Elegant e^3 Efficient
Easy to Use

ERL

Transmission Line Protection Relay

L-PRO 4000

Product Overview

The L-PRO 4000 provides easy-to-use, state-of-the-art comprehensive distance and directional line protection for medium to extra-high-voltage transmission lines using communication-based schemes. It provides control, automation, metering, monitoring, fault oscillography, dynamic swing recording, fault logging, event logging with advanced communications in a flexible cost effective package.

Apply the L-PRO 4000 system for high speed protection and complete control in multi-breaker applications in ring or breaker-and-a-half arrangements. The L-PRO 4000 is ideal for multi-circuit line applications to monitor mutual coupling.

- Easy-to-use, intuitive setting and analysis software
- IEC 61850 communication via optical/copper ports
- Selectable single and 3 pole trip and reclose
- High-speed five-zone user-defined mho or quad phase and ground distance protection
- Single and multi-breaker applications (i.e. ring bus and breaker-and-a-half capability, including breaker failure and individual breaker monitoring)
- 4 shot recloser with dead line/dead bus control and sync check
- High quality fault and swing recording and event log
- 8 setting groups for many operating conditions
- Ethernet ports with 2 unique MAC addresses accommodate network access security needs

dnp Distributed Network Protocol

10 Year WARRANTY

Application

- Primary and backup protection on transmission and sub-transmission lines (using pilot protection schemes)
- Overhead lines and underground cables
- Backup protection for generators, transformers and reactors
- Ideal for multi-circuit line applications (to monitor mutual coupling via additional VT and CT inputs)

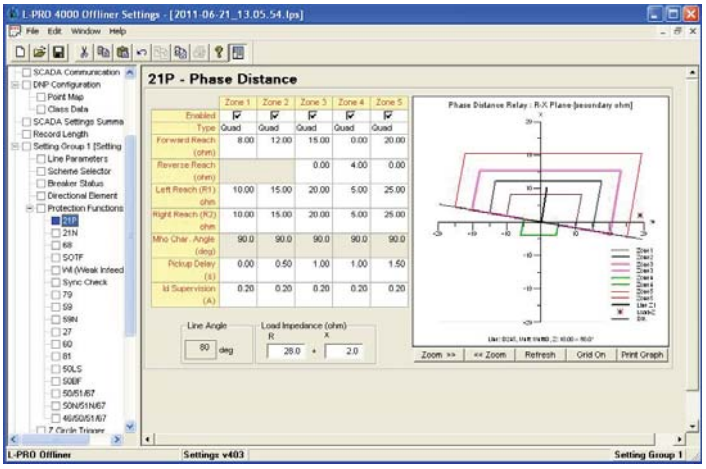
Protection & Control

- Protection functions — IEEE devices 21P, 21N, 25/27/59 (25C), 27, 50BF, 50LS, 50/51/67, 50N/51N/67, 46/50/51/67, 59, 60, 68, 79, 81, Dead Line Pickup (SOTF) and Weak Infeed, 59N and 60CTS
- High-speed 5 zones of phase and ground distance functions — user-defined Mho shapes or Quadrilateral phase and ground distance protection and communication based schemes
- Operating speed - 1.0 to 1.3 cycle at 80% reach
- Selectable single and 3 pole trip and reclose
- CCVT compensation
- Breaker failure and individual breaker monitoring 4 shot recloser with dead line/dead bus control and sync check
- Enhanced user-configurable logic – with ProLogic™ which includes 24 control logic statements
- 8 setting groups with unique Group Logic Control Statements – full Boolean graphics to create logic for setting groups switching based on a combination of given conditions

Features & Benefits

Ease of Use

- Easy-to-use, install, and maintain
- Easy to order – no complex product codes
- User-friendly, Windows®-based relay setting and record analysis software
- Setting software tool – relay specific application
- On-Line setting tool
- Flexible programmable logic for building customized schemes with ProLogic™ statements – 24 control logic statements (total of 192 statements)

