

Flickering Lights, Lost Neutral, and Utility-Side Faults

YES Electric • NEC 2026 with NEC 2023 numbers in parentheses

Draft 1 (October 2026). This chapter is under review. Code numbers are NEC 2026. Your local inspector may use an earlier edition, so ask your journeyman which one applies. Boxes marked "Picture coming" will get drawings and photos in a later version.

Phase 2, Troubleshooting and Service Calls.

Before this module: R2.1 (the service call routine) and R2.2 (meters and testers). You need to be able to read voltage at a receptacle and use a clamp meter.

Code edition. Code references are NEC 2026. Where a section moved, the NEC 2023 number is in parentheses. The local inspector (the AHJ) may enforce an earlier edition, so ask your journeyman which one applies.

Learning Objectives

When you finish this module you will be able to:

1. Work flickering lights in the order that saves callbacks: one fixture, one circuit, half the house, the whole house, then the utility.
2. Recognize a lost or loose neutral from the voltage pattern (one leg high, one leg low, swinging with load) and treat it as an emergency.
3. Recognize a lost or loose hot leg (half the house dead or weak, 240 V loads not working right).
4. Tell a problem on the customer's side from one on the utility's side, and know how to report it to Alabama Power and what to say.
5. Find a bad connection at the panel, the meter, or a splice, and know which ones you can fix and which you escalate.

Background: How Power Comes Into a House

Split-phase service

Almost every house we work on has a 120/240 V single-phase service. The utility's transformer, on a pole or in a green box on the ground, sends three wires to the house:

Wire	Also called	Voltage
Hot leg 1	L1, Line 1, "A"	120 V to neutral
Hot leg 2	L2, Line 2, "B"	120 V to neutral
Neutral	Grounded conductor, service neutral	0 V to ground

L1 to L2 is 240 V. In the panel, the breaker slots alternate between L1 and L2 going down each side (Arc Guide, Part 2, "Panels"). A single-pole breaker connects to one leg and feeds 120 V circuits. A two-pole breaker connects to both legs and feeds 240 V loads like a dryer, a range, a water heater, or the AC.

What the neutral does

When the loads on L1 and L2 are equal, their currents cancel and the neutral carries nothing. When they are unequal, the neutral carries the difference back to the transformer. Kuhlman's example: if L1 carries 20 A and L2 carries 30 A, the neutral carries 10 A (Kuhlman, Residential Electrical Troubleshooting, p. 45).

The neutral also holds each leg at 120 V. Each 120 V load sits between one hot and the neutral. If the neutral is solid, every 120 V load gets about 120 V no matter what else is running.

What happens when the neutral is lost

If the service neutral breaks or gets loose, the 120 V loads on L1 and the 120 V loads on L2 end up in series across 240 V. The voltage splits by how much load is on each side. The side with less load gets more of the voltage. The side with more load gets less.

Worked numbers (you will see this in the exercise):

1. L1 has 1,200 W of 120 V loads running. At 120 V that is like a $12\ \Omega$ resistor ($120 \times 120 \div 1,200 = 12$).
2. L2 has 400 W running. That is like a $36\ \Omega$ resistor ($120 \times 120 \div 400 = 36$).
3. With no neutral, the two are in series across 240 V. Total resistance is $48\ \Omega$. Current is $240 \div 48 = 5\text{ A}$.
4. Voltage on L1's loads: $5\text{ A} \times 12\ \Omega = 60\text{ V}$. Voltage on L2's loads: $5\text{ A} \times 36\ \Omega = 180\text{ V}$.
5. The L1 side goes dim. The L2 side goes bright, and anything on L2 that cannot handle 180 V gets damaged.

The two readings always add up to about 240 V. When a load turns on or off, both readings swing. That is the pattern you look for. The Arc Guide gives the same 60 V and 180 V range as an example (Part 10, "Lost / Floating Neutral").

Real loads change resistance with voltage, so real numbers will not match this exactly. The pattern holds: one leg up, one leg down, adding to about 240 V, changing as things switch on and off.

Picture coming: Lost-neutral diagram. A transformer at the left with L1, N, and L2. The neutral has a red break mark labeled "neutral open." In the house panel, L1 feeds a refrigerator, a microwave, and several lamps labeled "1,200 W – reads 60 V – dim, motors stall." L2 feeds a TV, a phone charger, and a smoke alarm labeled "400 W – reads 180 V – bright, electronics burn." Two meters show "L1-N 60 V" and "L2-N 180 V," with " $60 + 180 = 240$ " written between them. A dashed arrow from the panel neutral bar to a water pipe labeled "some neutral current may flow here if the water pipe is metal."

Why a lost neutral is dangerous

- **Equipment damage.** The high side can burn out TVs, computers, chargers, smoke alarms, and cheap power strips. Kuhlman has seen electronics and cheap plug strips melt, TVs ruined, and smoke detectors fail when a house lost its neutral (pp. 91–92). One of his photos shows smoke detectors that caught fire after a house lost its neutral (p. 114).
- **Motor damage.** The low side can stall refrigerator and furnace motors, which overheat.
- **Shock.** The service neutral is also bonded to the grounding system. With the neutral broken, neutral current looks for another way back to the transformer. If the house has a metal water pipe bonded to the electrical system, current can flow out on the water pipe. Kuhlman explains that in neighborhoods with metal water piping, the current can flow out through the pipes to the neighbors' houses and back on their neutrals (p. 87). If someone removes the bond wire to replace the water meter, they can be badly hurt or killed (p. 87). The Arc Guide describes a building owner shocked by a metal workbench because the main panel's incoming neutral had slipped out of its terminal (Part 10).
- **Fire.** A loose neutral connection that is not fully open heats up as current flows through it. That can melt the lug and the insulation.

NEC 250.24 explains why the neutral matters this much. At the service, the grounded service conductor (the neutral) is connected to the grounding electrode conductor and bonded to the service equipment (250.24(A)). The service neutral is the path that lets fault current get back to the utility and trip a breaker. When it is broken, both the normal return path and the fault path are compromised.

