

DOEPFER  
MUSIK ELEKTRONIK



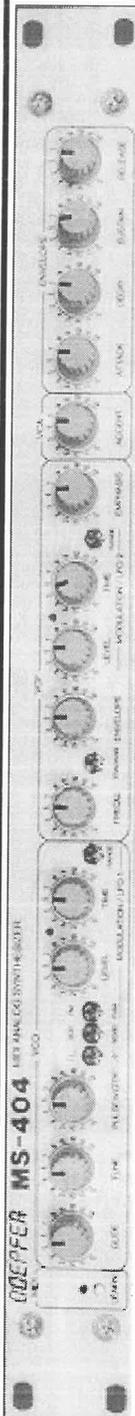
# MS-404

Owners Manual

## MIDI ANALOGUE SYNTHESIZER



UK Manual written and produced by EMIS (C) 1997  
The Old School House, Cossham Street  
Mangotsfield, Bristol, BS16 9EN



# Important Safety Instructions

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## CAUTION

- Read all of these instructions
- Save these instructions for later use
- Follow all warnings and instructions

**1) Read Instructions** - All the safety and operating instructions should be read before the product is operated.

**2) Retain Instructions** - The safety and operating instructions should be retained for future reference.

**3) Heed Warnings** - All warnings on the product and in the owners manual should be followed.

**4) Follow Instructions** - All operating and use instructions should be followed.

**5) Cleaning** - Unplug this product from the wall outlet before cleaning. Do not use liquid cleaners or aerosol cleaners. Use a damp cloth for cleaning.

**6) Attachments** - Do not use attachments not recommended by the manufacturer as they may cause hazards.

**7) Water and Moisture** - Do not use this product near water, for example - near a bath, wash bowl, kitchen sink, in a damp basement, near a swimming pool and the like.

**8) Accessories** - Do not place this product on an unstable stand, tripod, bracket or table. The product may fall, causing serious injury to a child or adult, and serious damage to the product. Use only with a stand, tripod, bracket or table recommended by the manufacturer. Any mounting of the product should follow the manufacturers instructions, and should use a mounting accessory recommended by the manufacturer.

**9)** A product and stand combination should be moved with care. Sudden stops, excessive force and uneven surfaces may cause the product and stand to overturn.

**10) Ventilation** - Slots and openings in the cabinet are provided for ventilation and to ensure reliable operation of the product and to protect it from overheating, and these openings must not be blocked or covered. The openings should never be blocked by placing the product on a bed, sofa, rug or other similar surface. This product should not be placed in a built-in installation such as a bookcase or rack unless proper ventilation is provided or the manufacturers instructions have been adhered to.

**11) Power Source** - This product should be operated only from the type of power source indicated on the marking label. If you are not sure of the type of power supply to your home, consult your product dealer or local power company.

**12) Grounding** - This product must be earthed, do not remove the mains earth to this equipment.

**13) Power Cable Protection** - Power supply cables should be routed so that they are not likely to be walked

on or pinched by items placed upon or against them, paying particular attention to cables and plugs, extension leads and the point where they exit from the product.

**14) Lightning** - For added protection for this product during a lightning storm, or when it is left unattended and unused for long periods of time, unplug it from the wall outlet and disconnect all input and output connections. This will prevent damage to the product due to lightning and power line surges.

**15) Overloading** - Do not overload wall outlets or extension cables as this can result in a risk of fire or electric shock.

**16) Object and Liquid Entry** - Never push objects of any kind into this product through openings as they may touch dangerous points or short-out parts that could result in a fire or electric shock. Never spill liquid of any kind on this product.

**17) Servicing** - Do not attempt to service this product yourself as opening or removing covers may expose you to dangerous voltage or other hazards. Refer all servicing to authorised service personnel.

**18) Damage Requiring Service** - Unplug this product from the wall outlet and refer servicing to qualified service personnel under the following conditions:

- a) when the power supply cable or plug is damaged.
- b) If liquid has been spilled, or objects have fallen into the product.
- c) If the product has been exposed to rain or water.
- d) If the product does not operate normally by following the operating instructions. Adjust only those controls that are covered by the owners manual as an improper adjustment of other controls may result in damage and will often require extensive work by a qualified technician to restore the product to its normal operation.
- e) If the product has been dropped or damaged in any way.

f) When the product exhibits a distinct change in performance, this indicates a need for service.

**19) Replacement Parts** - When replacement parts are required, be sure the service technician has used replacement parts specified by the manufacturer or have the same characteristics as the original part. Unauthorized substitutions may result in fire, electric shock or other hazards.

**20) Safety Check** - Upon completion of any service or repairs to this product, ask the service technician to perform safety checks to determine that the product is in proper operating conditions.

**21) Wall or Ceiling Mounting** - The product should be mounted to a wall or ceiling only as recommended by the manufacturer.

**22) Heat** - The product should be situated away from heat sources such as radiators, stoves or other products (including amplifiers) that produce heat.

Thank you for choosing the Doepfer MS-404 MIDI Analogue Synthesizer which offers pure analogue sound synthesis. It can be controlled either by MIDI or by CV/Gate, and offers an external audio input for processing external sounds as well.

The MS-404 has been designed using 100% analogue circuitry and control like vintage analogue synths of the past, however using modern components now offers a greater stability which was often the downfall of vintage instruments. Other present day "analogue" instruments use digital scanning for all the controls, and thus digitise the controls giving quantised "zipper" noise when the controls are swept. This method is required if the instrument has programmable memories. The MS-404 has avoided programmable memories in preference for a true analogue instrument. When using the MS-404 via it's MIDI input rather than the CV/Gate interface, there are compromises due to the limitations of MIDI, which only offers a 7-bit resolution, but only with MIDI pitch bend, MIDI filter sweep and MIDI velocity modulation - the front panel controls are always real unquantised analogue whether MIDI or CV/Gate input is used.

The controls of the MS-404 should be familiar to anyone who has used an analogue synth before,

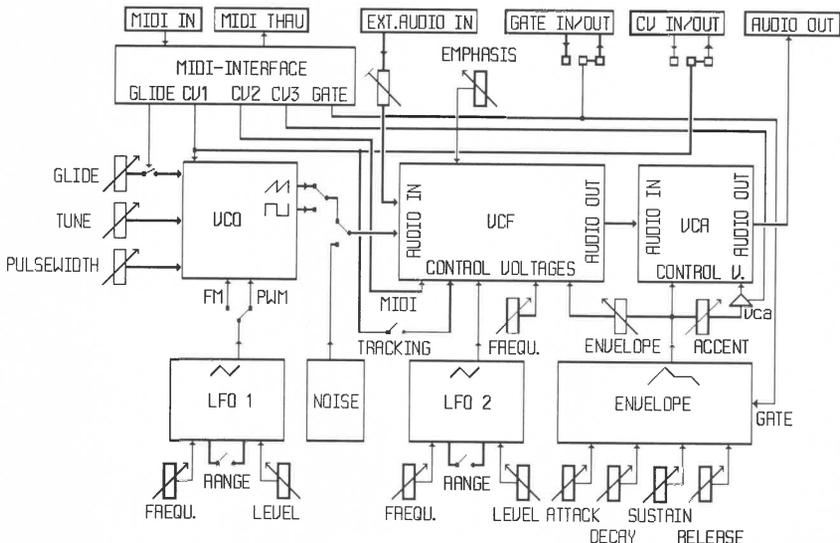
however there are a few less obvious functions, therefore it is best to read this manual before using the MS-404.

The MS-404 uses circuitry from the Doepfer A-100 modular system, and has the following modules:-

- 1 VCO
- 1 Noise Generator
- 1 VCF (24dB/Octave low pass with resonance)
- 1 VCA
- 1 Control VCA (used by the MIDI velocity Accent function)
- 1 Envelope (ADSR type)
- 2 LFO's (Triangle waveforms - one for VCO, one for VCF)
- 1 MIDI-CV interface providing 3x CV, 1x Gate and Glide switching.

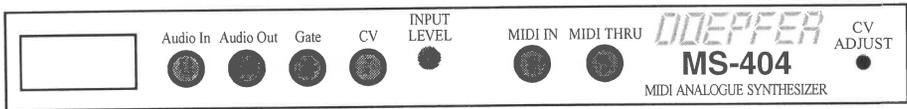
The MS-404 is housed in a standard 1u 19" rack case and has it's own power supply built in, avoiding "wall wart" mains adaptors.

Please remember that the MS-404 is analogue, and therefore is sensitive to temperature changes. If the MS-404 is moved to a new location, allow several minutes for the MS-404 to stabilise before use, or the VCO tuning may wander until a constant temperature is reached.



MS-404 Block Diagram

# MS-404 Connections



*MS-404 Rear Panel Connections*

## Audio In

The Audio in is a 1/4" mono jack socket at line level, typically from another synth, drum machine or sampler. It is not designed for direct connection from a microphone, which is unlikely to output enough signal level for this input. If a microphone is required to be processed by the MS-404 then a microphone pre-amp is needed to increase the signal level first.

## Audio Out

The Audio out is a 1/4" mono jack socket at line level, suitable for direct connection to a line input on a mixer, effects processor or amplifier. Be careful if connecting the Audio out to a microphone input stage of a mixer or amplifier, as the signal level coming from the MS-404 may be too high and cause distortion. If connecting to a hi-fi system do not use the Phono input (record deck) as not only is this a very sensitive input, it will also be equalised for a record deck. Instead use the Tape, CD, Tuner or Aux inputs.

## Gate

The Gate socket (1/4" mono jack socket) can either be an input or an output (an internal modification). It is factory set to output, thus allowing the MS-404 to control another instrument. The Gate output is a +5v pulse (V-Trig). The Gate polarity cannot be changed, and is therefore not compatible with S-Trig instruments such as Moog or Korg (except the Mono/Poly).

