M321 - Dual Channel Arbitrary Waveform Generator

User's Guide

Contents:

ETC company would like to thank you for purchasing the M321 generator. We believe it will meet your expectations. To keep you informed, please fill out and mail the registration card, you have obtained with the shipment. If you need assistance do not hesitate to contact our nearest dealer:

PACKAGE CONTENTS

The package you have received contains:
1 pc - EM321 PC add-on card
1 pc - A200/00 module connection wire
1 pc - 3.5 inch disk containing the GENERATOR software
1 pc - User’s Guide

Digital Adaptor is not the part of the M321 package.

The A321 Digital Adapter package contains:
1 pc - EA326 connector adaptor
1 pc - EA321 - digital buffer
2 pc - EA327/8 - adapter with clips

WARRANTY CONDITIONS

The Limited Warranty set forth below is given by ETC Ltd. with respect to the M321 Two channel arbitrary generator excluding the GENERATOR software. This limited warranty is only effective upon presentation of the warranty card. This product is warranted against defective materials or workmanship for half a year (when the registration card is filled out and mailed to ETC, the warranty period extends to one year), and is limited to repair, adjustment and/or replacement of the defective

product. Within the warranty period ETC will repair or replace the product free of charge, while the shipping fee is paid by the customer. After the warranty period, ETC will charge for parts, labor and shipping fee when returning the merchandise to customer. ETC shall not be responsible for any abuse, misuse, accident, negligence, or modification by anyone other than the manufacturer.

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RECOMMENDATIONS FOR GENERATOR USE

- read the README.TXT file before working with the device
- before adjusting or installing the add-on card turn your computer off
- secure the front panel with the screw before turning your computer on
- when setting the Base address, always install only one jumper
- do not connect voltage sources to the device outputs
- make sure that voltage connected to the trigger input does not exceed the range 0V to +5V

WHO IS THIS BOOK ADDRESSED TO

This book is addressed to the users of the M321 two channel arbitrary waveform generator. In order to fully understand the book and the software, the user should have a basic knowledge how to operate a generator type device, and some basic knowledge of working with Microsoft Windows. In case you are having problems with the environment, please consult MS Windows User’s Guide or MS Windows 95 User’s Guide or OS/2 Warp User’s Guide.

1. General information

The information contained in this chapter will help you understand the features of the M321 Two channel arbitrary waveform generator.

1.1. Generator characteristics

The M321 Two channel arbitrary waveform generator with digital synthesis utilizes features of the EM321 add-on card and computer itself. The add-on card allows fast synthesis of the analog signal from the digital information stored in the device’s internal memory. The user-friendly environment for creation of desired waveforms is achieved by utilizing computer features.

The EM321 internal memory contains four waveforms. Each of them is stored as 2048 samples with resolution of eight bits, and can be generated with the maximum speed of 20.480 Ms/s in single channel mode, or with the maximum speed of 10.240 Ms/s in two channel mode. The device has just one clock that controls the generating speed. As a direct consequence of this solution there is a restriction concerning the period variability of the generated waveforms; periods of waveforms generated by two independent channels on a single device can only be in a whole number ratio. This means that when we, for example, generate a ”Sine” signal with frequency of 10 kHz on primary channel, we can have a ”Saw” signal with frequency of 40 kHz on secondary channel. However, it is not possible to generate this signal with the frequency of 45 kHz. The main frequency of the M321 generator is digitally synthesized from the main oscillator reference frequency. Absolute accuracy of the main oscillator is better than 0.02% over the whole range of the operating temperatures. The frequency synthesis circuits allows the setting of the output frequency with the accuracy from 0.05% to 0.1% of actual value.

Each of the generator’s channels can operate in one of four operating modes:

- periodic
- synchronized
- externally triggered
- manually triggered

1. While in the periodic mode, the device generates an output signal periodically. It is, however, not possible to synchronize the signal externally. On the other hand, you are permitted to set its phase, e.g. shift of one channel with respect to the another one (has to be in periodic mode).

2.A periodically generated waveform can be synchronized either on leading, or trailing edge of the TTL compatible signal, which is connected to the synchronization input. A waveform is generated periodically, until the synchronization event occurs. After that the device starts to generate the waveform from the beginning.

3. Generating of the desired waveform can be triggered on either leading or trailing edge. The generator waits until the trigger event occurs and then generates just one period of the desired waveform, even though generating of the previous waveform is not finished.

4. It is possible to trigger the device manually. It is possible to combine the rest of the triggering modes as needed; this mode, however can only be active on all available channels at the same time.

The maximum guaranteed output voltage swing for channel with no load is -5V to +5V. It is possible to digitally regulate the output voltage swing all the way down to the zero value. The recommended adjustment range is 24dB. This value represents the swing value of minimum recommended output voltage (± 313 mV), and is calculated with respect to the setting step and a host computer interference. In case you need to generate very small voltage (in mV), we recommend you to attenuate the waveform as far as possible from computer’s display unit, because of very strong interference caused by its circuits. We also recommend you to order the EA424 Attenuator unit for the purposes of generating small output voltage. The EA424 Attenuator unit can attenuate either amplitude of both channel by 24dB or the amplitude of single channel by 48dB. This feature allows you to achieve the output voltage value of 14mVrms or 0.87mVrms. To connect the EA424 Attenuator unit to the EM321 add-on card use coaxial cables. Do it in a way, that the interference comming from the computer’s display unit does not interfere with the waveforms.

The output impedance of single channel is 75 ohm. To achieve

maximum correctness of the displayed output voltage values, this software allows you to enter the real load on the output channel. You can display the output voltage value as Vrms or Vpp.

The GENERATOR software offers you a wide range of predefined waveforms (sine, rectangle, saw, triangle, …). If none of these predefined shapes meet your expectations, you can use a powerful built-in Waveform Shape Editor to define your own waveform. To created a new user-defined waveform you can simply draw it by mouse or an other pointing device, or enter it as a mathematical expression. You can create an unlimited number of different waveform shapes.

The ETC M321 Two channel arbitrary waveform generator is equipped with the source of synchro pulses. It is therefore possible to synchronize all cooperating measuring devices. You can choose whether the synchronization connector will be use for input or for output. It is up to you to decide how the sychro connector will be used.

Besides generating digitally synthesized analog waveforms, the M321 Arbitrary waveform generator can also generate digital signals. The digital signal generated by this device is a signal with 2048 bits of binary information, which can be generated on eight (on single channel) or sixteen (on both channels) independent digital channels. To be able to generate the already mentioned digital signals, you have to use the A321 Digital adaptor. These digital channels are TTL & CMOS compatible. You can generate eight bit digital information (single channel mode) at the rate up to 20.480 Mbit/s. In two-channel mode, the rate of generating the sixteen bit digital signal drops to 10.240 Mbit/s.

The GENERATOR software allows you to create your own digital signals. The powerful Waveform shape editor offers you several ways to define a digital signal. It is possible to generate analog waveforms as a digital signal. If you want to do this, all you have to do is use the EA321 Digital adaptor.

If you need to work with four-channel generator, you can connect two M321 Two-channel generators together so that they will work as one four-channel generator.

1.1.1. Output filter

Each of the generator’s channel is equipped with a low pass filter, that eliminates possible interference that can be produced by channel’s DA converter. The interference can be, for example, a noise caused by the resolution of DA converter or a digital interference caused by any imperfections of the already mentioned digital-analog string. The frequency of this filter can be set either to 1 MHz, or 450 kHz. This choice depends on characteristics of the generated waveform. Filters can be set independently for each channel.

While generating standard harmonic waveforms, filters are enabled or disabled automatically. However, if you want to generate a user-defined waveform, you are responsible for handling the filters.

1.1.2. Dynamic address space allocation (DSA)

A serious problem of measuring devices designed as PC add-on cards is the lack of I/O address space. To solve this problem ETC Ltd. has designed the DSA system, which allows you to connect 248 devices using just 8 I/O addresses. We will describe the DSA system very briefly. If you would like to use the EM321 card in bigger systems, please contact the manufacturer.

