

H4000
Ethernet Transceiver

Technical Manual
EK-H4000-TM.PRE

H4000 ETHERNET TRANSCEIVER Technical Manual

EK-H4000-TM-PRE

November, 1982

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Chapter 1

Introduction

1.1 Technical Manual Overview

This manual is intended for those involved in the development of Ethernet products which will interface with the H4000 DIGITAL Ethernet Transceiver (hereafter referred to as the transceiver), those with an interest in the operation of the transceiver, and DIGITAL Field Service Personnel. This manual provides the following information:

- Physical and functional descriptions of the transceiver.
- The requirements for interfacing to the transceiver
- Sample circuits which may be used to interface with the transceiver.
- A description of the operation of the transceiver.
- Repair information applicable to the transceiver.

1.2 H4000 Digital Ethernet Transceiver

Figure 1-1 shows a sample configuration of an Ethernet physical channel of which the transceiver is a part. As shown, the transceiver provides the interface between the coaxial cable and the transceiver cable.

1.2.1 Transceiver Interfaces

Coaxial Cable Interface

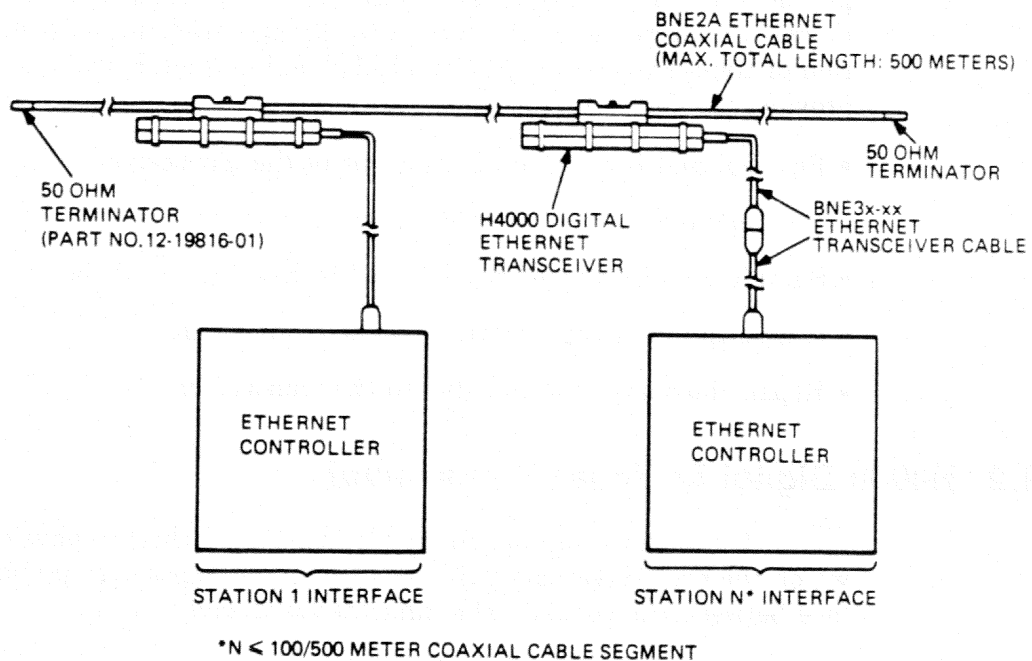
Figure 1-2, a cutaway view of the transceiver and the coaxial cable, shows the physical and electrical interface between the transceiver and the coaxial cable. The transceiver housing attaches directly to the coaxial cable, securing the transceiver to the cable. The transceiver housing contains braid contacts, center conductor contact, and center conductor backing pin. When the transceiver is attached to the coaxial cable, the braid contacts penetrate the coaxial cable outer jacket and make contact with the coaxial cable shield. The

center conductor contact and center conductor backing pin penetrate the coaxial cable outer jacket, shield, and dielectric through preconditioned holes and make contact with the coaxial cable center conductor. The center conductor backing pin makes certain that good contact is made and maintained between the center conductor contact and the coaxial cable center conductor. The braid contacts and center conductor contact of the transceiver connect to the transceiver module as shown in Figure 1-2.

Transceiver Cable Interface

The physical and electrical interface between the transceiver and the transceiver cable is provided by a 15 pin D sub-miniature connector on the transceiver module. This interface is used to:

- Supply power to the transceiver,
- Provide a communications link between the transceiver and a controller or repeater.



TK-9356

Figure 1-1: Sample Ethernet Physical Channel Configuration: Single Coaxial Cable Segment

