M116 Multi-scale Quantizer

FUNCTION DESCRIPTION

The M116 Multi-scale Quantizer is one the most usefull module in the family. It's a digital processor based module that manages high precision analog CV voltages.

From the input it takes CV signals from Sequencers, LFOs, Envelopes or pretty much any other module that produces CV signals, and, within 1 millisecond, it outputs CV converted to a selected scales to drive VCOs in a modular. Without the M116 conversion it is hard to dial in specific notes in a musical scale, so this multi-scale Quantizer gets rid of 'out of tune' incoming voltage values and produces the good voltage to match exact notes within the specified scale. In fact the M116 Quantizer is a CV-to-musical-note converter.

The M116 Quantizer works in two different modes at the same time. Free Running, where the incoming CV is immediately converted to the selected scale and and placed at the quantized output and Gate triggered, where an incoming Gate rising pulse will 'force' the present CV input to be processed and placed at the quantized output.

Any incoming CV changes or input rising Gate pulse will also trigger an appropriate MIDI note ON message at the MIDI out connector. A MIDI all notes OFF message will also be sent right after an incoming falling Gate pulse OR after a 3 sec. timeout from a quantized CV change with no Gate signal.

Features

The design features a PIC16F1783 running at 16Mhz (internal clock). A specially designed ADC/DAC module (SPI communication, 15 pins SIP pcb) is used to do 16 bits precision conversions on both input and output CV's. The use of the onboard UART allows MIDI output far more efficiently. A 20 steps rotary encoder is used to select one specific musical scales OR specific transpose keys. There are 25 musical pre-programmed scales to choose from and 12 transpose keys available.

Here is a list of the 25 musical pre-programmed scales:

Semi-Tones
Whole-Tones
Pentatonic major
Pentatonic minor
Heptatonic major
Heptatonic minor
Triad major
Triad augm.
Triad minor
Triad dimin.
Augmented
Diminished
Athar Kurd
Kumoi
Hon-Kumoi-Joshi
Egyptian
Nikriz
Persian
Hebrew
Dorian Mode
Phrygian Mode
Lydian Mode
Mixoydian Mode
Locrian Mode
Gypsy

The start-up transpose position is **C** but can be changed at any time.

G G# A A# B **C** C# D D# E F F#

A dedicated toggle switch is there to change the encoder's function:
SCALES or TRANSPOSE keys

Any incoming CV is continually processed from the CV INPUT through the BYPASS CV OUT and to the QUANTIZED CV OUT jack.
The quantized conversion takes approximately 1 msec.

The circuit also includes a LAG potentiometer on the quantized CV output to make 'portamento' effect. The standard **1V/oct scale** is used here so please note this product has been designed to work on this type of VCO. Other VCO's will not conform with the offered programmed 'musical' scales and will produce 'out of tune' notes.

The selected scale dictates a number of **steps** or **thresholds** per octave on incoming CV's to be continuously 'compared'. Quantized outputs will only change when incoming CV crosses one of the CV's scale thresholds. Otherwise, the quantized CV will stay at the same value until input CV crossing happens. The spaces between CV inputs crossings (or thresholds) have been evenly programmed for incoming CV's. The spaces between quantized output steps are uneven and according to the scale itself...

Figure 1 shows part of the 25 pre-programmed scales.
The first 10 scales are shown here:

1	2	3	4	5	6	7	8	9	10
0x0281	0x0281	0x0281	0x0281	0x0281	0x0281	0x0281	0x0281	0x0281	0x0281
0x051A									
0x07B4	0x07B4			0x06F5	0x06F5				
0x0A4D		0x08BD	0x08BD						
0x0CE6	0x0CE6			0x0B6A	0x0B6A	0x0CE6	0x0CE6	0x0CE6	0x0CE6
0x0F80		0x0EFA	0x0EFA	0x0FDE	0x0FDE				
0x1219	0x1219								
0x14B2		0x1537	0x1537	0x1453	0x1453				
0x174C	0x174C					0x174C	0x174C	0x174C	0x174C
0x19E5				0x18C7	0x18C7				
0x1C7B	0x1C7B	0x1B73	0x1B73						
0x1F14				0x1D3C	0x1D3C				
0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1
Semitone scale	Whole tone	Pentatonic major scale	Pentatonic minor scale	Heptatonic major scale	Heptatonic minor scale	Triad maj scale	Triad aug. scale	Triad min scale	Triad dim. scale
C 0x0281	C 0x0281	C 0x0281	C 0x0281	C 0x0281	C 0x0281	C 0x0281	C 0x0281	C 0x0281	C 0x0281
C# 0x051A									
D 0x07B4	D 0x07B4			D 0x07B4	D 0x07B4				
D# 0x0A4D		D# 0x0A4D	D# 0x0A4D		D# 0x0A4D			D# 0x0A4D	D# 0x0A4D
E 0x0CE6	E 0x0CE6			E 0x0CE6		E 0x0CE6	E 0x0CE6		
F 0x0F80		F 0x0F80	F 0x0F80	F 0x0F80	F 0x0F80				
F# 0x1219	F# 0x1219		F# 0x1219						F# 0x1219
G 0x14B2		G 0x14B2		G 0x14B2	G 0x14B2	G 0x14B2		G 0x14B2	
G# 0x174C	G# 0x174C				G# 0x174C		G# 0x174C		
A 0x19E5				A 0x19E5					
A# 0x1C7B	A# 0x1C7B	A# 0x1C7B	A# 0x1C7B		A# 0x1C7B				
B 0x1F14				B 0x1F14					
0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1	0x21B1