What happens when a hot leg is lost or loose

If one hot leg is lost, everything on that leg goes dead. That is about half the 120 V circuits in the house. The 240 V loads lose half their supply and do not work right. A loose hot leg (not fully open) drops voltage on that leg when load turns on.

A lost hot leg has a strange side effect. Kuhlman describes a customer who said "these lights only work when the dryer is on, and the dryer takes a long time to dry" (p. 93). With L2 open, turning on the dryer connects L1 through the dryer's heating element to the L2 bus. Every 120 V circuit on L2 gets weak power through the dryer, and the dryer runs at about half voltage (pp. 93–94). His photo of a utility triplex with a burned splice inside the tape shows the cause on one of these calls (p. 106).

Where the utility stops and we start

The service point is the point of connection between the utility's facilities and the premises wiring (NEC Article 100, "Service Point"). The utility works on its side. We work on ours.

Part	Overhead service	Underground service	Who works on it
Transformer	On the pole	Pad-mount box in the yard	Utility
Wires from the transformer to the house	Service drop (overhead triplex)	Service lateral (buried)	Utility in most cases. Ask your journeyman.
Connections at the house end of the utility wires	Splices at the weatherhead, often taped	Riser connections, tap box	Utility
Weatherhead, mast or SE cable, meter base	Customer	Customer, except where the utility owns the riser	Customer's electrician, with the utility cutting power first
Meter	Utility	Utility	Utility only. Never pull a meter.
Main breaker, panel, branch circuits	Customer	Customer	Us

Alabama Power's outage page tells customers that the meter box belongs to the customer, not to Alabama Power, and that if it is damaged by weather or an accident, a licensed electrician must make repairs before power can be restored (Alabama Power, "Outage Information"). For underground conversions, Alabama Power's plate AUP-06.002 notes describe the underground house riser as Alabama Power owned and maintained, while the SE cable stays customer owned and maintained. Ask your journeyman how ownership splits on the job in front of you, because it varies by service type and age.

Picture coming: Service point drawing. A house wall with an overhead drop coming from a pole. Labels from left to right: "Transformer – UTILITY," "Service drop – UTILITY," "Splices at drip loop – UTILITY," a heavy dashed line labeled "SERVICE POINT," then "Weatherhead and mast – CUSTOMER," "Meter base – CUSTOMER (meter itself is UTILITY)," "Main breaker and panel – CUSTOMER." A second smaller drawing below shows an underground service with a pad-mount transformer, buried lateral, and riser, labeled the same way, with a note "Underground ownership varies. Ask."

Part A: Questions to Ask

Ask the R2.1 intake questions first. Then ask these. Each answer moves you up or down the diagnostic order in Part B.

#	Ask	What the answer tells you
1	"Are your neighbors' lights flickering too? Is the power out on the street?"	Yes = utility problem. Arc Guide question 1 (Part 10, "Flickering Lights").
2	"Is it one light, one room, half the house, or the whole house?"	Sets the starting point in Part B.
3	"Do some lights get brighter while others get dimmer?"	Bright and dim at the same time is the lost-neutral sign (Arc Guide, Part 10).
4	"Does it happen when something big starts, like the AC, the dryer, the well pump, or the microwave?"	A brief dip at motor start can be normal. A long dip or bright-and-dim points to a connection problem (Arc Guide, Symptom 5, Step 5).
5	"Has anything burned out, smoked, or died recently? TVs, chargers, power strips, smoke alarms, light bulbs?"	Overvoltage damage. Kuhlman thinks of a voltage problem whenever he hears about smoke alarms going off and bulbs burning out (p. 101).
6	"Do the dryer, the oven, the water heater, or the AC work right? Do some lights only work when the dryer is on?"	240 V loads acting up = a lost or weak hot leg (Kuhlman, p. 93).
7	"Was there a storm, a tree limb, or digging in the yard lately?"	Damage to the drop or the buried lateral. Kuhlman's photo of a service ripped off a house by a tree branch and taped up (p. 111) is the kind of thing to ask about.
8	"Has Alabama Power been out already? What did they say?"	Kuhlman found the utility sometimes says the problem is not theirs when it is (pp. 87, 102-103). Write down what they said and when.
9	"Does anyone in the house use oxygen or other medical equipment that needs power?"	If you may need to shut off the main, you need to know this first.

Part B: The Diagnostic Order

The Arc Guide gives an order of questions for flickering lights, from widest to narrowest: neighbors, whole building, half the circuits, a specific appliance, one circuit, one fixture (Part 10, "Flickering Lights — The Diagnostic Order That Saves Callbacks"). Kuhlman's order is the same idea. If it is in one area, look for a local problem. If it is throughout the house on many circuits, look at the service or panel, neutral first, then the hot legs (p. 86).

Work it as a funnel. Use the answers from Part A and quick tests to decide which level you are on, then go to that procedure.

Level	How you know you are here	Procedure
Utility	Neighbors affected, or the readings at the panel show a problem and the panel, meter base, and drop look fine	Part G
Whole house	Lights on many circuits on both legs act up; bright and dim at the same time	Part E (lost neutral)
Half the house	Dead or weak circuits are all on one leg; 240 V loads act up	Part F (lost hot leg)
One circuit	Everything on one breaker flickers	Part D
One fixture	Only one light	Part C

Picture coming: Flicker diagnostic funnel, wide at the top and narrow at the bottom. Top band "UTILITY - neighbors too? call Alabama Power." Next "WHOLE HOUSE - bright and dim at once - lost neutral - EMERGENCY." Next "HALF THE HOUSE - one leg dead or weak, 240 V loads wrong." Next "ONE CIRCUIT - loose connection, backstab." Bottom "ONE FIXTURE - lamp, socket, dimmer, driver." An arrow on the side reads "Start with the question. Confirm with the meter."