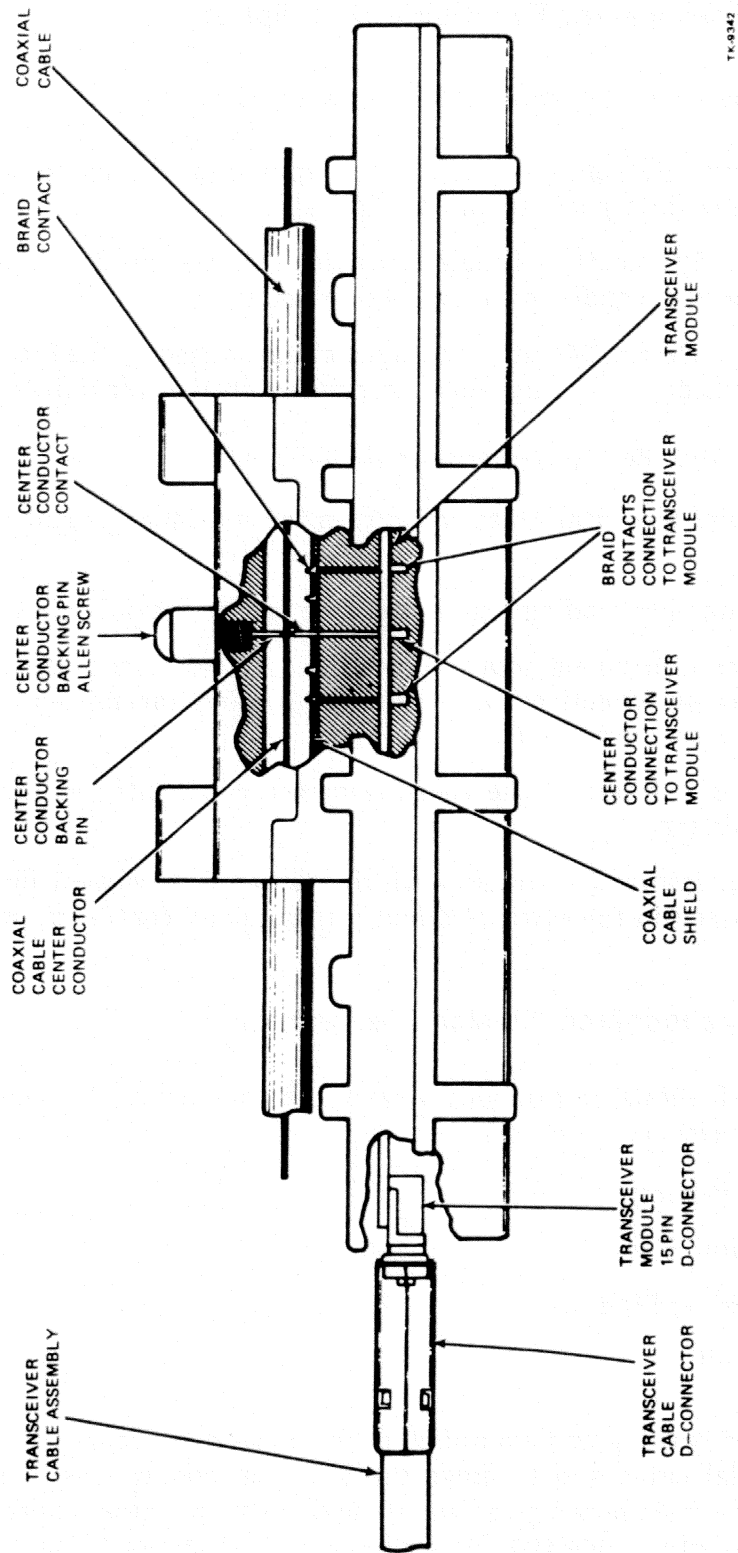


Figure 1-2: H4000 Ethernet Transceiver: Cutaway View Showing Coaxial Cable Interface

1.2.2 Transceiver Functional Description

The transceiver performs the following functions:

- **Transmit:** Responds to the signals input from the transceiver cable and transmits the signals on the coaxial cable.
- **Receive:** Responds to signals transmitted on the coaxial cable and couples the received signals to the transceiver cable.
- **Collision Detect:** Monitors the signals transmitted on the coaxial cable and, if a collision occurs, signals appropriately on the transceiver cable.

Additionally, the transceiver does the following:

- Maintains electrical isolation between the coaxial cable and the transceiver cable,
- Maintains low loading/high impedance on the coaxial cable,
- Provides continuous data loopback (i.e., the receiver portion of the transceiver is always active; thus, the message being transmitted is coupled back on the transceiver cable,
- Provides self test of the collision detection circuitry at the end of each transmission,
- Contains protective circuitry which ensures that network integrity will be maintained in the event of a faulty transceiver, controller, or repeater.