Figure 1

You can see that the incoming CV's beige vertical cells are equally spaced for 'musical' reading behaviour while their vertical white quantized result cells (lower rows) are unevenly spaced for quantization effects.
The cell's hexadecimal numbers are those used in the quantization process. These are 16 bits values sent to the DAC module (added with octave & transposition offsets) to be released at the quantized CV output.

The module also processes incoming GATE rising pulses through the GATE OUT. Any GATE pulse will trigger a new quantized CV output AND a MIDI note change on the MIDI out DIN connector.

In addition, pressing on the encoder's knob will engage a new menu to change the MIDI channel number from 1 to 16. LED indicators individually show the GATE input and the MIDI OUT activity.

The printed circuit board

The module uses a 2U Moog style front panel. The PCB is a double side board, 2.8" X 5.5", has 4 mounting holes mounted on 4 x 4-40 1/4" "standoffs.
All the front panels connections are positioned to be adjacents to their dedicated parts (encoder, jacks, pots, switches).
Alpha potentiometer is used for smooth response on the LAG adjustment.
Power is connected by use of a 6 pins 0.156" Molex type connector.
All the wiring cables are standard hook-up wires but the small ADC board's CV input which uses shielded type RG-174 coax.

The circuit description (main board)

The M116 Multi-scale Quantizer circuitry is mostly digital.
All the SPI ADC/DAC read/writes are managed by U6 which is a Microchip PIC16F1783. The software uses an 'Timer based interrupt' to access the devices and make the appropriate processes. All the logic exchanges between the ADC and DAC are made through SPI serial communication.
The rotary encoder is passed through a Flip-Flop based circuit (U8 & U9) that facilitates the encoder pulses reading by the PIC micro making the software implementation easier and much more reliable. The selected scale and transposition values are displayed using a 16X4 Blue LCD display.
The LCD communication uses 4 bits (MSB's 4-7)and is wired to a 10 pins header (H10) to the main board. This header communicates with the SPI based ADC/DAC board. The DAC's CV output is redirected to H16 which passes the quantized CV through an adjustable low pass filter made of P1, R24 and C32. The resulting 'Lag' CV is then buffered through U7. The ADC input is also redirected to jack J4 for buffering (U7) to jack J3.

The PIC's UART is used to generate MIDI signals to connector H4 (MIDI OUT). MIDI note ON messages will be sent whenever a quantized output value changes from a varying CV input OR when a Gate rising pulse is received. An ALL NOTE OFF MIDI message will occur from a falling GATE input OR after a 3 sec. timeout right after a CV input change without incoming Gate input signal. The Gate input jack is redirected to GATE OUT jack and buffered/inverted by Q1 and the result is read by the PIC Gate input.

ADC-DAC SIP module

H3 & H4 are both 16 bits ADC/DAC SPI converters mounted on small 15 pins SIP pcb's. The circuitry design of these small SIP converters was made possible with the help of a European engineer named Roman Sowa who agreed to help in my design process. He helped making the converters do their jobs with a maximum of precision and in a noise free pcb layout.

ADC-DAC SIP module (continued)

The incoming CV is connected to H2 through the CV input jack. Then the 0-8vdc incoming voltage is precisely dropped to 0-5vdc using a voltage divider made of 0.1% precision resistors R1,2,3. The voltage is then buffered by U3 which is a **OPA990** precision opamp. The buffered voltage is then fed to U1 which is a **MAX11100EUB+** precision 16 bits ADC. The ADC data is read through SPI communication to the PIC. The SRAM stored data can be read back by the PIC and sent to U4 which is a **LTC2641CMS8-16#PBF** precision 16 bits DAC. The 0-5v data needs then to be amplified back to 0-8v.. This is done using another **OPA990** precision opamp (U5) with the necessary gain setup with resistors R8,9,10,12. H3 connector send the final CV to the CV output jack.

Adjustments and trimmings:

P1 LCD contrast only needs to be adjusted here for correct LCD brightness and contrast.

The M116 is now ready for use.

September, 2021
Jean-Pierre Desrochers
ArcEnSon

ELECTRONIC SPECIFICATIONS

POWER CONNECTOR PIN ASSIGNMENTS

1	-15V
2	A GND
3	A GND
4	+15V
5	D GND
6	+5V

Lag pot: 1 to 200msec.
GATE input-thru impedance: >100k
GATE input pulse level: 3.5 volts peak min.
GATE BYPASS output imp: input's redirected
GATE output pulse level: input's redirected
CV input-thru impedance: 100k +/- 0.1%
CV input range: 0 to +8v
CV output impedances: 300 ohms +/-5%
CV output range: 0 to +8v

Power:
+15V @ 5mA,
-15V @ 5mA,
+5V @ 40mA.