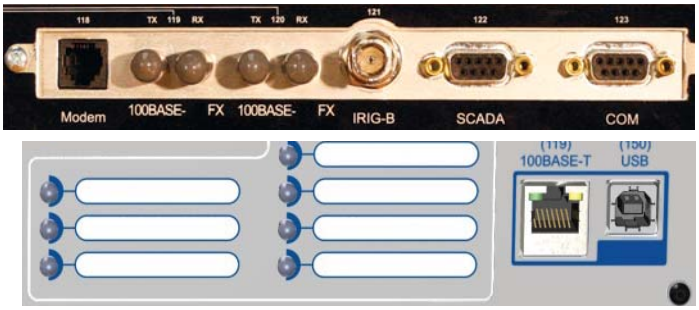


Reduce Installation and Operation Cost

- Substation automation cost – includes IEC 61850 protocol to display and transfer operational data via local-area network (LAN) for local HMI and wide-area network (WAN) for remote monitoring SCADA
- Engineering, installation and commissioning cost – IEC 61850 GOOSE messages communicate high-speed information between IEDs on the substation LAN such as transfer trips, interlocking, load-shedding and commands
- Product setting time – 240 x 128 LCD graphical user interface provides convenient means to check/change specific settings and parameters
- Front panel indicators – 11 user-configurable LEDs, Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm

Flexible Communications

- 2 rear ports, 100BASE-TX RJ-45 or 100BASE-FX 1300 nm multimode optical with ST style connector
- Ethernet ports with 2 unique MAC addresses that easily accommodate network access security needs
- Front panel USB and 100BASE-TX RJ-45 Ethernet port interfaces

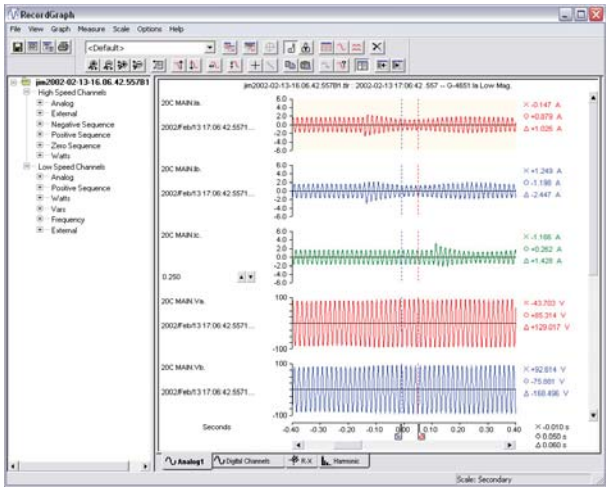


Substation Automation – Ethernet Ready

- IEC 61850 Station Bus on a dedicated optical/copper Ethernet Port
- Enhanced DNP3 SCADA communication protocol including user-selectable point lists, class support and multiple master station support
- Modbus SCADA communication protocol
- IRIG-B port (through BNC connector) for precise time stamping and sample synchronization
- Serial communication port
- 30 virtual inputs for local and remote control
- Optional internal modem

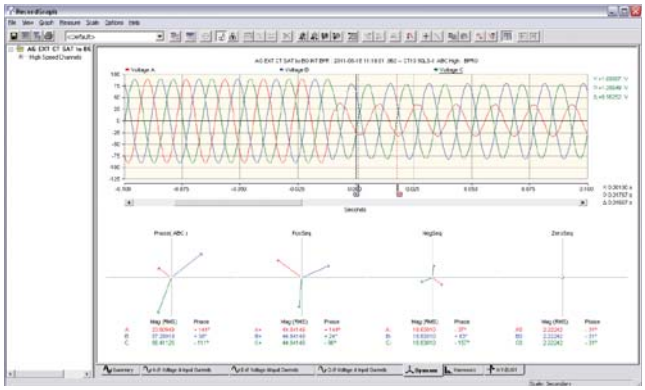
Multi-Functional Recording and Event Logging

- Exceptional fault recording capabilities (with 96 samples/cycle or 5760 Hz) and dynamic swing recording (at nominal frequency)
- Fault location — information provided by event log access or analog input point for SCADA
- Up to 75 x 2 second transient records, or up to 75 x 120 seconds swing records, or combination of transient, swing and optionally event records
- Breaker monitoring
- Metering functions for each input connection
- Sequence of Event Recorder – 250 events with 1 ms resolution
- Compressed event record capabilities – a compressed sequence of event file is created approximately every 230 events