## CV

The CV socket (1/4" mono jack socket) can be either an input or an output (an internal modification). It is factory set to output, thus allowing the MS-404 to control another instrument. The CV output is 1V/Octave and cannot be changed, therefore is not compatible with Hz/Volt instruments such as Yamaha and Korg (except the Mono/Poly).

## Input Level

The input level control sets the level for the Audio input signal that is routed to the VCF. This control needs to be set so that the incoming signal does not overload the input of the filter to avoid distortion (unless that is what you are wanting to do anyway!).

## MIDI In

The MIDI in should be connected to the MIDI out of your keyboard or sequencer. The MIDI functions are set using the Learn switch on the front panel.

## MIDI Thru

The MIDI thru is a hard wired through connection, and outputs everything received at the MIDI in. The MS-404 does not have a MIDI out, because it does not generate any MIDI information. If several pieces of MIDI equipment are needing to be chained together, then the thru connection becomes essential.

## CV Adjust

Do not touch this control! It is a precise calibration control, and is for servicing only. Although it may be possible for the user to adjust this control, incorrect adjustment will make the MS-404 play out of tune across its range.

## Power Switch & Mains Input

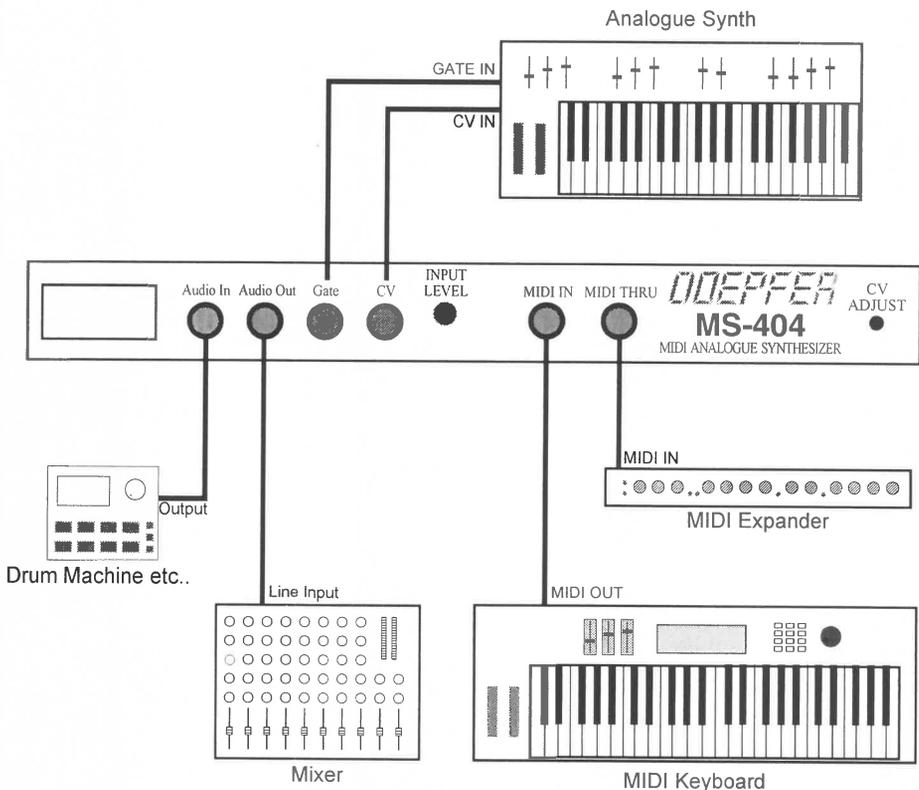
The UK version of the MS-404 is set for 240V operation and is fused at 1A. Never replace the fuse with anything other than a similar 1A fuse.

A power switch is provided on the rear.

When the MS-404 is switched off, you may hear the filter going into self oscillation momentarily, and producing a falling pitch sweep - this is quite normal and is just the MS-404 protesting about being switched off!

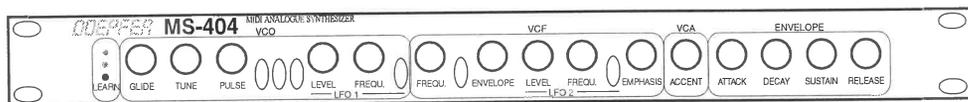
Make all the audio and MIDI connections required, plug the MS-404 in and switch on. There is no power light as such, but there is always activity from some of the four LED indicators on the front panel. Initially the Glide Led will light (as long as the connected MIDI keyboard does not have a Portamento footswitch enabled - in which case this LED will only light when the footswitch is pressed), the Learn LED will flash once briefly and the two LFO speed indicator LED's will flash (at the rate set by their Frequency and Range controls). If the LFO rate is set very fast, the LED will be constantly lit, normally used speeds will show the LED flashing, and very slow speeds will cause the LED to go out for some time. However, on initial power up, the LFO's are reset and therefore always start with a positive value, so the LED will always light up at initial power up.

It will be assumed here, that initially the MS-404 is being driven from a MIDI keyboard via the MIDI in connection, rather than from the CV and Gate input modifications that can be done with the MS-404. The MS-404 can respond to MIDI Velocity, Pitch Bend and Controllers, therefore it is best to use a MIDI keyboard that can transmit this information. If a keyboard length of more than five octaves is used, the MS-404 will only respond to the five octaves above the transpose base key that is set with the MIDI Learn function (see MIDI mixers).



At this stage there is no need to connect an external sound source to the Audio input, this will be covered later on in the manual. The additional MIDI expander and analogue synth is also not required at this stage. Once connected, switch on and get ready to play.

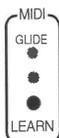
# Front Panel Controls



The front panel has 15 rotary controls, 6 three-position switches and a momentary "Learn" switch for MIDI functions. In addition to the controls there are 4 red indicator LED's (Light Emitting Diode - is a diode that lights up when powered, and only needs very low power to operate compared to filament bulbs).

The controls are divided up into five groups, and the signal path logically flows from left to right.

## MIDI - Musical Instrument Digital Interface

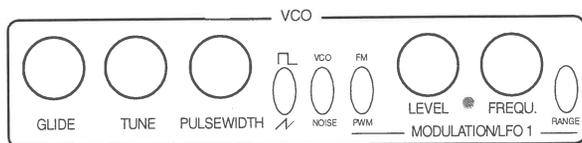


There are several MIDI functions, and these are accessed by pressing the "Learn" switch, at which point the LED above the switch starts to flash - the MS-404 is waiting for some MIDI data. For details on the MIDI functions, see the later section on MIDI Functions. If you wish to cancel the MIDI Learn mode, then simply press the Learn switch again. This stops the indicator flashing, and returns the MS-404 back to normal operating mode.

The Glide LED indicates the status of the MIDI Control 65 (Glide - or often referred to as Portamento) footswitch. With no pedal connected the LED will be on all the time, giving control of the glide to the front panel control. Note that the footswitch is connected to the controlling keyboard and not the MS-404 itself. When a pedal is connected, the Glide LED goes out, switching out the Glide function regardless of the Glide control position. When the pedal is pressed, the LED comes on, bringing in the Glide.

If using the MS-404 in CV/Gate input mode, rather than MIDI, then this section will have no effect, as it controls the built in MIDI-CV converter which is switched out in CV/Gate input mode.

## VCO - Voltage Controlled Oscillator



The VCO section includes LFO-1, as unlike many analogue synthesizers, the MS-404 has 2 dedicated LFO's, one for the VCO and one for the VCF.

**GLIDE** - variable from zero (off) to around 4 seconds. The Glide time is the time it takes for the VCO pitch to change from one note to the next. It does not matter how far apart the two notes are, the time it takes to change to the new note is the same. Note that the MIDI Glide function will override this control

when used. MIDI functions tend to refer to the glide function as portamento. This is just a different word for the same thing, therefore read Portamento and Glide as the same thing. In this manual, when referring to MIDI functions the term Portamento is used.

**TUNE** - simply adjusts the overall pitch of the VCO, and is intended for fine tuning (this is not a transpose function - this is done within the MIDI functions). The tuning range is around a tone up or down (+/- 200 cents), with a setting of 6 (central) being A=440Hz.

**PULSEWIDTH** - controls the width of the pulse waveform between 0% and 100% with 50% (square wave) in the central position. Although settings below 5% and above 95% become inaudible.

**WAVEFORM SELECTOR** - three position switch selecting Pulse wave (up), Off (Middle) or Sawtooth wave (down). The middle position switches the VCO off, allowing an external input to be used.

**SOUND SOURCE** - three position switch selecting the VCO (up), Off (middle) or Noise (down). The middle position performs the same task as the Waveform Selector switch by switching the sound source off, but still enabling any external input.

**LFO-1 MODULATION DESTINATION** - three position switch selecting LFO-1 to VCO pitch (up), off (middle) or LFO-1 to Pulse Width (down).

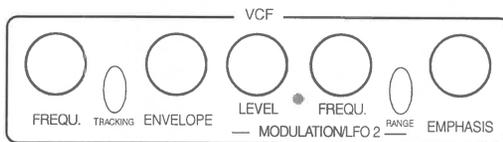
**LFO-1 LEVEL** - controls the amount of LFO-1 routed to the VCO (LFO or vibrato depth control)

**LFO-1 SPEED LED** - indicates the speed of the LFO. As the LFO is a triangle waveform, the brightness of the LED reflects the position within the waveform.

**LFO-1 FREQUENCY** - controls the speed of the LFO.

**LFO-1 RANGE** - three position switch selecting the frequency mode of LFO-1. Slow (up), Fast (middle) or Normal (down). The slow mode goes down to 0.003Hz (one cycle every 330 seconds) to about 5Hz, the normal mode from 0.05Hz (one cycle every 20 seconds) to around 50Hz and the fast mode ranges from around 10Hz to 5KHz.

## VCF - Voltage Controlled Filter



The VCF section like the VCO has its own dedicated LFO. This is unusual in an analogue synth and allows the MS-404 to produce many unique sounds.