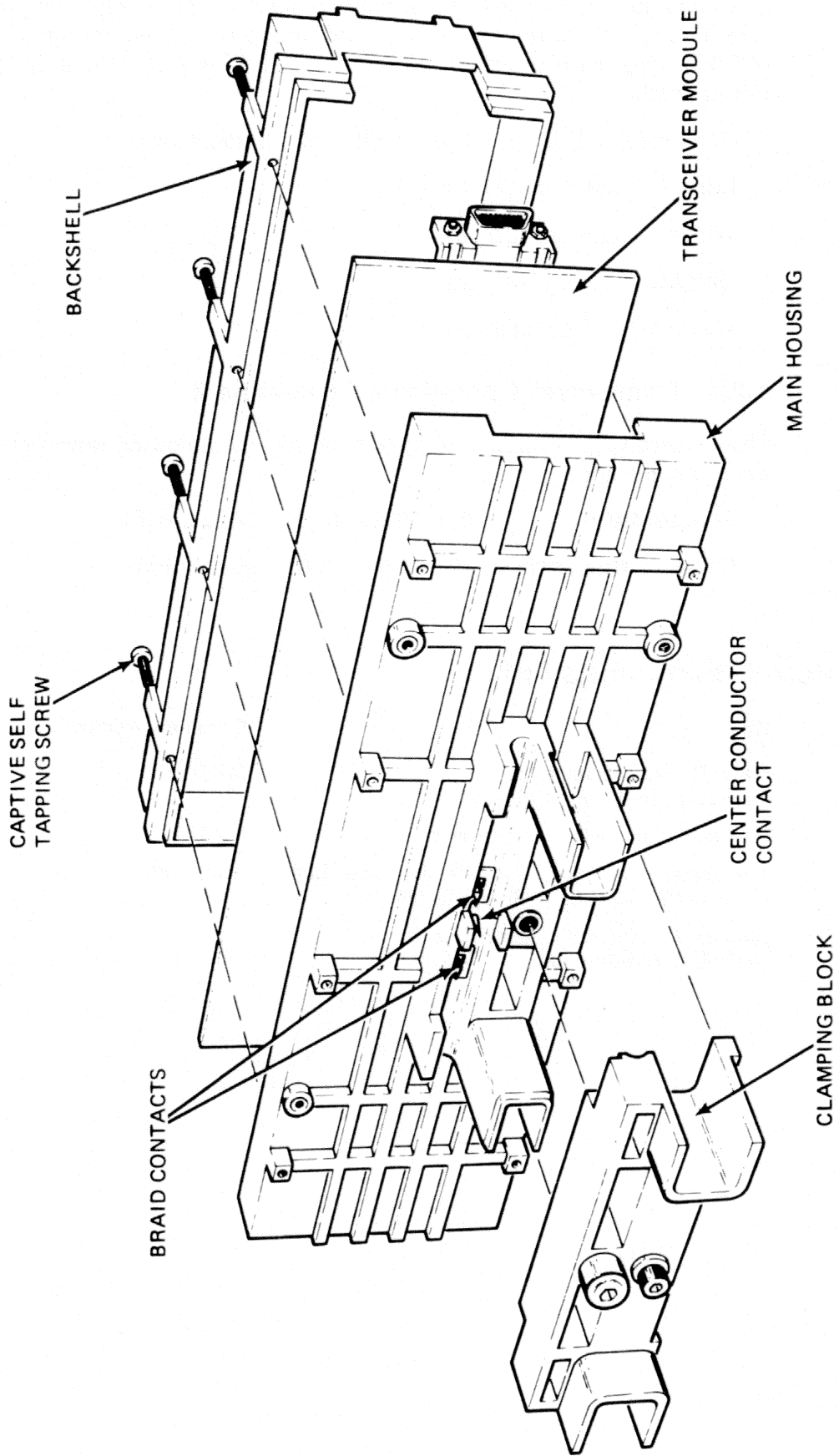
1.2.3 Transceiver Physical Description

Figure 1-3 shows an exploded view of the transceiver. As shown, the transceiver consists of:

- Main Housing
- Clamping Block
- Transceiver Module
- Backshell

The main housing and clamping block are used to secure the transceiver to the coaxial cable and to make the electrical connections with the coaxial cable. The main housing and clamping block make these connections through a non-intrusive cable tap. This allows the transceiver to be installed on an operational network without any disruption of the network.

The transceiver module contains the electronic portion of the transceiver and is press-fit into the main housing. A connector on the transceiver module provides the interface between the transceiver and the transceiver cable.



TK-9370

Figure 1-3: H4000 Ethernet Transceiver: Exploded View

The backshell is secured to the main housing with 8 self tapping captive screws. This allows the transceiver module to be removed and replaced without removing the transceiver from the coaxial cable and without disruption of the network.

The transceiver has the following physical characteristics:

Length: 30.2 cm (11.9 in)

Width: 9.5 cm (3.7 in)

Height: 9.0 cm (3.5 in)

Weight: 1.1 kg (2.5 lb)

1.2.4 Transceiver Operational Environment

The transceiver is designed to operate within the following ranges of environmental conditions:

Temperature: 5 to 50 deg C (41 to 122 deg F)

Relative Humidity: 10% to 90% (no condensation)

1.3 Related Documentation

Title	Document Number
H4000 Ethernet Transceiver Field Maintenance Print Set	MP-01369
Introduction to Local Area Networks	EB-22714-18
The Ethernet, A Local Area Network, Data Link Layer and Physical Layer Specifications	AA-K759A-TK
National Fire Protection Association National Electrical Code	

Chapter 2

Interfacing Requirements

2.1 Overview

This section specifies the requirements for interfacing to the transceiver. The physical and electrical characteristics are described in sufficient detail as to allow an engineer to design compatible interface circuits. Sample circuits which conform to the interface requirements of the transceiver are also shown.

2.2 Cabling

2.2.1 Transceiver Cable Configuration

A shielded and jacketed cable assembly must be used to connect the transceiver to the controller or repeater. To provide for the proper interface to the transceiver and to allow for end-to-end matching of the transceiver cables, the transceiver cable connectors must be configured as follows:

Transceiver End	Controller End
Female 15 Pin	Male 15 Pin
D Subminiature	D Subminiature
Connector with	Connector with
Slide Latch	Locking Post
Assembly	Assembly

The electrical connections for the transceiver cable are as follows:

Transceiver End		Controller End	
Backshell	-----Shield-----	Shield-----	Backshell
Pin 1	---Shield	Shield---	Pin 1
Pin 2	-----Collision Presence (+)-----	-----	Pin 2
Pin 3	-----Transmit (+)-----	-----	Pin 3
Pin 4	No Connection		Pin 4
Pin 5	-----Receive (+)-----	-----	Pin 5
Pin 6	-----Power Return-----	-----	Pin 6
Pin 7	No Connection		Pin 7
Pin 8	No Connection		Pin 8
Pin 9	-----Collision Presence (-)-----	-----	Pin 9
Pin 10	-----Transmit (-)-----	-----	Pin 10
Pin 11	No Connection		Pin 11
Pin 12	-----Receive (-)-----	-----	Pin 12
Pin 13	-----Power-----	-----	Pin 13
Pin 14	No Connection		Pin 14
Pin 15	No Connection		Pin 15

