Types TC–10B and TCF–10B

Frequency programmable power line carrier

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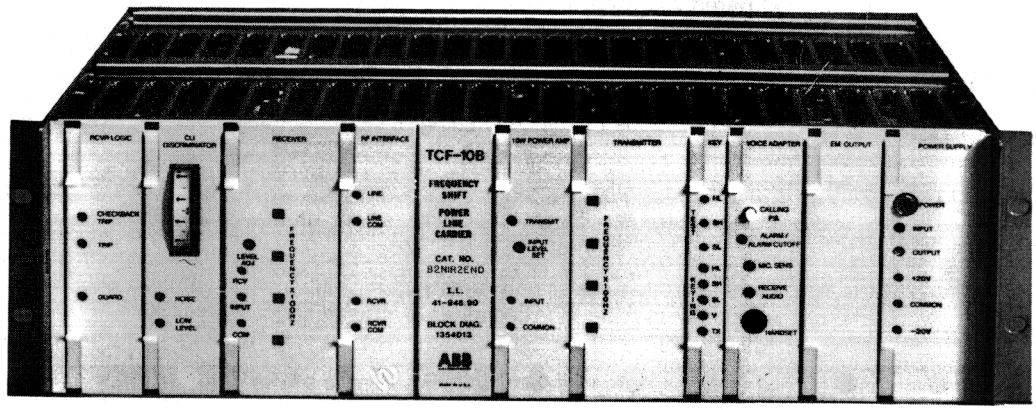
ASEA BROWN BOVERI

ABB Network Control & Protection



(SE 90629)

Features

- Programmable over 30–535 kHz (in 0.5 kHz steps) with direct frequency readout
- Frequencies are easily field selectable by rotary switches (no new parts required)
- No filter changes or adjustments
- Universal keying/receiver outputs
- Built–in carrier test pushbuttons
- Dc to dc isolated power supply, 48, 125, and 250 V dc available
- Chassis prewired for all options
- All inputs/outputs optically isolated
- Rear mounted terminal blocks
- 19" wide rack mounting (3 R.U.high) with plug–in modular construction
- Mounting flanges adjustable to vary depth
- Transparent smoked Lexan cover with "meter seal"
- Supports phase comparison, directional comparison, and transfer trip relaying
- Most modules common for TC–10B and TCF–10B

Application

General

To provide high speed clearing of end–zone faults on a transmission line, there must be some form of communication channel between the line terminals. This communication channel, in conjunction with the local relays, compares fault conditions at the line terminals to determine whether the fault is internal or external.

The channel sends either a blocking or a tripping signal from one line terminal to another. The blocking signal prevents tripping for external faults, in both directional and phase comparison relay systems. The tripping signal trips the remote line terminal for internal line, transformer or reactor faults on systems protected by transfer trip relaying. The channel can also be used in a permissive mode which requires receipt of trip signal and local pilot relay operation to initiate tripping.

TC–10B

The TC–10B is particularly suitable for use in Directional Comparison Blocking and Phase Comparison Blocking relay systems where a dedicated power–line–carrier channel is desired.

Directional Comparison Blocking

The basic elements of Directional Comparison Blocking systems include phase and earth overcurrent or distance pilot relays (21P, 21NP or 67NP), reverse looking carrier start relays (21S) and an on–off type channel. The local terminal's *carrier start* relay must be set to reach past the remote terminal's forward looking pilot relay. the pilot relays are normally set to reach 120 to 150 percent of the line. The TC–10B is an "on–off" carrier set which is normally in the off state and turned on only when an external fault is detected by the carrier start relays. If carrier is not received from the remote terminal and a fault is detected by the local pilot relays, the fault is determined to be internal to the protected line and tripping is initiated. An external fault past the remote terminal will be detected by the remote carrier start relay which turns on the remote carrier transmitter. The local carrier receiver will detect this frequency and block the local pilot relays from tripping. This type of scheme emphasizes dependability over security since a channel failure will not block high speed tripping.