Test B1. Read the house voltage at two receptacles

This is the fastest way to decide the level. You can do it in 2 minutes without opening the panel.

1. Prove your meter on a known live receptacle (R2.1, live-dead-live).
2. Set the meter to AC volts (V~).
3. At a receptacle on a circuit that is acting up, put the probes in the short slot (hot) and the tall slot (neutral). Write the reading.
4. Find a receptacle on the other leg. One way: at the panel, look at which breaker feeds the first receptacle. A breaker one space up or down on the same side is on the other leg (the slots alternate). Find a receptacle on that breaker by switching it off briefly with the customer's OK, or use your circuit tracer. Another way: if the kitchen has two countertop circuits, they are often on opposite legs.
5. Read hot to neutral at the second receptacle. Write it.
6. Turn on a big 120 V load on one of those circuits, such as a 1,500 W heater or a toaster. Read both again while it runs.

Readings	What it means	Go to
Both between 114 and 126 V, change less than about 3 V when the load turns on	Normal (Arc Guide, Part 3, voltage targets). The problem is below the service.	Part C or D
One reads high (above about 126 V) and one reads low, and they add to about 240 V	Lost or loose service neutral	Part E now
Both swing in opposite directions when the load turns on	Loose service neutral	Part E now
One leg drops a lot when its load turns on (for example 120 V to 105 V) and the other stays steady	Loose hot leg connection	Part F
One leg reads 0 V	Lost hot leg	Part F
Both legs low, both drop together under load	High-resistance connection on both hots, an overloaded or undersized service, or a utility supply problem (Arc Guide, Symptom 5, Step 6)	Part F and Part G

Kuhlman found 119 V on one leg and 114 V on the other at a three-family house and called a 5 V difference a red flag. He considers 1 to 3 V of difference fairly normal (p. 102).

Safety: stop on the lost-neutral pattern. If one leg reads high and the other low, or either reads above about 130 V, go straight to Part E, Step E1. Do not keep testing the house first.

Part C: One Fixture Flickers

Symptom. One light flickers, buzzes, or goes on and off. Others on the same circuit are fine.

Questions. Is it on a dimmer? What kind of bulb? Is it a recessed can? Does it flicker all the time, or go out and come back on after a few minutes?

Tests, in order.

1. **Bulb.** Turn the light off and let the bulb cool. Re-seat the bulb. Try a known good bulb of a different brand (Arc Guide, Symptom 5, Step 2). Cheap LED bulbs can flicker at the low end of their voltage range.
2. **Dimmer.** If it is on a dimmer, check that the bulb is marked dimmable and that the dimmer is rated for LED loads. A dimmer and LED mismatch is a common cause of flicker, and replacing the dimmer with one the lamp maker approves usually fixes it (Kuhlman, p. 23; Arc Guide, Symptom 8). R2.6 covers dimmers.
3. **Socket.** With the power off and proven dead, look at the center tab in the screw socket. Kuhlman explains that years of bulb changes push the center tab down. The bulb loses

good contact, carbon builds up, and the light flickers or dies. He pulls the tab back out and cleans off the carbon (pp. 48–49).

4. **Recessed can that goes off and on every few minutes.** That is the thermal protector opening from too much heat. Check the can's label for IC or non-IC and the maximum lamp wattage. Look for insulation packed against a non-IC can (Kuhlman, p. 48; Arc Guide, Symptom 5, Step 3).
5. **Fixture splice.** With the power off and proven dead, drop the fixture and check the splices in the box. A loose wire connector on the fixture leads causes flicker at that one fixture.

The fix. New bulb, correct dimmer, socket tab adjusted or socket replaced, the right lamp for the can, or a remade splice. R2.6 has the full lighting procedures.

Part D: One Circuit Flickers

Symptom. Every light and receptacle on one breaker flickers or dims, especially when something on that circuit runs. Other circuits are fine.

Questions. What else is on this circuit? Does it get worse when a heater, vacuum, or microwave runs on it? Has a receptacle or switch on this circuit felt warm?

Tests, in order.

1. **Voltage under load at the far end.** At a receptacle near the end of the circuit, read hot to neutral with nothing running on the circuit. Then plug in a 1,500 W heater on the same circuit and read again.

Drop from no load to 1,500 W load	Meaning
Less than about 3.6 V (3 percent of 120 V)	Normal for a branch circuit. The flicker is somewhere else (back to Part B).
3.6 to 6 V	Long or undersized run, or the start of a bad connection. Keep testing.
More than 6 V, or the reading jumps around	A loose connection on this circuit.

The 3 percent figure comes from the informational note to NEC 210.19, which says branch circuits sized to keep voltage drop to 3 percent at the farthest outlet, with 5 percent total for feeder and branch circuit together, give reasonable efficiency. It is advice, not a rule you are cited for. R2.2 teaches this test in full.

1. **Neutral and hot separately.** Read hot to ground and neutral to ground at the same receptacle under load. If hot to ground stays near 120 V but neutral to ground climbs above a few volts, the loose connection is on the neutral. The Arc Guide gives 0 to 2 V neutral-to-

ground at rest and up to 5 V under load as normal, and more than 5 V under load as a high-resistance neutral connection (Part 3).

2. **First box on the circuit.** Turn off the breaker, prove dead, and open the first box on the circuit, the one nearest the panel. The Arc Guide calls a loose neutral the most common cause of circuit-wide flicker and says to start at the first box (Symptom 5, Step 4).
3. **Work outward.** Open each box toward the end of the circuit. Look for backstabbed wires, loose screws, loose wire connectors, and discolored insulation. The Arc Guide ranks a backstabbed device with a loose connection as the most common root cause of flickering by far (Part 10, "Flickering Lights"). NEC 2026 406.10(3) now allows push-in terminals only on circuits of 15 A or less and only with 14 AWG solid copper. Older code editions left that limit to the device's UL listing.
4. **The breaker terminal.** With the breaker off and proven dead, check the wire at the breaker terminal and the circuit neutral at the bar (or on the breaker, for AFCI and GFCI). Look for discoloration and torque them to the label (110.14(D)).