Each device using the DSA system allocates eight consecutive I/O addresses. The lowest one is called the Base Address and its value is indicated by a jumper on the add-on card. To differentiate the active device, there is also the Module User Code (MUC), that is also indicated by a jumper on the add-on card. The MUC value can be from 0 to 7; therefore only eight devices of the same type can be installed into the same system. Before installing devices in a computer, it is important to set the same base address on each module.

WARNING: When installing more than one device of the same type, make sure they do not have the same MUC.

2. Installation

This chapter contains all useful information concerning the hardware and software installation.

2.1. Minimum computer requirements

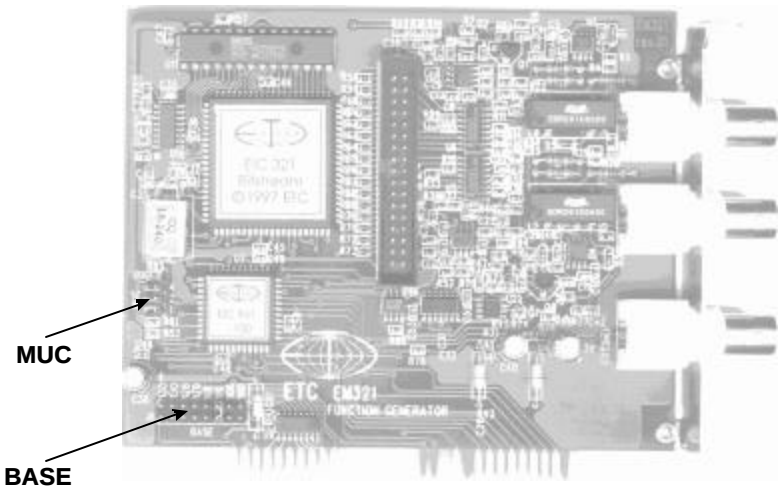
386 compatible computer
4 MB RAM
3.5 inch FDD
VGA display adapter
mouse or other pointing device
2 MB hard disk free space
MS Windows 3.1, MS Windows 95 or Win-OS/2, depending on purchased software version.

2.2. Setting up the EM321 add-on card

Before installing the device to the computer it is important to set the Base Address and MUC.

To set the Base Address simply install one jumper to the BASE part. When looking at the card (front panel on the right side), jumpers represent the following addresses (from left to right): 100h, 108h, 110h, 118h, 120h, 128h, 130h and 138h. It is very important to set the Base Address, so that none of already installed cards (except the cards that are the part of the EML System) have any of the eight consecutive addresses starting with the Base address. In case you want to add this device to an already existing EML (ETC Measuring Lab) system, please set the same base address as on the already installed devices. When using the 4-channel generator (two EM321 cards), both cards have to have the same Base Address. Usually a user does not have to change a factory preset Base address (110h).

fig. 2.2.1



WARNING: Never install two Base Address jumpers. It can cause a device malfunction.

To set the MUC, you can install any combination of up to three jumpers on the EM321 add-on card in the MUC part. The jumpers represent following values (from left to right): 4, 2, 1. To set the specific MUC, please see the following table:

The factory predefined MUC is zero (0). Usually, there is no reason to change it.

WARNING: It is very important that no two devices have the same MUC, because the software is not capable of handling this type of situation; therefore it might lead to undesired results. When installing two devices as the 4-channel generator, they have to have a different MUC.

TIP: We recommend, that you make a note of the MUC. It will ease the installation of the software.

MUC	4	2	1
0	CLOSED	CLOSED	CLOSED
1	CLOSED	CLOSED	OPEN
2	CLOSED	OPEN	CLOSED
3	CLOSED	OPEN	OPEN
4	OPEN	CLOSED	CLOSED
5	OPEN	CLOSED	OPEN
6	OPEN	OPEN	CLOSED
7	OPEN	OPEN	OPEN

2.3. Device installation

To install this device, simply insert it into any open ISA Bus slot. Please, discuss this action with your computer dealer. Always turn your computer off before installation. Before you turn your computer back on, secure the front panel with the screw.

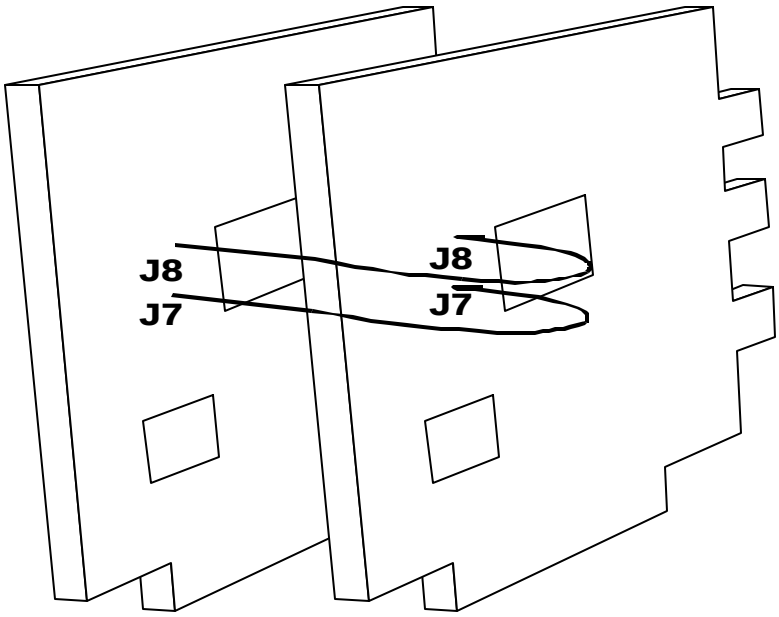
2.3.1. 4-channel generator installation

The GENERATOR software also supports two EM321 add-on cards working as a single four-channel generator.

WARNING: When installing two EM321 add-on cards as a 4-channel generator, it is necessary that they have the same base address and different MUC.

fig. 2.3.1.1.

Besides the steps that were already described you need to interconnect the two devices. You can do that by connecting the shells J7



and J8. To do that, you have to use the two module connection wires that you received with the devices. To connect the devices correctly (see Fig 2.3.1.1), we recommend you to follow these steps:

1. plug the connection wires into one device
2. insert this device into the computer
3. plug the connection wires into the other device
4. install the other device into the computer

2.3.2. A321 Digital adaptor installation

Digital adaptor package contains:
one EA326 connector adaptor
one EA321 digital buffer
two EA327/8 connection adaptors with clips

To install the Digital Adaptor to an already installed EM321 add-on card follow these instructions:

1. Install the EA326 reduction next to the EM321 add-on card, then plug the connector located at the end of the flat cable into the EM321 add-

on card. This concludes the installation inside the computer.

2. If you want to use the digital adaptor, simply plug the connector that is located on the end of flat cable coming from the EA321 separator into the connector located on the front panel of the EA326 reduction. Finally, connect the desired number of clips to the EA321.

2.4. Software installation

There are software versions for MS Windows 3.1, MS Windows 95 and Win-OS/2 available. The standard M321 shipment includes only one of these versions. It is possible to purchase more software versions for an extra fee.

The GENERATOR software has to be installed on the hard disk, and it needs approximately 2 MB of free space.

TIP: We recommend that you make a backup copy before the first installation.

WARNING: When installing more than one generator, it is not necessary to install the software more than once. It is possible to control several devices using just one software package.

Software is provided on one 3.5" disk. It contains the program that installs the whole software for you (SETUP.EXE). The version of the host operating system is indicated on the disk label.

2.4.1. Microsoft Windows 3.1 version

1. Insert the install disk into drive A or B.
2. Run Windows 3.1
3. Start PROGRAM MANAGER
4. Select FILE from the main menu
5. Select RUN
6. Input “a:\setup.exe” or “b:\setup.exe”
7. After running the installation software, it is possible to change the directory the software is going to be installed into. (C:\ETC_M321 - default)
8. Press the Start button, which initiates the installation of the software.
9. After the installation is finished, remove the disk from the drive

and store in a safe place.