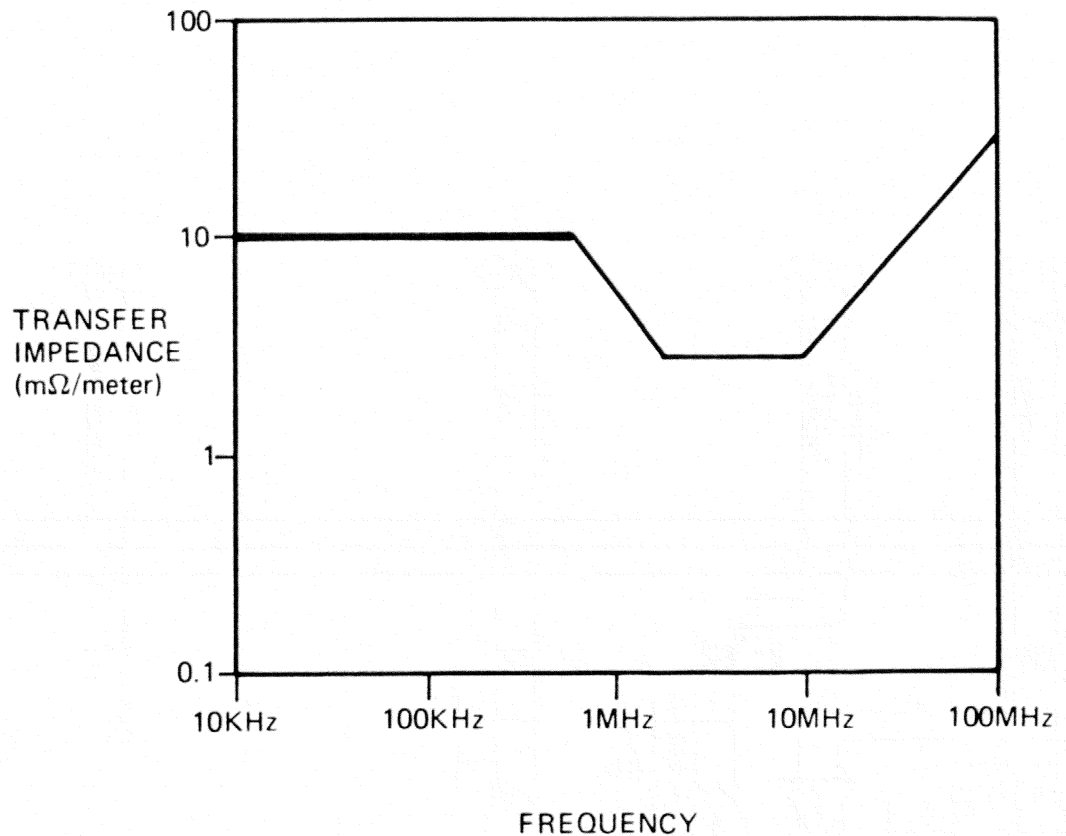
2.2.2 Transceiver Cable Electrical Requirements

The transceiver cable must meet the following requirements:

- Characteristic Impedance: 78 +/-5 Ohms
- Transfer Impedance (common mode): Shall not exceed the values shown in Figure 2-1 as a function of frequency.
- Transfer Impedance (differential mode): 20 dB lower than that specified for common mode with respect to any signal pair.
- DC Resistance: < 40 milli Ohms/meter
- Attenuation: < 3 dB (measured at 10 MHz) for the total length between the transceiver and the controller
- Propagation Velocity: 0.65 c minimum (5.13 nsec/meter)

2.3 Controller or Repeater Bulkhead Connector Requirements

Bulkhead connectors with internal filters designed for low-speed EIA or 20 mA loop devices should not be used. Use connectors which conform to MIL-C-24308 or commercial equivalent. The bulkhead connector must be a female 15 pin D subminiature connector with slide latch assembly.



TK-9348

Figure 2-1: Transceiver Cable Transfer Impedance as a Function of Frequency

2.4 Grounding and Shielding Requirements

The shield of the transceiver cable must be connected to the chassis of the device housing the controller or repeater as shown in Figure 2-2. The connection must be a direct, low inductance (not to exceed 50 nH) connection. Both Pin 1 of the bulkhead connector and the backshell of the mating transceiver cable connector must be connected to the chassis. Connecting Pin 1 of the bulkhead connector only is not adequate; a direct connection between the transceiver cable connector backshell and the chassis must be provided also.