Where three terminal lines are being protected with a Blocking system, the TC–10B transmit-

Application (cont'd)

ters must be offset 100 Hz from each other to prevent out–of–phase signal cancellation. The TC–10B is also suitable for multi–terminal lines where only a blocking function is required, using only a reverse looking relay to block for external faults.

Phase Comparison Blocking
In the Phase Comparison Blocking relay system, the remote square wave output is compared with local square wave quantities to determine if a trip is required. The local square wave is a direct representation of the 50/60 Hz sine wave of the power signal. The TC–10B is turned on and off at a 50/60 Hz rate when current exceeds the pickup setting of the relay to produce the remote square wave output. The comparison is an OR gate of the local and remote information. If the two square waves are in phase, then the fault is defined as an internal fault and breaker tripping is initiated. If the square waves are 180 degrees out of phase, the fault is external and continuous blocking occurs until the fault is cleared by the adjacent line relays.

Another feature of the TC–10B carrier is a maintenance voice channel. This is supplied as an optional module that provides half duplex voice communications over the power line between the two terminals using a push–to–talk handset.

Since the TC–10B is normally in the off state, the channel is not continuously monitored. To detect a deteriorating or failed channel, an automatic checkback function may be added as an optional module. The checkback module is programmable to test both high level (10 watts) and low level (1 watt) signals at regular intervals of 1 to 255 hours.

TCF–10B
The TCF–10B is particularly well suited for the following types of protective relay systems where a dedicated power–line–carrier channel is desired:

- Directional comparison unblocking
- Dual phase comparison unblocking
- Segregated phase comparison
- Direct transfer trip

Directional Comparison Unblocking
The basic elements of Directional Comparison Unblocking systems include phase and earth overcurrent or distance (pilot) relays (21P, 21NP, or 67NP) and a frequency shift keyed (FSK) carrier channel. The pilot relays are set to reach 120 to 150 percent of the protected line. The FSK channel is normally transmitting guard frequency at a 1 watt power output. The guard frequency is continuously monitored to *detect* channel trouble.

For an internal fault, pilot relays at both ends will operate, shifting the transmitters from "guard" to "unblock" and boosting power output to 10 watts. Tripping is initiated when the local pilot relays are picked up and unblock frequency is received. These two conditions are never met for an external fault since the local pilot relays only operate for faults in the direction of the protected line. A trip window is provided to allow high speed tripping for an internal fault that shorts carrier to earth, preventing receipt of the unblock frequency. For 150 ms after a loss of carrier is detected, *the pilot relays are permitted to trip without receiving trip frequency.* After the 150 ms, high speed pilot tripping is blocked until the channel status is returned to normal.

The dependability and security of the Directional Comparison Unblocking system makes it the most attractive of the protective schemes for transmission lines using power–line–carrier channels. Tripping for internal faults is insured by the 150 ms trip window while false tripping is avoided since both the pilot relay and channel are required to initiate tripping.

The scheme can also be applied to multi–terminal lines. Each terminal is assigned a unique transmitter frequency and each terminal must have multiple receivers to detect all other terminals transmitter frequencies. High speed tripping is initiated only when all terminals receive unblock frequencies from all other terminals.

Phase Comparison Unblocking
The TCF–10B can be utilized in two types of phase comparison schemes; the Dual Phase Comparison and the Segregated Phase Comparison system. The Segregated Phase Comparison System is designed for application on long, EHV, series capacitor–compensated lines, where significant transients during the fault present problems. This current only system can be supplied in two different configurations. The two–subsystem scheme uses delta phase current and earth current to detect faults. The three–subsystem scheme uses each phase current to detect the fault. Each subsystem consists of one channel and one relay. Therefore the *three*–subsystem scheme requires three TCF–10B channels.

