel 9 via the USB cable.

2. Channel 9 can record input waveforms (such as action potential, sine wave, etc.). The waveform can be recorded from an external source via the IN9 input. The waveform is saved in the memory of channel 9.

The saved waveform can be replayed in all the operational modes: FREE-RUN, TRIG, TRAIN and TWIN.

➢ **Notes**:

■ You can record a waveform, upload it to the PC, make modifications, and download the modified waveform to the Master-9.

■ You can combine the recorded waveform with pulses of channels 1-8 using the A, B and C outputs of Master-9.

■ It is possible to save 9 independent recorded waveforms, one for each paradigm.

For the following, please display channel 9 on the touchscreen of Master-9 (see chapter 9).

Channel 9 can operate in one of the memory modes: *RUN* or *MEM*.

13.1 The RUN mode

When in the *RUN* mode, the output of channel 9 delivers the input that was captured in the IN9 input during the duration time of channel 9. The channel also stores the captured waveform in a temporary memory, but not in the fixed memory – MEM**.**

13.2 The MEM mode

When in the MEM mode, OUT 9 delivers a waveform that is saved in the MEM memory. Channel 9 now disregards the IN 9 input and you may disconnect the source. The saved waveform can be replayed in all operational modes - FREE-RUN, TRIG, TRAIN, and TWIN.

13.3 Waveform as Excel file

13.3.1 Setting a waveform as Excel file:

1. The MEM memory of channel 9 contains 1000 points. Each point has a value in the range of -10 to +10, with maximum of 2 digits following the decimal point. These values express output voltage levels (e.g. -1.23 expresses -1.23 volts).

2. In an Excel file, insert 1000 values in the cells A1 to A1000.
    Save this file with the extension .CSV

Example: saving a ramp that starts from -10V and ends in +9.98V (see below more details concerning the ramp duration).

Save an Excel file with values as follows:

A1 = -10

$A_{i+1} = A_i + 0.02$ (i=1…999)

This file contains 1000 values in column A, in increments of 0.02. The first value in A1= -10 and the last value in A1000 = +9.98
Save this file as RAMP.CSV

13.3.2 Long waveforms, up to 32K points:

1. Using paradigm 9, the MEM memory of channel 9 contains 32K points (=32,768 points). Each point has a value in the range of -10 to +10, with maximum of 2 digits following the decimal point. These values express output voltage levels (e.g. -1.23 expresses -1.23 volts).

2. In an Excel file, insert the values that you want, starting A1. You can use any number of values up to 32,768 values. Save this file with the extension .CSV

13.3.3 Downloading the waveform from the PC to Master-9

1. Connect the Master-9 unit to the PC using the USB cable and run the **MASTER-9 CONTROL** software (see the chapter 13).

2. In the menu bar, go to PARADIGM, then to LOAD SCV FILE TO CHANNEL 9 and browse to the desired CSV file (e.g. RAMP.CSV that was saved in 12.5.1). This saves the waveform in the MEM memory of channel 9.

3. You can now disconnect the Master-9 from the PC.

13.3.4 Running the saved waveform

First, switch channel 9 to the MEM mode as follows:

1. Press the "RUN" key, and then press "MEM".

2. Channel 9 will now deliver the saved waveform. The 1000 points that were saved elapse during the set DURATION time of channel 9 – (e.g., if D9=1 msec the waveform elapses 1 msec, which is 1 µsec from one point to the next).

Example 1: After saving the RAMP.CSV file from the example above, switch channel 9 to MEM as described. Set channel 9 to run in the FREE-RUN mode, with D9=10 msec and I9=50 msec.

Channel 9 delivers the ramp that was saved (in 12.5.2). The ramp duration is now 10 msec.

If you modify to D9=40 msec, the ramp duration will also be modified to 40 msec.

Example 2 - Sine Wave:

You can download an Excel file with a sine wave waveform from our website: www.ampi.co.il

1. Go to DOWNLOADS and select DOWNLOADS FOR Master-9. Download the EXCEL FILES FOR CHANNEL 9 folder.

2. Open the downloaded folder, save the SINE.CSV file in channel 9 as described above, and follow the instructions in the SINE.DOC file.

13.3.5 Running the long waveform (paradigm 9)

In case that you use paradigm 9 (the Excel file contains up to 32K points), the points that were saved elapse during the set DURATION time of channel 9 (D9).

In the case of paradigm 9, the minimal time resolution from one point to the next point is 5 µsec.

Example 3 – Long Waveforms:

If you saved a waveform using all 32K points, and you set D9=163.8 msec you get a waveform with duration of 163.8 msec with time resolution of 5 µsec from one point to the next point (total 32K points). If you change now to D9 = 327.6 the resolution will be 10 µsec from one point to the next one.

