

Frame Rules in Mega Man 2

There are three types of frame rules we have to deal with in a Mega Man 2 TAS. I call them health bar frame rules, menu text frame rules, and Wily boss frame rules; you can think of the first two as boss entry and boss exit frame rules. They are controlled by the frame counter at memory address \$001C.

Health Bar Frame Rules

When you enter a boss room, the boss's health ticks up from 0 to a full 28 while they stand in the corner and intimidate you. It's iconic!



If you go frame by frame, you'll see that the health bar fills by one line every 4 frames. This behavior could have been created by starting a timer that counts down from 4, but the mm2 devs chose to do something a little different: they check if the frame counter is a *multiple* of 4. This is smart because checking for multiples of a power of 2 is really easy for a computer; you just have to check if the bits are clear. Something like:

```
if((frameCount & 3)==0)...
```

or

```
loop:  
LDA #$03  
BIT $1C  
BNE loop  
...
```

This and this alone is responsible for boss entry frame rules. The health bar will always fill up on a multiple of 4 frames, and you will always be allowed to move 2 frames after (\$1C is congruent to 2 mod 4). As such, saving 1 frame could save you 0 frames, or 4 frames, in typical

frame rule fashion. But once you finish the fight, you're not out of the water yet. There's another type of frame rule to contend with on your way out.

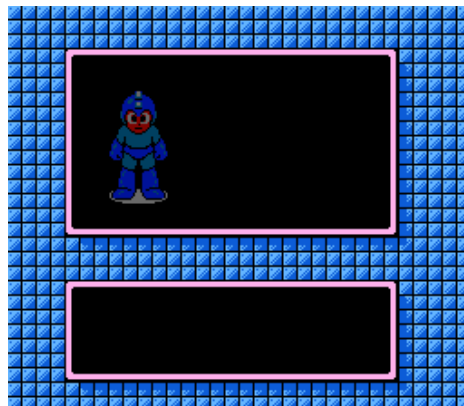
Menu Text Frame Rules

On the "GET EQUIPPED" screens, the letters in each sentence slowly appear one by one rather than being drawn instantly. On all versions of the game, these letters appear every 8 frames; the Japanese version is faster only because it has less text! Similarly to the health bar frame rules, the game checks for multiples of 8 in the frame counter rather than repeatedly run 8-frame timers. It simply ANDs with 7 rather than 3. This and this alone is responsible for boss exit frame rules.



Bubble Leet

This 8-frame rule also applies to the cute picture of Mega Man as he fades up from black. So you can use Mega Man's picture on the menu screen to gauge your position in the frame rule. If you beat the boss on a multiple of 8 frames, Mega Man will appear instantly; on any other remainder, he will appear after 1-7 frames. Once the picture appears on screen, all other text will always take the exact same amount of time, so you don't have to wait until the first actionable frame on the menu (when it will listen to you pressing up/down/select/start) to see if you beat a frame rule. Check the frame counter during the ~10 frames of loading lag to see what value you got.



Wily Bosses

Bosses in the Wily stages are subject to no fewer than *three* frame rules! They start off with the health bar frame rule just like the 8 regular robots, plus two more that are described below.

Explosion Frame Rules

The epileptic screen flash explosions after the dragon and tank fights are controlled by a 16-frame rule. Remember how I talked about dividing by X being more efficient than decrementing a timer? Well, the big boss explosions divide by 16...to decrement a timer. It's weird. You can find this timer at \$00B2. Mega Man will not start teleporting away until a set amount of time after \$B2 reaches 0.



This frame rule is a little more nuanced than the menu text frame rule. Because it occurs *before* you start to teleport away, you can still save time by ending the fight higher up, even if you make the same frame rule. It's best to compare your results against the map frame rule, described below.

Only Mecha Dragon and Guts Tank are affected by this frame rule. The other Wily bosses are affected by health bars, map draws, and a few ad hoc things, all of which are described below.

