8702 clock generator

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Introduction

The 8702 clock generator is a drop-in replacement for the MOS Technology 8701 clock generator used in the Commodore 64 and Commodore 128 computers. The 8702 clock generator performs the same function as the 8701 clock generator.

The 8702 is intended to be a drop-in replacement for the 8701: Simply replace the 8701 in the Commodore 64, Commodore 128 or Commodore 128DCR with an 8702 and the computer will work normally.

In addition contains logic for the power-on reset, reset button and restore key handling. This would allow a designer of a new C64 mainboard to remove the NE556 timer and related components, which are used to perform these tasks on current mainboards.

Why is it called 8702?

The 8702 is backwards compatible to the 8701 clock generator. It is quite common in MOS Technology part numbers that an improved part get an incremented number close to the original number, so this is historically consistent. Examples are for example the 6582 and 6581 SIDs, the 6525 and 6523 TPIs and the 6532/6530 RIOTs. The first “unused” number after 8701 in the MOS Technology product catalog is 8702.

Creating a 8702 clock generator

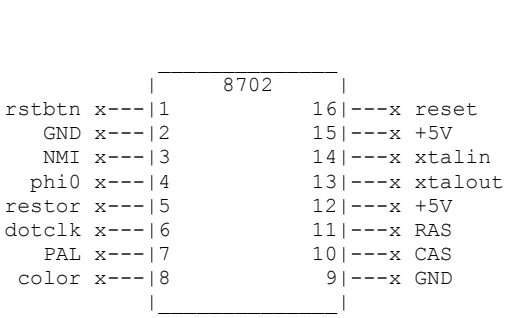
A 8702 clock generator is created from a GreenPAK SLG46536 integrated circuit. The chip must be programmed with an official programmer with the supplied .gp4 chip configuration file for the 8702.

Suitable programmers include the SLG4DVKDIP, the SLG4DVKLITE and SLG4DVKADV. The required software is the Renesas “Go Configure Software Hub”.

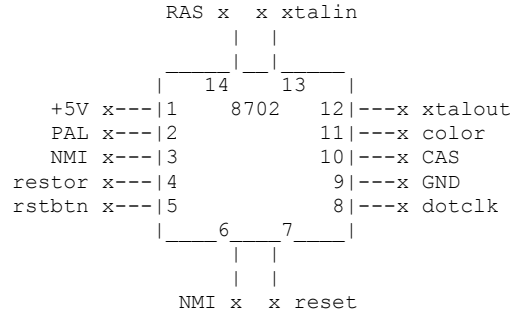
Pin description

DIP

(8701 compatible pinout)