RecordGraph™ and RecordBase View™

- Display multiple channels simultaneously and combine records
- Display multiple component voltage, current or summed channels
- Display THD, harmonic magnitude
- Zoom, alignment, scaling, unit functions
- Record summaries including event lists
- COMTRADE, PTI and MS Excel export



Best in Class Human-Machine Interface

Large LCD display, allows for better metering display

Navigation controls allow for an easy experience through settings, maintenance, service and view menus

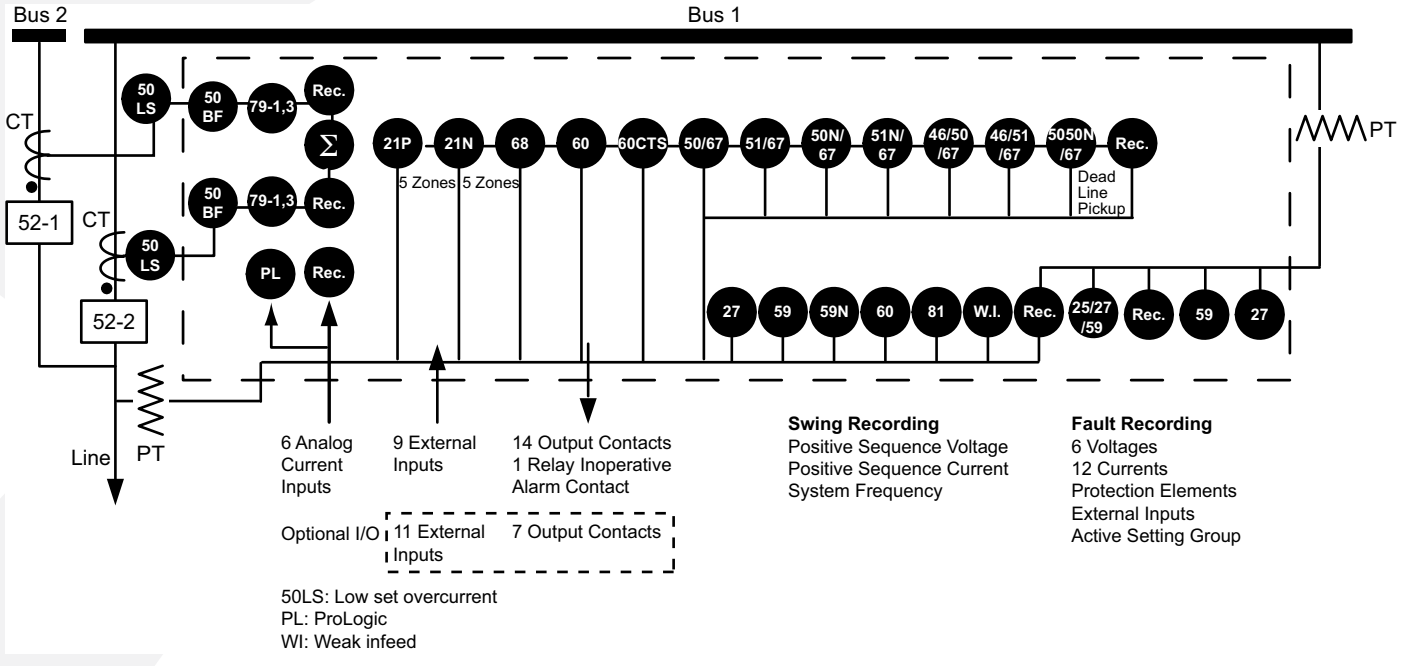
Programmable target LEDs provide tripping information to expedite response to systems events

New faster processor and hardware platform

Rear optical ports ready for IEC 61850 Goose

Unique front panel USB and Ethernet ports provide easy and fast access to settings and set up