2.4.2. Microsoft Windows 95 version

1. Insert the install disk into drive A or B.
2. Run Windows 95
3. Open the Control Panel group
4. Select Add/Remove programs
5. Enter the name and location of the installation software
“a:\setup.exe” or “b:\setup.exe” and press ENTER
6. After running the installation software, it is possible to change the directory the software is going to be installed into. (C:\ETC_M321 - default)
7. Press the Start button, which initiates the software installation.
8. After the installation is finished, remove the disk from the drive and store in a safe place.

2.4.3. Win - OS/2 version

1. Insert the install disk into A or B drive.
2. Run OS/2
3. Open the OS/2 Full Screen
4. Enter “a:\install.cmd” or “b:\install.cmd”, disk drive name and path, where the software is supposed to be installed into, and press ENTER.
Example: a:\install.cmd c:\etc_m321 <ENTER>
5. Press the Start button, which initiates software installation.
6. Exit the Win - OS/2
7. After the installation is finished, remove the disk from the drive and store in a safe place.

2.4.4. Running the GENERATOR program

After successful installation, SETUP creates a group called ETC Measuring Lab. In this group you will find an icon which runs the GENERATOR program. You can run the program by double-clicking on the icon or pressing ENTER when it is selected.

When running the program for the first time, the program tries to find and work with a device on the default base address (110h) and the default MUC (0). If you have moved the jumpers on the card, an error message will appear and Demo mode will start. For how to fix this problem see chapter 3.10.2. Setting the device parameters.

2.4.5. Exiting the program

It is possible to exit the program by several different ways:

· Select the item File|Exit or File|Leave from the main menu and press ENTER

· Press ALT+F and then ALT+X

· Use the host environment controls for exiting the running program

When exiting the program, program will ask whether you really want to exit. If your answer is positive, it will end. In case your reply was negative, it will keep running. Closer description of this function is available in chapter ”3.10.1. Exiting the program”

3. Using the generator

M321 Generator is a device, that allows you to convert your PC compatible computer into a two (four) channel arbitrary waveform generator. Controlling of this device consists of controlling a virtual generator, that

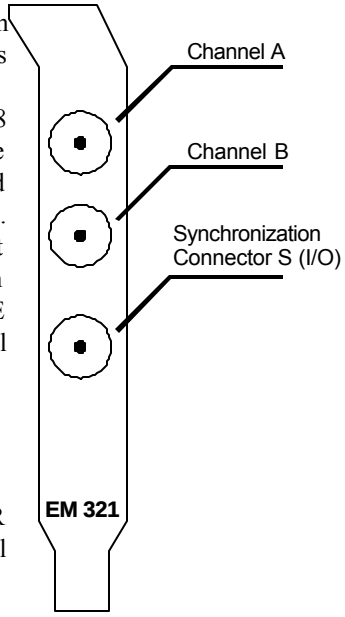
appears on the screen of your computer, and of handling the generator’s inputs and outputs.

3.1. Front panel

Several connector are located on the front panel of the EM321 add-on card. They are the outputs of both channels and a synchro signal connector. After theDigital adaptor installation has been finished, the TTL (CMOS) compatible outputs are accessible through EA327/8 connection adaptor, that is connected to the EA321 adaptor. When you look at the adaptor from the side of the plugged connectors, the clips are organized as shown in table 3.1.1.

The slot into which the EA327/8 clips adaptor is plugged determines the channel to which the eight bits represented by this particular EA327/8 adaptor belong. Right one represents the channel A (C), left one the channel B (D). The channels in parenthesis are the channels of the SLAVE device (when using the 4-channel generator).

Table 3.1.1.



3.2. Main window

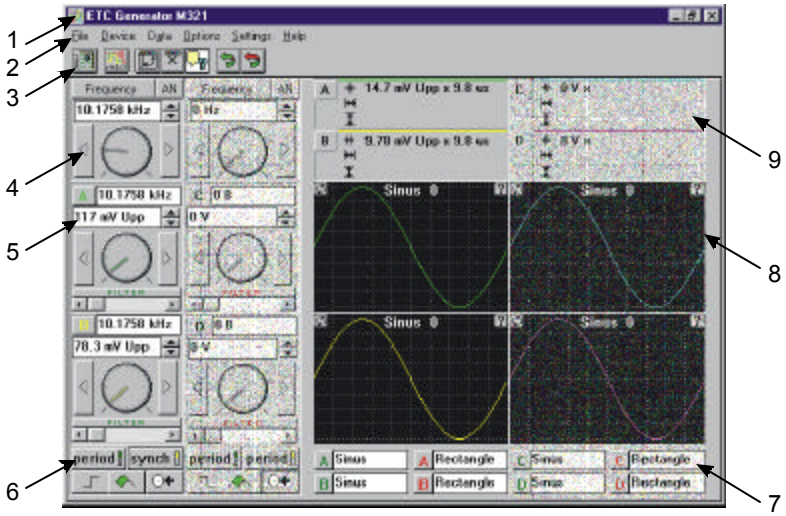
After running the GENERATOR software, a window containing all control elements appears on the screen.

Fig. 3.2.1. Generator main screen

Signal	Position	Wire color
D0	1st	Brown
D1	2nd	Red
D2	3rd	Orange
D3	4th	Yellow
D4	5th	Green
D5	6th	Blue
D6	7th	Violet
D7	8th	Gray
GND	9th, 10th	White, Black

Short description of on-screen controls:

1. System menu
2. Main menu
3. Tool bar
4. Frequency controls
5. Amplitude controls



6. Trigger controls
7. Waveform shape controls
8. Waveform shape display

9. Generated signal information

All control elements having direct relation to any of the measuring channels are color coded. It means that they are marked by the color of the channel they are related to. For example, channel B color is yellow; therefore, all control elements related to channel B (amplitude setting, triggering controls, etc.) are yellow.

TIP: In case you are not satisfied with channel colors, it is possible to change them. See main menu Settings | Change color.

Every single element can be controlled by either keyboard or mouse. The software was designed to be easy-to-use, keeping all MS Windows control standards. In the following text, the mouse control will be described as being the main, and the keyboard one as an additional. You should understand the following terms in order to understand the rest of the text in this manual.

Click - point the mouse cursor over the component and press the left mouse button.

Double click - point the mouse cursor over the component and press the left mouse button twice quickly.

Grab - point the mouse cursor over the component you want to move and press the left mouse button (do not release). Move the mouse cursor together with the component. After releasing the mouse button, component will move to its final position.

Recommendation: When working with the GENERATOR software, we recommend you to use a mouse or other pointing device. Operating the software through the keyboard seems very clumsy compared to using a mouse.

3.3. Setting the frequency

In order to understand output frequency control circuits you should read the following part. It contains information concerning the M321

Generator architecture. Circuits that influence the output frequency are shown on fig. 3.3.1.

The generator creates output waveforms out of the samples stored in the device’s memory. These samples are taken out of the memory by clock pulses, and they are sent to the output as an analog waveform. Clock pulses are generated by oscillator. The frequency of the output waveform can be controlled either by oscillator frequency, or by various ways of waveform arrangement in the device’s memory. If we, for example, store one sine waveform into the memory of channel A (one period takes 2048 samples), and four sine waveforms into the memory of channel B (one period takes 512 samples), the frequency ratio between the channel A and channel B is fa/fb = 1/4.

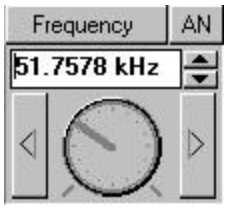


fig. 3.3.1.

Besides analog waveforms, the M321 arbitrary waveform generator is also capable of generating digital signals and can be used as a pulse generator. In order to make controlling of the device as simple as possible, there are two modes of frequency setting available. The Scheme of the analog mode frequency setting is illustrated on figure 3.3.2.