Direct Transfer Trip
The TCF–10B carrier can be applied for transformer or breaker failure protection in a Direct Transfer Trip (DTT) scheme where remote clearing of faults is necessary. Since receipt of trip is not supervised by a fault detecting relay, it is usually supplied in a dual channel configuration requiring a received trip from both channels to initiate tripping. Narrow band filters are normally used to reduce sensitivity to channel noise thereby increasing the likelihood that a trip will be received during the high noise conditions which are typical during a fault. The slightly increased channel time caused by the narrow band filter is generally an acceptable trade off for more reliable tripping. The carrier can be applied in a *uni*–directional mode with transmitters at one end and receivers at the other. *Transceivers at both ends may also be used when bi-directional tripping is required.*

Three Frequency System
The TCF–10B may be applied in a three frequency configuration which combines an unblocking *function with a direct transfer trip function.* In this application one TCF–10B channel is required to perform two functions. The transmitter will shift 250 Hz above center frequency for an unblock function and 250 Hz below center frequency for a transfer trip function. This arrangement will also conserve frequency spectrum.

Design

General

The TC–10B and TCF–10B use identical backplanes and chassis which are prewired for all options. The transmitter, receiver, power supply, 10 watt power amplifier, RF interface and voice adapter modules are interchangeable between the TC–10B and TCF–10B.

The carrier is completely field programmable with direct frequency readout on the front panel of the receiver and transmitter modules. Frequencies are selectable between 30 and 535 kHz in *0.1* kHz steps. No other parts or adjustments are necessary to change or set the frequency.

All inputs and outputs are optically isolated *from the carrier power supply* and wired to terminal blocks mounted on the rear of the chassis. The terminal blocks will accept up to a 10 AWG wire size and can be either pressure or lug connected.

The carriers may be 19" rack mounted with varying depths, by adjusting the location of the mounting flange. Vertical mounting is also possible and sometimes necessary if replacing a type KR carrier with the TC–10B.

The maximum power output is 10 watts but may be adjusted as low as 0.1 watt if required. An external amplifier, TAMP–100, is available when power output up to 100 watts is required.

Keying input voltages are selectable among 15, 48/60, 110/125 or 220/250 V dc.

An optional internal carrier level indicator (CLI) is available, with a scale of –20 dB to +10dB. An external CLI meter may also be driven by this output.

TC–10B

The TC–10B is fully compatible with earlier models of on–off carrier, like the TC–10A, TC–10, TC, or KR at the opposite end of the line. The same telephone handset and maintenance voice channel may be used as well.

Independent carrier start and stop inputs, with selections for circuit opening or closing keying, allow the carrier to be applied to a wide range of relay schemes. Two independent outputs are provided, each selectable for 20 mA, 200 mA or 15 V dc.

Wide band (1200 Hz) and narrow band (600 Hz) units are available. The standard is the wide band with the narrow band being used in directional comparison systems where improvement in signal to noise ratio is required. The wide band has a sensitivity of 60 mVrms and the narrow band is 20 mVrms.

The TC–10B is available with three options:
- Automatic checkback module for periodic testing of the carrier channel at programmable intervals.
- Voice module with signalling
- Alarm and carrier level indication

TCF–10B

The TCF–10B has optically isolated keying inputs and outputs (static or electromechanical), providing versatility to be applied to most every type of direct transfer trip, directional comparison, or phase comparison line relaying system requiring a frequency–shift power–line–carrier channel. Both the guard and trip RF outputs may be adjusted individually from 0.1 watts (up to 100 watts if used with an external 100 watts amplifier like the TAMP–100).

The TCF–10B is available as an individual transmitter, receiver or transceiver. Any configuration requires only one 3 RU high chassis. A voice function may be added to the transceiver where communication with the remote substation is desired.

Bandwidths available for the TCF–10B are 300, 600, and 1200 Hz. The narrow band (300 Hz) is used where speed is not critical or where spectrum conservation is important, usually in direct transfer tripping applications. The medium band (600 Hz) is used in high speed relaying such as a directional comparison unblocking system. The extra–wide band (1200 Hz) can be used for systems that require a super–high speed channel. The channel shift is dependant on the bandwidth. For the 300 Hz set, the shift is +/– 100 Hz. The 600 Hz set shifts +/– 250 Hz and the 1200 Hz set shifts +/– 500 Hz. *A +/– 100 Hz shift is also available with the medium bandwidth receivers where interfacing with existing older TCF equipment at the remote terminal is required.*

If the electromechanical outputs option is ordered, the user may individually select between guard, trip 1 or trip 2 (three frequency application) for the six relay outputs. The contacts are also selectable between normally closed or normally open states.