STQFN

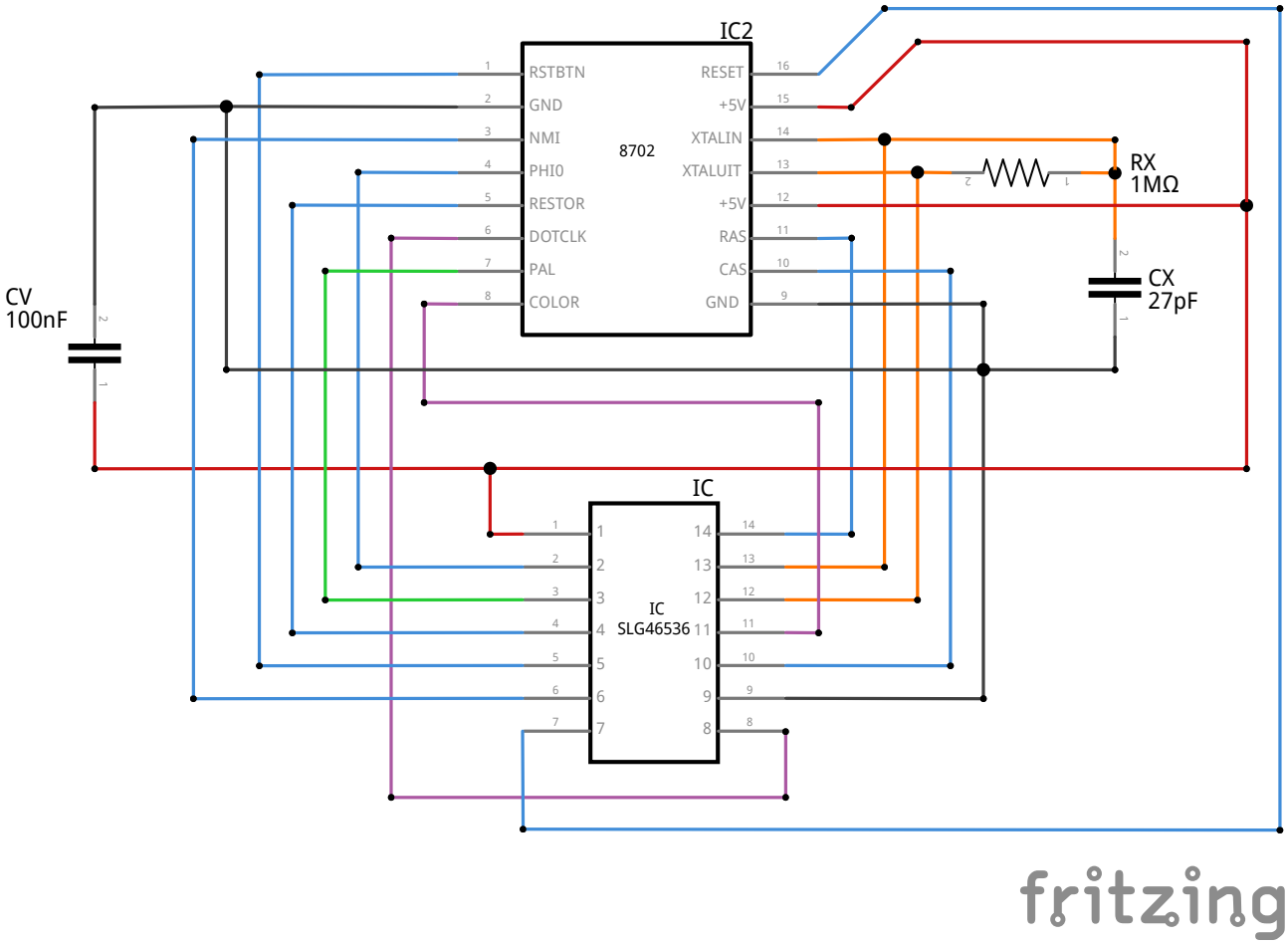


Pin 8702	**Pin SLG46536**	**Signal**	**I/O**	**Description**
1	5	RSTBTN	I	Connect a reset button between this and GND. This pin has a built-in pull-up resistor and is a low voltage input: Voltage has to be below 0.77V to trigger a reset.
2	9	GND		Ground
3	6	NMI	O	If you want to use the 8702 for implementing the RESTORE key on the C64 keyboard, connect this pin to the NMI line of the 6510. This pin is open-drain.
4	2	PHI0	I	If you want to use the RAS/CAS generator of the 8702, you should provide an 1MHz clock on this pin. This pin has a built-in pull-down resistor.
5	4	RESTOR	I	If you want to use the 8702 for implementing the RESTORE key on the C64 keyboard, connect this pin to the RESTORE key. This pin has a built-in pull-up resistor. *On the original 8701, this pin was called RES and did reset the dotclock counter that divides by 3.5 or 4.5. The 8702 does not provide the RES function. Pin 5 is unconnected on the Commodore 64/128.*
6	8	DOTCLK	O	On this pin, the 8702 outputs the dot clock, a 7.71MHz clock for PAL machines or a 8.18MHz clock for NTSC machines.