**FREQUENCY** - the cutoff frequency of the filter ranges beyond the range of hearing, exceeding 20Hz to 20KHz.

**TRACKING** - three position switch selecting keyboard tracking on full (up), tracking off (middle) and 50% tracking (down).

**ENVELOPE DEPTH** - controls how much of the envelope signal modulates the filter cut off point. Remember that the cutoff Frequency and Envelope Depth interact.

**LFO-2 LEVEL** - controls the amount of LFO-2 routed to the VCF (modulating the cutoff frequency)

**LFO-2 SPEED LED** - indicates the speed of the LFO. As the LFO is a triangle waveform, the brightness of the LED reflects the position within the waveform.

**LFO-2 FREQUENCY** - controls the speed of the LFO.

**LFO-2 RANGE** - three position switch selecting the frequency mode of LFO-2. Slow (up), Fast (middle) or Normal (down). The slow mode goes down to 0.003Hz (one cycle every 330 seconds) to about 5Hz, the normal mode from 0.05Hz (one cycle every 20 seconds) to around 50Hz and the fast mode ranges from around 10Hz to 5KHz.

**EMPHASIS** - controls the amount of resonance on the filter. The terms resonance, Q and emphasis all mean the same thing, various instruments use different terminology, meaning the same thing.

## Front Panel Controls

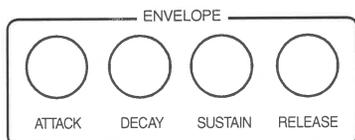
### VCA - Voltage Controlled Amplifier



The VCA only has just one control, as the envelope generator is routed directly to the VCA control internally. There are two more internal connections to the VCA from the MIDI input velocity and control 7 (volume). Control of these functions are done through the MIDI learn function.

**ACCENT** - controls the output of the VCA, which basically becomes the volume control. However, this control can be overridden by MIDI control 7 (Volume) and MIDI velocity, depending on the way that the MIDI parameters are set up.

### ENVELOPE Generator (ADSR)



The envelope is a standard ADSR type, triggered from the keyboard gate. The output of the envelope is routed to the VCA and to the VCF via the VCF Envelope Depth control. The envelope can also be triggered from the external Gate input on the rear of the MS-404 provided an internal modification of switching the input/output mode has been made. Note that this modification involves opening up the MS-404, and if not performed by an authorized service center, will invalidate the warranty.

The Attack, Decay and Release are timing controls, with the higher the setting, the longer the time. The sustain control is a level control.

**ATTACK** - controls the attack time upto 15 seconds at maximum. A setting of zero is virtually instantaneous.

**DECAY** - controls the decay time from virtually instantaneous to 20 seconds.

**SUSTAIN** - controls the sustain level from 0% to 100%.

**RELEASE** - controls the release time from virtually instantaneous to 20 seconds.

That completes the front panel, the only control on the rear panel is the external input level. This trims the external input level to match the input level required by the filter. Although quite a sensitive input, it is unlikely to accept microphone level signals, although it depends on the output level of the microphone. In doubt, give it a try, the only thing that may happen is that you will not hear anything from the microphone.

There are no indicators or switches to show the status of the MIDI functions, although there are only a few MIDI functions, some front panel controls may not react correctly if the MIDI parameters are interacting. So first off, the MIDI control side of the MS-404 will be explained. The MS-404 has the following MIDI functionality:-

- MIDI Channel selection - 1 ~ 16 (omni mode is not supported as it has such limited use)
- MIDI Transpose - Note 1 ~ 127 (the MS-404 has a five octave range, and the lowest note set becomes the pitch offset)
- MIDI Notes - Within the 5 octave operating window, the note number and velocity generate CV's and a gate signal.
- Pitch Bend - The pitch-bender adds or subtracts from the key CV with a 1 octave bend depth.
- Control 7 - MIDI Volume controls the MS-404 VCA level.
- Control 64 - MIDI Sustain pedal (Hold) keeps the gate on, when a key is released.
- Control 65 - MIDI Portamento (Glide), switches the glide on and off.
- Control XX - One controller can be set to modulate the VCF or VCA (usually Mod Wheel)
- Program Change - Program change messages are used to switch the six MIDI functions of the MS-404 (Program change 0 ~ 5)

## Channel Selection and Transpose

All MIDI settings are controlled by use of the LEARN switch and the associated indicator LED above this switch. The keyboard transmit channel and MS-404 receive channel must be the same, at this stage all you need to concern yourself with is to press the LEARN switch, this makes the LED above the switch flash - the MS-404 is waiting for some MIDI input. Press the lowest C note on your keyboard, the LED stops flashing indicating that the MS-404 has learnt it's parameter. This procedure has set two important MIDI parameters at once. Firstly, the MIDI receive channel has been set to that of the transmitting keyboard (infact, you don't even need to know what that is - the MS-404 has "learnt" the channel by itself) and secondly the lowest note (transpose) has been set. By pressing the lowest C note, this disables the transpose function - which is the normal mode of operation, so it is important to ensure that it was the lowest C note that was pressed, as the MS-404 will not respond to any notes below this setting. These MIDI settings are stored in non volatile memory (the MS-404 remembers these settings when powered off), so do not need to be set every time the unit is powered up.

## Notes and Velocity

The MS-404 converts MIDI note numbers into an analogue control voltage routed to the VCO (pitch) and VCF (tracking). The velocity value also produces a control voltage which is routed to the VCF and VCA.

## Controller 64 (Sustain)

The MS-404 always responds to Controller 64, which is the sustain (or Hold) pedal. When the sustain pedal is pressed, the following Gate signal is held until the pedal is released. The Gate LED on the panel stays lit to show the status of the gate. It is perhaps best to clarify that the Sustain/Hold pedal function does not generate a gate signal, but simply holds an existing gate signal on.

## Controller 65 (Portamento)

Controller 65 is for portamento (or Glide), and the MS-404 receives this status at all times. If no pedal is used, then the Glide is on all the time, using the Glide Time controller on the front panel to set the Glide time, a value of 0 turns the glide off. When a pedal is being used to switch the Glide function, the Glide LED goes out switching the glide off, regardless of the position of the Glide control, when the pedal is pressed the Glide LED comes on, and the set Glide value is active. If no pedal is available (as not all keyboards have a portamento pedal function), the Controller 65 data can be manually entered into a sequencer using a value of 0 to turn the Glide off, and a value of 127 to turn the Glide on.

# MIDI Functions

## Controller 7 (Volume)

Controller 7 is the standard MIDI volume control parameter and is received at all times. However, the VCA Accent control controls the depth of control 7 (MIDI Volume) routing to the VCA. So with the VCA Accent control at 0, Control 7 will have no effect, and the volume will be at it's lowest. In order to achieve normal MIDI Control 7 volume control, set the VCA Accent control to maximum (12). There is an internal jumper that can be made allowing a small amount of envelope signal to be sent to the VCA, even with the VCA Accent control at 0, this is to prevent the MS-404 going into complete silence with a MIDI controller 7 value of 0. Adding this jumper involves opening the unit, and must only be done by an authorized service centre, otherwise it will invalidate the warranty.

## Pitch Bend

Pitch Bend information is added to or subtracted from the note CV with a depth of an octave up or down. Be careful not to exceed the five octave range of the MS-404, as notes played in the lowest octave and bent downwards or notes in the highest octave bent upwards will take the note beyond the five octave range. This will prevent the note from bending any further when it hits the limit.

## Definable Controller

One further controller is available which can be routed to the VCF. This can be any MIDI controller number (usually between 0 and 63), though is usually the Mod Wheel (controller number 1). Some controllers have reserved MIDI functions, therefore it is best to select the controller number carefully. Below is a list of the controllers that have a reserved function:-

<i>Controller #</i>	<i>Reserved Function</i>
0	Program Change Bank (MSB)
1	Modulation Wheel
2	Breath Controller
4	Foot Controller
5	Portamento Time
6	Data Entry
7	Volume
10	Pan
11	Expression
32	Program Change (LSB)
38	Data Entry (LSB)

Originally the MIDI spec reserved Controller 0 to 31 as the most significant bit (MSB) and controller 32 to 63 as the least significant bit (LSB), so controllers 0 and 32, 1 and 33 etc.. are linked (MSB and LSB). However, as MIDI never seems to have enough controllers anyway, this standard is not often followed (the Bank message Control 0 and Control 32 are the obvious exception).

Try to avoid using control 0 or control 32, as it is now used for non controller functions (selecting program changes), although the MS-404 will not respond to control 0 or 32 as program changes (as it does not have any program memories), it could cause problems if the MS-404 sequence track is applied to another instrument that may respond to such messages.

To set a controller, press the MIDI Learn switch on the MS-404 and then move the relevant controller. This will set the MS-404 definable controller to that controller. For example: To set the mod wheel to control the VCF, first press the MIDI Learn switch - the LED indicator will flash prompting you for an input, move the mod wheel. It does not matter where you move the wheel to or from, as long as the MS-404 detects movement, it will learn the MIDI controller. Be careful not to press a key on the keyboard when in MIDI learn mode.

Controller numbers above 64 can be used, but these are switch functions (on/off) and will cause the VCF to go from zero to maximum when pressing the controller.

## MIDI Receive Modes

There are six further MIDI receive modes that the MS-404 can be set to. As there are no MIDI function switches on the MS-404, these functions are selected by sending MIDI program change messages when in MIDI Learn mode. The MS-404 uses six program change commands to set the functions, though these are actually three toggle functions. Program change 0, 2 and 4 switch a function on and Program Changes 1,3 and 5 turn the respective function off. To set a function: Press the MIDI Learn switch - the LED starts to flash, send the relevant program change number - the LED stops flashing indicating the function has been set.

Be aware that MIDI program changes start at 0 and not at 1. Therefore, the MS-404 responds to MIDI program numbers 0 to 5 (and not 1 to 6). However, it depends on how the programs are numbered on your controlling instrument. In this manual MIDI program changes are referred as 0 to 5 as this is technically correct, and is more than likely how a sequencer will display this data.