Technical data

General

The TCF–10B and TC–10B meet or exceed all applicable ANSI, IEEE and *IEC* standards

Transceiver power requirements		Supply current (AMPS) At nominal voltage		
Nominal Battery Voltage	Permissible Voltage Range	Receive/ standby	1 Watt Transmit	10 Watt Transmit
48/60 V dc	38–70 V dc	630	940	1600
110/125 V dc	72–140 V dc	240	360	600
220/250 V dc	170–280 V dc	120	180	300

Permissible ripple on incoming dc	5%
Carrier frequency at dc input leads when transmitting 10 W	20 mV (max)
Loss of dc alarm (option)	Form A or B selectable, 100 VA

Dimensions

Equipment	Net Weight		Height		Width		Depth		Rack
	lbs	Kg	Inch	mm	Inch	mm	Inch	mm	Space
Transceiver	21	9.53	5.25	133.4	19.0	482.6	13.50	342.9	3 RU
Transmitter	14	6.35	5.25	133.4	19.0	482.6	13.50	342.9	3 RU
Receiver	12	5.45	5.25	133.4	19.0	482.6	13.50	342.9	3 RU

Environmental	
Ambient temperature range of air–contacting equipment	–20 to +60°C
Relative humidity	Up to 95% at 40°C (for 96 hours) up to 1500 m
Altitude	Up to 6000 m with derating
Transient withstand capability	All external user interfaces must meet SWC specification of ANSI C37.90 (1978)
1–minute withstand	Only isolated inputs, outputs and all alarms: 2500 V dc from each terminal to earth, up to 1500 m. Up to 6000 m with derating
Impulse withstand capability	Center conductor of coaxial cable to earth, 3000 V dc, using 1.5 x 50 µs impulse
Electromagnetic interference capability	IEEE Trial–use–Standard P734/D5/R4 (ANSI C37.90.2)
TC–10B Transmitter/receiver	
Frequency range	30–535 kHz in *0.1* kHz steps (*0.5 kHz* offset range)
RF input/output impedance	50, 75 or 100 ohms (nominal unbalanced)
Frequency stability	±10 Hz (typical)
Output power	10 watts (user adjustable 0.1 to 10.0 watts)
Receiver bandwidth and Sensitivity *Bandwidth* *Wideband (1200 Hz)* *Narrowband (600 Hz)*	*Sensitivity (selectable)* *17 Vrms (max.) 70 Vrms (max.)* *15 mVrms 60 mVrms* *5 mVrms 20 mVrms*
Channel speed at 15 dB margin Wideband Narrowband	 2.5 msec (operate) 2.5 msec (reset) 3.6 msec (operate) 3.6 msec (reset)
Harmonic distortion	–55 dBmO (55 dB below full power)
Reduced power	Built–in P/B switch
Manual keying	Built–in P/B switch
Receiver outputs	
Two relaying outputs	Each ouput provides 200 mA, +15 V dc or *20 mA*
Alarm and level option	
Loss of dc	Form A or B contact (selectable) rated 100 VA: 0.5 s dropout delay
Received margin low	Form A or B contact (selectable) rated 100 VA: 0.5 s dropout delay
Transmit power on	Form A or B contact (selectable) rated 100 VA: 0.5 s dropout delay
Carrier level indicator scale	–20 dB below 10 W
Output for external carrier level indicator	0–100 µA
TCF–10B Transmitter	
Frequency range	30–535 kHz in *0.1* kHz steps
RF output impedance	50, 75 or 100 ohms (nominal unbalanced)
Output power	10 watts (max) 0.1 watt (min) 100 watts (with optional external amplifier)
Low RF output alarm (option)	Form A or B selectable, 100 VA
Modulation type	Frequency–shift keyed (FSK): strapable for either two or three–frequency operation