The fix. Remake the bad connection. Move backstabbed wires to the screw terminals and torque them. Replace burned devices and cut back damaged conductor. Check every box you opened. Re-run the load test and confirm the drop is under 3.6 V.

Motor-start flicker. If the lights on one circuit dip for under a second when a motor on that circuit starts (a vacuum, a garage door opener), that is normal physics. The Arc Guide counts a brief motor-start dip as normal and a sustained one as not normal (Part 10, question 4). Measure it. If the voltage drops more than about 10 V or stays down, treat it as a connection problem and keep testing.

Part E: Lost or Loose Service Neutral

Symptom. Lights on many circuits get brighter and dimmer, often at the same time in different rooms. Electronics, power strips, smoke alarms, or bulbs burn out. Readings show one leg high and one leg low. Sometimes AFCI breakers trip, and some AFCI breakers record an overvoltage trip. Eaton's Type CH dual-purpose AF/GF breaker, for example, trips and records code 4 at 160 V rms or more, and Eaton's listed resolution is to investigate the utility power for phase imbalance or loss of neutral (Eaton TD003006EN, Table 3).

The Arc Guide describes the signature as lights across the house that are brighter or dimmer than normal, appliances on different circuits failing at once, and one leg significantly high and the other low, adding up to about 240 V (Part 10).

Step E1. Protect the people and the house first

This is an emergency. Do these before more diagnosis.

1. Tell the customer, in plain words: "Your house has a problem with the main return wire that comes in with your power. It's making some outlets run high and some run low. Please unplug TVs, computers, and anything expensive right now."
2. Ask Part A question 9 (medical equipment) if you have not.
3. Call your journeyman from the house. Give them the two readings.
4. The Arc Guide says to shut off the main breaker if you suspect a lost neutral and not to diagnose it live (Part 10). Your journeyman decides when the main goes off. It usually should, because it stops the overvoltage damage and the stray current through the house. Before it goes off, the journeyman may want one set of readings at the panel and on the water pipe bond (Steps E2 and E3) to give the utility. Those readings are taken by the journeyman or under the journeyman's direct supervision.
5. If the main goes off, tell the customer that the house will have no power until the neutral is fixed and who is fixing it.

Where the main is. Newer houses may have the service disconnect outdoors. In NEC 2026, service disconnects for one- and two-family dwellings go in a readily accessible outdoor location, on the house or within sight of it, unless an outdoor emergency disconnect is installed under 225.41 (230.70(A)(1)). When the service equipment on one of these houses is replaced, those rules apply (230.70(E)). 225.41 (2023: 230.85) requires an outdoor emergency disconnect for one- and two-family dwellings unless the service disconnect is already outdoors and readily accessible. Older houses usually have the main breaker at the top of the indoor panel. Some older panels have up to six disconnects instead of one main (230.71 permits existing equipment with up to six). On those, every disconnect has to go off.

Safety: the service conductors stay live. Turning off the main breaker does not de-energize the wires from the meter to the main breaker's line side, the main lugs, or the meter base. They stay live until the utility disconnects them (Arc Guide, Job 4). Keep hands and tools away from the top of the panel and the line-side lugs.

Safety: the neutral can carry current with the main off. With a metal water pipe bonded to the system, neutral current from neighboring houses can flow into the house's grounding system through the water pipes and onto the service neutral (Kuhlman, p. 87). Never loosen, lift, or cut a service neutral or the water pipe bond without the utility disconnecting the service, and without clamping it first to confirm 0 A.

Step E2. Measure the currents (journeyman-supervised)

Kuhlman's neutral test uses a clamp meter on four conductors at the service and compares them (pp. 45, 86). It is done with the house energized, so it is done by the journeyman or with the journeyman standing beside you.

1. Set the clamp meter to AC amps.

2. Make the load lopsided on purpose. Kuhlman runs a shop vacuum and a toaster on the leg that already has more load, so the two legs differ by at least 10 A. Readings with less than about 1 A of difference between legs are too small to prove anything (p. 45).
3. Clamp L1 at the panel (the service conductor or the main breaker load side, wherever the journeyman says is safe). Write it down.
4. Clamp L2. Write it down.
5. Clamp the service neutral. Write it down.
6. Clamp the grounding electrode conductor to the metal water pipe, if there is one. Write it down.

What you read	Meaning
Neutral = L1 minus L2 (for example 20 A and 10 A, neutral 10 A); water pipe bond 0 to 0.1 A	Neutral is good (Kuhlman, p. 45).
Neutral less than L1 minus L2, and the water pipe bond carries the rest (for example L1 20 A, L2 5 A, neutral 5 A, water pipe 10 A)	Bad neutral connection somewhere. The current that should be on the neutral is going out the water pipe (Kuhlman, p. 45).
Water pipe bond carries more than 0.1 A at all	A problem. Kuhlman treats any current on that conductor as a sign of trouble (pp. 45, 87).

The Arc Guide's amperage targets give the same flag: grounding electrode conductor 0 to 0.1 A, over 0.1 A means a neutral or ground issue (Part 3).

Kuhlman's photo of a clamp on a water pipe grounding conductor reading 6.4 A came from a house where every LED light was flickering. The cause was a bad neutral connection at the overhead drop (p. 46).

If there is no metal water pipe. Houses with plastic water lines have no water pipe path. Kuhlman points out that ground rods do little to carry the neutral current in that case, and if the neutral opens fully, outlets around the house can see 240 V (pp. 45, 87). That makes the voltage pattern worse and the emergency more urgent.

Step E3. Look for the bad connection, in order

Kuhlman's order is the panel, then the meter enclosure, then the overhead connections, and then the utility (pp. 86–87). A visual inspection is usually enough, because a loose neutral often shows melting or burn marks (p. 86).