## Velocity to VCA

Sending Program Change #0 turns OFF velocity control of the VCA (basic setting).

Sending Program Change #1 turns ON velocity control of the VCA.

## Velocity to VCF

Sending Program Change #2 turns OFF velocity control of the VCF (basic setting).

Sending Program Change #3 turns ON velocity control of the VCF.

## Trigger Mode

All mono synths have some form of key priority to generate the trigger, when more than one note is pressed, or a legato style of playing is used (pressing a new note before releasing the previous). The MS-404 allows either no re-trigger unless re-keyed or high note priority re-trigger, where any new higher key will trigger the envelope. In this mode releasing higher notes will cause the lower notes to re-trigger, this is perhaps the most useful mode, and is the system used by many vintage analogue mono synths such as the Minimoog etc..

Sending Program Change #4 turns OFF re-trigger mode.

Sending Program Change #5 turns ON re-trigger mode (basic setting).

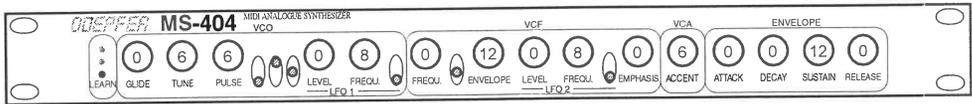
It is important that the MIDI settings are set correctly when following this manual, unless specified the basic settings are shown above, and form part of the "Basic Patch". For reference if your controlling keyboard numbers programs 1 upwards and not 0 upwards, use the program numbers shown in brackets.

To set these quickly do the following:-

Press MIDI Learn  
Transmit Program Change #0 (#1)  
Press MIDI Learn  
Transmit Program Change #2 (#3)  
Press MIDI Learn  
Transmit Program Change #5 (#6)

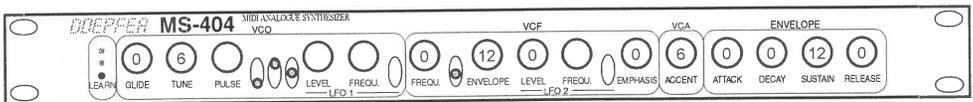
# The Basic Patch

There are 21 controls on the front panel of the MS-404, and each of these controls has to be in the right place to create the right sound, therefore initially you will need to start with a "basic initial" patch as basis for editing. This is standard practice for all synths (not just analogue), and the basic settings on the MS-404 is no different than would be expected of an analogue synth. Throughout this manual a front panel diagram will be shown to show the panel settings, so assuming the basic MIDI settings have been made (see previous MIDI functions section), below is the "basic initial" patch.



*Basic Patch*

On some sounds, certain controls will be irrelevant, and therefore will not be shown. For example: if the LFO-2 level is set to 0, then it is essentially turned off, so the frequency and range settings of the LFO will not effect the sound, so these settings need not be set. LFO-1 can be switched between FM, PWM or off, and when the switch is in the central off position, then the level, frequency and range controls have no effect, and so their settings is not important. The basic patch as above, could be shown as this:-



*Basic Patch (simplified)*

This setting only involves 15 settings rather than 21 (not counting the MIDI functions), and throughout this manual, settings that are not applicable to the sound will not be shown. This will also show, the components that are not used within the sound.

The settings shown are not the definitive setting, as values are shown to a maximum resolution of one decimal place, final adjustments are best made by ear after the approximate value has been set from the patch chart.

In order to understand why the controls are at these positions requires some knowledge of the MS-404 architecture and some principles of analogue synthesis. So before we explain why the basic patch is set this way, an introduction to analogue synthesis as implemented on the MS-404 is required.

# Principles of Analogue Synthesis

Analogue synthesis is not actually the correct term to use, as it describes the circuitry used to produce the sound and not the form of synthesis used. The correct form of synthesis that the MS-404 uses is "subtractive synthesis". This is the principle of starting with a harmonically rich sound (bright), and then filtering out some of the harmonics followed by controlling the volume level. This leads us to the well established theory of there only being three elements of sound that will describe any sound. That is:- Pitch (frequency), Tone (harmonic content) and Volume (amplitude).

If we take a Piano that plays middle C and then the same piano playing D, the tone and volume is the same, but the pitch is different. The difference we perceive of frequency changes, is musical pitch differences, thus pitch is the first vital element in sound and is the job of the VCO.

Next, if a Clarinet plays middle C and then a Trumpet plays middle C, they sound very different. The pitch and volume are the same, but the harmonic content is different. The human ear (actually the brain) can recognize differences in sound by it's harmonic content. So tone (or harmonic content) is the second vital element, and this is controlled by the VCF.

Finally, if an organ plays middle C and then a Piano plays middle C, then the piano sound dies away to nothing, whilst the organ is still playing. It is the volume of the sound that has decayed away, giving the Piano sound it's level character. So the volume of a sound also describes the sound, and this is the function of the VCA.

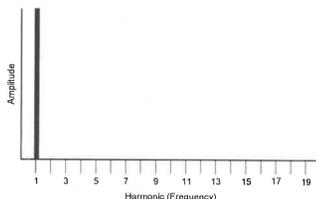
So that is the three elements that define a sound. Or is it? No. Despite popular belief of the magical three elements of sound (pitch, tone and volume), there is infact another one - *modulation*, and this one is probably the most important. It is not just the pitch, tone and volume of a sound that define a sound, but it is the way in which these elements change over time that is really important. If the piano sound did not decay away, it would not sound like a piano, if an oboe sound decayed like a piano, it would not be so recognisable as an oboe sound - infact a fast decaying oboe actually sounds more like a harpsichord (this was how a lot of sounds were produced on early electronic organs of the 70's, simply by applying different modulations to different sounds. A tuba with decay becomes a piano, and a sustained clavichord becomes a violin).

In a subtractive system (that is the MS-404 - in case you weren't paying attention earlier on!), we have to start with an oscillator that is rich in harmonics.

## Harmonics

Theoretically, any instantaneous sound can be broken down into a set of harmonics, each harmonic being at a different amplitude. A harmonic is a single sine wave. The most important harmonic is the one that determines the pitch or frequency of the sound. This harmonic has a name of it's own called the *fundamental*. The *fundamental* is usually the loudest harmonic, and is also usually the lowest frequency harmonic in the *spectrum*. (Ahh! - another technical word to fight with! *Spectrum* is a technical term that describes the collective group of harmonics and their associated levels). A simple sine wave only has one harmonic (the *fundamental*) and it's harmonic *spectrum* just contains one harmonic. If there was a second harmonic, this would be twice the frequency of the fundamental, and would be the second harmonic, and a sine wave three times the fundamental would be the third harmonic. The sine wave is of no great use to us in subtractive synthesis, because it cannot be filtered any more. A filter cannot change the tonal character of a sine wave, because it has no harmonics to control. This is why the MS-404 does not offer a sine wave waveform (although the MS-404 can output a sine wave - but more on that later).

### Wave Shape and Harmonic Spectrum of the Sine Wave

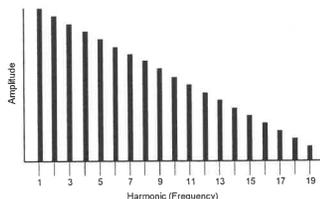


# Principles of Analogue Synthesis

## Sawtooth Waveform

The Sawtooth waveform is made up of lots of harmonics, in fact it contains all harmonics at descending amplitudes (the higher the harmonic, the lower the amplitude).

The waveform and harmonic spectrum are:-

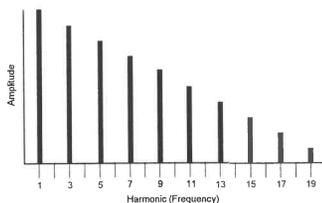
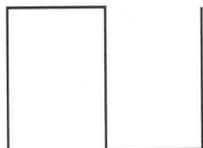


The fact that the harmonic spectrum provides a saw shape is purely coincidental, the shape of the harmonic spectrum does not represent the waveform shape. The sawtooth provides a good source of harmonics for the filter to manipulate, but there is another waveform that allows us to alter its shape, and thus allow "tonal" changes from within the oscillator before it even reaches the VCF (you weren't expecting this to be easy were you?).

## Pulse Waveform

The pulse waveform is often referred to as the *Square Wave*. This is only true when the width of the pulse is 50%. A pulse wave rises to maximum immediately (we will not go into slew rates here, but it is safe to assume that the wave rises very quickly), it then stays at maximum, and then drops immediately to zero, stays at zero a while and then repeats. When the ratio of the time at high and low is equal, it is said to have an equal mark space ratio (50% high and 50% low), and therefore is a perfect square wave. Once the ratio of high to low changes, the waveform is no longer square, and is then referred to as a pulse wave, the ratio of high to low times is usually referred to as a percentage which defines the pulse width.

Below is the wave shape and harmonic spectrum of the 50% pulse wave (square wave).



The pure square wave is made up of just the odd harmonics, and the even harmonics only come in when the pulse width is above or below 50%. To the ear a pulse width of 75% sounds exactly the same as a pulse width of 25%, this is because the ratio is the same in both cases (3:1 or 1:3), it is actually the phase of the waveform that is different, and in isolation the ear is not very good at discerning phase, which is why it sounds the same. However, the ear is very critical of a pure square wave. After a little experience you will find it easy to adjust the Pulse width to a pure square wave.