Harmonic and spurious output	55 dB below 10 W
Output variation	+/– 1 dB over temperature and voltage range

Frequency stability	XMTR	RCVR
300 Hz BW	±10 Hz	±20 Hz
600 Hz BW	±15 Hz	±20 Hz
1200 Hz BW	±20 Hz	±20 Hz

Keying

5 optically–isolated keying inputs, strapable at 15/20, 48, 125, 250 V dc	– Unblock or phase comparison – Direct transfer trip – Power boost – RF power on/off – Voice adapter
Maximum input keying burden	*10 mA*
Manual keying	Recessed pushbutton switches for high–frequency keying, low–frequency keying and power boost
Trip and guard keyed alarm (option)	Form A or B selectable, 100 VA

TCF–10B Receiver

Receiver input impedance (4–wire)	1000 ohms*
Low RF received alarm relay (option)	Form A or B selectable, 100 VA
Five static, optically–isolated outputs for 15/20 V dc circuits	– Unblock trip (space) – Low–level signal – Guard (mark) – Noise – Checkback trip
Output relays (optional) 6 contacts selectable for guard trip	Rated make and carry 30 A for 100 ms (form A or B)

Contact operating times (add to channel speed if used)	NO contact	NC contact
	NO contact	NC contact
	Closes	Opens
	Opens	Closes
	2.8 ms	2.0 ms
	2.8 ms	3.8 ms
	1.9 ms bounce	
	4.0 bounce	

Receiver sensitivity and channel speed:

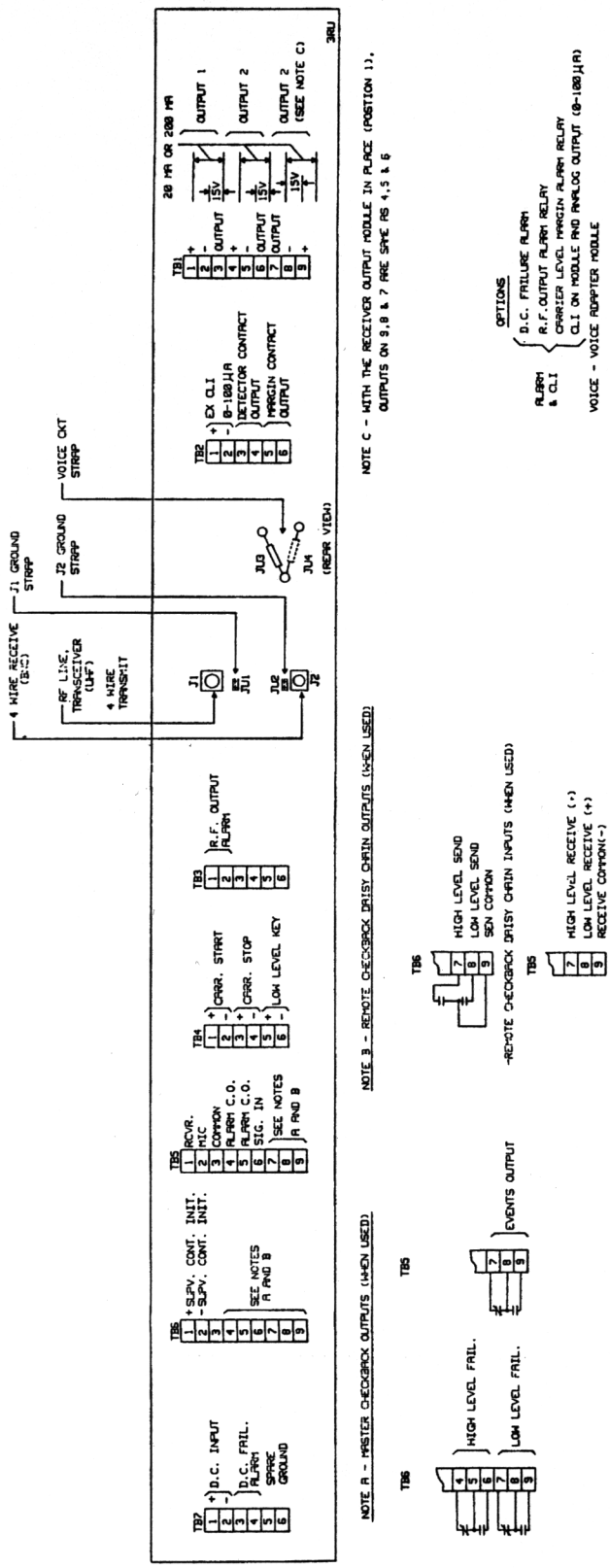
Bandwidth	Shift	Sensitivity
Channel speed		
300 Hz	±100 Hz	
5mVrms (min) 17Vrms (max)		
8 ms		
600 Hz	+100 Hz	
5mVrms (min) 17Vrms (max)		
6 ms		
600 Hz	+250 Hz	
5mVrms (min) 17Vrms (max)		
5 ms		
1200 Hz	+500 Hz	
15mVrms (min) 17Vrms (max)		
3.5 ms		