13.4 Record and deliver a waveform from an external source

13.4.1 Record a waveform from an external source

Channel 9 can record input waveforms from an external source via the IN9 input. There is no need to connect the Master-9 to a PC.

Prior to delivering the waveform, the external source will deliver a trigger pulse. Connect this trigger pulse to the IN1 (or IN2 or IN3) trigger input.

For the following, please display channel 9 on the touch screen of Master-9 (see chapter 9).

1. Set channels 1 and 9 to the TRIG mode, and in the connection table connect channel 1 to trigger channel 9.

2. Now channel 9 is in the RUN mode (default) and the output of channel 9 delivers the captured input that exists in the IN9 input during the duration time of channel 9 (with a constant delay of 6 µsec). The channel also stores the last captured input in a temporary memory, but not in the fixed memory - MEM.

3. Connect the output of channel 9 to an oscilloscope and set the delay time and the duration time of channel 9 so that the timing of D9 (duration time of channel 9) will overlap the external waveform appearance.

4. The V key of channel 9 (V9) is NOT the voltage output as in the case of the other channels. **V9 is the Voltage multiplicative factor: Vout = V9 X Vin**.

Example: If you want the output to be inverted and the output amplitude to be equal to 0.5 of the input amplitude, set V9 = -0.5.

➢ **Note**: The temporary memory (and the MEM memory) of channel 9 contains 1000 points. Channel 9 samples the input on these 1000 points, with interval time between one point and the next equal to D9/1000.

Example: You have a source of a sine wave, and you want to capture a waveform that is just the first 50 msec of this sine wave. In order to do this, you will apply the sine wave to the IN 9 input, set channel 9 to the TRIG mode with D9=50 msec, and trigger channel 9 (you can externally trigger channel 1, 2, or 3 that will internally trigger channel 9) at the start of the sine wave. Set channel 9 to the RUN mode.

OUT 9 will now deliver the first 50 msec of the sine wave.

13.4.2 The SAVE key

In order to store the last waveform, press the "SAVE" key while in RUN mode. OUT 9 will keep following the IN 9 inputs, but only the last **saved** waveform is stored in the MEM memory. This way you save a waveform, but can still choose a better waveform (e.g. action potential) to save.

13.4.3 Replay the saved waveform

First, switch channel 9 to the MEM mode as follows:

1. Press the "RUN" key, and then press "MEM".

2. Channel 9 will now deliver the saved waveform and disregard the IN 9 input. The saved waveform can be replayed in all operational modes – FREE-RUN, TRIG, TRAIN, and TWIN.

3. You may disconnect the source of the external waveform.

14 Communication with a PC

Master-9 can operate as a standalone unit via its touchscreen. In addition it can communicate with a PC using the **MASTER-9 CONTROL** and **Master-9 SDK** software.

You can also download new versions for the Master-9 unit (firmware upgrades) from our website, and upgrade your **Master-9** to the newer version.

Please visit our website: www.ampi.co.il.

You can download the following files and folders (free of charge):

1. **Master-9 USB -** The first time you use the USB port, the USB driver for windows must be installed. If the PC requests a file, browse to the Master-9 USB folder.

2. **MASTER-9 CONTROL** - Using the **MASTER-9 CONTROL** Software you can see and modify all the parameters directly from your PC monitor. Another powerful feature of this software is the Scheduler. You can set a list of events that you want to happen at scheduled times such as triggering channels, switching paradigms, modifying time parameters, etc.

3. **Master-9 SDK (Software Development Kit)** - Now you can also program and control your experiment from within your own application or software (LabView, Matlab, VBScript, etc.), using our new **Master-9 SDK**. Using the **Master-9 SDK** you can easily access all instructions of Master-9 in real-time in your application or software. This way you have a real-time feedback to/from your preparation.

4. **Upgrades** - Master-9 can be upgraded at any time with our firmware upgrades.
   From time to time, be sure to check our website for new upgrades. You will be able to download them and upgrade your Master-9.

5. **Excel files for Channel 9** – you can download examples of waveforms (like sine wave) for channel 9.

15 Clocks

In addition to its 9 channels, Master-9 features 2 internal clocks. The first one is called "Clock" and counts the time in seconds up to 24 hours. The other one is called "stopwatch" and it counts the time in tenths of seconds up to 1 hour.

Press the "CLOCK" key in order to see the clocks.

15.1 The Clock (CLK)

The clock is used to measure the time that elapses from an event (e.g. beginning of the experiment).

The clock can be reset to zero by pressing the clock time. The clock never stops running.

15.2 The Stopwatch (SW)

When you first press the **"STOPWATCH"** it starts running. The next press stops it, the next press resets it to zero, and the next press starts it running again.