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El sintetizador Formant es un diseño de los años 70 motivo por el cual en la actualidad algunos de los componentes electrónicos no están ya disponibles o bien pueden ser encontrados con mucha dificultad en el mercado de segunda mano (cuando no en el del coleccionista).

Esta problemática afecta en particular a determinados componentes utilizados en circuitos críticos del Formant como el clásico uA726 (par de transistores compensados térmicamente) que forma parte de un módulo tan importante como el VCO

En este capítulo se aportará información sobre el reemplazo de los componentes obsoletos y la solución tomada para su sustitución en esta versión del Formant.

**Importante:**

**(1)**

Los datos relativos a los componentes que realizan la sustitución de estos componentes obsoletos (características técnicas, suministradores, precios etc) son válidos en el momento de redactar este documento y pueden dejar de serlo más adelante.

**(2)**

Anexo a este documento se aportan también las hojas de datos (*datasheet*) de los componentes afectados, tanto los sustituidos como los nuevos.

## consideraciones de diseño

En la mayoría de los casos, los componentes obsoletos no pueden reemplazarse “pin a pin” dado que el nuevo componente o circuito equivalente que lo sustituye no es compatible en forma o encapsulado o bien porque simplemente se trata de un circuito equivalente formando por varios componentes que realizan la tarea del componente sustituido.

## componente: ca3080

El CA3080 es un Amplificador Operacional de Transconductancia variable (OTA).

Las primeras unidades fueron producidas por *RCA* en 1969, antes de ser adquirida por General Electric, hoy día su producción está descontinuada.

Una de las principales aplicaciones de este tipo de amplificadores es la implementación de aplicaciones de control electrónico, tales como osciladores de frecuencia variable, filtros y etapas de amplificador de ganancia variable, que son más difíciles de implementar con amplificadores operacionales estándar.

La sustitución de este circuito se realizará utilizando el circuito **LM13700** (Texas Instruments), este circuito integrado además es doble, contiene dos amplificadores OTA independientes, pudiendo sustituir dos CA3080 por un LM13700.

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| **Amplificador Operacional de Transconductancia variable (OTA)** | | | | |
| **COMPONENTE OBSOLETO** | **REEMPLAZO** | **FABRICANTE(s)** | **DESCRIPCIÓN** | **SUMINISTRADOR** |
| CA3080 | LM13700 | Texas Instruments | Dual Operational Transconductance Amplifiers  With Linearizing Diodes and Buffers | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 533-9656 |



Figura 1. Circuito integrado LM13700.



Figura 2. Circuito integrado CA3080.

## componente: ca3084

El CA3084 es un circuito integrado manufacturado por *American Microsemiconductor, Inc., Intersil etc* y que contiene una serie de transistores de pequeña señal de propósito general en varias configuraciones, hoy día su producción está descontinuada.

Dos de estos transistores son dos *PNP Matched Transistors* y son utilizados en el Formant en diversos módulos

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| **COMPONENTE OBSOLETO** | **REEMPLAZO** | **FABRICANTE(s)** | **DESCRIPCIÓN** | **SUMINISTRADOR** |
| CA3084 | BCM856DS | Nexperia | matched double transistors | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 792-0847 |

## componente: uA726

El circuito integrado uA726 es sin duda el componente más singular del Formant, se trata de un par de transistores NPN con compensación térmica en el encapsulado, fabricado por *Fairchild Semiconductor*. Este circuito integrado incluye una compensación de temperatura que mantiene constante la temperatura del componente lo que asegura la linealidad de la respuesta de los transistores.

En el Formant, se utiliza en los VCOs como fuente de corriente constante.

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| **Par de transistores emparejados** | | | | |
| **COMPONENTE OBSOLETO** | **REEMPLAZO** | **FABRICANTE(s)** | **DESCRIPCIÓN** | **SUMINISTRADOR** |
| uA726 | SSM2212RZ | Analog Devices |  | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 802-3679 |
| MAT01GHZ | Analog Devices |  | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 709-8512 |

## componente: BF245

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| **JFET N Transistor** | | | | |
| **COMPONENTE OBSOLETO** | **REEMPLAZO** | **FABRICANTE(s)** | **DESCRIPCIÓN** | **SUMINISTRADOR** |
| BF245A,B,C | BF545A,B,C | NXP/Philips | Transistor JFET, canal N | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 626-2327 |

## componente: 7413

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| **Puerta Lógica NAND 4 entradas Schmitt Trigger** | | | | |
| **COMPONENTE OBSOLETO** | **REEMPLAZO** | **FABRICANTE(s)** | **DESCRIPCIÓN** | **SUMINISTRADOR** |
| 7413 | 74HCT132 | NXP/Philips | Puerta NAND de cuatro entradas schimtt trigger.  Se sustituye por uno C.I. de cuatro puertas NAND de dos entradas Schmitt trigger | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 663-0483 |

## otros componentes

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| **Back Plane, Racks** | | | |
| **COMPONENTE** | **FABRICANTE(s)** | **DESCRIPCIÓN** | **SUMINISTRADOR** |
| Back Plane 21 slots | Vero  http://www.verotl.com/en/product/222-63630-96-96-way-version-21-slots-pcb-only | Panel trasero de 21 slots para conectar tarjetas de PCB. | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 110-2523 |
| Back Plane 10 slots | Vero  http://www.verotl.com/en/product/222-63631-96-96-way-version-10---pcb-only | Panel trasero de 10 slots para conectar tarjetas de PCB. | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 110-2539 |
| RACK 3U | Rittal  Ref. 3684.036  <http://www.rittal.com/es-es/content/es/start/> | Chasis de montaje en rack Rittal 3684.036, 3U x 84hp x 245mm, Aluminio Ripac VARIO | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 186-804 |
| RACK 6U | Rittal  Ref. 3684.045  <http://www.rittal.com/es-es/content/es/start/> | Chasis de montaje en rack Rittal 3684.045, 6U x 84hp x 245mm, Aluminio Ripac VARIO | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 187-059 |
| Guías tarjetas C.I. |  |  | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 487-729 |

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| **Interruptor cuádruple analógico con baja resistencia ON** | | | |
| **COMPONENTE** | **FABRICANTE(s)** | **DESCRIPCIÓN** | **SUMINISTRADOR** |
| ADG1411 | Analog Devices | iCMOS, Quad SPST Switches.  Cuádruple interruptor SPST con Resistencia interna ON de 1.5 Ω y alimentación simétrica de ±15V/+12V/±5 V. | RS Amidata  [www.rsonline.es](http://www.rsonline.es)  Código RS: 709-7629 |
|  |  |  |  |

## notas

https://www.allaboutcircuits.com/projects/diy-synth-series-vco/

1 voltio/Octava

Conversor MIDI/VOctava

https://www.midi-hardware.com/index.php?section=prod\_info&product=MINICV

### Synthesizer Type and Music Theory

The synthesizer that we will be designing was extremely common back in the day. It's known as a 1V/Octave synthesizer. This means that for every 1V increase on the input, the output frequency will go up by one octave (i.e., by a factor of 2).

Now for this module to work correctly, it needs an exponential converter on the input. This converter will take a linear voltage in and produce an exponential voltage which is fed into the VCO. Why do we need an exponential converter? The answer is in the nature of human hearing and music theory!

If you take a piano and play the middle A note (A4), it makes a specific tone which has a frequency of 440Hz. If you now play the A note to the right of this one (12 notes up, A5) the note sounds the same except higher pitch and has a frequency of 880Hz. (The lower note is a harmonic of the upper note which is why they sound OK when played together). Now, if you play the next A note to the right (A6), the note sounds higher pitched than the previous A note; it has a frequency of 1760Hz.

Any two same notes that are separated by 12 keys is called an octave. For any two keys that are an octave apart, the upper key will have a frequency twice that of the first. The reason for this is because by nature human hearing is logarithmic. This means that for something to sound twice as loud, its amplitude (or frequency in the pitch realm) needs to go up by a factor of two.