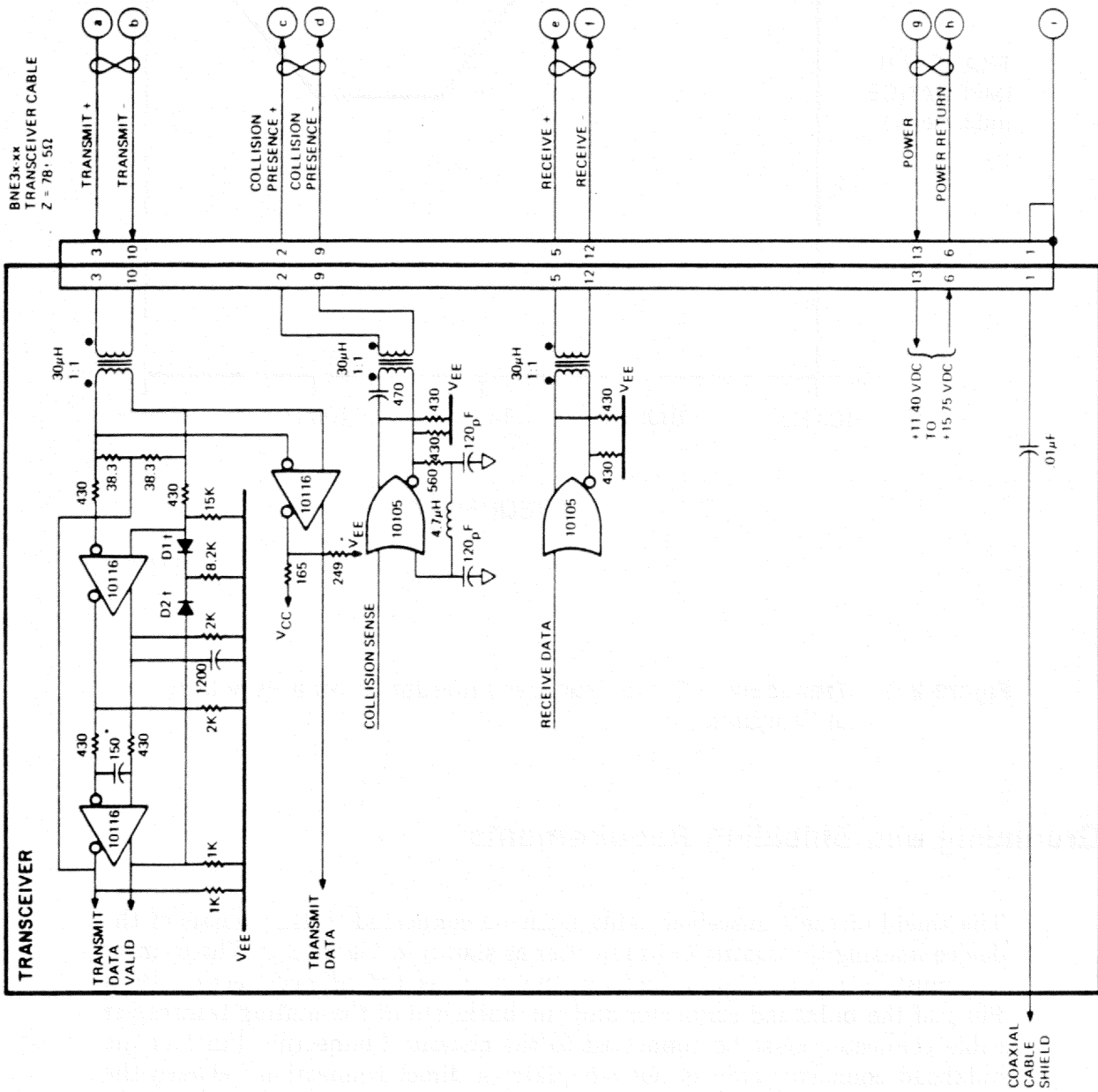
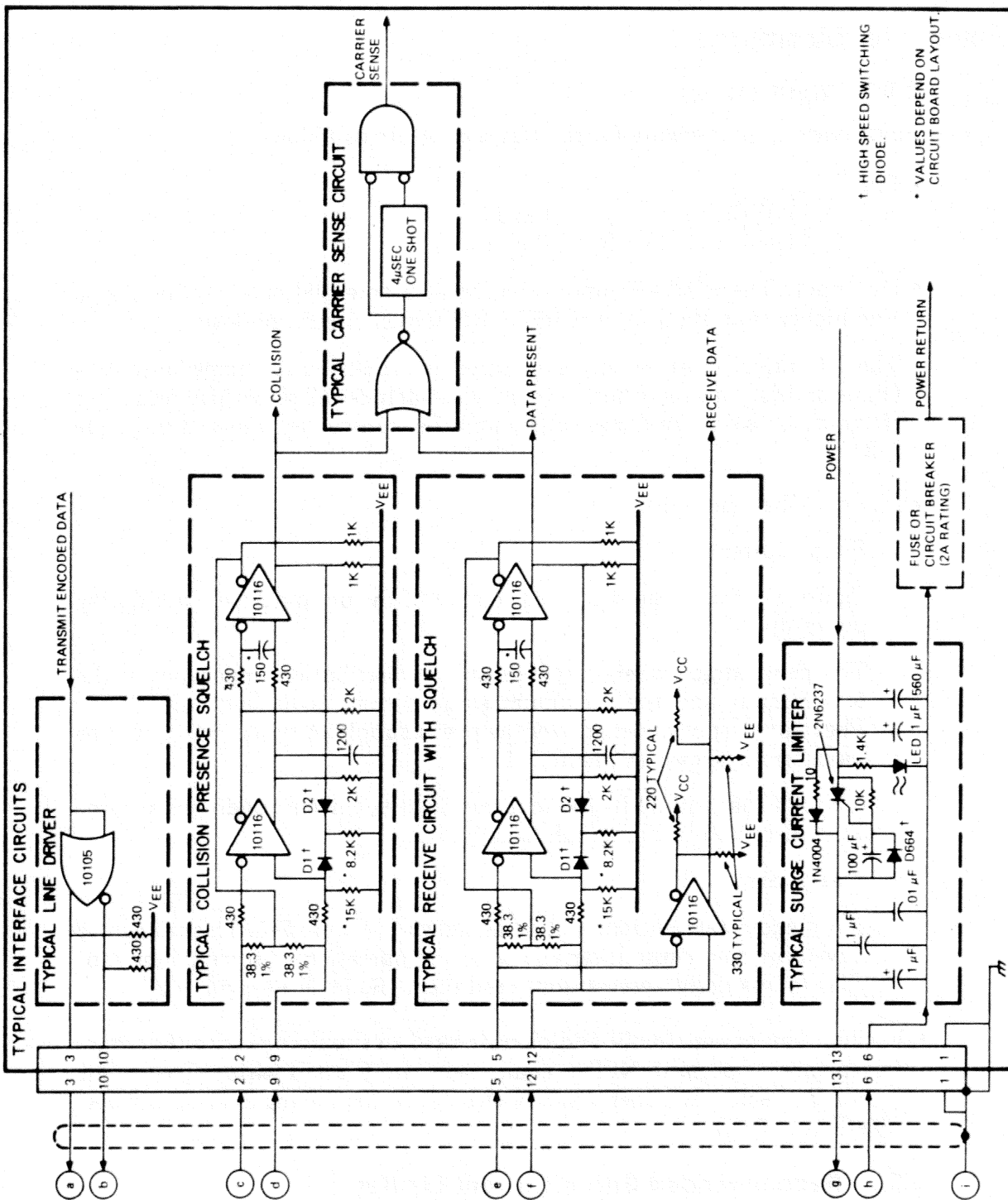