7	3	PAL	I	Pull this pin to ground for PAL mode, leave it unconnected or pull it high for NTSC mode.
8	11	COLOR	O	On this pin, the 8702 outputs the colour clock, a 17.344MHz clock for PAL machines or a 14.318MHz clock for NTSC machines.
9	9	GND		Ground
10	10	CAS	O	If you apply an 1MHz clock on PHI0, you will get a CAS signal on this pin.
11	14	RAS	O	If you apply an 1MHz clock on PHI0, you will get a RAS signal on this pin.
12	1	+5V		5V power supply
13	12	XTALUIT	O	Quartz crystal output. See schematic.
14	13	XTALIN	I	Quartz crystal input. See schematic.
15	1	+5V		5V power supply
16	7	RESET	O	If you want to use the RESET button or the undervoltage monitor inside the 8702, connect this pin to the RESET line of the Commodore 64. *Note that this pin has nothing to do with the RES pin 5 on the original 8701. The RES pin of the 8701 was unused and unconnected in the C64 and the 8702 does not provide this function.*

Schematic

The programmed SLG46537 must be combined with an 1MΩ resistor and 27pF capacitor and placed on a PCB adapter to get an 8701 compatible replacement. The following schematic shows the connections:



Do not use a value of 12pF for CX as recommended in the data sheet of the SLG46536. It results in a too fast clock, which can result in a black & white picture. Its value has been derived from the electronics theory behind a Piece oscillator instead.

The value of capacitor CX is calculated using the formula:

$$C_L = \frac{C_1 \times C_2}{C_1 + C2}$$

According to the Commodore 64 schematics, the load capacitance C_L of the crystals on the Commodore 64 mainboard is 18pF. The trimmer capacitor on the mainboard is rated between 7pF and 40pF, we target the trimmer in the middle, so we will work with 23.5pF. We also assume there is 10pF parasitic capacity on both the crystal input and output. This results in:

$$18 = \frac{(10 + C_1) \times (10 + 23.5)}{10 + C1 + 10 + 23.5}$$

$$18 = \frac{(10 + C_1) \times (33.5)}{C1 + 43.5}$$

$$18 = \frac{335 + 33.5 \times C_1}{C1 + 43.5}$$

$$18 \times C_1 + 783 = 335 + 33.5 \times C_1$$

$$448 = 15.5 \times C_1$$

$$C_1 = 28.9\,pF$$

Rounding to common capacitor values, we select 27pF for CX.

DOT clock generation

The 8702 generates the dot clock in a very similar way to the 8701. First, the color clock is multiplied by 2 by means of delaying it through propagation delay and a XOR gate.

After that the clock is dividend by 4.5 in PAL mode and 3.5 in NTSC mode.

NE556 timer replacement

The original 8701 had many unused pins. The 8702 clock generator uses this pins to provide the function of the NE556 timer that is on C64 long boards. This means that designers of modern Commodore 64 mainboards do not need a 556 timer if they use the 8702.

The NE556 in the Commodore 64 has two functions: Holding RESET low during power on and generating a pulse on the NMI line when the RESTORE key is pressed.

For NMI, if a falling edge is detected on the RESTORE input, the NMI line is pulled down for 120us. The original NE556 pulls down NMI for 21us. Early in the NMI handler in the KERNAL, the Commodore 64 disables interrupts on CIA2, in order to prevent further NMIs to occur. By pulling down for 120us, the 8702 prevents that another NMI can occur before the KERNAL disables the CIA2 interrupt. This also serves to debounce the RESTORE button: Falling edges that occur within this 120us window, are ignored.

The RESET handling inside the 8702 is more sophisticated than the NE556 did. When the Commodore 64 powers on, the following happens:

- If Vcc reaches 2.7V, the 8702 starts up.
- Once the 8702 becomes conscious, it pulls down RESET.
- If Vcc reaches 4.4V, power is considered acceptable.
- Should Vcc drop below 4.2V, power will be considered unacceptable
- There is an analog 1MHz low-pass filter in front of the voltage monitoring circuit to prevent that power supply ripple triggers power decisions.
- The crystal oscillator only runs when power is acceptable.

- If power remains acceptable for half a second, RESET is released.

RSTBTN has to be be below 0.77V for more than 55us for a reset to be triggered. If a reset is requested via RSTBTN, RESET will be pulled down for half a second.

RAS/CAS generator

The 8701 can generate RAS/CAS signals for DRAM. This functionality is unused in the Commodore 64. The 8702 clock generator implements the RAS/CAS generator. To use it, connect an 1MHz clock to PHI0, and RAS/CAS signals will appear on the RAS and CAS outputs.

SLG46536 datasheet

It is recommended to read the datasheet of the SLG46536 that you are using to implement the 8702 clock generator to have the full specifications.