If, for example, we increase the frequency of a waveform from 1Hz to 2Hz, that would be considered an octave apart according to the human ear. But increasing a waveform frequency from 440Hz to 441Hz does not result in an octave change. In fact, the human ear would not be able to distinguish between these two frequencies because the human ear is good at relative changes as opposed to absolute changes.

So with all that complicated theory out of the way, we need to find a method to take in a linear voltage source (1V Octave Keyboard) and convert it into a voltage source that produces exponential voltages. To do this we will use a component that has inherent exponential qualities, the bipolar junction transistor or BJT.

### The Exponential Converter

So we need a circuit to take in a linear voltage from the keyboard/controllers and produce an exponential voltage which doubles in value for every octave.

Since our VCO is operating on a single supply 5V rail, the output of the converter needs to be between 0V and 5V. With a 5V input range, that gives the possibility of a 5-octave keyboard with a total of 60 keys.

The table below shows the input voltage from the keyboard and the required output voltage from the converter.

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| --- | --- | --- | --- | --- |
| **Key** | **Key #** | **1v Octave V** | **Expo Output** | **Frequency** |
| C0 | 1 | 0.0833 | 0.1655 | 65.4078 |
| C#0 | 2 | 0.1667 | 0.1754 | 69.2971 |
| D0 | 3 | 0.2500 | 0.1858 | 73.4177 |
| D#0 | 4 | 0.3333 | 0.1969 | 77.7834 |
| E0 | 5 | 0.4167 | 0.2086 | 82.4086 |
| F0 | 6 | 0.5000 | 0.2210 | 87.3089 |
| F#0 | 7 | 0.5833 | 0.2341 | 92.5005 |
| G0 | 8 | 0.6667 | 0.2480 | 98.0009 |
| G#0 | 9 | 0.7500 | 0.2628 | 103.8284 |
| A0 | 10 | 0.8333 | 0.2784 | 110.0023 |
| A#0 | 11 | 0.9167 | 0.2950 | 116.5434 |
| B0 | 12 | 1.0000 | 0.3125 | 123.4734 |
| C1 | 13 | 1.0833 | 0.3311 | 130.8155 |
| C#1 | 14 | 1.1667 | 0.3508 | 138.5942 |
| D1 | 15 | 1.2500 | 0.3716 | 146.8355 |
| D#1 | 16 | 1.3333 | 0.3937 | 155.5668 |
| E1 | 17 | 1.4167 | 0.4171 | 164.8172 |
| F1 | 18 | 1.5000 | 0.4419 | 174.6178 |
| F#1 | 19 | 1.5833 | 0.4682 | 185.0011 |
| G1 | 20 | 1.6667 | 0.4961 | 196.0018 |
| G#1 | 21 | 1.7500 | 0.5256 | 207.6567 |
| A1 | 22 | 1.8333 | 0.5568 | 220.0046 |
| A#1 | 23 | 1.9167 | 0.5899 | 233.0868 |
| B1 | 24 | 2.0000 | 0.6250 | 246.9468 |
| C2 | 25 | 2.0833 | 0.6622 | 261.6311 |
| C#2 | 26 | 2.1667 | 0.7015 | 277.1885 |
| D2 | 27 | 2.2500 | 0.7433 | 293.6709 |
| D#2 | 28 | 2.3333 | 0.7875 | 311.1335 |
| E2 | 29 | 2.4167 | 0.8343 | 329.6345 |
| F2 | 30 | 2.5000 | 0.8839 | 349.2356 |
| F#2 | 31 | 2.5833 | 0.9364 | 370.0022 |
| G2 | 32 | 2.6667 | 0.9921 | 392.0037 |
| G#2 | 33 | 2.7500 | 1.0511 | 415.3134 |
| A2 | 34 | 2.8333 | 1.1136 | 440.0092 |
| A#2 | 35 | 2.9167 | 1.1798 | 466.1736 |
| B2 | 36 | 3.0000 | 1.2500 | 493.8937 |
| C3 | 37 | 3.0833 | 1.3243 | 523.2621 |
| C#3 | 38 | 3.1667 | 1.4031 | 554.3769 |
| D3 | 39 | 3.2500 | 1.4865 | 587.3419 |
| D#3 | 40 | 3.3333 | 1.5749 | 622.2670 |
| E3 | 41 | 3.4167 | 1.6685 | 659.2690 |
| F3 | 42 | 3.5000 | 1.7678 | 698.4711 |
| F#3 | 43 | 3.5833 | 1.8729 | 740.0044 |
| G3 | 44 | 3.6667 | 1.9843 | 784.0073 |
| G#3 | 45 | 3.7500 | 2.1022 | 830.6268 |
| A3 | 46 | 3.8333 | 2.2272 | 880.0185 |
| A#3 | 47 | 3.9167 | 2.3597 | 932.3471 |
| B3 | 48 | 4.0000 | 2.5000 | 987.7874 |
| C4 | 49 | 4.0833 | 2.6487 | 1046.5242 |
| C#4 | 50 | 4.1667 | 2.8062 | 1108.7538 |
| D4 | 51 | 4.2500 | 2.9730 | 1174.6838 |
| D#4 | 52 | 4.3333 | 3.1498 | 1244.5341 |
| E4 | 53 | 4.4167 | 3.3371 | 1318.5379 |
| F4 | 54 | 4.5000 | 3.5355 | 1396.9423 |
| F#4 | 55 | 4.5833 | 3.7458 | 1480.0088 |
| G4 | 56 | 4.6667 | 3.9685 | 1568.0147 |
| G#4 | 57 | 4.7500 | 4.2045 | 1661.2537 |
| A4 | 58 | 4.8333 | 4.4545 | 1760.0370 |
| A#4 | 59 | 4.9167 | 4.7194 | 1864.6942 |
| B4 | 60 | 5.0000 | 5.0000 | 1975.5747 |