Figure 2-2: Typical Interface to Transceiver



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Figure 2-2 (Cont.): Typical Interface to Transceiver

2.5 Power Requirements

2.5.1 Input Power

Input power requirements for the transceiver are as follows:

- Pins:

POWER	Pin 13
POWER RETURN	Pin 6

- DC Input: The POWER input must be at a potential of +11.40 to +15.75 Vdc higher than the POWER RETURN (Open circuit; no load).

The DC input must be supplied through a distribution impedance of 4 Ohms or less. This distribution impedance includes all series loop resistance elements between the power source and the transceiver as shown in Figure 2-3.

- Current Characteristics:

1. Surge Current:

Figure 2-4 shows the equivalent circuit of the dc-to-dc converter during power-up.

The peak surge current depends on the distribution impedance of the power input and the maximum surge current is limited only by the Thevenin output impedance of the power supply. A typical surge current waveform is shown in Figure 2-5.

A circuit that will limit the surge during peak current conditions at turn-on is discussed in Paragraph 2.5.2.

2. Steady State

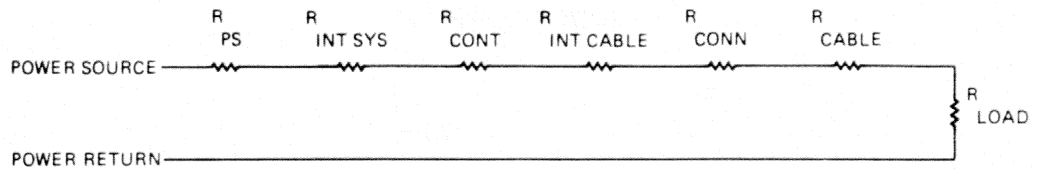
The steady state current will be as shown in Figure 2-5. This triangular waveform may cause interference to the operation of some power supplies unless design precautions are taken. (Refer to Paragraph 2.9.)

- Fusing: The power supply and circuits used to supply power to the transceiver must conform to NFPA requirements for Class II wiring. The circuit may be protected by either a fuse or circuit breaker having a rating of 2.0 A. (See Figure 2-2.)

2.5.2 Recommended Surge Current Limiter

It is recommended that a surge current limiter such as the one shown in Figure 2-2 be used to limit the current during turn-on. This circuit inserts a resistor in series with the POWER input to the transceiver during start-up. The resistor is bypassed by an SCR after about 40 msec, which is a sufficient time to limit the initial surge current.

If a surge current limiter is used, the impedance added by the circuit must be considered in the distribution impedance of the power input to the transceiver.



R_{PS} - POWER SUPPLY OUTPUT IMPEDANCE

$R_{INT\ SYS}$ - WIRE RESISTANCE FROM POWER SOURCE TO CONTROLLER. (TYPICALLY 85.8 MILLI OHMS/METER FOR 24 AWG WIRE.)

R_{CONT} - ETCH RESISTANCE OF CONTROLLER.