Order	Where	What to look for	Who works on it
1	Panel: the service neutral lug and the neutral bar	Discoloration, melted insulation, a lug that is loose, corrosion, water stains	Journeyman, with the utility disconnect if the service neutral lug must be tightened
2	Meter base	Burn marks at the neutral lug, melted plastic, water, rust (visible from outside without opening it)	Journeyman with the utility; the meter is never pulled by us
3	Weatherhead and drip loop (overhead)	Cracked conductors at the weatherhead (Kuhlman's photo, p. 105), burned or swollen tape on the splices, a sagging or damaged drop	Utility for the splices and drop
4	Underground tap box, pedestal, or riser	Tape bubbling or melting on splices is a sign of a bad connection (Kuhlman, p. 102)	Utility in most cases
5	The utility's side: transformer, buried lines between their boxes	You cannot see it	Utility

Safety: never open the meter base or touch the drop. Meter base lugs, weatherhead splices, and the drop are energized from the utility and have no breaker protecting them. Kuhlman's photo of cracked service conductors at a weatherhead notes that a short there has no breaker to stop it (p. 105).

Step E4. The fix

- **Loose neutral in the panel (customer side).** The journeyman arranges for the utility to disconnect the service if the neutral lug is on the line side or the service neutral, then retorques to the value on the panel label (110.14(D)), or replaces a damaged lug, neutral bar, or panel. A burned neutral bar usually means a panel replacement (R1.5).
- **Bad neutral in the meter base or SE cable (customer side).** Customer-owned. Write it up as a repair for the office. The utility disconnects and reconnects. Alabama Power says a damaged meter box must be repaired by an electrician before they restore power (Alabama Power, "Outage Information").
- **Bad neutral on the utility side.** Report it (Part G). The utility repairs it.
- **After any neutral repair.** Re-read both legs under a lopsided load and clamp the water pipe bond again. Both legs should be 114 to 126 V and the bond should be at or near 0 A. Check every GFCI and AFCI. Tell the customer to look for damaged electronics, smoke alarms, and power strips, and recommend replacing any smoke alarm that saw the overvoltage (R2.8).

Part F: Lost or Loose Hot Leg (Half the House)

Symptom. About half the house is dead. The dryer, range, water heater, or AC does not work or works weakly. Lights on the dead side may come on only when a 240 V appliance runs (Kuhlman, p. 93). Or the lights on one leg dim a lot when something big on that leg turns on.

Questions. Part A questions 1, 6, 7, and 8. Also: "Did the main breaker trip or did you turn anything off?"

Tests.

1. **Map the dead circuits.** Walk the house with the customer. Note which circuits are dead. At the panel, see whether all the dead circuits sit on alternating slots, which means one leg. The Arc Guide notes that losing one leg makes roughly half the house go dark and makes 240 V appliances work partially or not at all (Symptom 9, Step 1).
2. **Voltage at receptacles.** Read hot to neutral on a dead receptacle (0 V or very low) and a live one (about 120 V). Turn off the dryer, range, water heater, and AC before you read, because a running 240 V load can back-feed weak voltage onto the dead leg and confuse the reading (Kuhlman, pp. 93–94).
3. **Voltage at the panel (journeyman-supervised).** With the dead front off, read L1 to neutral, L2 to neutral, and L1 to L2 on the load side of the main breaker.

Reading at the main breaker load side	Meaning
L1-N 120 V, L2-N 0 V, L1-L2 120 V or less	L2 is lost before the panel bus
Both legs 120 V, but one side of the bus is dead past a point	Problem in the panel: a burned bus, a failed main breaker pole, or a loose bus connection (Arc Guide, Symptom 9, Step 2)
One leg drops sharply when a load on that leg runs	Loose connection on that hot leg. Kuhlman's toaster test: plug a toaster into a receptacle on each leg in turn and watch the voltage. The bad leg can drop to 100 V or less (p. 93).

1. **Line side of the main (journeyman only).** If the load side of the main shows a dead or weak leg, the journeyman reads the line side of the main breaker. Good line side and bad load side means the main breaker has failed. A bad line side means the problem is in the service conductors, the meter base, or the utility. The Arc Guide adds that if you can safely test at the meter base and it shows good voltage while the panel shows a dead leg, the problem is between the meter and the panel (Symptom 9, Step 3). That test is for the journeyman.
2. **Look at the main breaker.** Kuhlman has seen stab-on main breakers fail where they plug onto the bus, because they rely on pressure with no bolts. Look for melted plastic and feel the outside of the breaker for heat (p. 95).

3. **Then the meter base, then the overhead connections, then the utility** (Kuhlman, p. 95), in the same order as Part E, Step E3.

Safety. Half-house dead is panel-level or service-level work. The Arc Guide calls it a high-priority symptom that usually points to the service entrance or panel (Symptom 9). A helper maps the circuits and takes receptacle readings. The journeyman does every reading inside the panel and the meter area.

The fix.

- Utility side: report it (Part G).
- Failed main breaker or burned bus: a panel repair or replacement. Escalate. The Arc Guide notes a main breaker replacement is permit work in most places (Symptom 10, Step 3).
- Loose connection at the main lugs: journeyman, with the utility disconnecting if it is on the line side. Torque to the label (110.14(D)).
- Meter base or SE cable: customer-owned repair, with the utility disconnecting and reconnecting.

Part G: Utility-Side Faults and How to Call Alabama Power

When it is the utility's problem

Report it to Alabama Power when any of these is true:

- Neighbors have the same problem.
- The drop is down, sagging into a tree, or pulled off the house.
- Your readings point to the service and the panel, meter base, and weatherhead show no damage.
- You bypassed or checked the customer-owned part and the problem is still there.

Kuhlman's experience with utilities is that they sometimes say a problem is not on their side when it is, and that you need to be confident in your diagnosis because they will often argue (p. 87). In his "North Andover" flickering call, the utility said its side was fine. The owner paid to replace his own underground lines, and the flicker and the current on the water pipe bond were still there. The utility then found its own neutral between two of its underground boxes hanging by a strand (pp. 102-103). In "Somerville," his readings (114 V and 119 V legs, 6 A on the neutral, 9 A on the water pipe bond) were enough for the utility to find and replace ruined underground wiring (pp. 101-102).