To achieve a pure square wave on the MS-404, start with the basic patch and switch the waveform switch to PULSE and set the PULSEWIDTH control to 6. It will need to be very precise to get a perfect 50% square wave, but by listening whilst adjusting the PULSEWIDTH control, it will become obvious when the perfect square wave is achieved. If the pulse width is moved away from 6 on the MS-404 panel, the harmonic spectrum changes from what was all odd harmonics at descending amplitudes to increasing amounts of all the harmonics depending on the PULSEWIDTH setting. At 6 the pulse wave had a pulse width of 50%, but if the MS-404 PULSEWIDTH control is moved to around 2, the sound becomes thinner and we then have a pulse width of around 25%, which looks like this:



If we keep reducing the PULSEWIDTH, at around a value of 1, the sound completely disappears, this is because the pulse width has reached 0%. Infact when the pulse width goes below 5% the ear is unable to detect the sound. You may have noticed that when the PULSEWIDTH control is moved whilst playing a note, a chorus effect is achieved. This is what is known as Pulse Width Modulation (PWM), and LFO-1 can be used to sweep the pulse width up and down.

## Noise

Noise is not actually a function of the VCO, but is a sound source, so it will be considered here. Noise is a combination of all harmonics (and inharmonic - that is harmonics that are not related to the fundamental) at random amplitudes. As there is no fundamental as such, noise has no obvious pitch to it, therefore is the same wherever it is played across the keyboard (assuming filter tracking is off).

## Voltage Controlled Filter (VCF)

The VCF is the back bone of analogue synthesizers, for it is the filter that gives each instrument it's characteristic sound. The low pass filter in the MS-404 removes the upper harmonics from the waveform's harmonic spectrum, thus filtering high frequencies and allowing low frequencies to pass, which is why it is called a low pass filter. The actual effective frequency is set by the Cut Off Frequency, and is also dependant on the "roll off" of the filter. The roll off is described as how much attenuation (dB/Octave - decibels per octave) of harmonics across an octave is suppressed by the filter. That is, if the first harmonic was 440Hz and the second harmonic is at 880Hz, if the filter cutoff was set to 440Hz then at 880Hz the signal would be attenuated by so many decibels. The number of decibels depends on the filter. The MS-404 VCF is 24dB/octave (sometimes referred to as four-pole, where a one-pole filter offers 6dB/octave roll off), so in the above example the 880Hz harmonic would be 24dB lower in level than it was before it entered the filter, whilst the 440Hz harmonic would be unaffected.

An additional feature of an analogue filter is to provided an emphasis of the harmonics around the cutoff point, this is the *emphasis* control (known also as resonance or Q). It is how this emphasis control reacts that gives the filter it's sound, because the filter will break into oscillation itself, adding harmonics to the spectrum as well as filtering some of the oscillators harmonics out. The filter is best swept, rather than remaining static, and it is the job of the envelope generator, velocity, keyboard tracking and an LFO to keep the cutoff point moving, thus keeping the sound more interesting.

# Principles of Analogue Synthesis

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## Voltage Controlled Amplifier (VCA)

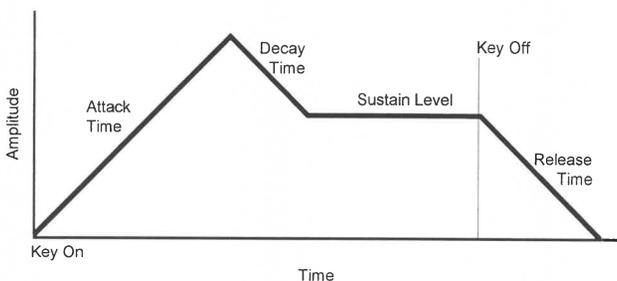
The VCA is an amplifier under voltage control. That is, the volume of the sound is determined by a voltage level at the VCA input, this usually comes from an envelope generator. Without the VCA the sound would never decay or stop, even after a key was released. Despite being called an amplifier, most of the time the VCA actually attenuates the sound, often down to nothing, but as a device that controls the level of a sound, it is still referred to as an amplifier. It could be called a Voltage Controlled Attenuator, which is more what it is doing, but this term is not used, and you must refer to it as a voltage controlled amplifier.

## Low Frequency Oscillator (LFO)

The LFO generates a low frequency rising and falling voltage that will control the VCO or VCF. If the LFO is applied to the oscillator it generates vibrato, and to the filter as wah-wah (although the term wah-wah is not used much today, simply filter modulation is perhaps more suitable). The LFO in the MS-404 goes beyond being an LFO, because it can generate frequencies into the audio range allowing the VCO to be modulated by a frequency similar to the VCO, this kind of frequency modulation (known as FM) produces extra harmonics (sidebands), although in the MS-404 the LFO is not tracking the keyboard, so this effect is best used for effects rather than pitched keyboard tracking sounds.

## Envelope (ADSR)

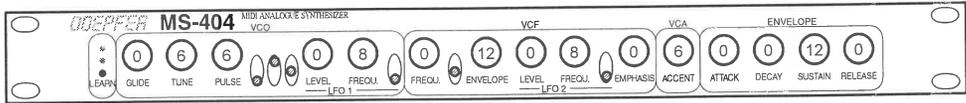
The main modulation source in an analogue synth is the envelope generator. Known also as the ADSR, the envelope generates a rising and falling voltage. Firstly the ATTACK time determines how fast the voltage rises, once risen to it's maximum it then falls back down at a speed set by the DECAY, but falls to a level set by the SUSTAIN, and finally when the envelope gate is removed (when a key is released or the sustain pedal released - whichever comes last) the voltage falls to zero at a rate set by the RELEASE control.



If all this sounds too complicated, never mind, because the best synthesis techniques are discovered empirically (by experiment). The following pages show sounds and how they work, which should be more educational than the previous pages.

## Basic Patch

Now armed with a bit more background information, we will talk about the basic patch.



### Basic Patch

Taking the controls from left to right, the glide is set to 0, this is basically turning off the glide function. Glide (or portamento as it is also called) slows down the transition between different notes. Set the basic patch as above and play some notes, don't worry about the sound not being very interesting yet. Move the Glide control to 6. Now play some different notes, the pitch slides from one note to the next. You will notice that it does not matter how far apart the notes are that you play, it always takes the same amount of time for the pitch to reach the new note. A Glide setting of around 2 is perhaps the most useful, giving a good even glide between notes, however the optimum setting depends on how fast you are playing, for slower melodies a longer (higher panel value) glide time is usually needed.

If you have a controller that can generate control 65 (Portamento on/off) then the Glide can be switched on and off by a footswitch. This allows the glide to be introduced to only certain notes in real time, allowing the Glide control to stay in it's preferred position, whilst the glide is switched out. Note that the Glide footswitch function is not latching, therefore the footswitch has to be held down for as long as the glide is required. The front panel Glide LED lights up when the Glide is enabled, the footswitch must be pressed before a new note is played in order to make the glide engage. At this point return the Glide control back to zero before continuing.

Next along is the TUNE control, this simply tunes the MS-404 to A=440Hz and allows detuning of just over a semitone up or down. The normal "in tune" position is at 6 (Central). Remember that analogue circuitry is temperature conscious, and in extreme conditions, the TUNE control may have to be set away from 6 for A=440Hz tuning. The only reason to deliberately detune the MS-404 is if it is layered with another instrument (maybe a second MS-404), to create a detuned, chorused sound.

The PULSEWIDTH control setting is not important in the basic set up because it is the sawtooth waveform that is being used, and any adjustment to the Pulsewidth will have no effect. However, when needing to switch to pulse wave, it is more useful to have the pulsewidth setting set to 6 (50% pulse-square wave), as a setting of 0 (0% pulse width) would produce no sound at all.

The waveform selector is set to sawtooth, and the sound source to VCO which makes sure that the noise generator and pulse wave are not selected.

LFO-1 is switched off by means of the LFO-1 destination switch. Set to FM the LFO would introduce vibrato, by setting the LFO frequency to 8 with a range set to normal (switch down), this gives a typical vibrato speed. It is then just a case of turning up the LFO-1 level control to set the vibrato depth.

With the VCF cutoff frequency set to 0, it is the envelope depth set at maximum which is keeping the filter open. When the filter is held completely open (as it is in the basic patch) the filter key tracking will have no effect (because it cannot open the filter any further), so it's basic Patch position is set to off (middle position).

LFO-2 is also switched off by the setting of the LFO-2 level control at zero. The LFO-2 frequency and range, set a typical speed for initial experiments.

The Accent control in this patch acts as a volume control (as MIDI velocity has been switched off under MIDI functions).

The basic envelope shape is set to a simple gate shape, that is immediate attack, no decay because the sustain is at maximum, and the release is set to zero (immediate), so when a key is released the sound stops straight away.

It is rather unlikely that this patch will ever be used as a final sound, but it is a good idea to memorize this patch as starting point for experimentation. Infact, the concept of where the controls are, will apply to any analogue synth (or digital synth that works in a subtractive "analogue" way).

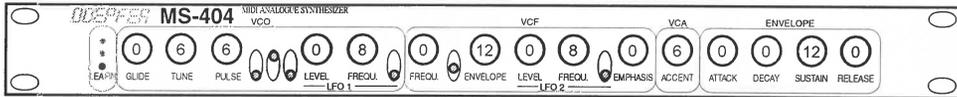
In all the following examples, remember that the mod wheel is the definable controller, and that it is assumed that the wheel is positioned at zero position (or the filter will be held open).

# Basics

## PWM

When the pulse width is altered in real time (usually by an LFO), it is known as Pulse Width Modulation or PWM for short. For single VCO instruments (like the MS-404) it is used to give movement in a sound, and can immitate the effect given by a detuned dual oscillator sound.

In order to describe the merits of Pulse Width Modulation (PWM), start off with this patch.