Protection & Control Function Diagram



Detailed Specifications

L-PRO 4000 Transmission Line Protection Relay

Item	Quantity/Specs	Notes
General		
Nominal Frequency	50 or 60 Hz	
Operate Time	1.0 to 1.3 cycles at 80% reach	Including relay output operation
Power Supply	43 – 275 Vdc, 90 – 265 Vac	Power Consumption: 25 – 30 VA (ac) 25 – 30 W (dc)
Memory	Settings and records are stored in non-volatile memory	Records are stored in a circular buffer
Protection Functions		
IEEE Dev. 21P-1, 2, 3, 4,5, 21N-1, 2, 3, 4,5, 27, 50BF, 50LS, 50/51/67, 50N/ 51N/67, 46/50//51/67, 59, 59N, 60, 68, 79-1, 3, Sync Check, 81, Switch On To Fault, 60CTS, Weak Infeed, Mutual Compensation and Virtual Inputs	2 x 3-phase voltage inputs for synchronizing during reclosing 2 x3-phase current inputs for protection Extra 6 currents used for recording and ProLogic input	Suitable for ring bus configurations and integrated HV breaker auto-recloser
ProLogic™	24 statements per setting group	5 inputs per ProLogic™ statement
Group Logic	8 (16 group logic statements per setting group)	5 inputs per group logic statement
Recording		
Transient (Fault)	96 s/c oscillography of all analog and external input channels	User-configurable 0.2 to 10.0 seconds Record length and 0.1 to 2 seconds prefault length
Dynamic Swing	1 s/c phasor measurements of line positive sequence V and I plus frequency	User-configurable 60 – 120 seconds. Pre trigger time fixed at 30 seconds
Events	250 events circular log with 1ms resolution	When event auto save is enabled, a compressed event record is created every 250 events.
Record Capacity	75 records of a combination of transient, swing and optionally event records	
Input & Output		
Analog Voltage Inputs 2 sets of 3-phase voltage inputs (6 voltage channels total)	Nominal Voltage Continuous rating over voltage Maximum over-scale thermal rating Burden	Vn = 69 Vrms 2x Vn = 138 Vrms 3x Vn = 207 Vrms for 10 seconds <0.15 VA @ 69 Vrms
Analog Current Inputs 4 sets of 3-phase current inputs (12 current channels)	Nominal Current Full Scale/Continuous Maximum full-scale rating Thermal rating Burden	In = 1 Arms or 5 Arms 3x In = 3 Arms or 15 Arms 40x In for 1 second symmetrical 400 Arms for 1 second <0.25 VA @ 5 Arms
Amplitude measurement accuracy	+/-0.5% for 54 to 66 Hz +/-0.5% for 44 to 56 Hz	
Analog Sampling Rate	96 samples/cycle for recording 8 samples/cycle for protection	Records up to 25th harmonic

L-PRO 4000 Transmission Line Protection Relay

Item	Quantity/Specs	Notes
Input & Output		
Burden	Burden resistance: > 10 k ohms	
External Inputs	9 isolated inputs (3U chassis) 20 isolated inputs (4U chassis)	Optional 48, 110/125 or 220/250 Vdc nominal, externally wetted
Isolation	2 KV optical isolation	
External Input Turn-on Voltage	48 Vdc range = 27 to 40 Vdc 125 Vdc = 75 to 100 Vdc 250 Vdc = 150 to 200 Vdc, 0% to 80% of nominal	Specified voltages are over full ambient temperature range.
Output Relays (contacts)	14 programmable outputs (3U chassis) and 1 relay inoperative contact (N.C.) 21 programmable outputs (4U chassis) and 1 relay inoperative contact (N.C.)	Externally wetted Make: 30 A as per IEEE C37.90 Carry: 8 A Break: 0.9 A at 125 Vdc resistive 0.35 A at 250 Vdc resistive
Virtual Inputs	30 Virtual Inputs	
Interface & Communication		
Front Display	240 x 128 pixels graphics LCD	
Front Panel Indicators	16 LEDs: 11 programmable and 5 fixed	Fixed: Relay Functional, IRIG-B Functional, Service Required, Test Mode, Alarm Target (11 programmable) Default assignments: Ground Distance, Phase Distance, Phase Overcurrent, Breaker Failure, Over/Under-Frequency, Switch On To Fault, Communication Trip, Power Swing Trip, ProLogic 1 – 8, ProLogic 9 – 16, ProLogic 17 – 24
Front User Interfaces	USB port and 100BASE-TX Ethernet port	Full Speed USB 2.0, RJ-45
Rear User Interfaces	LAN Port 1: 100BASE Copper or Optical 1300 nm LAN Port 2: 100BASE Copper or Optical	Copper: RJ-45, 100BASE-T Optical: 100BASE-FX, Multimode ST style connector
	Two Serial RS-232 ports to 115 kbd modem	Com port can support an external modem
Internal Modem	33.6 Kbps, V.32 bis	Optional internal modem
SCADA Interface	IEC61850 (Ethernet) or DNP3 (RS-232 or Ethernet) or Modbus (RS-232)	Rear port
Time Sync	IRIG-B, BNC connector B003,B004,B123 and B124 Time Codes	Modulated or unmodulated, auto-detect
Self Checking/Relay Inoperative	1 contact	Closed when relay inoperative