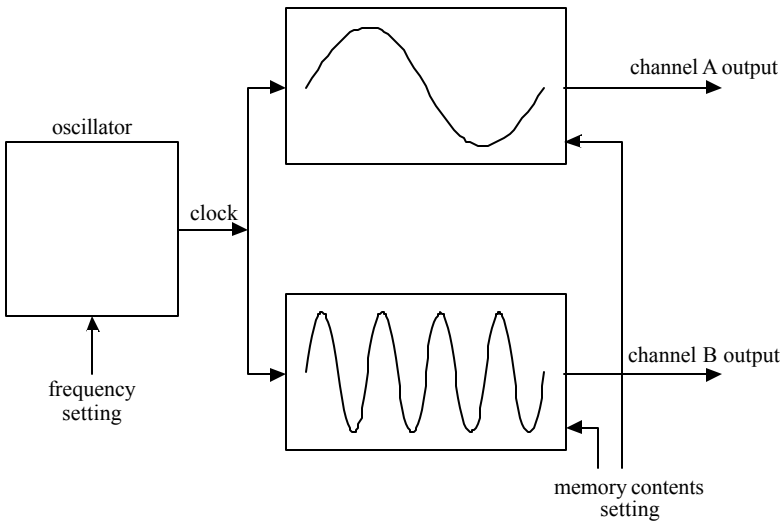
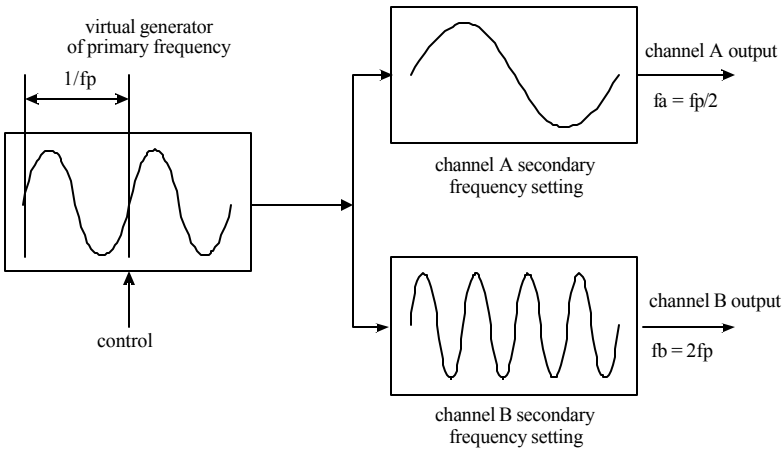


fig. 3.3.2.

Setting frequency in analog mode

While working in the analog mode, the whole system has one central frequency source fp (primary frequency), which corresponds to the oscillator frequency, that controls both channels. The value of the primary



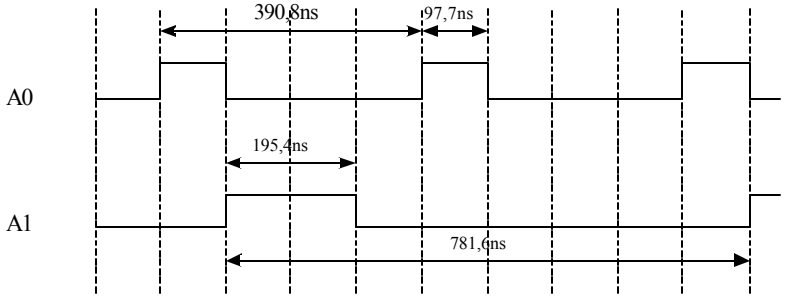
frequency is equal to the frequency of the output waveform only in case that clock pulses are generated with the maximum rate and the number of periods of the waveform stored in the channel’s memory is equal to the number of periods stored in the virtual memory from which the primary frequency is generated. In case the situation would be as shown on fig. 3.3.2., e.g. the primary frequency is generated from two periods, the frequency of channel A (has just one period stored in memory) is half the primary frequency; the frequency of channel B (has four periods stored in memory) is double the primary frequency. The output frequency of the channel is called frequency:secondarythe secondary frequency of the channel.

Setting frequency in the digital mode is different from the analog mode. In this mode, the basic information unit is 1 bit; therefore, the primary frequency is actually the frequency of each channel. Output frequency depends on the contents of the channel’s memory. If we, for example, store the successive combination of 0100 (0100010001000100...) into bit number 0, combination 00110000 (0011000000110000...) into bit number 1, and set the primary frequency at 10.24 MS/s (megasamples per second), then these two bits will generate pulses with parameters shown in fig. 3.3.3. Output frequency generated by the bit A0 would be 2.56 MHz and by the

bit A1 would be 1.28 MHz.

fig. 3.3.3.
Example of output digital signals

The two already mentioned modes of frequency setting are just the ways of setting and displaying the frequency. It means that, even when the frequency is set and displayed in the digital mode, you can generate



analog waveforms.

3.3.1. Setting the primary frequency

There is a group of control elements in the upper left-hand corner. Using these control elements you can control the generator’s primary frequency. You can control the primary frequency in two modes.

You can control the mode by pressing the button in the upper right-hand corner of the group.

- while in analog mode, the program displays the frequency (period) of the analog waveform. The real output frequency can only be a whole number ratio of the primary frequency.
- while in digital mode, the program displays the value of the frequency of clock pulses.

By pressing a button, which is located in the left hand upper corner you can cause data to be displayed either as a frequency or as a time period.

- program displays data as a frequency

- program displays data as a time period

There are several ways to set the primary frequency (period). You can:

- **type a value directly** into the frame, where it is displayed and press ENTER

WARNING: It is not possible to set any frequency; therefore, when you type desired frequency value into the frame, the program may set and display frequency which is slightly different from the one you have entered. In case the value was correct (in the generator frequency range), the value corrected by the program will not differ from the entered by more than +-0.05%. It the value was not correct (e.g. out of the generator frequency range), program will ignore it.

- **approximate setting** - grab the pointer of the big round button and rotate it either to the left or to the right. When you rotate the button ccw the frequency decreases. The frequency value increases when you turn the button clockwise.

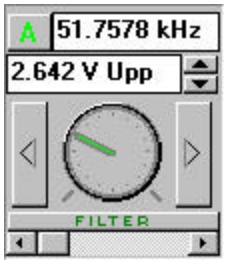
- **fine setting** - use two buttons located just to the right side of the frame where the frequency is displayed. When you press the up-arrow button frequency will be set to the closest possible higher value. The closest possible lower frequency value can be set by pressing the down-arrow button.

- setting the half/double the frequency - use two buttons located on the left and right side of the big round button. When you press one of these buttons you double or half the current frequency. When you press the left-arrow button the currently set frequency halves. To double the current frequency, simply press the right-arrow button.

3.3.2. Setting the channel’s secondary frequency

The way you set the secondary frequency is determined by the mode of primary frequency setting. The value of the secondary frequency is displayed in upper part of the group of amplitude control elements.

- while in analog mode, you can set the secondary frequency by using two buttons that are located on each side of big round button. When you press the left-arrow button the frequency decreases to half of its current value. To double the current frequency simply press the right-arrow button. The secondary frequency range is limited by the value of primary frequency. If you set primary frequency with only one period in the memory, you will not be able to set the secondary frequency lower than the primary frequency. There are also limitations for setting higher values of the secondary frequency. If that it is not possible to increase or to decrease the secondary frequency, the program simply does not respond to you pressing either of the two buttons.

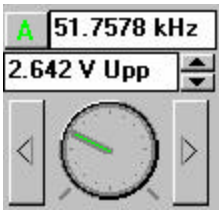


- digital mode is different from the analog. While in digital mode, the value of the secondary frequency does not influence the frequency of output signal. It is just the displayed value. You can use this feature to set the displayed value to the real frequency with respect to the number of bits of which the signal is made of. When you press the secondary frequency control buttons, the program displays the value of the corresponding number of bits instead of the frequency (time period).

3.4. Setting the amplitude

EM321 add-on card allows you to generate waveforms with amplitude up to 10 Vpp. Amplitude can be set independently for each channel. There are four groups of amplitude control elements (one per

channel). Each contains a frame that serves for displaying and editing the value, two control elements for fine setting and a big round button for approximate setting.



As you can see, there are several ways to set the amplitude. You can:

- **write it directly** into the frame, where the current value is displayed, and press the ENTER key.

- **approximate setting** - grab the pointer of the big round button and rotate it left or right. When you rotate the button anticlockwise, the amplitude decreases. To increase the amplitude of the waveform, simply rotate the button clockwise.