*PWM Patch*

This patch gives a square wave (50% pulse wave) sound, with no modulation at all. This sound is uninteresting and needs some movement in the sound to make it more interesting. The pulse waveform allows us to change it's wave shape by voltage control in realtime. This is done using LFO-1 to sweep the pulse width over time. Increasing the LFO-1 Level control introduces the pulse width modulation, set this control to a value of 8, you may need to adjust the LFO-1 Frequency until the desired modulation speed is achieved. There are two settings here, that can cause the sound to break up, though they are both down to the same reason. With PWM we are sweeping the pulse width from 50% square upwards, back down to 50%, then down lower and then back up to 50%. This sweeping action gives us a sound similar to having two oscillators detuned, however if the pulse width narrows too much (to around 5% or 95%) then the sound becomes inaudible in parts of it's sweep, giving an uneven broken up sweep. This is due to the initial Pulse Width control not being exactly central (set at 6). With the LFO-1 level set at 10, set the Pulsewidth to 10 as well. Now the sweep is so uneven that the sound is breaking up. To correct this, either reduce the LFO-1 level so that the sweep is not so great (about a value of 6), or centralise the sweep, by setting the Pulsewidth to 6. It is usually best to ensure that the initial pulsewidth is central at 50% (Pulsewidth set to 6).

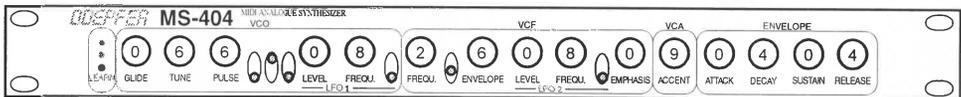
Having a very slow sweep speed is often effective, setting the LFO-1 frequency to slow mode (Range switch up) with a frequency setting of around 8. It is best to have a greater PWM depth at slower speeds, so set the LFO-1 Level to maximum (12) and the Pulsewidth central (set to 6).

Alternatively, though mainly for special effects, the PWM modulation speed (LFO-1) can be set very high (in the audio range) by setting the range switch to it's central position and frequency set to 6 (set the LFO-1 level to maximum). This gives a ring modulation type effect, although it will not track the keyboard, as the LFO speed is not keyboard tracked, but it does produce a very metallic sound usually only associated with two oscillator instruments (though of course in reality the LFO-2 is a second oscillator, it is just that it is not voltage controlled like the VCO).

Subtle use of the LFO-1 level control in this mode can just add a little distortion to "roughen" up the sound, try an LFO-1 Level of 1 or 2 and experiment with different values of LFO-1 frequency.

## Filter Sweep

The backbone of analogue subtractive synthesis is the filter, and the elements that control it are just as important. This is the patch for the basic filter sweep set up.



*Filter Sweep Patch*

Initially this patch causes the filter to close over time (sweep). It is the envelope that is controlling the VCF, so we will first discuss the workings of the envelope.

The envelope is a modulation source that defines a changing voltage which is used to modulate another synthesis element such as the VCF or VCA. The MS-404 uses the most conventional envelope - the ADSR. With four controls the envelope is routed to the VCF and VCA with control of 3 timings: Attack, Decay and Release and a Sustain level control.

When a key is pressed, a Gate trigger is produced and this starts the envelope off on it's cycle. On receiving the Gate trigger the envelope starts to produce a voltage that starts at zero and rises to maximum at a speed determined by the Attack control. An attack time of zero is instantaneous and higher values slow the rise timing. With the above patch the envelope is opening immediately giving a percussive sound. With an Attack time of 5 the sound comes in slowly, and with an Attack time set to 12, the sound takes around 15 seconds to come in fully. Set the Attack time back to zero.

Our sound set here is decaying away to nothing quite quickly, the speed at which it decays is set by the Decay time control. With a Decay setting of 12, the envelope takes nearly 20 seconds to decay, and at a setting of 0 is so fast, that all that is heard is a very quick blip. The level to which the decay drops to is set by the Sustain level control. At present we have it set at 0 which means the sound decays away completely, but by setting the Sustain level to 4 the sound does not decay away, but it is held at the Sustain level. A good trick here to get a percussive sound is to set the envelope to a setting of 0, 0, 3, 4 (ADSR), the zero decay setting causes a percussive blip that helps keep the sound aggressive. Return the patch to the above Filter Sweep Patch.

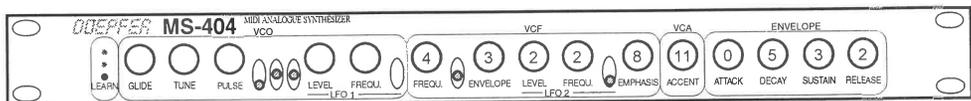
Now with a basic understanding of what the envelope is doing, we can now see how the filter reacts to this modulation. The VCF in the MS-404 is a 4-pole filter, that is, it has a 24dB/Octave cutoff slope, all frequencies above the VCF frequency setting are attenuated by a factor of 24dB per octave - this is a Low Pass filter. In order to emphasize the filter sweep, a resonance control is used to accent the cut off point, this resonance control is the backbone to a good analogue VCF (labelled Emphasis on the MS-404). Set the emphasis control to 8, and the typical analogue filter sweep sound is achieved. Any emphasis setting much above 8 will cause the filter to self oscillate, this can be further proved by switching the VCO out by setting the waveform select switch to it's central position. Set the patch back to the above Filter Sweep Patch.

The VCF has it's own dedicated LFO to modulate the cutoff point, the same principles of filter modulation apply as were used on the PWM LFO modulation described previously.

It is possible to play the filter as an oscillator. Set the VCF envelope control to 0 and the emphasis to 12 (making sure the LFO-2 level is at 0). Switch the VCO off, and ensure that filter tracking is switched on full (tracking switch in up position). The filter produces a basic sine wave output, and by modulating the VCF by LFO-2 which is a triangle wave, FM effects can be produced. Though remember, like the LFO-1, the LFO's do not track the keyboard for pitch, so this FM is limited to effects only.

## External Input

By connecting an external sound source to the MS-404, the sound can be processed by the MS-404's VCF and VCA.



External Input

In order for the external input to work at it's best, the MS-404 needs to be gated in order for the envelope to be triggered. The best external signal source is a MIDI instrument. This way, when the sound source is played, it simultaneously sends a MIDI gate to the MS-404 which triggers the envelope. If the sound source is not a MIDI instrument, then the envelope will not be triggered and the filter will have to be swept by the front panel VCF cutoff Frequency control or by the defined MIDI controller (usually the mod wheel).

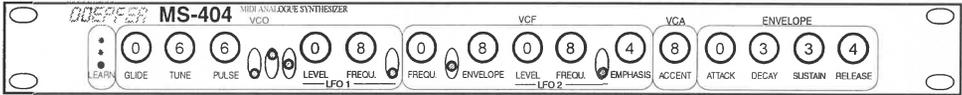
The MS-404's VCO can be added to the external input signal, so the two sound sources can be used together. Don't forget of course that the MS-404's LFO-1 and Tune will not affect the external sound source, although will still affect the internal VCO as normal.

The External input socket is quite sensitive, and you must be careful not to overload the input with a too high signal, or the sound will distort. There is no visual overload indicator for this input, so let your ears be the judge when setting the rear panel level control for the external input level.

# Sound Examples

## Saw Bass

This synth bass sound is typical of what is expected of an analogue synth, and it is the element of resonance in the filter that still gives analogue the edge over it's digital impersonations.



*Saw Bass*

This basic bright saw bass sound uses the envelope to control the filter, by setting the VCF Envelope Depth to 8 it stops the filter opening completely, and an Emphasis setting of 4 emphasises the filter sweep, giving the infamous “twang” of a resonant filter. The envelope Decay and Release times set the sweep speed, and have to be adjusted to suit the speed of the bass line being played, that is, the faster the bass line, the shorter the Release time needed (lower value). In order to keep the sound the same with legato (notes held down) or staccato (notes released quickly) make sure that the Decay and Release settings are about the same.

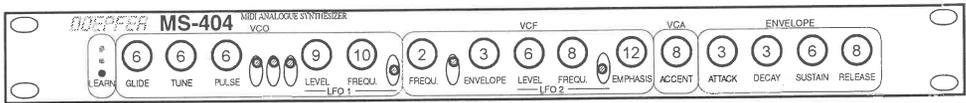
A quick reduction of the VCF Envelope Depth to 7 and increasing the Emphasis to 7, makes the sound softer and “more analogue”. Reducing the Decay time to 1, opens up the sound to be used for arpeggios or fast bass lines.

Returning the Envelope Decay to 3 and increasing the Sustain to 6 will make the bass sound hold. As the envelope is holding the VCF and VCA open, the Sustain control sets the sustained level and filter cutoff. At a Sustain level of 6 this is too high for the VCA, though a setting of 3 is right for the VCA but too low for the VCF - so don't we need a different extra envelope? No, we don't, by increasing the VCF Cutoff control to around 3 (returning the Envelope Sustain to 3), the VCF cutoff sweep has been increased without affecting the VCA sweep. It is worth remembering that the envelope (ADSR), Envelope Depth, Tracking and cutoff Frequency all interact, therefore it is best to get the envelope to do what you want it to do to the VCA first, and then set the VCF second.

As this sound now is sustaining, held notes become straight and uninteresting, therefore we need to introduce some form of modulation. A small amount of vibrato is called for here, first, set the LFO-1 destination switch to FM (frequency modulation), and turn the LFO-1 Level control up a little. This has introduced VCO modulation from LFO-1 (simply known as vibrato). The LFO frequency and level settings are critical here, mainly because the range of both of these controls on the MS-404 is extremely large. To get the LFO-1 to introduce vibrato, a depth (LFO-1 Level) of less than 1 is all that is needed.

## Dissonance

This sound is pretty nasty, for those off the wall aggressive moments

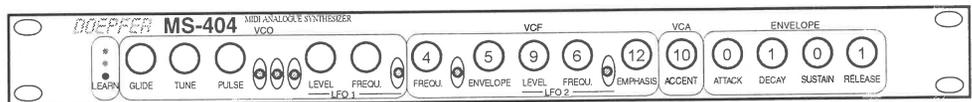


*Dissonance*

This patch does just about everything to make the sound as unmusical as possible. There is not a lot of fundamental pitch there, the VCO is being modulated at nearly 5KHz by the LFO-1, and the filter is similarly being modulated at audio frequency by LFO-2. Note that the sound varies across the keyboard because the LFO is not tracking the keyboard, therefore the frequency ratio differs across the keyboard, so varying the harmonic content, rather than a pitch shift. The envelope is causing a rising and falling of pitch, though not from the VCO (as the envelope does not control the VCO on the MS-404), but by the self oscillating filter. Moving the mod wheel cause a further filter sweep, causing more dissonance between the VCF oscillating and the VCO. Also, moving the pitch wheel causes a similar effect by altering the VCO frequency. It is essentially the ratio of filter self oscillation and VCO frequency that is causing the dissonance, so it does not matter which one is altered, as it is the ratio between the two that is causing the effect.