Mecha Dragon & Double Death

If you manage to kill the dragon and die on the same frame, and the frame counter happens to be a multiple of 16 frames, you will save 16 frames of waiting. Though it may seem like you're saving a frame rule, you're actually making the same frame rule and setting the wait timer to a lower value. This is very mysterious to me...

Picopico Spawns

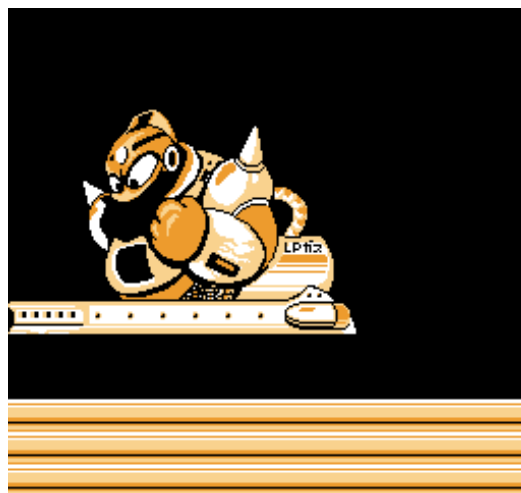
Picopico-kun operates on a very lenient 31-frame rule: once a wall block has been defeated, the next one will spawn on a multiple of 31 frames. However, this is relative to the *start* of the fight, so if you come *in* 4 frames sooner, you'll come *out* 4 frames sooner. This is an interesting case where a frame rule exists but does not affect your final time.

All the sprite spawners (which generate an endless supply of pipis, tellies, or prop-tops) behave in a similar way. Therefore, it's likely that Picopico is controlled by a similar spawner object.

Guts Tank

Guts Tank is the one boss in the game without a health bar frame rule! Every frame counts when facing him. At least until the 16-frame explosion rule just after...

Watching the nametable as he spawns can give us some insight as to why. We can see the tank slowly being drawn off-screen for about 20 frames after his health bar fills up. This draw starts relative to you entering the room and always takes the same amount of time, so it's the limiting factor for starting the fight.



Boobeam Trap

Nothing to report here, just the standard health bar + map rules. I suppose you could count them firing their bullets at you, but that has no effect on the timing of the fight.

Map Frame Rules

Similarly to menu text, the path tiles on the Wily castle map screen are drawn once every 4 frames. It does a bit test just like the other frame rules (AND 3). I recommend timing your Wily fights to the frame the first path tile is drawn.



Lag & Frame Rules

Lag affects frame rules in a subtle but important way. The frame counter at \$1C does *not* increment during lag, so the entire frame rule pattern gets pushed back by a frame. To illustrate this, I'll extend darbian's famous bus stop metaphor.

Here's the base scenario: you have to take a bus to work. It shows up at your stop every hour on the hour (8:00, 9:00, 10:00...). On Monday you get there by 8:30, which means you have to wait for the 9 AM bus. On Tuesday, you get up nice and early, and make it to the bus stop by 8:15. Nice hustle, but you still gotta wait for the 9 AM bus. You could've slept in!

Now let's give some agency to the bus driver. Let's say he wakes up hungover and is 20 minutes late to work. After a cup of coffee and a slap to the face he's just fine, but now he's showing up to the stop every hour, 20 minutes *after* the hour (8:20, 9:20, 10:20...). So let's revisit your week. On Monday you arrive at 8:30, but now you have to wait for the 9:20 bus. So slow! But on Tuesday, with your nice hustle, and your 8:15 arrival time...you can catch the 8:20 bus. So when the bus is running late, you'll probably be late to work, but you *could* be early.

But of course, lag frames are something you can manipulate, so maybe you and the bus driver are drinking buddies...? The metaphor starts to fall apart at this point, but you get the idea. Here's a dumb diagram that will almost certainly add nothing to this write-up:

