

Technical Reference

POWERHOUSE™
Digital Command Control

SW9-SR

Drop-In Decoder

Dimensions:
1.95 x .830 x .120 inches
50 x 21 x 3.0 mm

Version 3.2

\$29.95

This decoder is designed for easy installation in
Lifelike Proto 2000 SW9/SW1200 Locomotives

This is an EPF (extended packet format) decoder supporting:

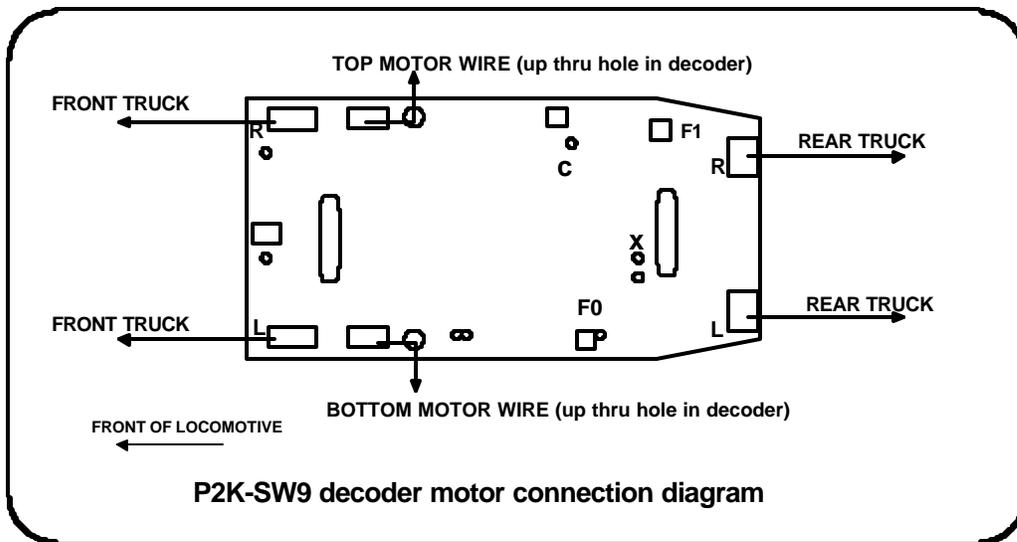
- , Silent Running™ High frequency motor drive eliminates motor hum or buzz
- , Programmable Start, Mid and Maximum speed works for all speed modes
- , Motor rating 1.3 Amp continuous, 2 Amp peak (stall)
- , **Three** function outputs each with an independent effects generator
- , Select from 14 different lighting effects (Mars, strobes, beacons, etc)
- , Function outputs can be mapped to different functions (highly compatible with Soundtraxx™ DSX decoders)
- , Two or Four digit addressing
- , Uploadable speed table interpolated to 128 speed steps
- , 28 and 128 Speed mode operation (always works internally at 256 steps)
- , Decoder assisted consisting
- , All forms of operations mode programming (programming on the mainline)
- , All forms of service mode programming (programming track)

Every attempt has been made to ensure this decoder complies with all applicable NMRA Standards and Recommended Practices. NMRA Conformance test results on this decoder are available on our website at www.ncedcc.com

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General Installation Procedure (see the lighting installation options on following pages before actually installing the decoder):

- , Remove the shell from your locomotive
- , Cut the wires soldered to the existing locomotive circuit board. Cut as close as possible to the circuit board.
- , Unclip the circuit board from the plastic motor mount bosses and discard.
- , Install the decoder component side up with the narrow end toward the rear of the locomotive. If you want to use a white LED for the headlight see the section on connecting the lights to see where to solder it *before* mounting the decoder.
- , Refer to the motor connection diagram below. Trim the locomotive wires to length as they are soldered to the decoder. Strip about 1/8" of the insulation off the end of each wire and tin the end. (To "tin" a wire melt a little solder on the end to keep the individual strands wire together). There is already a small amount of solder applied to each solder pad on the decoder. Just place the tinned wire on its solder pad and touch your soldering iron to the tinned wire and pad to solder the wire in place. Leave about 1/4" slack in the motor leads and wires from the front truck. Leave about 1/2-3/4" slack in the rear truck wires. Watch for shorts!
- , Ensure the decoder is properly seated on the motor bosses



Now is a good time to test the locomotive before installing the lights and replacing the body shell. Double check your wiring and make sure that there are no pinched or broken wires. We see many decoders returned due to wires getting pinched between the body shell and frame causing shorts.

Always test your decoder installation on a current limited programming track before trying it on full track power. If you have a Digitrax, Lenz Set-02 or MRC system that does not provide current limited programming use a 100 Ohm resistor in series with one of the track leads and listen for the "click" that verifies correct operation as you program the decoder. Test run the locomotive on your main line or test track to verify that it runs correctly. After initial testing is complete it's time to wire in the lights.

Wiring the Lights:

Due to the high in-rush current of incandescent grain-of-wheat type bulbs (about 10 times the normal operating current) function outputs are rated at 40mA each. We recommend Miniaturics part number 18-014-10 (2.4mm diameter 14 volt/30mA) or number 18-712-10 (1.7mm diameter 12 volt/30mA) bulbs for good results.

The P2K-SW9 decoder ships from the factory with **three** usable function outputs, Headlight, Rearlight and an optional rotary (flashing) beacon activated as F1.

Remove the front light and its associated brass tabs from inside the body shell.

There are three options available for wiring the Headlight:

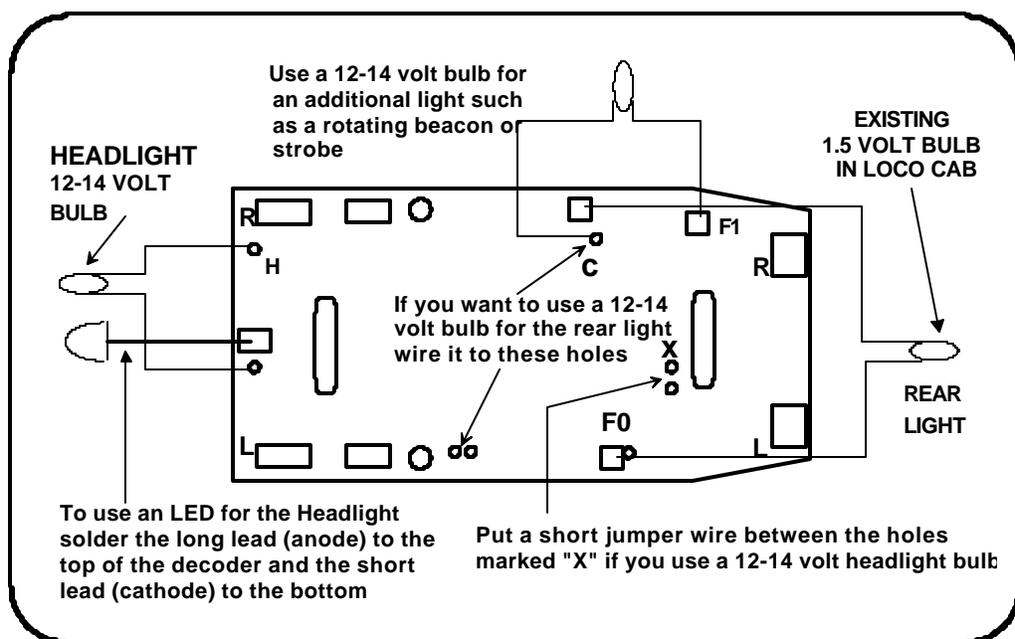
- **12 or 14 volt bulb:** Wire a 12 - 14 volt bulb to the holes indicated in the drawing below. Solder short jumper wire between the holes marked with an "X" to connect the function output to the Headlight bulb (or just solder the wire marked "H" to the lower "X" hole).
- **White LED:** Solder white LED (part number CMD204UWC-ND from Digikey Electronics 1-800-DIGIKEY) to the solder pads at the front of the decoder. The long lead (anode) of the LED solders to the top pad of the decoder. Be sure to insulate the lower lead with shrink tubing or line the groove in the locomotive weight with a strip of black tape to keep the LED from shorting to the frame. There is already a 1K resistor installed on the decoder for the LED.
- **Use the existing 1.5 volt bulb:** This installation requires a 270 Ohm 1 Watt resistor required installed in one of leads of the existing bulb. This resistor is physically large and may generate enough heat to melt the shell of the locomotive.

There are two options for wiring the Rear Light:

- **Use the existing 1.5 volt bulb:** Remove the brass tabs from the inside of loco shell and from the rear light wires. Tin the end of the wires and solder them to the pads marked F0 and * on the decoder. A 100 Ohm resistor is already mounted on the bottom of the decoder to limit the voltage at the bulb. This bulb is powered with "half wave" power and the resistor is sized to properly dissipate the heat when the decoder is operated at normal (12-16 volt) track voltage.
- **12 or 14 volt bulb:** Wire a 12 - 14 volt bulb to the holes indicated in the drawing below for a 12-14 volt rear light

Optional extra function:

If your prototype has a rotary beacon or other light you can add an additional 12 volt bulb connected to the holes marked "C" and "F1". This output is controlled by F1.



Fine tuning locomotive operation

The factory settings of the P2k-sr normally provide good performance for most locomotives in HO-Scale. You may want to improve or fine tune performance by adjust the starting characteristics or top speed .

There are five CVs that define:

- The voltage at which the motor starts
- How much 'kick' the motor gets to start it turning
- The maximum speed
- The response characteristics or 'speed curve'.
- The frequency of the drive pulses to the motor

Start Voltage - CV2 (Vstart):

Before programming the start voltage we recommend programming CV65 (Kick Start) to zero. Kick start is used to overcome the 'stiction' of the motor by giving it a voltage 'kick' when starting from a stop. We don't want it getting in the way of setting Vstart.

We prefer using Operations Mode Programming (Program on the Main) to set CV2 so the locomotive is **just able** to maintain movement at speed step 1. You can also use the programming track... it just takes a bit longer to find the right setting for CV2.

Kick Start - CV65

After the start voltage is set . Program CV65 to provide a smooth and reliable start when you advance the throttle from stop. The high frequency drive pulses of the D408SR act more like smooth DC voltage than the low frequency pulses of a standard decoder making it harder for the decoder to overcome that starting 'stiction' of the motor. This is why the Kick start CV is needed.

If the value is too low the motor will not start moving reliably, too high and the locomotive will lurch or leap as it starts.

Vmax - CV5:

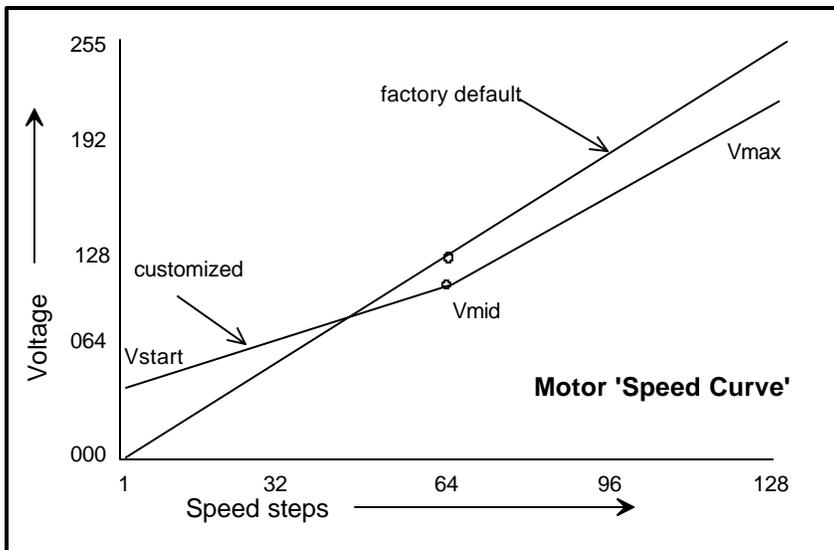
If your locomotive runs too fast you can use CV5 to lower its maximum speed. Setting CV5 to 255 uses the maximum possible voltage to run the motor when full speed is requested. Set CV5 to a smaller value to reduce the top speed. A value of 128 will yield approximately ½ full voltage to the motor at top speed. 192 will provide about ¾ full voltage. All speeds from the middle speed step to the maximum will be proportionally reduced (see diagram). If CV5 is set to 0 the decoder will use 255 for maximum speed. Always make sure CV5 is greater than CV6 to avoid erratic operation.

Vmid - CV6:

CV6 determines how the motor responds through its middle speed ranges to advancement of the throttle.

If you set CV6 lower than half the maximum speed you'll have smaller increases in motor speed through the lower speed ranges. Then, as you hit the upper speed ranges there will be larger increases between speed steps. In the diagram below you can see this best illustrated by the factory default line. If you set Vstart larger than 0 you'll most likely want to raise Vmid so a reasonable slope is maintained in the 'speed curve'. If CV6 is set to 0 the decoder will use 127 as the value.

Motor Drive Frequency - CV9: When CV9 is set to 0 the Silent Running™ motor drive frequency of 15,625 Hz is used. If a value of 1-255 is programmed into CV9 the motor drive frequency will be calculated by the formula: $\text{Frequency} = 1/(\text{CV9} * .000128)$.



Description of EFX configuration CVs

CV120 - Lighting effect configuration for output 1 (headlight).

CV121 - Lighting effect configuration for output 2 (rearlight).

CV122 - Lighting effect configuration for output 3 (marked F1 on decoder).

Each output wire can select from 15 different lighting effects by using its associated EFX configuration CV. Pick the value for the CV from the table below, add 1 or 2 if you want the effect to be directional (footnotes 2 and 3), then add 128 if you are using a white LED for the effect. Ditch lights should not be made directional, they're not directional in real life.

bit weight	128	64	32	16	8	4	2	1
bit name	LED ¹	---	Effect configuration			REV ²	FWD ³	

Value for CV	Description of lighting effect	Hex (for Digitrax users)
0	Standard on/off function output	0
4	reserved	4
8	Mars light	8
12	Rotary Beacon	0C
16	Gyalight	10
20	Double Strobe	14
24	Strobe A	18
28	Strobe B (alternates with Strobe A)	1C
32	Dim when F0 and F4 on, otherwise bright	20
36	Dim when F0 and F8 on, otherwise bright	24
40	Dim in forward, bright in reverse	28
44	Dim in reverse, bright in forward	2C
48	Type 2 Right Ditch light, effect on if F2 on, output off otherwise	30
52	Type 2 Left Ditch light, effect on if F2 on, output off otherwise	34
56	Type 1 Right Ditch light, effect on if F0 <i>and</i> F2 on, bright if F0 on <i>and</i> F2 off, off if F0 off	38
60	Type 1 Left Ditch light, effect if F2 <i>and</i> F0 on, bright if F0 on <i>and</i> F2 off, off if F0 off	3C

1 - Functions are designed to use 12-16 volt 30-40ma incandescent lamps. If you are using a white LED (with 1K limiting resistor) add 128 to the CV value.

2 - If you want the function to be active only in the reverse direction add 2 to the CV value

3 - If you want the function to be active only in the forward direction add 1 to the CV value

Description of function mapping CVs:

Function mapping can change which output wire(s) are controlled by a function command from your handheld cab. It is possible to have one command control several outputs. In the tables below each row corresponds to a function mapping CV and each column indicates an output number. A '1' under an output number means that output will be controlled by the function corresponding to the row. In the table below the factory value of CV33 is 1 which means F0 will control Output #1.

Example: Say you have output 4 set to be a Mars Light (CV123=8) and you want it to come on when the headlight (F0) is on. In the CV33 row place a '1' in Output 4 column, there is already a '1' in the Output 1 column. Now F0 will control both Output 1 and Output 4. To calculate the value that goes in to CV33 just add up the 'bit weights' for each column that has a '1' in it. In the case of our example the value will be 9. F3 has been set at the factory to control Output 4 so you may want to put 00 in to CV37 to make sure Output 4 (Mars light) doesn't come on by accident if F3 is activated.

There are more examples of function mapping on page 7.

The tables below show the original factory settings for each mapping CV. The NMRA recommended practices do not provide for mapping all functions to all outputs. The tables below are the prescribed function mapping dictated by NMRA RP-9.2.2. Note: In this decoder CV33 and CV34 operate identically. They are not directional...directionality is provided in the EFX configuration CV for each output.

Factory default function mapping values

OUTPUT NUMBER	3	2	1
Bit weight CV33-CV37	4	2	1
CV33 F0 Fwd	0	0	1
CV34 F0 Rev	0	1	0
CV35 F1	1	0	0
CV36 F2	0	0	0
CV37 F3	0	0	0

Function mapping and effects programming examples

Mars Light:

What we want to do:

- Use output 3 (marked F1 on decoder) for a Mars light.
- It is to be on in the forward direction only

How to do it:

- ✓ Output 3 is already activated by F1 (factory default setting of CV35=4).
- ✓ Configure output 3 as a forward only Mars light. Set CV122 to 9. We get the value of 9 by using 8 (Mars Light) plus 1 (output operates only in forward direction)

Rule 17 lighting:

Rule 17 refers to how the locomotive engineer operates the locomotive headlights during the running of the train. The rule varies from road to road but generally requires the dimming of the headlight(s) when in a siding waiting to meet another train, passing through passenger stations or moving within yard limits.

What we want to do:

- Use output 1 for the Headlight
- The headlight is to be on bright in both directions of locomotive travel
- We also want to be able dim the headlight

How to do it:

- ✓ Output 1 is already activated by F0 (factory default setting of CV33 =1).
- ✓ Configure output 1 as a standard output, on in both directions, yet dimmable when F4 is activated. Set CV120 to 32 (20 hex). You can optionally set CV120 to 36 is you want F8 to control the dimming instead of F4.
- ✓ Configure

Switcher:

What we want:

- Headlights that dim in the opposite direction that the locomotive is travelling
- Use output 1 as Headlight and output 2 as Rearlight

How to do it:

- ✓ Outputs 1 and 2 are already activated by F0 due to the factory default settings.
- ✓ Configure output 1 as bright in forward dim in reverse. Set CV120 to 40 (28 hex)
- ✓ Configure output 2 as bright in reverse dim in forward. Set CV121 to 44 (2C hex)

About the function outputs:

The rating of each function output on this decoder is 100mA continuous with a non- incandescent lamp (such as an LED) and 40mA with an incandescent lamp. The total allowable current that can be drawn by all functions is 300mA. We recommend Miniaturics part number 18-014-10 (2.4mm diameter 14 volt/30mA) or number 18-016-10 (2.4mm diameter 16 volt/30mA) bulbs for good results. If you wish to use 50-80mA rated lamps we suggest using a 22 ohm 1 Watt resistor in series with each bulb to greatly extend bulb life, especially if any lighting effects are used.

Recommend dropping resistors if using 1.5 volt bulbs

Bulb Current	Track Voltage								Wattage
	12.5	13	13.5	14	14.5	15	15.5	16	
15ma	680	680	720	750	820	820	910	910	¼ watt
30ma	330	360	360	390	390	430	430	470	½ watt
40ma	240	270	270	300	300	300	330	330	1 watt
50ma	200	200	220	220	240	240	270	270	1 watt
60ma	160	180	180	200	200	200	220	220	1 watt
80ma	120	130	130	150	150	160	160	160	2 watt

Factory default values for decoder Configuration Variables (CVs)

CV	Default value		Description	CV	Default value		Description
	decimal	hex			decimal	hex	
1	3	03	short address	70	12	0C	alt spd table step 4
2	0	00	start voltage	71	16	10	alt spd table step 5
3	0	00	acceleration	72	21	15	alt spd table step 6
4	0	00	deceleration	73	26	1A	alt spd table step 7
5	0	00	Maximum speed	74	30	1E	alt spd table step 8
6	0	00	Mid speed	75	35	23	alt spd table step 9
9	0	00	PWM frequency	76	40	28	alt spd table step 10
17	192	C0	long address high byte	77	47	2F	alt spd table step 11
18	0	00	long address low byte	78	51	33	alt spd table step 12
19	0	00	consist address	79	58	3B	alt spd table step 13
21	255	FF	consist functions F1-F8	80	65	41	alt spd table step 14
22	63	3F	consist function FLF,FLR	81	72	48	alt spd table step 15
23	0	00	acceleration adjust	82	79	1F	alt spd table step 16
24	0	00	deceleration adjust	83	84	54	alt spd table step 17
29	2	02	decoder configuration	84	93	5D	alt spd table step 18
30	0	00	reset/error register	85	100	64	alt spd table step 19
33	1	01	Output(s) controlled by F0	86	112	70	alt spd table step 20
34	2	02	Output(s) controlled by F0	87	121	79	alt spd table step 21
35	4	04	Output(s) controlled by F1	88	135	87	alt spd table step 22
36	8	08	Output(s) controlled by F2	89	147	93	alt spd table step 23
37	16	10	Output(s) controlled by F3	90	161	A1	alt spd table step 24
38	4	04	Output(s) controlled by F4	91	177	B1	alt spd table step 25
39	8	08	Output(s) controlled by F5	92	196	C4	alt spd table step 26
40	16	10	Output(s) controlled by F6	93	219	DB	alt spd table step 27
41	32	20	Output(s) controlled by F7	94	255	FF	alt spd table step 28
42	64	40	Output(s) controlled by F8	118	20	14	Ditch light hold time
65	0	00	Kick start	119	255	FF	EFX page access
67	2	02	alt spd table step 1	120	1	01	Output 1 EFX generator
68	5	05	alt spd table step 2	121	2	02	Output 2 EFX generator
69	7	07	alt spd table step 3	122	0	00	Output 3 EFX generator
				123	0	00	Output 4 EFX generator

Configuration Variables used by SW9-SR Decoders

- CV1** short decoder address; 1-127 valid
- CV2** Start Voltage (useful range 0-100)
- CV3** acceleration rate (each unit = 7mS between speed steps) 255 max.
- CV4** deceleration rate (each unit = 7mS between speed steps) 255 max.
- CV5** Vmax, speed at highest speed step. 0=use factory default of 255
- CV6** Vmid, speed (on a scale of 1-255) at speed step 7,14,or 63. 0=use default of 128
- CV7** Manufactuer ID. NCE = 11 (0B hex)
- CV8** Decoder version number. This decoder is 32 which means version 3.2
- CV9** Motor drive frequency
- 1-255 = PWM drive frequency period in 128uS increments,
- 0 = PWM frequency is 15,625 Hz
- CV17** High byte of long (4 digit) address
- bit 6,7 always= 1
- bits 0-5 are upper 6 bits of address
- CV18** low byte of long (4 digit) address
- CV19** Consist address. (0 or 128 = no consist active)
- bits 0-6 short consist address (1-127 valid)
- bit 7 0= direction is normal, 1= direction is reversed
- CV21** Functions active in consist mode. Bits 0-7 control F1-F8 respectively
- each bit 1=function can be controlled at consist address, 0 = no consist control
- CV22** Functions active in consist mode. Bits 0,1 control FLF and FLR respectively
- each bit 1=function can be controlled at consist address, 0 = no consist control
- CV23** acceleration rate adjust (in 7mS increments) this value is added to CV3
- CV24** deceleration rate adjust (in 7mS increments) this value is added to CV4
- CV29** - bit 0 1= direction of operation is reversed, 0= direction is normal
- bit 2 1= analog operation mode enabled, 0 = disabled
- bit 4 1= alternate speed table active, 0= use table defined by CV2,5,6
- bit 5 1= use long address in CV17/18, 0= use short address CV1
- bits 1,3,6,7 are ignored by the decoder
- CV33-CV42** function mapping CVs for F0-F8
- CV65** Kick start - number of 1/1000s of a second to 'kick' motor when starting
- CV67-CV94** Uploadable speed table steps 1-28 (128 speed mode calculates intermediate steps)
- CV118** Ditch light hold time (in ¼ second increments) after F2 goes off.
- CV119** Lighting effects page. Must be set to 255 for access to CVs120-127
- CV120-CV123** Effects configuration registers for outputs 1-4

CV NOTES: All CV numbers not listed above are ignored.

14 Speed mode is scheduled to be dropped as a requirement by the NMRA. This decoder does not support headlight control in 14 speed mode. It *will* operate the motor and F1-F8 correctly with all systems however the headlight may not operate correctly with older systems.

PROGRAMMING TRACK INFORMATION: This decoder complies with NMRA RP-9.2.3 for all forms of paged, direct (bit and byte) and register mode programming.

Ops mode programming (Programming on the Mainline): Decoders do not respond to the long form ops mode programming instructions at their consist address (per RP-9.2.1). This is to avoid setting CV29 while in a consist then later wondering why the decoder now only responds to it's long address rather than the short or vice-versa.

Tip for using consists and long (4 digit) addresses: leave CV1 set to 3, or some other conveniently remembered address and only use the extended address (CV17, CV18) set to your desired value. This avoids mixing up normal 'short' addresses with consist addresses.

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