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Item	Quantity/Specs	Notes
Environmental:		
Ambient Temperature Range	-40°C to 85°C for 16 hours -40°C to 70°C continuous	IEC 60068-2-1/IEC 60068-2-2 LCD contrast impaired for temperatures below -20°C and above 70° C
Humidity	Up to 95% without condensation	IEC 60068-2-30
Insulation Test (Hi-Pot)	Power supply, analog inputs, external inputs, output contacts – 2 kVrms, 50/60 Hz, 1 minute	IEC 60255-5, ANSI/IEEE C37.90
Electrical Fast Transient	Tested to level 4 – 4.0kV 2.5/5 kHz on Power and I/O lines	ANSI/IEEE C37.90.1, IEC/EN 60255-22-4, IEC 61000-4-4
Oscillatory Transient	Test level = 2.5 kV	ANSI/IEEE C37.90.1, IEC/EN 60255-22-1, IEC61000-4-12 Level 3
RFI Susceptibility	10 V/m modulated, 35 V/unmodulated	IEEE C37.90.2:35 V/m / (IEC 60255-22-3/ IEC61000-4-3): Level 3
Conducted RF Immunity	150 kHz to 80 MHz	IEC 60255-22-6 / IEC 61000-4-6 Level 3
Shock and Bump	5 g and 15 g	IEC 60255-21-2, IEC/EN 60068-2-27: Class 1
Sinusoidal Vibration	10 Hz to 150 Hz, 1.0 octave/min, 40 sweeps	IEC/EN 60255-21-1, IEC/EN 60068-26, Class 1
Voltage Interruptions	200 ms interrupt	IEC 60255-11 / IEC 61000-4-11

Physical

Weight	3U chassis - 10.3 Kg 4U chassis - 11.9 kg	22.6 lbs (3U chassis) 26.2 lbs (4U chassis)
Dimensions	3U chassis: 13.2 cm height x 48.26 cm width rack mount x 32.8 cm depth 4U chassis 17.7 cm x 48.3 cm x 32.8 cm	5.2 height x 19 width rack mount x 12.9 depth 6.93” x 19 x 12.9

Time Sychronization and Accuracy

External Time Source	Synchronized using IRIG-B input (modulated or unmodulated) auto detect	In the absence of an external time source, the relay maintains time with a maximum 90 seconds drift per year at a constant temperature of 25C. The relay can detect loss of re- establishment of external time source and automatically switch between internal and external time.
Synchronization Accuracy	Sampling clocks synchronized with the time source (internal or external).	

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Overall L-PRO Accuracies

Current	±2.5% of inputs from 0.1 to 1.0 x nominal current (In)
	± 1.0% of inputs from 1.0 to 40.0 x nominal current (In)
Voltage	± 1.0% of inputs from 0.01 to 2.0 x nominal voltage (Vn)
Impedance	±5.0% or 5 mΩ of set value from 0.05 to 66.00 ohms secondary (0.25 to 330.00 ohms secondary 1 A nominal)
Directional Phase Angle	±2.0° of set value of Positive Sequence Line Angle value from 25.0° to 89.0°
Frequency Elements	±0.001 Hz (fixed level)
	±0.05 Hz (df/dt)
Sync Check Elements	±0.2 degrees
Timers	±3 ms of set value
Inverse Overcurrent Timers	±2.5% or ±1 cycle of selected curve
Definite Overcurrent Timers	±2.5% or ±1 cycle non-directional
	±2.5% or ±1.5 cycle directional
Frequency Timer	±2.5% of set value plus 1.25 cycles to 1.75 cycles of inherent delay (fixed level) at 2x pickup, error <40 ms (df/dt) at 0.1 Hz/s above pickup, error <100 ms
Burden	AC Voltage Inputs, < 0.15 VA @ 69 V
	AC Current Inputs, ≤0.5 VA @ 5 A