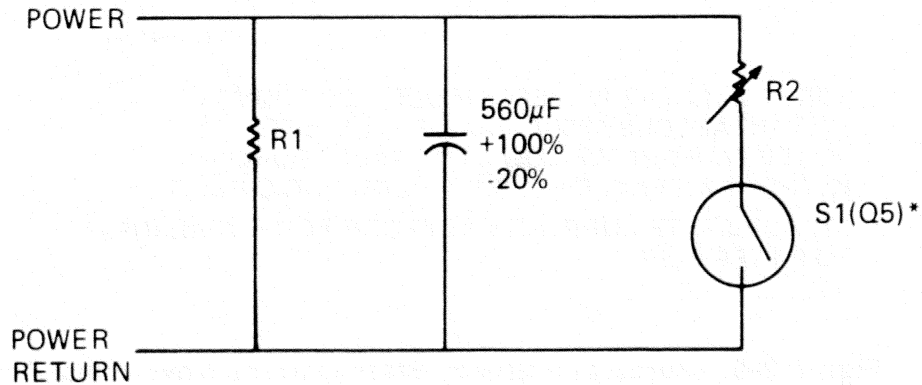
$R_{INT\ CABLE}$ - WIRE RESISTANCE FROM CONTROLLER TO TRANSCEIVER CABLE CONNECTOR.

R_{CONN} - RESISTANCE OF CABLE CONNECTORS (5 MILLI OHMS PER D-CONNECTOR PAIR)

R_{CABLE} - DC RESISTANCE OF TRANSCEIVER CABLE. (33.9 MILLI OHMS/METER FOR DIGITAL TRANSCEIVER CABLES.)

TK-9345

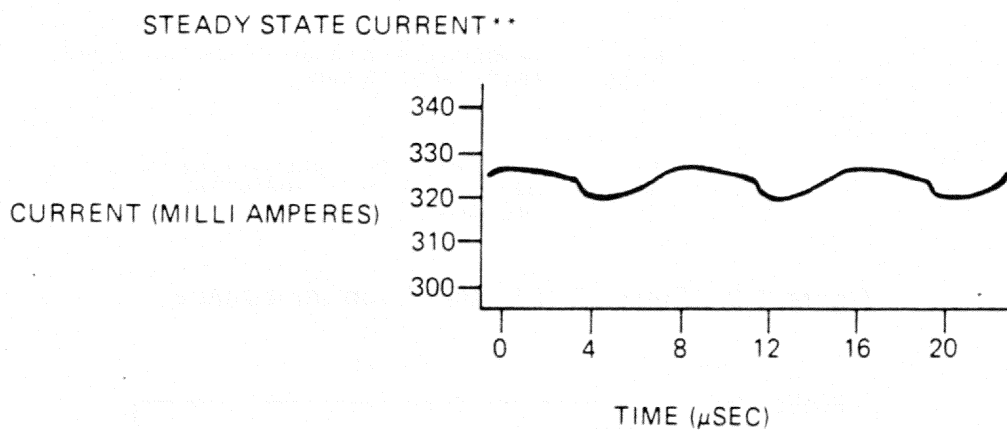
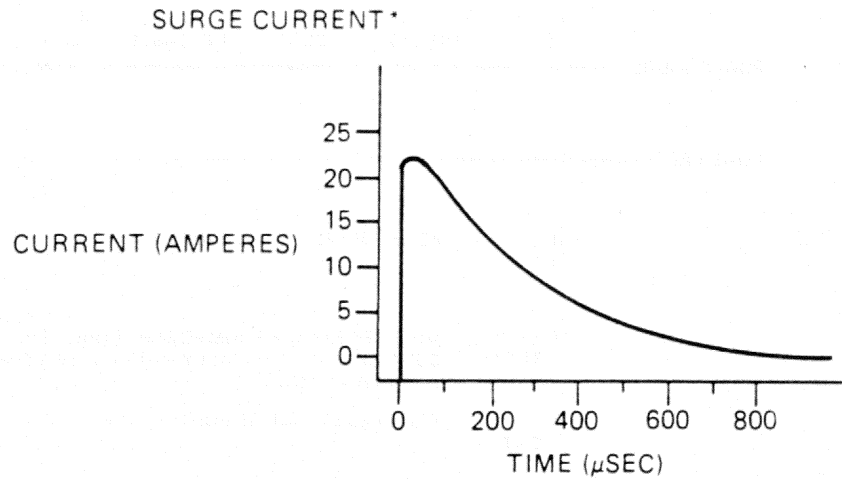
Figure 2-3: Power Distribution Loop Impedance



* STATE OF S1 IS NOT DEFINED AT T_0 :
 S1 OPEN (Q5 OFF), $R1 \sim 175\ OHMS$;
 S1 CLOSED (Q5 ON), $R2 =$ RESISTANCE OF Q5 WHEN ON, INPUT INDUCTOR, AND COUPLING TRANSFORMER. (SECONDARY EFFECTS OF S1 ARE SOURCE IMPEDANCE DEPENDANT.)

TK-9476

Figure 2-4: Equivalent Circuit of DC-to-DC Converter at Time Power is Applied to Transceiver



- * SURGE CURRENT WAVEFORM DERIVED FROM INSTANTANEOUS ASSERTION OF +12 Vdc TO POWER PAIR FROM A LOW IMPEDANCE SOURCE, WITHOUT AN EXTERNAL SURGE LIMITING CIRCUIT.
- ** STEADY STATE CURRENT WAVEFORM FOR +12 Vdc INPUT TO POWER PAIR.

TK-9346

Figure 2-5: Surge and Steady State Current Waveforms: Power Pair

2.6 Transmit Pair

2.6.1 Drive Circuit Requirements

To transmit, the transmit pair of the transceiver cable must be driven as follows:

- Pins:

TRANSMIT (+)	Pin 3
TRANSMIT (-)	Pin 10
- Drive Levels: +/-550 mV minimum, +/-1.2 V maximum
- Source Impedance of driver: > 415 Ohms

2.6.2 Recommended Transmit Signal Line Driver

A typical line driver circuit which may be used to drive the TRANSMIT (+) and TRANSMIT (-) signal line pair is shown in Figure 2-2. The output impedance of the line driver shown in Figure 2-2 is 430 Ohms, nominally.

