

OP-1 MODS

for the original OP-1, firmware 246



USER MANUAL

Version 1.0

The new stuff only. Everything stock works the way teenage engineering's guide says.

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What's In It

This is an unofficial firmware mod for the original OP-1. It adds a synth engine, a sequencer, six effects, an LFO, chords, scales, a Shift latch on the knob presses and MIDI CC control of almost every knob. It runs on the OP-1's own processor, on top of firmware 246. Your tape, sounds and albums are not touched by installing it.

This manual only covers what the mod adds. For everything else, teenage engineering's OP-1 guide is still the manual.

Addition	What it is	Where you find it
Scales	White keys play the scale you pick	Synth, T2, hold Shift
Chord mode	One key plays a chord, 15 shapes	Synth, T2, Shift + white key
KEYS	Electric keyboard engine: tine, reed, clav	Engine list (Shift + T1), presets in folder KEYS
TRACK	Piano-roll sequencer you can play into	The sequencer list
CRUSH	Bitcrusher	Effect list (Shift + T3)
BELL	Ring mod into four tuned strings	Effect list
MOON	Phaser into Uni-Vibe	Effect list
MIMIC	Tempo-locked echo	Effect list
LINGER	Plate reverb with freeze	Effect list
SPIN CYCLE	Rotary speaker	Effect list
TIDE	LFO with shapes, phase, skew and sync	LFO list (Shift + T4)
Shift latch	Press a knob to get its Shift job	Any knob press
MIDI CC	CCs set engine, envelope, effect, LFO and master knobs	USB MIDI, see the chart
ITER, FILTER	teenage engineering's own hidden engine and effect, switched on	Engine list, effect list

One habit that saves you trouble

Before you ever go back to stock firmware, switch every sound off the new engine, effects and LFO. Stock firmware doesn't know them and won't boot with them loaded. Full steps on the "Going Back to Stock" page.

Before You Install

- **Original OP-1 only.** Not the OP-1 Field. The Field is a different machine and none of this applies to it.
- **Firmware 246.** The patch is made against teenage engineering's official `op1_246.op1`, the last firmware for the original OP-1. You download that file from them yourself; the patch contains none of it.
- **Python 3.8 or newer.** A Mac already has it. On Windows, get it from python.org. The patcher uses nothing outside the standard library.
- **Back up first.** Put the OP-1 in disk mode (Shift + COM, then T3) and copy the whole drive to your computer. Tape, synth, drum, album, all of it.
- **At your own risk.** It has been run on two OP-1s of different hardware revisions. The bootloader (te-boot) stays stock, so a bad flash can always be redone, but nobody is promising anything.

What's in the download

<code>op1-mod-1.0.op1patch</code>	The changes. Copy instructions and new bytes, nothing of teenage engineering's.
<code>apply.py</code>	Applies the patch to the official firmware file on your computer.
<code>OP-1_Mods_User_Manual_1.0.pdf</code>	This manual.

Installing

1. **Get the official firmware.** Download `op1_246.op1` from teenage engineering's OP-1 downloads page.
2. **Make the modded file.** Put `op1_246.op1`, the patch and `apply.py` in one folder, open a terminal there and run

```
python3 apply.py op1_246.op1 op1-mod-1.0.op1patch
```

It checks that your firmware file is the exact one the patch was made for, writes the modded `.op1` next to it and reads it back to verify. If any check fails it writes nothing.
3. **Put the OP-1 in upload mode.** Power off and unplug USB. Hold COM while you switch it on. Press 1, then plug in USB. A drive called OP-1 shows up on your computer.
4. **Copy the modded `.op1` file onto that drive, then eject it.**
5. **Press COM on the OP-1.** That starts the update. It takes several minutes. Don't pull the cable or power off.
6. **Power cycle when it's done.** It boots to the tape like always.

On a Mac, if the copy fails or the update refuses the file, try another USB cable or port first. That is teenage engineering's own advice for te-boot, and it's usually the answer.

Going Back to Stock

Stock 246 doesn't know the new engine, effects or LFO. If a synth sound, a drum sound or the master is using one of them when you flash stock, the OP-1 stops at boot with an "Invalid synth patch" message.

Before you flash anything older, switch every sound off these

Engine: KEYS, ITER. **Effects:** CRUSH, BELL, MOON, MIMIC, LINGER, SPIN CYCLE, FILTER. **LFO:** TIDE.

Check all eight synth sounds, all eight drum sounds, and the master effect.

Then flash the official `op1_246.op1` the same way you installed the mod (steps 3 to 6).

If you forgot

You don't need a factory reset. Go into upload mode, flash the mod again, let it boot, switch the sounds, then go back to stock.

What doesn't need switching

Chord mode, scales and the Shift latch aren't saved in your sounds, so stock ignores them. TRACK saves its notes in a place stock firmware doesn't read, and tells stock it was set to Pattern, so stock boots fine and just shows Pattern.

Scales

Pick a root and a scale, and the white keys play that scale. In a seven-note scale that's one scale degree per white key, seven to the octave, so you can play any melody in key with no wrong notes. The black keys go silent.

Setting it

1. In synth mode, press **T2** (the envelope page).
2. Hold **Shift**. The play-mode screen shows the scale.
3. Turn the **white** and **orange** knobs to set the root and the scale type.

Root C with type major reads **SCALE OFF / ALL KEYS**. That's the bypass: every key plays as stock.

The scale is global. It affects every synth sound, and it's also what chord mode and BELL build their chords from.

This started as stfj's note quantization patch. In this build it's moved in memory so it stops crashing the OP-1 revisions it used to crash, and the scale tables are corrected (in the original, every scale except C major came out a fourth off).

Chord Mode

One key plays a whole chord. The chord tones follow the scale you set, so if a scale is on, a triad on each white key stays in key as you walk up.

Turning it on and picking a shape

In synth mode press **T2**, then hold **Shift** and tap a white key. The shape shows next to the play mode, for example **POLY TRI**.

Shift + key	Shape	Shift + key	Shape
low F	chords on / off (back to your last shape)	F (second)	Ad9, add 9
G	Tri, triad	G	Pwr, power chord
A	7th	A	Oct, octave
B	9th	B	Opn, open voicing
C	Su2, sus 2	C	Shl, shell voicing
D	Su4, sus 4	D	Qrt, quartal
E (first)	6th	top E	cycles Mi7 / Mi9 / Ma7

The left half of the table is the lower octave of white keys, the right half the upper one.

Mi7, Mi9 and Ma7 are parallel shapes. They ignore the scale and play the same chord quality on every key: minor 7, minor 9 and major 7 stabs, the classic house move.

Things to know

- Chords need a **POLY** play mode. Mono, legato and unison play single notes.
- Everywhere else, Shift + key works as stock (it's note entry for the stock sequencers).
- Two held chords can share notes. That's handled; nothing hangs.
- Chords record into TRACK as separate notes. They don't reach the stock sequencers (Endless, Pattern and so on), which send their own notes.
- The shape you picked doesn't survive a power cycle yet.

KEYS

A new synth engine: three electric keyboards in one. Tine (the electric piano with tines), reed (the reed piano) and clav. There are no samples. Each voice is a few phase-modulated sine oscillators with their own decays, so higher notes die faster and the attack changes with how hard you set it, the way the real instruments behave. Six voices.



The action under a lid, with a drink on top.

Getting to it

Start from a preset: Shift + a sound key opens the preset browser. Folder **KEYS** has TINE, REED and CLAV. You can also pick KEYS in the engine list (Shift + T1), but that only swaps the engine and keeps the old sound's envelope, effect, LFO and octave, which can make KEYS sound wrong until you set those.

The knobs

Blue: BARK

How hard the key is hit: more growl and more attack. The OP-1's keys don't send velocity, so this stands in for it.

Green: TONE

Pickup position. Tine and reed: adds the hollow, nasal even harmonics. Clav: moves the second pickup, thin to honky.

White: DECAY

How long a held note rings. A quarter of the natural time at the bottom, natural in the middle, four times at the top. Read when a note starts.

Orange: TYPE

Bottom third TINE, middle third REED, top third CLAV. Read when a note starts.

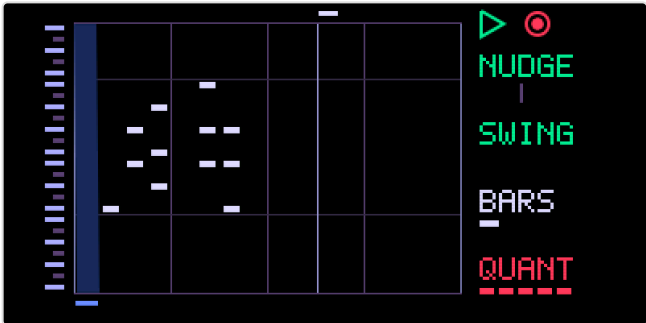
Shift + knob is fine adjustment. The screen: the hammer throws more sparks with BARK, the pickup slides with TONE, the curve top left is the ring time, and the mechanism and the drink change with TYPE (tine and a martini, reed and a milkshake, clav and a whiskey). The six bars are the voices.

Things to know

- The stock tremolo LFO on a tine is the classic sound. Start there.
- Clav adds a short click on key release when the envelope's release is above zero. Set release to zero on clav if you don't want it.
- MIDI CC 16-23 (engine knobs) don't reach KEYS in this version. Everything else on the chart does.

TRACK

A seventh sequencer with a piano roll, built to play into. Record live, punch notes in at a step, nudge them off the grid, add swing. It starts and stops with the tape.



The piano roll. The dim blue column is the cursor, the thin line is the playhead.

Picking it

Hold Shift and press the sequencer key to open the sequencer list, then pick TRACK at the bottom. It stays chosen after a power cycle, and so do your notes. There is one track for synth and one for drum, up to 160 notes each.

Keys and buttons

Do this	What happens
Play the keys	They always play, whether or not you're recording.
REC	Arms recording.
Armed, loop running	What you play is recorded where you play it, quantized on the way in (see record quantize).
Armed, loop stopped	Tap a key to put that note at the cursor step, or take it out if it's there.
Shift + key	Puts the note at the cursor and moves the cursor on one step.
PLAY	Starts and stops the loop.
STOP	Stops and rewinds to the top.
LIFT	Cuts the notes under the cursor.
DROP	Pastes them at the cursor.
Shift + LIFT	Clears the whole track.

The knobs

Knob	Plain	With Shift
Blue	Cursor	Move the notes under the cursor by whole steps

Green	Nudge, in twelfths of a step. Carries notes across step lines	Swing, 50 to 74
White	Note length	Loop length, 1 to 4 bars
Orange	Transpose	Record quantize, 0 to 100 (100 = hard on the grid)

Notes are drawn early, on the step or late, so you can see a nudge.

With the tape

Start the tape and the loop starts from the top. Stop the tape and it stops. A **T** lights next to REC while the tape is driving it.

If the loop doesn't start with the tape

The tape only starts the loop when the track has notes in it or REC is armed. An empty, unarmed track stays put. Nothing on screen says so yet.

Switching between synth and drum stops the loop, the same as the stock sequencers.

The New Effects

All six are in the effect list (Shift + T3) with the stock ones, and work on a synth sound, a drum sound or the master. As on stock effects, Shift + knob is fine adjustment. Every one has its own screen, and the knobs and the audio both move it.

CRUSH

A bitcrusher. Clean at the top, then steps down in half-bit steps. Silent when nothing is playing.

Blue: CRUSH Sample-rate crush: holds each sample for 1 to 32 samples.

Green: DENTS Bit crush, 0 (clean) to 12. Up is more.

White: MIX Dry to wet.

Orange: FILTER Low-pass on the crushed signal, to take the fizz off.

The screen: a boot crushing a can, and a stair-step wave that follows the CRUSH knob.

BELL

A ring modulator feeding four tuned strings. Every note you play retunes two of the strings to that note's chord tones in the current scale, and a tone at those pitches follows your playing, so a single note rings out with a chord behind it. On a drum sound the strings hold a fixed chord on the scale's root.

Blue: STRIKE Six steps: from no ring mod up to a harder, more metallic strike with more drive.

Green: CHORD What the strings are tuned to: UNI (root and octaves), 5TH, TRI, 7TH, 9TH, as steps of the scale.

White: RING How long the strings ring, about 0.1 s to 10 s, and how bright they stay.

Orange: MIX Equal-power dry to wet. The top quarter adds a slow drift to the ring mod.

The screen: a lab scope, with a tuning fork per string that glows as its string rings.

MOON

A phaser that turns into a Uni-Vibe. On the master the left and right sweeps run a quarter turn apart.

Blue: RATE Sweep speed, 0.05 to 10 Hz.

Green: DEPTH How far it sweeps.

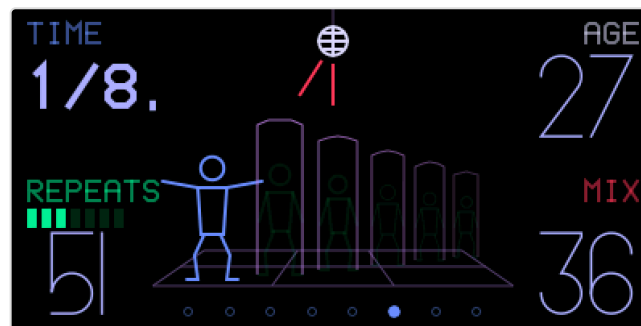
White: COLOR Feedback: more resonant, more vocal.

Orange: TYPE **PH8** eight-stage phaser, **PH4** four-stage, **UNI** the stages spread out like a Uni-Vibe with its lamp-and-photocell throb, **VIB** the dry fades out and leaves pure vibrato.

The screen: the phases of the moon.

MIMIC

A tempo-locked echo whose repeats wear out like tape.



A dancer copied in mirrors, one per repeat, each one dimmer than the last.

Blue: TIME Ten note values from 1/32 to 1/2, locked to the tempo. Changing it glides, like moving a tape head.

Green: REPEATS Feedback, up to 120%. Past 100% it runs away. Pull it back before it gets out of hand.

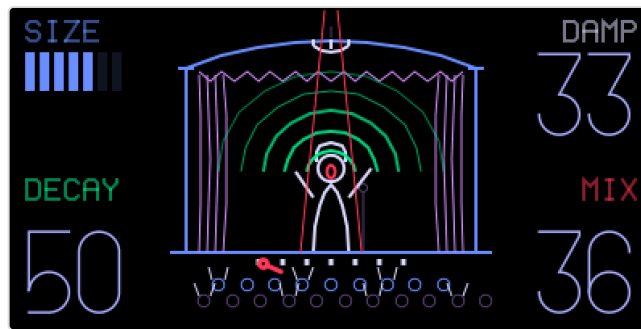
White: AGE How worn each repeat gets: saturation plus wow and flutter.

Orange: MIX Dry to wet.

On the master, MIMIC always ping-pongs left and right.

LINGER

A plate reverb with a freeze.



The stage. The curtains close with DAMP.

Blue: SIZE

How big the plate is.

Green: DECAY

From about 0.4 s up to tails of 20 seconds and more. At the very top it's **HOLD**: the tail freezes and keeps going until you turn it down.

White: DAMP

Takes the top end off the tail.

Orange: MIX

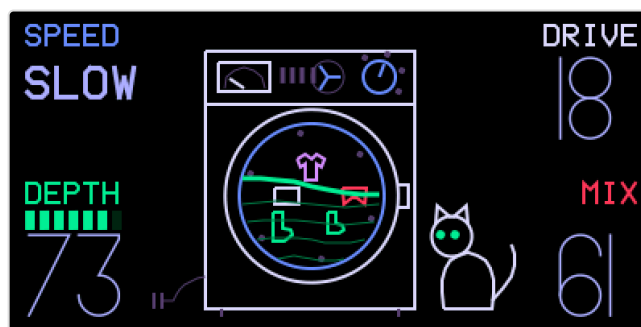
Dry to wet.

LINGER is the heaviest effect on the OP-1. It's been recorded clean with six KEYS voices on one synth sound. Running it on a synth sound and the master at the same time hasn't been measured.

The screen: a stage. SIZE widens the stage and the audience, DAMP closes the curtains, a fermata shows at HOLD.

SPIN CYCLE

A rotary speaker: a horn and a drum spinning opposite ways, two microphones, and a drive in front.



The washing machine. MIX loads the clothes.

Blue: SPEED

One click per mode: **BRAKE** (stopped), **SLOW**, **FAST**, **AUTO** (fast while you play, slows down when you stop). The horn changes speed quickly and the drum slowly, so switching ramps like the real thing.

Green: DEPTH

How much of the spin you hear.

White: DRIVE

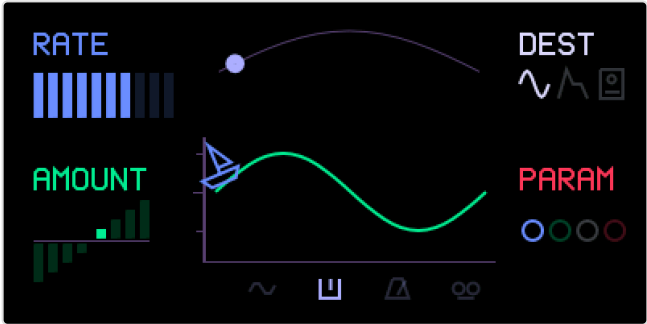
Overdrive into the speaker.

Orange: MIX

Dry to wet.

TIDE

A new LFO type, in the LFO list (Shift + T4) between RANDOM and TREMOLO. It does what the stock VALUE LFO does (one destination, one parameter) and adds seven waveforms, a start phase, a skew control and four sync modes. With SHAPE sine, PHASE 0, SKEW centred and SYNC key, it behaves exactly like the value LFO.



The waveform is the sea, the boat is where the LFO is right now, the moon on its arc is PHASE.

Knob	Plain	With Shift
Blue	RATE. Lower half tempo-locked (8 divisions, 1/16 beat to 8 beats a cycle), upper half free	SHAPE: sine, triangle, saw, ramp, square, sample-and-hold, smooth random (one click each)
Green	AMOUNT, positive or negative	PHASE: where in the cycle it starts, 0 to 360 degrees
White	DEST: engine, envelope (drum: the T2 page), effect	SYNC: free, key, beat, tape (one click each)
Orange	PARAM: which knob of the destination	SKEW: moves the middle of the cycle. A triangle leans into a saw or a ramp, a square changes its pulse width

Sync modes

- **free:** never restarts.
- **key:** restarts on every note (what the value LFO does).
- **beat:** locked to the master clock, so it can't drift against a sequence. Needs RATE in its tempo-locked half. It lines up with the beat grid, not with bar 1.
- **tape:** the place in the cycle is the place on the tape. The same spot on the tape always sounds the same, and the LFO stands still when the tape stops. Needs RATE in its tempo-locked half.

DEST "effect" includes the new effects, so TIDE can sweep MOON's rate or CRUSH's DENTS.

Knob Press = Shift Latch

Press any of the four knobs and the knobs switch to their Shift job without you holding Shift. Press a knob again to switch back. Pressing a mode key or T1 to T4 also drops it, so you never end up stuck in the second layer on a new page.

While it's latched, holding Shift gives you the first layer. It works anywhere the stock firmware gives the knobs a Shift job, including the fine adjust on effects and TIDE's second set of knobs.

There's no on-screen indicator for the latch in this version. If a knob seems to be doing the wrong thing, press it once.

ITER and FILTER

The OP-1 has an engine and an effect that teenage engineering built and never put in the lists: ITER (synth engine) and FILTER (effect). The community has been switching them on with repacked firmware for years. This build includes both, with their stock graphics. They're teenage engineering's work, not mine, and they're as finished as teenage engineering left them.

MIDI CC Implementation Chart

Send these over USB on the OP-1's MIDI channel (channel 1 unless you changed it). Each CC **sets** a knob of the sound you're playing, meaning the active synth sound in synth mode or the active drum sound in drum mode. Values 0 to 127 cover the knob's whole range and the screen follows. CC 1-4 stay with the stock MIDI LFO.

CC	Synth sound	Drum sound
16	Engine knob 1 (blue)	ignored
17	Engine knob 2 (green)	ignored
18	Engine knob 3 (white)	ignored
19	Engine knob 4 (orange)	ignored
20-23	Engine values 5-8, only on engines that store them: D-Synth (20-23), Phase (20)	ignored
24	Attack	T2 page, knob 1
25	Decay	T2 page, knob 2
26	Sustain	T2 page, knob 3
27	Release	T2 page, knob 4
28	Play mode: poly, mono, legato, unison (four zones)	T2 page, value 5
29	Portamento	T2 page, value 6
40	Effect knob 1 (blue)	the drum sound's effect, knob 1
41	Effect knob 2 (green)	the same, knob 2
42	Effect knob 3 (white)	the same, knob 3
43	Effect knob 4 (orange)	the same, knob 4
44	LFO knob 1 (blue)	the drum sound's LFO, knob 1
45	LFO knob 2 (green)	the same, knob 2
46	LFO knob 3 (white)	the same, knob 3
47	LFO knob 4 (orange)	the same, knob 4
48	LFO shape (tremolo: its Shift + orange value; TIDE: SHAPE)	the same
50	Master effect knob 1 (blue)	the same
51	Master effect knob 2 (green)	the same
52	Master effect knob 3 (white)	the same
53	Master effect knob 4 (orange)	the same
56	LFO value 5 (TIDE: SHAPE)	the same
57	LFO value 6 (TIDE: PHASE)	the same
58	LFO value 7 (TIDE: SYNC)	the same
59	LFO value 8 (TIDE: SKEW)	the same