The component that will be used for its exponential properties is the BJT. Most will be familiar with the equation that relates the base current to the collector current but this relationship is linear.

The equation that relates the base-emitter voltage to the collector current is exponential:

[https://latex.codecogs.com/gif.latex?I_C&space;=&space;I_S&space;%28e%5E%7B%28%5Cfrac%7BqV_%7Bbe%7D%7D%7BkT%7D%29%7D-1%29](https://www.codecogs.com/eqnedit.php?latex=I_C&space;=&space;I_S&space;(e%5e%7b(\frac%7bqV_%7bbe%7d%7d%7bkT%7d)%7d-1))

Where

* **Ic** - Collector current
* **Is** - Saturation current
* **q** - Electron charge
* **Vbe** - Base-emitter voltage
* **k** - Boltzmann Constant
* **T** - Temperature (in kelvin)

Luckily for us, there are clever people who have already done the hard mathematics ([see here for the math](http://schmitzbits.de/expo_tutorial/index.html)) and the circuit design.

Below is the complete exponential converter that will be used in our VCO engine to convert the input linear voltage into an exponential voltage (where the voltage output doubles for every 1V increase in the input).

508-3088

Conector DIN 41612 RS Pro, 2.54mm, 64 contactos, 2 filas, Ángulo de 90°, Macho, Clase C1, tipo C, Soldador

508-3101

Conector DIN 41612 RS Pro, 2.54mm, 64 contactos, 2 filas, Recto, Hembra, Clase C1, tipo C, Soldador

663-0483

728-8743

Tarjeta Eurocard PCB RE318-LF, Una Cara DIN 41612 C FR4 con 33 x 55 1mm de orificio, 2.54 x 2.54mm de paso,

527-9324

Placa de matriz RE320-LF, cara única, DIN 41612 C, FR4, orificios: 37 x 53, diámetro 1mm, paso 2.54 x 2.54mm

Amazon

sourcingmap® 10 PCS hojas A4 Papel de transferencia de tóner por PCB Electronic Prototipo DIY

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| **CN\_21** | **TIPO:** |  |
| **PIN** | **NOMBRE** | **DESCRIPCIÓN** |
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