Clock rate

From Nesdev wiki

The **clock rate** of various components in the NES differs between consoles in the USA and Europe due to the different television standards used (NTSC M vs. PAL B). The color encoding method used by the NES (see NTSC video) requires that the master clock frequency be six times that of the color subcarrier, but this frequency is about 24% higher on PAL than on NTSC. In addition, PAL has more scanlines per field and fewer fields per second than NTSC. Furthermore, the PAL CPU's master clock could have been divided by 15 to preserve the ratio between CPU and PPU speeds, but Nintendo chose to keep the Johnson counter structure, which always has an even period, and divide by 16 instead.

So the main differences between the NTSC and PAL PPUs are depicted in the following table:

Property	NTSC (2C02)	PAL (2C07)	Dendy	RGB (2C03)	RGB (Vs. 4)	RGB (2C05)
Master clock speed	21.477272 MHz ± 40 Hz 236.25 MHz ÷ 11 by definition	26.601712 MHz ± 50 Hz 26.6017125 MHz by definition	Like PAL	Like NTSC		
CPU	Ricoh 2A03	Ricoh 2A07	UMC 6527P	Ricoh 2A03		
CPU clock speed	21.47~ MHz ÷ 12 = 1.789773 MHz Same as NTSC Amiga clock ÷ 4	26.60~ MHz ÷ 16 = 1.662607 MHz	26.60~ MHz ÷ 15 = 1.773448 MHz Same as PAL Amiga clock ÷ 4	Like NTSC		
APU Frame Counter rate	60 Hz	50 Hz[1] (http://forums.nesdev.com/viewtopic.php?p=160349#p160349)	59 Hz[2] (http://forums.nesdev.com/viewtopic.php?p=174970#p174970)	Like NTSC		
PPU	Ricoh 2C02	Ricoh 2C07	UMC 6538	Ricoh 2C03	Ricoh 2C04-0001 through 2C04-0004	Ricoh 2C05
PPU clock speed	21.477272 MHz ÷ 4	26.601712 MHz ÷ 5	Like PAL	Like NTSC		
PPU dots per CPU cycle	3	3.2	3	Like NTSC		
Height of picture	240 scanlines	239 scanlines	Like PAL	Like NTSC		
Nominal visible picture height (see Overscan)	224 scanlines	268 scanlines	Like PAL	Like NTSC		
"Post-render" blanking lines between end of picture and NMI	1 scanline	1 scanline	51 scanlines	Like NTSC		
Length of vertical blanking after NMI	20 scanlines	70 scanlines	20 scanlines	Like NTSC		
Time during which OAM can be written	Vertical or forced blanking	Only during first 20 scanlines after NMI	Like NTSC	Like NTSC		
"Pre-render" lines between vertical blanking and next picture	1 scanline					

Total number of dots per frame	341 × 261 + 340.5 = 89341.5 (pre-render line is one dot shorter in every other frame)	341 × 312 = 106392	Like PAL	341 × 262 = 89342		
Vertical scan rate	60.0988 Hz	50.0070 Hz	Like PAL	60.0985 Hz		
Color of top border	Always black ($0E)					
Side and bottom borders	Palette entry at $3F00	Always black ($0E), intruding on left and right 2 pixels and top 1 pixel of picture	Like PAL [3] (https://forums.nesdev.com/viewtopic.php?p=173764#p173764)	Like NTSC[4] (https://forums.nesdev.com/viewtopic.php?p=179705#p179705)		
Color emphasis (with correlating bit in PPUMASK)	Blue (D7), green (D6), red (D5)	Blue (D7), red (D6), green (D5)	Like PAL	Blue, green, red (full scale)		
Other quirks	Early revisions cannot read back sprite or palette memory			Missing $2D and $3D greys	Permutated palette	PPUCTRL and PPUMASK are swapped; revision ID in PPUSTATUS (D4-D0)

Some frequencies in the above table are rounded.

The 2C03, 2C04, and 2C05 PPUs were all found in Nintendo's Vs. System and PlayChoice-10 (a.k.a. PC10 or PC-10) arcade systems. Famicom Titler, Famicom TVs, and RGB-modded NES consoles would use either the 2C03 or a 2C05 with glue logic to unswap $2000 and $2001. (Later RGB mods used a 2C02 in output mode and faked out all palette logic.)

The color emphasis bits on the PAL NES have their red and green bits in PPUMASK swapped

The authentic NES sold in Brazil is an NTSC NES with an adapter board to turn the NTSC video into PAL-M video, a variant of PAL using NTSC frequencies but PAL's color modulation.

Dendy is a clone of the Famicom distributed by Steepler and sold in Russia. The chipset in Dendy and several other PAL famiclones (6527P+6538) is designed for compatibility with Famicom games, including games with CPU cycle counting mappers (e.g. VRC4) and games that use a cycle-timed NMI handler (e.g. *Balloon Fight*). This explains the faster CPU divider and longer post-render period vs. the authentic PAL NES.

To compensate for these differences, you can detect the TV system at power-on.