Detailed Environmental Tests

Test	Description		Test Level
	Type Test	**Test Points**	
FCC Part 15	RF emissions	Enclosure ports	Class A: 30 – 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 – 30 MHz
IEC/EN 60255-25	RF emissions	Enclosure ports	Class A: 30 – 1000 MHz
	Conducted emissions	ac/dc power ports	Class A: 0.15 – 30 MHz
IEC/EN 61000-3-2	Power line harmonics	ac power port	Class D: max.1.08, 2.3, 0.43, 1.14, 0.3, 0.77, 0.23 A.... for 2nd to nth harmonic
		dc power port	N/A
IEC/EN 61000-3-3	Power line fluctuations	ac power port	THD/ 3%; $P_{st} < 1$, $P_{lt} < 0.65$
		dc power port	N/A
IEC/EN 61000-4-2 IEC/EN 60255-22-2	ESD	Enclosure contact	+/- 6 kV
		Enclosure air	+/- 8 kV
IEEE C37.90.3	ESD	Enclosure contact	+/- 8 kV
		Enclosure air	+/- 15 kV
IEC/EN 61000-4-3 IEC/EN 60255-22-3	Radiated RFI	Enclosure ports	10 V/m: 80 – 1000 MHz
IEEE C37.90.2	Radiated RFI	Enclosure ports	35 V/m: 25 – 1000 MHz

Detailed Environmental Tests

Test	Description		Test Level
IEC/EN 61000-4-4 IEC/EN 60255-22-4 IEEE C37.90.1	**Type Test**	**Test Points**	
	Burst (fast transient)	Signal ports	+/- 4 kV @ 2.5 kHz
		ac power port	+/- 4 kV
		dc power Port	+/- 4 kV
		Earth ground ports	+/- 4 kV
IEC/EN 61000-4-5 IEC/EN 60255-22-5	Surge	Communication ports	+/- 1 kV L-PE
		Signal ports	+/- 4 kV L-PE, +/-2 kV L-L
		ac power port	+/- 4 kV L-PE, +/-2 kV L-L
		dc power port	+/- 2 kV L-PE, +/-1 kV L-L
IEC/EN 61000-4-6 IEC/EN 60255-22-6	Induced (conducted) RFI	Signal ports	10 Vrms: 0.150 – 80 MHz
		ac power port	10 Vrms: 0.150 – 80 MHz
		dc power port	10 Vrms: 0.150 – 80 MHz
		Earth ground ports	10 Vrms: 0.150 – 80 MHz
IEC/EN 60255-22-7	Power frequency	Binary input ports: Class A	Differential = 150 Vrms Common = 300 Vrms
IEC/EN 61000-4-8	Magnetic field	Enclosure ports	40 A/m continuous, 1000 A/m for 1 s
IEC/EN 61000-4-11 IEC/EN 61000-4-29	Voltage dips & interrupts	ac power port	30% for 1 period, 60% for 50 periods
			100% for 5 periods, 100% for 50 periods
		dc power port	30% for 0.1 s, 60% for 0.1 s, 100% for 0.05 s
IEC 60255-11	Voltage dips & interrupts	dc power port	100% reduction for up to 200 ms
IEC/EN 61000-4-12 IEC/EN 60255-22-1	Damped oscillatory	Communication ports	1.0 kV Common, 0 kV Diff
		Signal ports	2.5 kV Common, 1 kV Diff
		ac power port	2.5 kV Common, 1 kV Diff
		dc power port	2.5 kV Common, 1 kV Diff
IEEE C37.90.1	Oscillatory	Signal ports	2.5 kV Common, 0 kV Diff
		ac power port	2.5 kV Common, 0 kV Diff
		dc power port	2.5 kV Common, 0 kV Diff
IEC/EN 61000-4-16	Mains frequency voltage	Signal ports	30 V continuous, 300 V for 1 s
		ac power port	30V continuous, 300 V for 1 s
IEC/EN 61000-4-17	Ripple on dc power supply	dc power port	10%

NOTE:

The L-PRO 4000 is available with 5 or 1 amp current input. All current specifications change accordingly.

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