- **fine setting** - use the two button located just to the right side of the frame, where the amplitude is displayed. When you press the up-arrow button amplitude will be set to the closest possible higher value. The closest possible lower amplitude value is set when you press the down-arrow button.

It is possible to display and set the amplitude as a ”peak-peak” value, e.g. voltage between minimum and maximum of generated waveform, or as effective voltage for the currently set waveform shape. It is possible to calculate these values as the amplification or attenuation with respect to entered reference value.

You can set amplitude displaying mode as well as the reference value using the main menu (see chapter 3.9.4. Setting up the channel parameters).

To set the real amplitude, it is very important to be aware of the load that is connected to the generator’s output. The software allows you to

Signal amplitude	sign	reference value
peak - peak	Upp	N/A
true RMS	U_{RMS}	N/A
peak - peak gain	dB (Upp)	Upp
true RMS gain	dB (U_{RMS})	U_{RMS}

set these standard loads:

WARNING: The displayed value of amplitude is correct only when the selected load is really connected to the generator’s output.

Load	resistance	output voltage range
none	infinite	0 to 10 Upp
50 Ohm	50 Ohm	0 to 4 Upp
75 Ohm	75 Ohm	0 to 5 Upp
other	Rx	0 to Rx/(Rx+75)*10 Upp

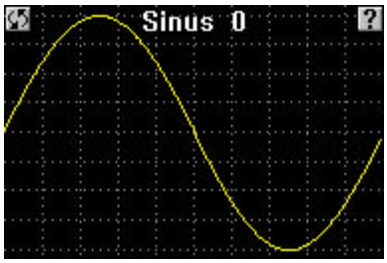
WARNING: When you type the desired frequency value into the frame, program may set and display an amplitude slightly different from the one you have entered. In case the value was correct (in the generator amplitude range), the value corrected by the program will not differ from the entered by more than half the setting step. If that the value was not correct (e.g. out of the generator frequency range), the program will ignore it.

WARNING: Amplitude setting does not influence digital signalsdigital signalsdigital outputs.

3.5. Setting the shape of the generated waveform

For setting the shape of generated waveforms, there is a group of control elements located in the lower part of the main window. There are two control elements for each channel.

One of these elements displays the name of the waveform. To the left of the name of the generated waveform is the channel’s name in either red or green. Green indicates the currently generated (active) waveform. Red indicates the alternative waveform. The shape, phase shift and name of the currently generated



waveform is displayed in the area in the middle of the main window.

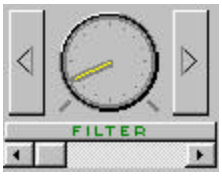
You can switch between the active and the alternative waveform by using the button, which is located in the upper left-hand corner of the waveform displaying area. If you need an information about the shape of the alternative waveform, click on the button located in the upper right-hand corner of the display area. Using this button does not affect the currently generated signal.

To choose the active or alternative waveform shape, simply click on the button with the channel’s name. This will open a window, where you can choose the waveform shape by clicking on the desired one. Confirm your selection by clicking the OK button.

TIP: If you are not satisfied with the predefined waveform shapes, go into the Waveform shape selection window, click on the frame where no waveform shape is displayed, and click on the Edit button to run the Waveform shape editor. See chapter 4, Waveform shape editorwaveform shape editorwaveform shape editor.

3.6. Output filter

Each of the M321 Generator channels is equipped with one low pass filter. This filter is used to eliminate any imperfections and possible noise caused by the DA converter. The purpose of the control element located below the amplitude control elements group is to activate or deactivate this filter.



The color of the ”FILTER” sign located on this button depends on the state of the filter. Green color indicates that filter is set to the 450kHz frequency range. When you set the filter to 1Mhz range, the color of the ”FILTER” sign turns red. You can switch between these two states by clicking

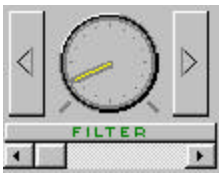
on this button.

WARNING: When generating the standard waveforms, the filters are set automatically. However, when generating user defined waveforms, you are responsible for enabling or disabling the filters.

3.7. Phase shift

The predefined phase shift of the waveforms generated by the M321 Generator is 0 degrees. However, it is possible to set this value anywhere in the range of 0 to 360 degrees. To do this, use the scroll-bar located on bottom edge of the amplitude control elements group.

When you move the scroll-bar left, the value of phase shift decreases. To increase the phase shift move the scroll bar right.



WARNING: The displayed phase shift value is the value of shift with respect to the unshifted waveform, e.g. in case you shift both waveforms, the real value of the phase shift is the phase shift difference between the two channels.

3.8. Channel activation

You can activate the desired channel by pressing the button located in the upper left-hand corner. When the channel is active (a channel’s name appears in the color of the corresponding channel), the generator generates the currently active waveform. An output voltage of 0V appears on the analog output (7Fh on digital output) if the channel is deactivated (channel’s name appears in gray).

3.9. Triggering

The M321 generator offers you four different triggering modes:

- periodic (period)
- synchronized (synch)
- externally triggered (trigger)

· manual (single)

You can find a more detailed description of these modes in chapter 1.1. Generator characteristics.

The control elements are located in the lower left-hand corner of the main window. The state of these control elements is written on them. If you wish to change its state, simply click on it.

The following control elements serve to control the trigger signals:

Sets the direction of the synchro signals through the ”S” connector located on the front panel of the add-on card:

- serves as a trigger input

- serves as a trigger output of the synchro pulses generated by the M321 Generator. While in this mode, a pulse appears on the output after every period of the generated waveform. It is necessary that you indicate the channel that will generate the trigger pulses. See chapter ”3.11.4. Setting the channel’s parameters”.

WARNING: When you set any of the channels into ”single” mode, the same mode will be automatically set for the rest of the channels.

Sets the mode of external triggering on:

- leading edge

- trailing edge

- while in ”single” mode, this button starts the generator

WARNING: A device malfunction can be caused by

connecting a voltage outside the 0 to +5V range.

WARNING: Do not connect a voltage, that exceeds the range of -3 to +8V to S connector. This could cause permanent damage to the device.

3.10. Main menu

The main menu bar offers you access to all menu items. When it is active one submenu item is highlighted. The highlighted submenu item represents the currently selected submenu or command. You can select submenu or command either by mouse (by clicking on it) or by keyboard (by pressing the combination of Alt and underlined letter). It is possible to move around the menu using the cursor keys.

When the item name is followed by ellipsis, the dialog box opens, when you select such an item. If the item name is followed by right arrow (>), it opens a submenu.

3.10.1. Exiting the program

You can exit the program GENERATOR in two different ways. The first one exits the programs and shuts the generator down (e.g. there is no signal on any of the outputs of the EM321 add-on card).

The other way exits the program and does not shut the generator down, e.g. the generator keeps running (e.g. it keeps generating the waveforms) without software support until you run the GENERATOR software again.

- To exit the program and stop generating the waveform, select File|Quit from the main menu
- To exit the program and keep generating the waveform, select File|Exit from the main menu.

TIP: In case you need to generate the same waveform over and over, exit the GENERATOR program by selecting File|Exit. When you do this, you free some memory and speed up the system a bit.

TIP: When you finish working with generator, quit the program using the File|Quit item in main menu.

3.10.2. Setting parameters of an individual device

The GENERATOR software package allows you to control several measuring devices connected to the same computer. To select the active device (e.g. device you are currently working with) use Device|Choose device device item in the main menu.

Selection of this item opens a dialog window, which contains the list of all devices configured to work with the GENERATOR system. To activate any of the devices in this list, simply click on its name. It is possible to add devicesadd devicesadd devices to this list.

To set parameters such as base address and user code (MUC) simply pick Device | Config device from the main menu. It opens a dialog window in which the user is able to change the device parameters.

To add a new device, pick Device | Add device from the main menu. It opens the same dialog window. The user is expected to state the device name, type, version, base address, user code and number of channels (for 4-channel generator see chapter 2.3.1.). In case you want to use the 4-channel generator, it is important to input the other device’s MUC. Channels A and B will be represented by the primary device and channel C and D by the secondary one. After confirmation, it will be possible to pick the device in the upper right corner of the main window.