* Where 70Vrms (max) is required, instead of 17Vrms, sensivity is reduced to 20mVrms (for 300 and 600 Hz BW) and 60mVrms for 1200 Hz BW receivers (link settable). Receiver input impedance becomes 5000 ohms.

Voice adapter option

Modulation	Amplitude modulation with compander
Transmission	Full–duplex
Frequency response	300 to 2000 Hz
Signalling	370 Hz AM with signalling pushbutton Form A or B selectable, 100 VA

Diagrams



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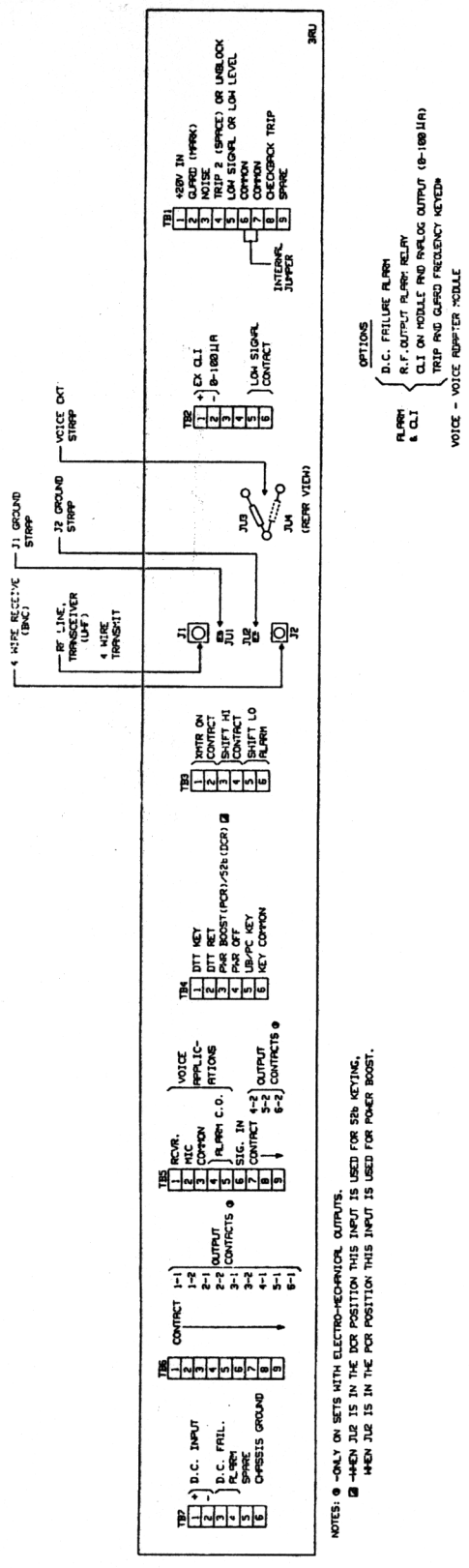
TC–10B Connection diagram