That is why the readings matter. A report that says "the lights flicker" gets less attention than one with numbers.

Where to find the number

The Alabama Power customer service and outage phone number is printed on the customer's bill and on alabamapower.com. Alabama Power also has an online outage report and an outage map at outagemap.alabamapower.com (Alabama Power, "Outage Information"). Who places the call is up to your journeyman. Often it is the customer, because the account is in their name. Have the customer's account number or service address ready.

What to say

Write it down before you call so you say it the same way every time. Use this two-sentence script, filled in with your readings:

"This is [name] with YES Electric at [service address]. We measured [L1 reading] volts and [L2 reading] volts to neutral at the main panel, with [X] amps on the grounding conductor to the water pipe, and we have checked the panel, meter base, and weatherhead on the customer side and found no damage, so we believe there is a neutral [or hot leg] problem on your side and need a crew to check the service connections and transformer."

Then answer their questions with the readings and the time you took them. Ask for a ticket or reference number and write it on the job board.

If the drop is down or arcing, the call is an emergency and the first sentence says so: "There is a service drop down and arcing at [address]." Keep everyone away from it.

Do not put license numbers in any message to the utility or the customer. If they ask who you are, "a licensed electrical contractor" is enough.

What to tell the customer

"The problem is on Alabama Power's side of the service. They own the wires that come to your house and they have to fix it. [We have called them / please call them using the number on your bill]. Here is the reference number. Until they fix it, [the main breaker is off / please keep sensitive electronics unplugged]."

Worked Example Service Calls

Call 1: Smoke alarms going off and bulbs burning out

Based on Kuhlman's "Somerville" call (pp. 101–102).

Complaint. The smoke alarms go off a lot, and light bulbs burn out fast.

Intake. At the house, the tech learns it is a three-family building and that all three units have the same problem. Question 5 points to voltage.

Tests. The meter bank and panels look new and fine. The underground tap box is old. The splice tape looks normal. Leg voltages read 119 V and 114 V. The neutral clamps at 6 A. The water pipe bond clamps at 9 A. A shop vacuum on the low leg adds about 5 A to the water pipe and almost nothing to the neutral, and the low leg drops a few more volts.

Diagnosis. More current on the water pipe bond than on the neutral means a bad service neutral. The customer-side equipment looks fine.

Action. The utility is called with the readings. Four days later the utility replaces ruined underground wiring and the problems stop.

Call 2: Lights that only work when the dryer runs

Based on Kuhlman's description (pp. 93–94) and photo (p. 106).

Complaint. "Some lights only work when the dryer is on, and the dryer takes forever."

Tests. With the dryer off, the receptacles on alternating breakers read 0 V. With the dryer on, they read about 50 to 60 V and lights glow dimly. At the panel, the journeyman reads L1-N 121 V and L2-N 0 V at the main load side, with the dryer off.

Diagnosis. L2 is lost before the panel. The dryer's element is back-feeding the L2 bus from L1.

Action. The journeyman checks the main breaker (no heat, no damage) and looks at the meter base and the weatherhead from the ground. At the drip loop, one hot splice inside the utility's tape is burned, like Kuhlman's photo of a customer who lost a hot conductor (p. 106). It is on the utility side. The customer reports it with the readings. The tech tells the customer to keep the dryer off until the utility repairs it, because running it back-feeds the dead leg at low voltage.

Call 3: Flicker on one bedroom circuit

Complaint. The lights and the TV in one bedroom flicker when the space heater runs.

Test B1. The bedroom receptacle reads 121 V with nothing running. A kitchen receptacle on the other leg reads 120 V. Not a service problem.

Part D tests. At the far bedroom receptacle: 121 V with no load, 109 V with a 1,500 W heater. A 12 V drop. Neutral to ground climbs to 9 V under load. Hot to ground stays near 120 V. The loose connection is on the neutral.

Search. The first box on the circuit is a hallway receptacle. Its neutrals are backstabbed, and one is loose and brown. Breaker off, proven dead, cut back to clean copper, wires moved to the screw terminals and torqued.

Verify. 121 V no load, 118 V with the heater. A 3 V drop. Neutral to ground 2 V under load. Flicker gone. Every box on the circuit was checked and every backstab moved to screws.

Call 4: The utility says it's not them

Based on Kuhlman's "North Andover" flickering call (pp. 102–103).

Complaint. Flickering lights throughout the house. Alabama Power already came out and said their side was fine.

Tests. Panel and meter look fine. The water pipe bond carries a lot of current. That means a neutral problem.

What Kuhlman did. To test whether the customer's underground neutral was the problem, his crew temporarily ran a length of 4 AWG copper above ground from the neutral lug at the meter to the neutral in the utility's tap box, bypassing the buried neutral. The current on the water pipe did not change. The problem was before the tap box, on the utility side. That kind of temporary bypass is journeyman work done with the utility's involvement and is not something you do on your own.

What happened. The owner replaced his underground lines anyway, against the crew's advice. The flicker and the water pipe current were still there. With that proof, the utility looked again and found its own neutral broken between two of its tap boxes.

What you take from it. Write down the readings before and after every step. They are what gets the utility to look again.

Call 5: A lost neutral in progress

Complaint. "The lights went really bright and then the TV made a pop."

Test B1. Living room receptacle 142 V. Kitchen receptacle 98 V. They add to 240 V. When the microwave runs on the kitchen leg, the living room goes to 151 V and the kitchen to 89 V.

Action. Step E1: tell the customer to unplug electronics, ask about medical equipment, call the journeyman with the readings. The journeyman arrives, clamps the neutral and the water pipe bond (water pipe carrying 11 A), sees burn marks on the service neutral lug in the panel, and turns off the main. Alabama Power is called to disconnect so the neutral lug and bar can be repaired. The office prices the repair.