Name - device’s user given name (can be anything). This name will represent the relevant measuring device in the list of measuring devices.
Type - when using the GENERATOR software, always enter ”Generator”.
Version - when using the GENERATOR software, always enter ”EM321”.
Base address - address corresponding to the jumpers installed on EM321 card.
User code (MUC) - corresponding to jumpers installed on EM321 card.

If there are two EM321 add-on cards installed in your computer, you can select these two to work as:

- two 2 two-channel generators
- one four-channel generator

To select either one of these above mentioned modes of device cooperation click on the ”Settings” button, choose the desired cooperation mode and enter the MUC of the other EM321 add-on card.

If you want to remove a device from the list, select Device|Delete

device and then after the dialog window opens choose the device you want to remove.

3.10.3. Automatic autodetection of measuring devices

The GENERATOR software includes the built-in feature of detecting all ETC Measuring Lab line devices. After clicking on the Device | Autodetect item in the main menu, a dialog window opens. It is important to indicate all the addresses where you want the software to attempt the detection of devices. After clicking on the Detect button, the list of detected devices will be displayed.

WARNING: If you attempt detection of a device on address which is already used by another device not manufactured by ETC, the computer can ”freeze”. When this happen try to reinstall ETC measuring devices on a different address.

WARNING: The fact, that a device is not found even on the address where it is installed can be caused by having some other device from another manufacturer occupying the same address.

3.10.4. Setting up the channel parameters

There are several ways to display the value of the voltage of each of the channels. This software offers the possibilities that are shown in following table.

The currently selected display mode is emphasized by distinguishing mark. If you want to change displaying mode, simply select the desired mode from the main menu. If you select the mode where the

Sign	Meaning	Menu Item
Upp	pek - peak voltage	*Options|Channel X|Upp*
U_{RMS}	true RMS voltage	*Options|Channel X|*U_{RMS}
dB Upp	ratio to peak-peak reference voltage	*Options|Channel X |dB|Upp*
dB U_{RMS}	ratio to true RMS voltage	*Options|Channel X |dB|*U_{RMS}

voltage value is calculated as a ratio, you will be asked to enter the reference voltage value.

If you want the real amplitude of the output waveform to be equal to the displayed value, it is necessary to select load, which is connected to the generator output. This software allows you to select one of the following loads:

The amplitude setting is described in more detail in chapter 3.4. Amplitude setting. You can enable or disable the phase shift compensation of the channel phase shift of channels B and D with respect to channels A

Load	Resistance	Menu Item
none	infinite	*Options|Channel X|No load*
R 50	50	*Options|Channel X|R50*
R 75	75	*Options|Channel X|R75*
Rx	x	*Options|Channel X|Rx*

and C by selecting Options|Channel X|Offset compensation. We recommend you disable this compensation only if any distortions of output signal occur. You can find detailed description of this problem in chapter 5.1. Shape restrictions of output waveform.

3.10.5. Digital Adapter

You can generate digital signals by using the A321 Digital adapter

set. If you want to generate digital signals, you have to enable the digital adapter by selecting Options|Digital adapter from the main menu. You can disable the digital adapter by selecting the same menu item.

WARNING: You can enable the digital adapter only if it is correctly connected to the EM321 add-on card.

TIP: When you are not using the digital adapter at the moment, disconnect it, you will gain better ”clarity” of the output analog waveform.

3.10.6. Attenuator unit

In case you need to generate the waveforms with very small amplitude (in mV), we recommend you use the EA424 Attenuator unit. When using the EA424 Attenuator unit you can attenuate amplitude by 24 dB on both channels or by 48 dB on single channel. If you want the software to display amplitude values correctly you need to indicate that the EA424 Unit is or is not in use. To do that, simply select the Options|Channel X|Attenuator from the main menu; this opens a dialog window, where you can indicate the way the EA424 Attenuator unit is connected to the output channels.

The EA424 Attenuator unit is not a part of the standard shipment of the M321 Two Channel Arbitrary Waveform Generator.

TIP: To achieve the best results, put the EA424 Attenuator unit as far as possible from any possible sources of interference (e.g. computer monitor, wall socket …)

3.10.7. Saving settings on disk

When using the GENERATOR software, it is possible to save the status of all control elements on disk. You can later restore the saved file. The name of the file, where all settings are stored is defined by the user. The predefined extension of this kind of file is INI. Besides the files created by the user, there is a file GENERATO.INI located in the GENERATOR software working directory. In this file the software stores the status of all control elements when you exit the program. The software automatically restores these settings after restarting the program. You can use Settings|Save

settings and Settings|Load settings to store and restore the settings. If you want to set all control elements to the default state (most of the control elements are turned off), you can select Settings|Reset settings from the main menu.

3.10.8. Other settings

If you are not comfortable with the preset colors of channels, cursors and some other elements, it is possible to change them by clicking on the Settings | Change color item from the main menu. In the dialogue window which appears after choosing this item, the program displays control elements and their colors. To change the color, click on Set color button, and pick the color in the dialog window, that follows it.

WARNING: After changing the color of channels A, B, C or D, all elements related to certain channel in any way will change their color too.

If you want to control another EML (ETC Measuring Lab) device or simply just want to clear out some space on the desktop, use Settings|Small window item from main menu. This option minimizes the window size, so that the only visible elements are the amplitude and frequency control elements. If you want to restore the window to its original size, double click on the title bar. The minimized window has a ”floating” feature, e.g. this window always floats on the surface; therefore, it is always visible.

TIP: If you are using 640x480 resolution, and wanting to use the ETC M321 Oscilloscope and the ETC M321 Generator at the same time, just run both of the programs and minimize the GENERATOR window by using Settings|Small window item from the main menu. Then put the minimized generator window to the right side of the oscilloscope window. If you need to use any of the oscilloscope control elements just minimize the generator window into an icon. If you want to see all the generator control elements, you can maximize the the window.

By using the item Settings|Control Panel you can turn the tool bar on or off (see following chapter).

The last item in the Settings submenu is Commix. If there is a ”ü” in front of the word Commix, it means, that this option is on. With Commix help on, when you point the mouse cursor over any element, a brief help text is displayed after a short period of time.

TIP: For the user, who has already mastered the generator use, we suggest turning the Commix help off, so as not to be disturbed when working.

3.11. Tool bar

You can use the bar located right below the main menu to control some of the generator functions. These functions are also controllable through the main menu. You can control these functions by clicking on the corresponding button on the tool bar.

The meaning of the buttons is as follows:

- (red arrow) - exits the program and turns the generator off . File|Quit

- (green arrow) - exits the program and leaves generator running. File|Exit

- turns the Commix help on or off. Settings|Comix help

- turns the display of the tool bar on or off. Settings|Control Panel

- runs the Waveform Editor. Data|waveform shape editor

- minimizes the window into a small window. Settings|Small window

3.12. Help

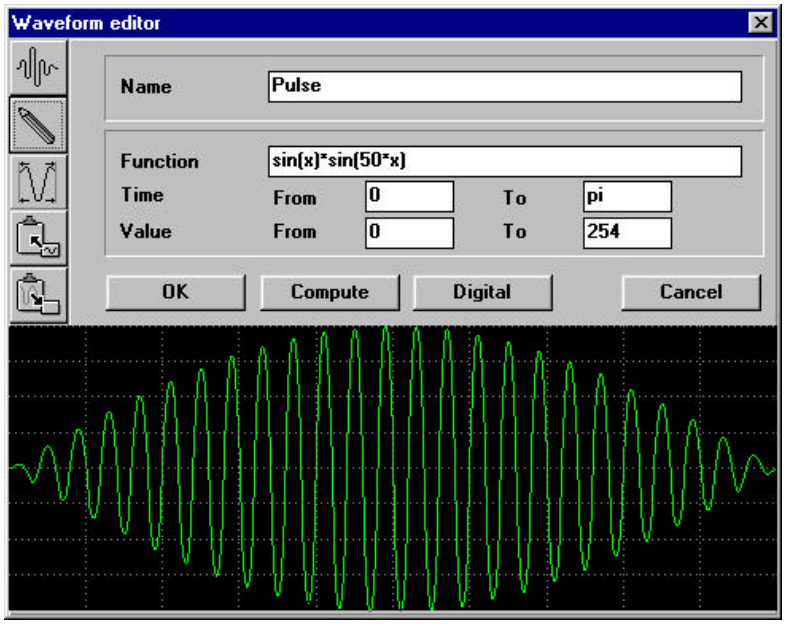
When you are struck by a problem while working with the GENERATOR software, you can find help either in the User’s guide or in the GENERATOR software by selecting the Help item

in the main menu. The help option in the GENERATOR software is written with respect to the standards of the MS Windows environment. You can find more thorough information concerning Help and its use in the MS Windows User’s guide.