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TCF–10B Connection diagram

Ordering

TCF–10B Ordering information

Typical catalog number: B 2 N 1 R 2 E N D

Chassis
Transmitter only — T
Receiver only — R
Transmitter/receiver *(transceiver)* — B

Transmitter power output
1/1 Watt — 1
1/10 Watt — 2
10/10 Watt — 3
10/100 Watt * — 4
100/100 Watt — 5
None (receiver only chassis) — 6
* Includes 6 RU external amplifier with output transformer and skewed hybrid
Uses series regulated power supply

Bandwidth/frequency shift
300 Hz BW, *+/–100 Hz* shift (Direct transfer trip) — N
600 Hz BW, +/–100 Hz shift (line relaying, use when matching up with existing wideband TCF, TCF–10 or TCF–10A carrier at remote end of line) — W
600 Hz BW, +/–250 Hz shift (line relaying) — M
1200 Hz BW, +/–500 Hz shift (line relaying, use when a higher than normal speed channel is desired) — X

Power supply
48/60 V dc battery input — 4
110/125 V dc battery input — 1
220/250 V dc battery input — 2

Alarms and carrier level indication
Transmitter alarms only (loss of dc, trip and guard frequency keyed* and RF power out alarms) — T
Receiver alarms CLI only (loss of dc and low level received RF alarms: carrier level indicator and output for external CLI meter) — R
Transmitter and receiver alarms with CLI (loss of dc, trip and guard frequency keyed*, RF power out and low level received RF alarms: carrier level indication and output for external CLI meter) — B
No alarms or carrier level indication or carrier level outputs — N
* Trip and guard frequency keyed alarms are disabled for phase comparison transmitters. For three frequency directional comparison systems, trip and guard become “trip 1” and “trip 2”, respectively.

Channel type
2 frequency (standard application) — 2
3 frequency (directional comparison line relaying plus transfer trip) — 3

Receiver output interface
Static (transistor outputs) — S
Electromechanical (six contact outputs) — E
No outputs (transmitter only chassis) — N

Voice
Voice adapter module (available in transmitter/receiver chassis only) — V
No voice adapter module — N

Receiver logic
Directional comparison (unblock, POTT, PUTT, DUTT or direct transfer trip) — D
Phase comparison — P
Telemetry (slow speed direct transfer trip, contains no noise processing or channel logic, not recommended for line relaying applications) — T
No logic (transmitter only chassis) — N

Ordering (cont'd)

TC–10B Ordering information

Typical catalog number

E 1 M 1 W V A

Basic transmitter/receiver
Static programmable transmitter/ receiver assembly for phase or directional comparison relaying, or supervisory control — E

Power output
10 watt output — 1
100 watt output (includes 6 RU external amplifier with output transformer and skewed hybrid wired out to terminals – may be used with parallel external transmitters – external 100 watt amplifier uses series regulated power supply) — 2

Automatic checkback
Master checkback module with event counter — M
Master checkback module without event counter — C
Remote checkback module — R
No checkback module — N

Dc/dc converter power supply
48/60 V dc battery input — 4
110/125 V dc battery input — 1
220/250 V dc battery input — 2

Bandwidth (filter range)
Wideband filter (1500 Hz – standard application for phase or directional comparison relaying and/or super–visory control) — W
Narrowband filter (600 Hz – special application for directional comparison relaying) — X

Voice
Voice adapter module with signalling — V
No voice adapter module — N

Alarm and carrier level indication
With loss–of–dc power alarm relay RF output alarm relay, received carrier level margin alarm relay, carrier level indicating instrument on module and carrier level analog output (0–100 ua) for external instrument — A
No alarm relays, no carrier level indication or carrier level output — N

References

TC–10B Transmitter/receiver	IL 41–944.80
TCF–10B Transmitters and receivers	IL 41–945.90
RF Skewed hybrid H1SB	IL 41–948.6
RF Hybrids type H1R, H2R, H3X, H1RB, H2RB, H3XB	IL 41–948.5
TAMP–100 100 watt amplifier	IL 41–968.1