Close-out. After repair: both legs 120 V and 121 V under a lopsided load, water pipe bond 0 A. Customer told to check electronics and replace any smoke alarm that saw the overvoltage.

Common Mistakes

1. **Starting at the fixture when the whole house flickers.** Ask the scope questions and take the two-receptacle reading first.
2. **Reading only one leg.** One receptacle at 128 V looks almost normal. The second receptacle at 112 V shows the pattern.

3. **Testing voltage with no load.** A loose connection often reads normal until current flows. Add a 1,500 W load and read again (Arc Guide, Part 10, "Voltage Drop").
 4. **Diagnosing a lost neutral slowly while the house is being damaged.** Step E1 comes first.
 5. **Touching the service neutral or the water pipe bond without the utility disconnecting and without a clamp reading of 0 A.** It can carry current from the neighbors.
 6. **Pulling the meter or opening the meter base.** That is the utility's and the journeyman's work.
 7. **Trusting "the utility checked it."** Kuhlman's "North Andover" utility was wrong the first time (p. 103). Readings settle it.
 8. **Leaving the dryer on during readings on a half-dead house.** It back-feeds the dead leg and confuses every reading.
 9. **Calling the utility without numbers.** Give them leg voltages, neutral current, and water pipe current.
 10. **Forgetting the smoke alarms after an overvoltage.** Overvoltage can damage them (Kuhlman, pp. 91, 114). Test every one and recommend replacing any that saw it.
 11. **Calling motor-start dips a fault without measuring.** A dip under a second can be normal. A sustained dip or a bright-and-dim pattern is not.
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Field Exercise: Open the Neutral and Open a Hot

Setup. Use the training panel with a switchable service neutral and switchable hot legs. It must have its own overcurrent protection and be set up by your journeyman. Never open a neutral on a customer's service. Wear safety glasses. Keep one hand on your meter.

Part 1: Normal. Connect a 1,500 W heater to a receptacle on L1 and a 60 W lamp to a receptacle on L2. Read L1-N and L2-N at the receptacles and L1-L2 at the panel. Write all three.

Part 2: Open the neutral. Your journeyman opens the service neutral. Read L1-N and L2-N at the receptacles. Turn the heater off and on and watch both readings swing. Write the readings in each state. Do the math from the Background section using the actual wattages and compare it to what you measured. Name which appliances in a real house would be damaged by the high side and which would be dim or stall on the low side.

Part 3: Water pipe path (if the training panel has a simulated electrode path). With the neutral open, clamp the simulated water pipe bond and note the current. Explain where that current goes in a real neighborhood and why the water meter bond jumper matters. (NEC 250.53(D)(1) says the grounding path from a metal water pipe cannot rely on the water meter.)

Part 4: Open a hot. Close the neutral. Your journeyman opens L2. Show that the L2 receptacles are dead and that a 240 V load (a 240 V heater element or the training dryer load) does not run

right. Turn the 240 V load on and show that the L2 receptacles now read low voltage through it. Explain why.

Part 5: The utility call. Write the two-sentence script for each fault (lost neutral and lost hot) with your readings filled in. Say it out loud to your journeyman as if they were the utility.

Pass standard. You pass when your journeyman signs off that you read both legs every time, explained the lost-neutral math with your own numbers, explained the dryer back-feed, never touched the neutral path with it open, and gave a utility report that had the address, the readings, and what was checked on the customer side.

NEC 2026 Cross-References

Section	What it says	Why it matters here
Article 100, "Service Point"	The point of connection between the utility's facilities and the premises wiring	Where the utility's responsibility ends
110.14(D)	Terminal torque to the value on the equipment or instructions, using an approved means	Main lugs, neutral lugs, breaker terminals
210.19 Informational Note	3 percent voltage drop at the farthest outlet on branch circuits and 5 percent total for feeder plus branch provide reasonable efficiency	Voltage-drop test in Part D
225.41 (2023: 230.85)	Outdoor emergency disconnect for one- and two-family dwellings, readily accessible, on or within sight of the dwelling, unless the service disconnect already qualifies	Where to shut the house off
230.70	A means to disconnect all ungrounded conductors in the building from the service conductors	The main breaker or service disconnect
230.70(A)(1)	For one- and two-family dwellings, the service disconnect is in a readily accessible outdoor location on or within sight of the dwelling, unless a 225.41 emergency disconnect is installed	Newer houses may have the main outside
230.70(E)	Replacement of one- and two-family service equipment must meet 230.70(A), (B), and (C); replacing only meter sockets, SE conductors, or raceways does not trigger 230.70(A)(1)	What a service repair can trigger
230.71	Each service has only one service disconnect unless 230.71(B) is met; existing equipment with up to six disconnects is permitted	Older panels with several mains
250.24(A)	At each service, the grounding electrode conductor connects to the grounded service conductor	Why the service neutral is also the ground path
250.53(D)(1)	The grounding path from a metal underground water pipe cannot rely on the water meter or filters	Water meter bond jumper
250.104(A)(1)	Metal water piping is bonded to the service equipment, the grounded conductor at the service, the grounding electrode conductor, or the electrodes	Why neutral current can show up on the water pipe
406.10(3)	Push-in terminals only on circuits of 15 A or less, with 14 AWG solid copper only (new in 2026; older editions left this to the UL listing)	Backstabs cause circuit flicker

End-of-Chapter Checklist

Questions - [] Asked about neighbors, scope (one light to whole house), bright-and-dim, motor starts, burned-out electronics, 240 V appliances, storms, prior utility visits, and medical equipment.

First reading - [] Read hot to neutral at two receptacles on opposite legs. - [] Repeated both readings with a 1,500 W load running. - [] Sorted the call: fixture, circuit, half house, whole house, or utility.