## Analogue Snare Hit

Using the same idea as the above patch, a few modifications can make the VCF become like a noise generator for percussion sounds.



*Analogue Snare hit*

The first thing to notice with this patch is that the VCO is not used, therefore the VCO and LFO-1 settings are not relevant as long as the VCO switch positions are set off (to their mid positions). As glide is a function acting on the VCO, then it's setting is also irrelevant. The sound generation is coming from the self oscillating VCF, which is being modulated by a high frequency LFO-2. Perhaps terminology is getting in it's own way here, how can we have a high frequency low frequency oscillator? Remember the LFO's on the MS-404 will go upto 5KHz, an oscillator is really only called an LFO when it is sub audio (under 30Hz), but it is customary on an analogue synth to use the term LFO for a modulating oscillator. Of course we could call it the modulator oscillator and the filter (in this patch) the carrier oscillator, but this is beginning to sound like Yamaha DX7 style FM synthesis terminology which was always perceived as "too complicated" - so we will stick to an LFO running at a slightly higher than normal frequency.

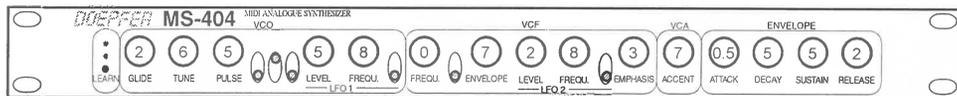
The important setting in this patch is the envelope Decay control, this must be set short enough to give a percussive snare effect, making sure that the Release is set to the same setting as the Decay control, this ensures that the same sound is achieved by holding or releasing the notes. The Sustain control must be set at least less than 1 or the sound will not decay. If the Decay is set too high, you will achieve more of an 8-bit computer game laser effect than a drum - but perhaps you may want this anyway.

Note that the VCF key tracking has been switched off (Tracking switch central), this gives any key the same effect, so it does not matter which key is pressed.

# Sound Examples

## Solo Lead

Suitable for lead lines this patch uses delayed modulation for exposed lead lines.



*Solo Lead*

Delayed modulation is always useful for lead sounds that need modulation when the note is held, but do not need it for the shorter notes. Normally you would go to the delayed LFO depth control function to do this, but as the MS-404 does not have a delayed LFO function, we have to find another way of doing it, and this patch illustrates how it is done.

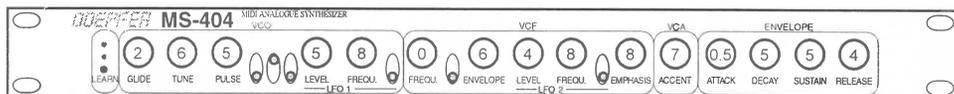
First though, a quick look at what the VCO is doing. A short glide time of 2 can be increased for slower lead lines, or reduced for blinding speed solo's. The pulse width and LFO-1 have been set here ready for a quick change in sound by simply flicking the Waveform selector upto to pulse. This changes the VCO to a pulse width modulation, putting a lot more movement in the sound.

The filter is where all the action takes place in this sound. The cutoff frequency is set to zero, giving complete control of the filter to the envelope and LFO-2. It is the LFO-2 that is providing the modulation in the form of filter cutoff modulation, and this is how the delayed effect occurs. The envelope and LFO-2 modulation interact (as does the mod wheel), when the filter is held open (by the envelope) the LFO-2 cannot open it any more, therefore the envelope stops the LFO-2 having any effect. When the envelope decays to a lower level (time set by the Decay control), this then gives the LFO-2 room to have an effect, and so produces the delayed effect.

Note that the Attack on the envelope is set just above zero, this takes the sharp edge off of the front edge of the sound, but not so much as to make it an obvious slow attack.

The Filter tracking is set to half tracking (switch down) to ensure that the filter does not open too much at the top end of the keyboard. With filter tracking set to full, it would cause the delayed effect to be longer at the top end of the keyboard. The Emphasis is set a little to give the bottom notes more of a zap, having little effect on the higher notes. The Emphasis must not be set too high, or it will emphasize the modulation, though this could become another sound anyway.

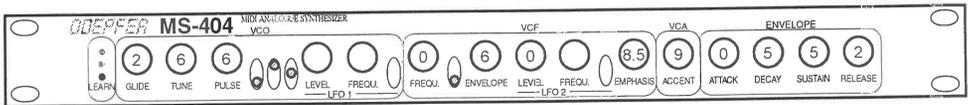
The new sound becomes this-



*Lead Filter Mod.*

## Raw Bass

Suitable for all speeds of bass line, the mod wheel allows real time filter sweeping of the filter cutoff. This is the kind of sound that is very difficult to sample into a sampler. The envelope on the filter has a different decay time to release time, this means that when a key is played and held, the sound decays slowly (about 3 seconds), yet when the key is released, the envelope decays faster (around 1 second). As the filter sweep has a strong resonance, a sampler would need to sample the whole decay time of the sound without trying to loop it (around 3 seconds for key on and 1 second for key off). To cover the MS-404's 61 note range, 61 x 4 second samples would be needed requiring 244 seconds of sample time in 61 multisamples (just over 4 minutes sample time). At full bandwidth (44.1KHz) this would need around 10Meg of sample ram to capture. And after all of this, would the real time filter sweep of the mod wheel still give that resonant zap? Game set and match to the MS404 !



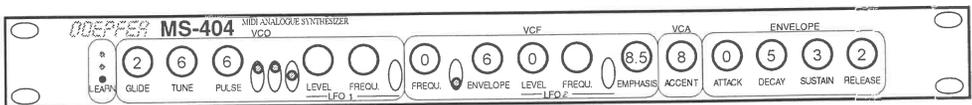
*Raw Bass 1 (Saw)*

For these types of sounds the use of glide seems to work well, although like always the amount of glide time is dependant on the speed of playing, slower playing will allow a greater glide time. As the sawtooth wave contains more harmonics, it is best used when a pronounced resonance is required, and that is what we need here, so the VCO waveform is set to saw. Bass sounds usually do not need any pitch modulation, so the LFO-1 is not used.

The envelope does not actually fall completely to zero (Sustain level set to 5), so it is important that the filter cutoff Frequency is set to zero, allowing the VCF Envelope Depth to take the cutoff point low enough to mute the sound during the envelope sweep.

The Emphasis control is set as high as can be, before the filter starts to self oscillate. This takes place usually around a setting of 9. To set this precisely (actually we do not need to do this, but it is good experience to see what is really going on), turn the VCO off by setting the waveform selection switch to it's central position (Waveform off), play notes on the keyboard whilst turning up the Emphasis control, at the point you hear a sound, that is the point where the VCF is breaking into self oscillation, back the control off slightly until no sound is heard, that is the optimum Emphasis setting for this patch. Go back to the VCO waveform selector switch and turn the saw wave back on.

Another form of raw bass can be achieved using a square wave instead of the sawtooth. Set up the following patch.



*Raw Bass 2 (Square)*

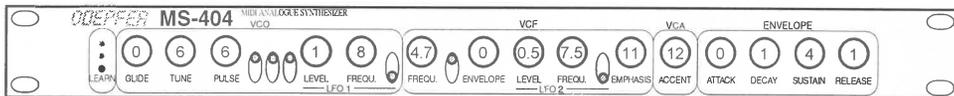
The only differences here is the VCO waveform is now a square wave (50% Pulse width) and the envelope Sustain has been reduced to 3. Due to the lack of even harmonics in the square wave, the resonance (emphasis) on the filter sweep is not so pronounced. A good variation can be achieved by altering the Pulse Width control.

# Sound Examples

## Organ 8' + 2'

A monophonic organ sound? Well, yes it is, though the title "Organ" is really to describe the type of sound, rather than imitate an organ. The point of this sound is show how to get 2 different pitches (2 octaves apart) from the MS-404, which remember only has one oscillator - and we are not using the LFO's in the audio range this time.

The setting up of this sound is very precise, and very careful setting of the VCF cutoff Frequency is vital.



*Organ 8' + 2'*

After setting this patch, it is not going to sound right until the VCF cutoff Frequency is tuned. To do this, temporarily set the LFO-1 mode to it's central position and turn the LFO-2 Level to zero. Hold a note down (somewhere in the middle of the keyboard will be best) then tune the VCF Frequency until the sound stops beating. Make sure that the setting is just under 5, if you set it to just under 4, it will actually be an octave out (effectively an 8' + 4' organ sound, and a setting just over 5 will give 8' + 1'). To check the accuracy play a low note and then a high note to check tuning, if the sound warbles or beats, then adjust the VCF Frequency again, until the whole keyboard is in tune. Note that you do not have to move the VCF Frequency much, in this mode of operation the setting is very sensitive. Once you are happy that the setting is in the right place, return the LFO-1 mode switch to FM (upward position) and the LFO-2 Level to 0.5. If the sound start to warble again, it may be because the LFO level (1 or 2) is set too high, or the two LFO's are not near enough in frequency. Try to get the two LFO's to be the same speed.

If you hadn't noticed, what is going here is that the filter has gone into self oscillation, and with the VCF Tracking set to full (switch upwards), the filter is tracking the keyboard, and therefore following the tuning of the VCO. What is critical is that the VCF and VCO are in tune, albeit two octaves apart. The Emphasis control actually controls the level of the 2' content, but be careful, as lowering the level of the Emphasis will upset the VCF self oscillation frequency, and you will need to retune the VCF after moving the Emphasis.

The envelope is set to give a percussive edge (Attack at zero) and the Decay and Sustain settings give a short transient level before settling quickly to a lower level. This produces an overall lower output, which is why the VCA Accent has been set to maximum to compensate for this.

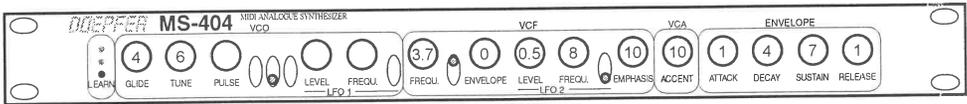
Moving the mod wheel on this patch will give rather unpredictable results in terms of tuning, but may give some useful pitch sweeping effects.

The whole sound can be thrown into chaos quite easily by simply setting the LFO-2 range switch to high (middle position) and turning the LFO-2 Level to 6. It remains just about in tune, if not very melodic.

As a final variation, simply reduce the Emphasis to zero, this gives a distorted effect like an organ going through a power amp that has just blown half an output stage giving 90% distortion.

## Noisy Whistle

A simple whistle tone with an emphasized breath noise. Like the previous sound (Organ 8' + 2') the setting up of this sound is very precise, and very careful setting of the VCF cutoff Frequency is vital for the sound to play in tune.



*Noisy Whistle*

This time we introduce the noise generator. The VCO is not used here, so the VCO settings are not relevant and do not need to be set up (including LFO-1). The noise generator is not actually a function of the VCO, and noise itself has no inherent pitch anyway. Therefore you cannot alter the pitch, glide or modulate the "frequency" of the noise. However, tuning of the VCF Frequency is critical here, and you may find it easier to use the VCO to calibrate the VCF and then switch it back to noise when done. Use the same method as described in the previous Organ 8' + 2' patch to set this up.

As this is a human type whistle, there is plenty of glide (a setting of 4), again as mentioned before, this setting is dependant on the speed of the playing, twenty notes a second solo's will need a slightly lower Glide time setting.

The whistle needs a little vibrato to keep it interesting and this is provided by LFO-2 (and not LFO-1 as you may have expected - things are not always what they seem!). Vibrato is normally the LFO modulation of the VCO, except in this patch it is the self oscillating VCF that is generating the pitch, therefore the filter LFO (LFO-2) is used for vibrato.

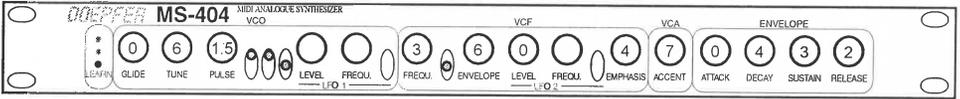
The Emphasis control, once reaching a setting of 9 will self oscillate and higher settings increase the level of the sine waveform output, therefore the Emphasis control can be used as a balance control between the noise and the sine wave, however, don't overlook that fact that moving the Emphasis control will upset the tuning of the VCF, and it will need to be recalibrated after Emphasis adjustments.

If the VCO is not being used, and noise has no pitch, why does the pitch wheel bend the pitch? You may have noticed that this phenomena does take place, and it is because the keyboard control voltage and the pitch bend wheel data is added together within the MS-404's internal MIDI to CV converter. This summed CV is then sent to the analogue circuits of the MS-404. This means that the keyboard CV fed to the VCF Tracking includes pitch bend data, and therefore alters the filter tracking and consequently the pitch of the self oscillating filter. Most other analogue synths introduce the pitch bend data directly to the VCO, and so the Keyboard CV fed to the filter is not affected. This wonderfully unique phenomena of the MS-404 enables the Noisy Whistle patch to have pitch bend.

# Sound Examples - Quickies

## Clavi Pulse

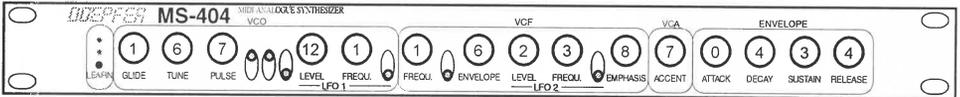
A thin Hohner Clavinet type sound, best for fast moving bass riffs.



Clavi Pulse

## Arpeggio

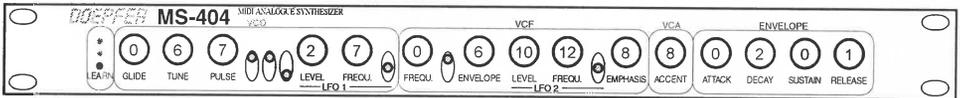
An evolving sound that works best with arpeggios, giving a good movement of tonal variations.



Arpeggio

## Rough Percussive

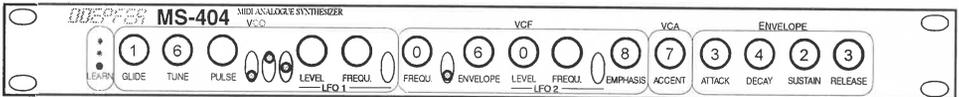
A rough sound suitable for rhythmic riffs.



Rough Percussive

## 70's Moog

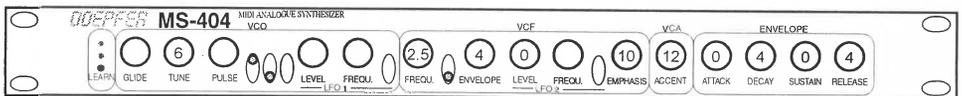
A typical sound of the early 1970's when the Minimoog appeared everywhere it should'nt have!



70's Moog

## 70's Syndrum

Speaking of the 70's, the entirely dated syndrum could not go without a mention.



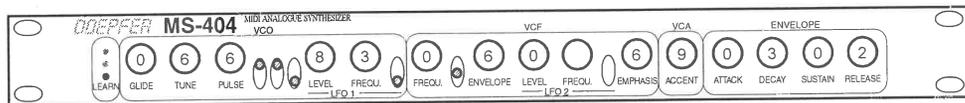
70's Syndrum

# Sound Examples - MIDI Functions

Up until now we have not used any MIDI velocity control, so we will finish off demonstrating the MIDI functions. Set the patch up below, before setting the MIDI parameters.

## Velocity PWM

This sound is very dependant on the velocity scaling of your controlling keyboard.



*Velocity PWM*

This is a simple pulse wave sound with a slowly moving pulse width, suitable for sequenced riffs. We add a bit more movement to the sound by altering the filter cutoff with velocity. Set the following MIDI function:- Press MIDI Learn, transmit program change #3 (maybe 4 on your keyboard). Now, as MIDI velocity is adding to the overall control voltage to the VCF, you will have to back off the Envelope Depth control to around 2, but this depends very much on how the controlling keyboard velocity scaling is set (and how hard you hit the keys). Now the filter opens up more with harder key strikes, giving realtime control over the filter cutoff point.

You may notice that you now have to be careful with your playing style. The retrigger mode cannot generate a velocity value on a note that has not been restruck, so you have to play somewhat more staccato (detached) when using MIDI velocity to control the filter. If the filter cutoff Frequency is increased to 6, this phenomena is not so obvious.

Now turn off the velocity to filter function by accessing MIDI Learn and program change #2 (maybe 3 on your keyboard) and turn on the velocity to VCA function with program change #1 (maybe #2). This time the velocity is controlling the volume of the sound. Again depending on the velocity scaling of the controlling keyboard, you may find it best to set the VCA Accent control to maximum, and allow the velocity to control the VCA completely. Again, be careful of your keying - make sure you play detached notes.

There is no reason why you cannot have both velocity to VCF and VCA on together.

Finally, we will experiment with the retrigger modes. Set the Velocity PWM sound back up, but switch velocity control of the VCF and VCA to off. (MIDI Learn - program change #0 and #2). Assuming that the retrigger mode is on (MIDI Learn - program change #5), if you play and hold a note (say middle C) and then press a higher note as well, the new note plays, if you release the higher note, then the lower note retriggers, this enable you do "hammer on" type effects, and generally enables smoother playing.

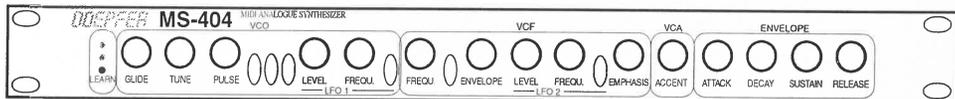
Now turn retrigger mode off by entering MIDI Learn and program change #4. Now in order to get any note to sound, you must release a note completely before striking another note. It is personal preference as to which playing mode is best suited to your style of playing, but the retrigger on mode, is recommended and infact is the method used by nearly all previous vintage mono synths of the past.

# Patches

Patch Name

## MIDI Functions

Velocity to VCF		Definable Controller	
Velocity to VCA		Retrigger Mode	

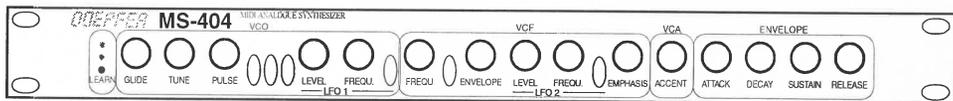


Notes

Patch Name

## MIDI Functions

Velocity to VCF		Definable Controller	
Velocity to VCA		Retrigger Mode	

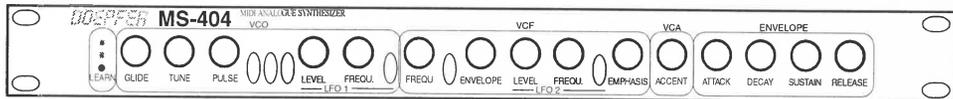


Notes

Patch Name

## MIDI Functions

Velocity to VCF		Definable Controller	
Velocity to VCA		Retrigger Mode	



Notes