4. Waveform shape editor

Part of the M321 Generator software is a powerful waveform shape editor. It is possible to edit both analog and digital waveforms. After running the editor an editor main window appears on the screen (see fig. 4.0.1)

The shape of the currently edited waveform is displayed in the bottom part of the window. It is possible to redraw the displayed waveform



shape by using the mouse. If you want to do that, simply click on the waveform, hold the mouse button pressed and drag it to the new position, then release the button. When you are drawing on the edges of the window, move the mouse slowly, otherwise you will not redraw the firs or last couple of pixels.

On the upper left-hand side of the window, there is a group of control elements. Their meaning is as follows:

Switches between the digital or analog editing mode:

- analog mode

- digital mode

Switches between two different waveform shape drawing modes:

- freehand drawing

- straight-line drawing

WARNING: We recommended you use the whole vertical range, otherwise the amplitude values will be inaccurate.

Switches between different display modes:

- standard display from beginning to the end

- mode, that displays waveform in halves, first from half to the end, than from the beginning to half of the waveform

- moves the waveform shape to waveform shape editor. This data can be used in any spreadsheet, such as MS Excel.

- reads the data from the clipboard. Data has to be in EML format, e.g. they were stored by a device from the EML (ETC Measuring Lab) system, or gained by selecting one column in any spreadsheet.

TIP: You can check the waveform at the beginning with respect to the end of the period by using the mode that displays waveform in halves.

TIP: When you are using the M321 Digital Oscilloscope (part of the EML system), and want to generate the waveform measured by the oscilloscope, simply move it to the generator by using the clipboard and start to generate.

There are several input lines in the upper part of the Waveform editor window. Into the upper one you can write the name of the currently edited waveform. The rest are for defining waveforms by mathematical expressions (see following chapter).

4.1. Defining waveforms by mathematical expressions

The waveform shape editor allows you to define an analog waveform by mathematical expressions. To do this write the desired mathematical expression into the ”Expression” input line. Into the input lines labeled ”From” and ”To” write the interval in which you want the expression to be defined. Then press ENTER.

You can also set the range of values calculated from the entered mathematical expression. The values 0 to 254 are default. They represent following voltage values (amplitude is 10 Vpp):

0	-	-5V
127	-	0V
254	-	+5V

You can set this range anywhere from 0 to 254. If we, for example, set the interval from 127 to 254 and enter the function sin (x). The calculated waveform will be a sine wave with Upp = 5V, maximum value +5V and minimum value 0V.

WARNING: If the value range is different than <0,254> the amplitude values displayed by the software are incorrect.

The expression you enter can be a combination of any of the following mathematical functions:

sin (x) - sine of X
cos (x) - cosine of X
tan (x) - tangent of X
asin (x) - inverse sine of X
acos (x) - inverse cosine of X
atan (x) - inverse tangent of X
sinh (x) - hyperbolic sine of X
cosh (x) - hyperbolic cosine of X
tanh (x) - hyperbolic tangent of X
exp (x) - e to the Xth power
ln (x) - natural logarithm of X
log (x) - common logarithm of X
sqrt (x) - square root of X
floor (x) - truncates the decimal part of X
ceil (x) - rounds X to the closer bigger whole number
abs (x) - absolute value of X
deg (x) - conversion of X from degrees to radians
rad (x) - conversion of X from radians to degrees
sgn (x) - signum X
random (x) - random number in the range <0,X>

You can also use the following mathematical operators and constants

+ addition
- subtraction
* multiplication
/ division

pi 3.14159265358979323846
e 2.71828182845904523536

These constants can also be used when entering the interval. When you are entering the expression you can use either x or t as a variable. To start calculating the waveform shape click on the ”Evaluate” button. The curve will be calculated for all 2048 samples of waveform.

Here are a couple of functions:

Sine	-	sin (x)	<0,2*pi>
Saw1	-	x	<0,1>
Saw2	-	x	<1,0>
Triangle	-	1 - abs (x)	<-1,1>
Rectangle	-	floor (x)	<0,2>
Stairs	-	floor (x)	<0,10>
Burst	-	sin (7*x)*exp(-abs(x))	<-10,10>
Pulse	-	sin (7*x)*exp(-abs(6*x))	<-10,10>

WARNING: The entered expression has to be defined over the whole interval. Otherwise, the software will report an error.

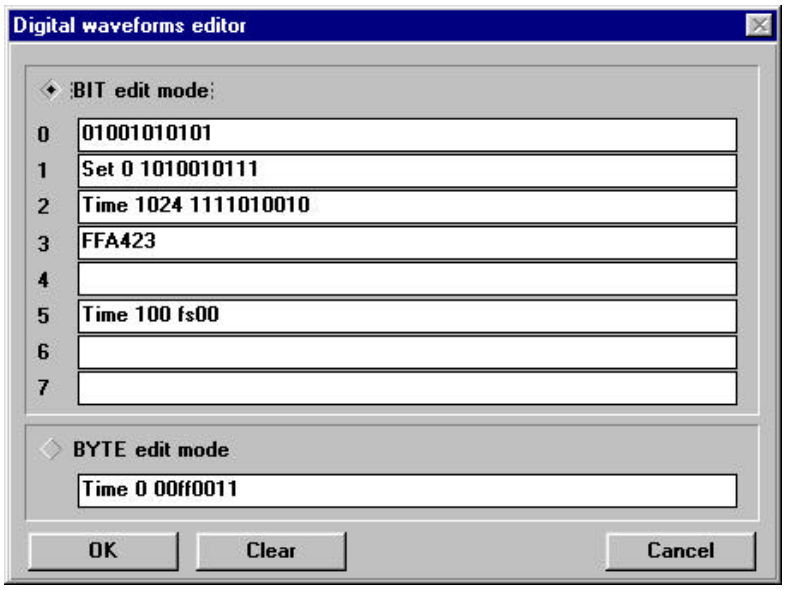
WARNING: In case that the result of the expression is constant over

Value	Waveform
> 0	245 (max)
= 0	127 (0 V)
< 0	0 (min)

the whole interval, the waveform will have a constant value.

4.2. Digital editing mode

The Waveform editor offers you also a digital editing mode, e.g. allows you to edit the 8 bit digital signal. To enter this mode click on the ”Digital” button in the editor main window. This will open the window for



digital editing.

When you use one channel of the M321 Generator you can access up to 8 digital outputs. When you edit the signal you can work in two modes: bit mode and byte mode. When you work in bit mode, you enter values for each bit separately. When you switch to byte mode, you can enter values for all 8 bits at once. For editing in bit mode, there are eight input lines, that represent eight bits (downwards: from Least Significant Bit to Most Significant Bit). If you want to work in byte mode, you can use the input line located at the bottom of the Digital Editor main window. You can select the digital editing mode by clicking on either ”Bit mode” or on ”Byte mode”.

You can use the following commands for editing the digital signals:

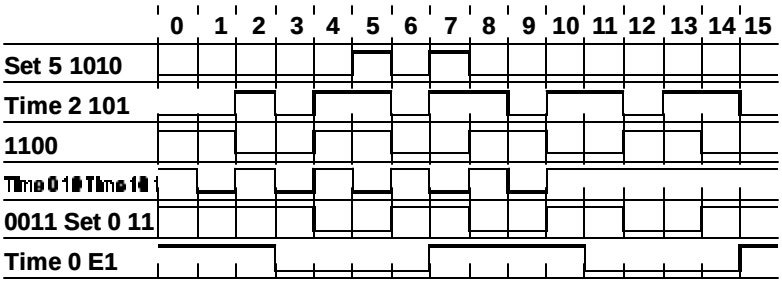
Set <*time*> <*value*> - sets defined value at defined time

Time <*time*> <*value*> - Repeats the entered value from the entered time to the end or to the next command

Fill <*value*> - Fills the whole signal with defined value. Do not write ”Fill” when entering the value.

<*time*> - has to be a whole number in the range from 0 to 2047. It represents the position in the generator’s memory.

<*value*> - digital value of the signal. Can be entered either as a



binary or hexadecimal number (example: 00101111 equals to 2F)

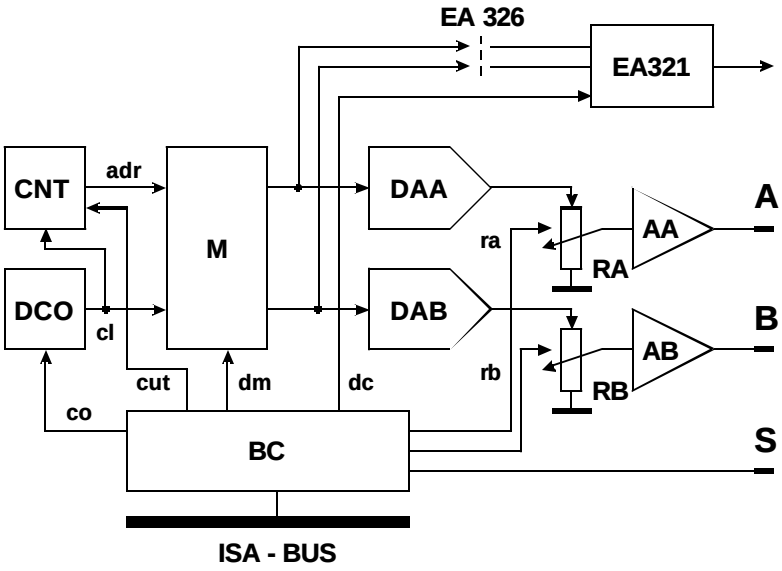
You can enter more commands separated by space into a single input line. They are executed from left-to-right.

WARNING: All signals are in zero state in the beginning.

WARNING: The generator’s memory is 2048 samples long, but the window where the digital signals are displayed does not have such a resolution; therefore, the signal has to be transformed to fit the window. This transformation can cause some of the short pulses to become invisible. This transformation, however, does not affect the output

signal in any way.

5. Hardware



The generator’s hardware consists of the EM321 ISA bus eight bit add-on card, the EA326 connector adaptor and the EA321 digital buffer. You can see the block scheme of the whole system on fig. 5.1. In the following part, we will attempt to describe each of the units.

Each of the two channels of the EM321 add-on card consists of output amplifier AA (AB). The purpose of this amplifier is amplifying and transforming the impedance of output signal. The input of each of the amplifiers is controlled by the digital potentiometer RA (RB). Using this potentiometer it is possible to set the desired output voltage level of the fast DA converter DAA (DAB). Data is fetched from memory M, by the device control unit. The clock is provided by numeric controlled oscillator DCO, which is controlled by the BC unit, which provides communication with the eight bit part of the ISA bus. The S connector can be used either as the input or output of synchro pulses from/to cooperating devices. Digital

data can be accessed by a special connector located on the EM321 add-on card.

The EA326 connector adaptor makes the digital signals more accessible (connector is on computer’s input/output place).

The EA321 Digital buffer, which produces TTL and CMOS compatible digital outputs, can be connected to this connector. The dc signal to the EA321 Digital buffer can set digital outputs to the floating state.

5.1. Output waveform shape restrictions

It is important to be aware of the generator’s technical specifications when creating any user-defined waveform shape. Each channel is equipped with one low pass filter. The frequency of this filtercan be set to either 1 MHz or 450 kHz. The purpose of this filter is to eliminate any possible imperfections and noise caused by DA converters. The consequence of these facts is that all harmonic components of the waveform with frequency higher than the frequency of the filter are eliminated. It is not possible, for example, to generate a voltage change with an edge shorter than 350 ns (when filter frequency is set to 1 MHz) or 700ns (when filter frequency is set to 450 kHz). It is therefore obvious that the shape of non-harmonic waveforms with a frequency close to the frequency of filter will be somehow distorted.

When the generator works in two-channel mode, the phase shift between the channels A (C) and B (D) occurs. Channel B (D) is delayed with respect to channel A (C). While generating at low frequencies, the phase shift is negligible; e.g. with a frequency of 5kHz it is 1/4096 of the signal period (0.088°). However, with output waveform frequency rising, the phase shift also rises, with frequency of 80 kHz it is 1.4°, and with a frequency of 1.28MHz it is 22.5°. The software offers you a so-called ”phase shift compensated” working mode. In this mode, the software eliminates any possible phase shift. However, when you attempt to generate the signal at the high frequency rate, the waveform may be somehow distorted. If you wish to eliminate this fact, simply switch to ”phase shift uncompensated” mode. The phase shift will occur in this mode, but you will observe significantly lower level of distortions.

The generator output waveform is synthesized out of 2048 samples that are stored in the device’s memory. While generating waveforms with an output frequency higher than 10kHz in single-channel mode, or higher than 5kHz in two-channel mode, the number of samples for generating a single period halves, every time the frequency doubles. With the output

frequency of 80kHz the waveform shape is synthesized out of 256 samples (128 in two-channel mode), or with frequency of 1.28 MHz out of 16 samples (8 in two-channel mode). You need to be aware, that the reduction of samples is not really a restriction, because of the output channel filter. In other words: even though we would be able to synthesize the waveform out of more samples, the generator would not be able to generate it.

5.2. Generating the digital signal

It is possible to generate eight bits bytes through both channels (all four when using two EM321 add-on cards as one four channel generator). When generating the digital signal using both channels, channel shift occurs. Channel B will always be half a clock tick behind the channel A. If we, for example, are generating the digital signal at rate of 10Mbit/s, then the output of channel B will be 50ns behind channel A output.

If we are using two EM321 add-on cards as one four-channel generator, there is no phase shift between channels A and C. The phase shift only occurs between the pairs A, C and B, D.

6. Technical specifications

Number of channels	2
Maximum voltage range (no load)	-5 V to +5V (10 Vpp)
Output impedance	70 Ohm ±1%
Output voltage	from 2.5 Vpp to 10 Vpp in less than 50 mV steps from 0 V to 2.5 Vpp in less than 12.5 mV steps
Recommended output voltage range	500 mVpp to 10 Vpp
Output voltage accuracy	± 2.5%
Output filter	450 kHz of 1MHz user selectable
Output protection against short circuit	unlimited
Memory capacity	2048 samples per waveform
Memory capacity (in waveforms stored in memory)	4 waveforms
Maximum generating speed	single channel - 20480 ksamples per second both channels - 10240 ksamples per second
Minimum generating speed	156.25 samples per second
Frequency setting step	<0.1 % of actual value
Long time frequency stability	<0.02% of actual value
Modes of operation	periodic, synchronized, single, triggered
Synchronization connector (S)	can be configured either as TTL compatible input or as output

Synchro voltage threshold level	cca 1.2 V
Recommended synchro voltage range	0V to +5V
Maximum synchro voltage range	-3V to +8V
Synchro output level (no load)	TTL compatible
Synchronization output impedance	cca 75 Ohm

APPENDIX A: Hardware requirements

Minimum hardware recommendation
- PC 386 compatible computer
- 4 MB RAM
- VGA
- 3.5 inch FDD
- HDD
- mouse or other pointing device

APPENDIX B: Host environment versions

Host environment	Compatible versions
Microsoft Windows 3.1	Microsoft Windows 3.11 Microsoft Windows for Workgroups Microsoft Windows 95
Microsoft Windows 95	N/A
Win-OS/2	OS/2 2.X Full Pack* OS/2 Warp Full Pack* OS/2 Warp Connect Full Pack*

*Full Pack is the OS/2 version that includes WIN-OS/2

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Others