Lost neutral - [] Told the customer to unplug electronics. - [] Called the journeyman with the readings right away. - [] Main breaker decision made by the journeyman; customer told what is off and why. - [] Never touched the service neutral or water pipe bond without the utility disconnect and a 0 A clamp reading. - [] Journeyman clamped L1, L2, neutral, and water pipe bond with a lopsided load. - [] Inspected panel, meter base (from outside), and weatherhead or tap box, in that order.

Lost hot leg - [] Mapped dead circuits to one leg. - [] Turned off 240 V loads before reading. - [] Journeyman read the main breaker load side and line side. - [] Checked the main breaker for heat and damage.

One circuit or fixture - [] Took the voltage-drop reading under load at the far end. - [] Split hot and neutral with hot-to-ground and neutral-to-ground readings. - [] Started at the first box and worked outward. - [] Moved backstabs to screws and torqued every connection made.

Utility - [] Wrote the readings and times before calling. - [] Used the two-sentence script with numbers. - [] Got a reference number and put it on the job board. - [] Told the customer whose problem it is and what happens next.

Close out - [] Re-read both legs under a lopsided load after any repair. - [] Tested GFCIs, AFCIs, and every smoke alarm after an overvoltage event. - [] Documented readings, photos, cause, and who is fixing it. No prices. No license numbers.

Sources

- Jesse Kuhlman, Residential Electrical Troubleshooting (2019). PDF page numbers equal book page numbers. Pages cited: 23 (dimmer and LED pairing), 45–46 (neutral current, water pipe bond test, 6.4 A photo), 48–49 (recessed thermal cutouts; Edison socket center tab), 86–92 (flickering lights; neutral connection issue; water pipe path; 240 V on outlets; melted plug strips), 93–95 (hot leg connection issue; dryer back-feed; stab-on main breakers), 101–103 (Somerville; North Andover flickering), 105–106 (cracked weatherhead conductors; lost hot conductor splice), 111 (service ripped off by a tree branch), 114 (smoke detectors after a lost neutral). All paraphrased. No photos reproduced.

- Arc Workforce, Residential Electrical Field Guide. Symptom 5 (flickering), Symptom 8 (dimmers), Symptom 9 (partial power loss), Symptom 10 (complete power loss), Part 2 (panels), Part 3 (voltage and amperage targets), Part 10 ("Lost / Floating Neutral," "Flickering Lights — The Diagnostic Order That Saves Callbacks," "Voltage Drop"), Job 4. Its code references are NEC 2020; this chapter uses NEC 2026.
 - Alabama Power, "Outage Information," <https://www.alabamapower.com/residential/outages-and-storm-center/outage-information.html> (meter box belongs to the customer; online outage report and outage map). Outage map: <https://outagemap.alabamapower.com/>
 - Alabama Power, Underground Distribution plate AUP-06.002, "Metering – Overhead to Underground Conversion – Alternate UG Service Connection Option," notes 1–3 (riser Alabama Power owned and maintained; SE cable customer owned and maintained). Local text ; the public URL was not recorded.
 - Eaton, Type CH (3/4-inch) dual purpose arc fault/ground fault circuit interrupter, Technical Data TD003006EN, September 2014, Table 3, code 4 (overvoltage at 160 V rms). Retrieved from <https://inspectapedia.com/electric/Eaton-AFCI-Type-CH-Breaker-Installation-Guide.pdf>
 - NFPA 70, National Electrical Code, 2026 edition, sections listed above.
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Videos to watch

These videos are made by other electricians and companies, not YES Electric. Watch each one after you read the section it goes with. Where a video does something differently from this module, the caution line says so. Follow this module and your journeyman, not the video. Click a title to open it on YouTube.

Section	Video
Part E Lost or loose service neutral (E2 measure, E3 find the bad connection)	I Had a Loose Neutral Connection! Here's How I Found It Smarter Sparky • 40:39 A master electrician logs min/max voltage at a receptacle (97 to 135 V), proves line-to-line stays at 240 V while each leg to neutral swings, then moves a two-meter test from the panel to the outdoor disconnect and finds the loose, corroded neutral lug. Caution: His own house, 40 minutes long. He works with the line lugs live and torques the lug 'close enough' with an extension; YES torques to the label. Once a lost neutral is confirmed, the module's Step E1 (protect people and equipment first) comes before the hunt.
Part E Lost neutral; Part G Utility-side faults	Finding a bad neutral on a Service - Raw footage Bobsdecline - Lineman blogger • 9:27 A utility lineman pulls the meter, shows 123/122 V with no load and 119/127 V with load on, explains that the bad connection is always on the source side of the point where the voltages split, and walks the test up to the transformer to find the bad connector. Caution: Lineman on the utility side. A YES tech never pulls the meter or works on the drop or transformer; this shows what Alabama Power does after we call it in. Channel is Canadian, but the 120/240 V service is the same.
Background: What happens when the neutral is lost	What is a Lost Neutral? Lost Neutrals demonstrated Morgan Inspection Services • 12:21 A home inspector's light board shows six bulbs on two legs: with the neutral cut, the legs go in series and one bulb gets about 212 V while others go dim. Caution: Demonstration board, not a real call. He calls an open neutral inside the house 'much less serious'; inside a house it can still be a multiwire neutral that does the same damage (Part D).
Part D One circuit flickers (lost neutral on a multiwire branch circuit)	NOT SAFE? Losing a Neutral in a Multi-Branch Circuit Electrician U • 14:56 Electrician U works the numbers for a toaster and a TV sharing a neutral: with the neutral lost, the toaster gets about 60 V and the TV about 180 V. Caution: Whiteboard math only; no field footage.
Part F Lost or loose hot leg (half the house); Part G Utility-side faults	Half The House No Power or Lights Dim? (220v Appliances Don't Work!) electronicsNmore • 11:21 On a no-AC call the meter reads 200 V at the condenser, then one leg at 88 V to ground at the panel lugs; a tree had landed on the service drop, so it is a utility call. Caution: Not a licensed electrician, and he probes the live service lugs with a cheap meter. His comment that FPE panels are fine is wrong; see R-OLDHOUSE.