A CC for a knob that the current engine, effect or LFO doesn't have is ignored.

CC 40-43 and 50-53 on the new effects

Effect	40 / 50	41 / 51	42 / 52	43 / 53
CRUSH	CRUSH	DENTS	MIX	FILTER
BELL	STRIKE	CHORD	RING	MIX
MOON	RATE	DEPTH	COLOR	TYPE
MIMIC	TIME	REPEATS	AGE	MIX
LINGER	SIZE	DECAY	DAMP	MIX
SPIN CYCLE	SPEED	DEPTH	DRIVE	MIX

On the stock effects, 40-43 are the four knobs in screen order: blue, green, white, orange.

CC 44-48 and 56-59 on TIDE

CC	44	45	46	47	48 / 56	57	58	59
TIDE	RATE	AMOUNT	DEST	PARAM	SHAPE	PHASE	SYNC	SKEW

Engines that don't take CC 16-23

KEYS and **ITER** (not wired up yet), and **Sampler** (its start, end and loop points depend on each other, so setting them one at a time from outside would break the sample).

Saving

A value set by CC is written into the sound about half a second after the last CC for that page, the same way a knob turn is. The master effect is the exception: its knobs aren't part of a sound in the OP-1, so CC changes there aren't saved.

Don't flood it

About 200 CCs a second is fine. A burst of hundreds with no gaps makes the OP-1 stop listening to USB MIDI until you unplug the cable and plug it back in. Nothing crashes. If you draw dense automation in a DAW, thin it out.

The OP-1 doesn't send CCs when you turn its knobs. That isn't built yet.

Known Limits

- Chord mode doesn't reach the stock sequencers. Use TRACK for chord sequences.
- The chord shape is forgotten at power off.
- TRACK: no count-in, no groove templates yet, and nothing on screen says when the tape will or won't start the loop.
- CC 16-23 don't reach KEYS or ITER.
- The OP-1 doesn't send CCs from its knobs.
- The Shift latch has no on-screen indicator.
- LINGER is heavy. One instance on a synth sound with six voices is measured clean; more than that isn't measured.
- Clav clicks on release with the envelope's release above zero.

Troubleshooting

What you see	What to do
<code>apply.py</code> says the firmware file doesn't match	It has to be the official <code>op1_246.op1</code> , untouched. Download it again from teenage engineering. A repacked or already-modded file won't work.
The update doesn't start after you eject	Press COM on the OP-1. That's what starts it.
"Invalid synth patch" at boot after going back to stock	A sound still uses something from the mod. Flash the mod again, switch the sounds (list on "Going Back to Stock"), then go back.
KEYS sounds wrong or dull	Load a preset from the KEYS folder. Picking KEYS from the engine list keeps the old sound's envelope and LFO.
TRACK won't start with the tape	Arm REC or put a note in the track first.
Chords play single notes	Set the play mode to POLY.
The OP-1 stopped responding to MIDI	Too many CCs at once. Unplug USB and plug it back in.
A knob does its Shift job when you don't want it	The latch is on. Press the knob once.
Anything else	Tell me on Discord: which OP-1 you have and what you were doing when it happened.

Credits

- **stfj**, for the original OP-1 note quantization patch that scales grew out of.
- **xndcn**, for the OP-1 emulator that every build here was tested on before it went near hardware.
- **teenage engineering**, for the OP-1, and for ITER and FILTER.

The mod is free. If it's worth something to you, there's a tip jar at buymeacoffee.com/justinjoe. Updates go to the email list at justinjoe.com/op1-mod.

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