2.6.3 Transceiver Input Response Characteristics

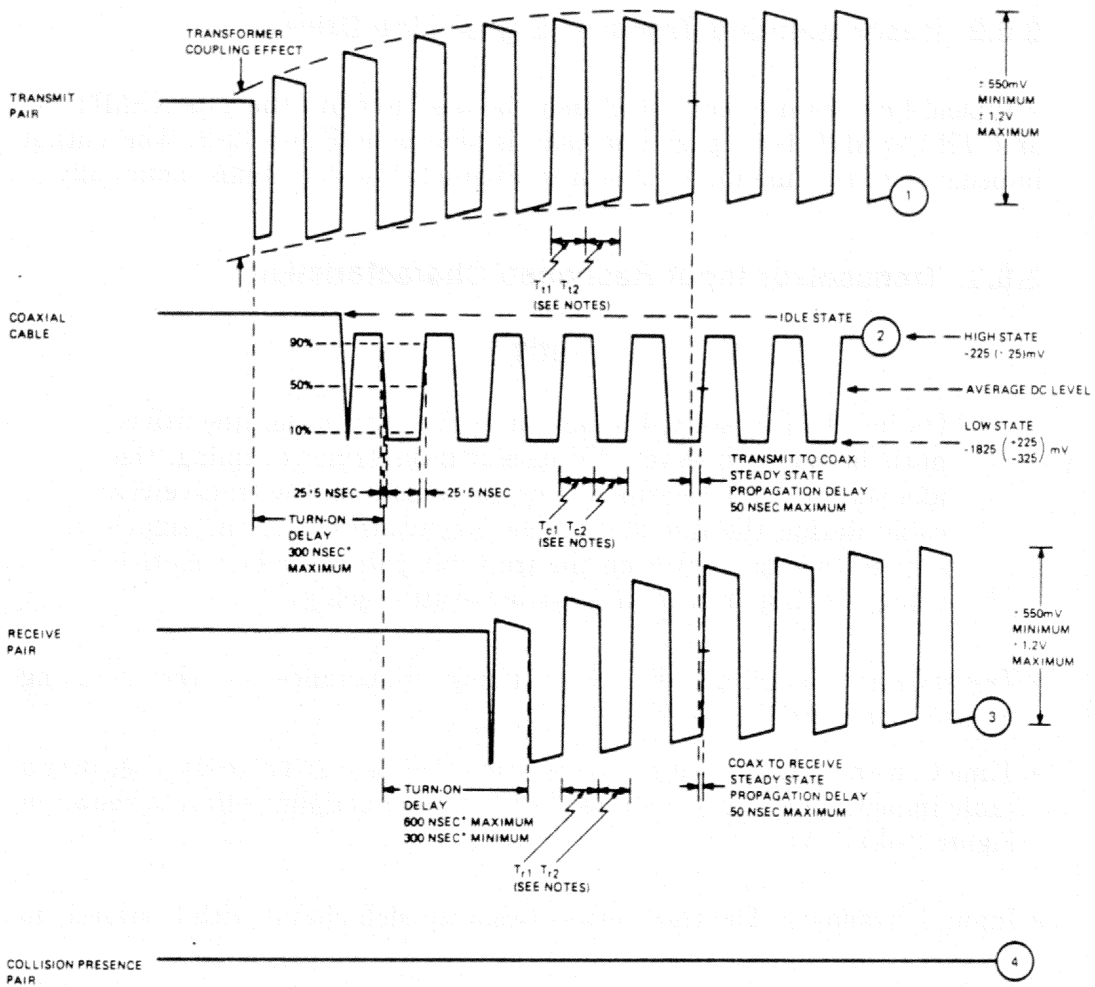
NOTE

During the idle state, the output of the differential line driver must be high. However, because of transformer coupling, the idle state output voltage will decay to zero on the transceiver cable during the idle state. The first transition of the signal sent to the transceiver on the transmit pair must be negative going; the last transition must be positive going.

- Transformer Coupling: The magnetizing inductance of the coupling transformer is 30 uH +/-10%.
- Time Constant: Inductive-Resistive Time Constant is 335 to 600 nsec over a cable impedance of 78+/-5 Ohms. (Transformer coupling effect is shown in Figure 2-6.)
- Input Thresholds: The transceiver uses a squelch circuit with hysteresis to provide noise immunity. The squelch thresholds are as follows:
 1. Transmit Turn-On: The differential input signal must be more negative than -350 mV, nominal, (-400 mV, minimum) for a period of between 50 and 100 nsec to turn off the transmitter squelch.
 2. Transmit Stay-On: The differential input signal must be more negative than -150 mV, nominal, to keep the transmitter squelch turned off.
- Transmitter Timing:
 1. Turn-on Delay: The transmitter will turn on and transmit the first valid data on the coaxial cable within 300 nsec (maximum) after the first negative-going transition is sent on the TRANSMIT (+) and TRANSMIT (-) signal line pair.
 2. Turn-off: The transmitter will turn off between 120 and 160 nsec after the last positive transition is sent on the TRANSMIT (+) and TRANSMIT (-) signal line pair.

2.6.4 Transmit Waveform Data

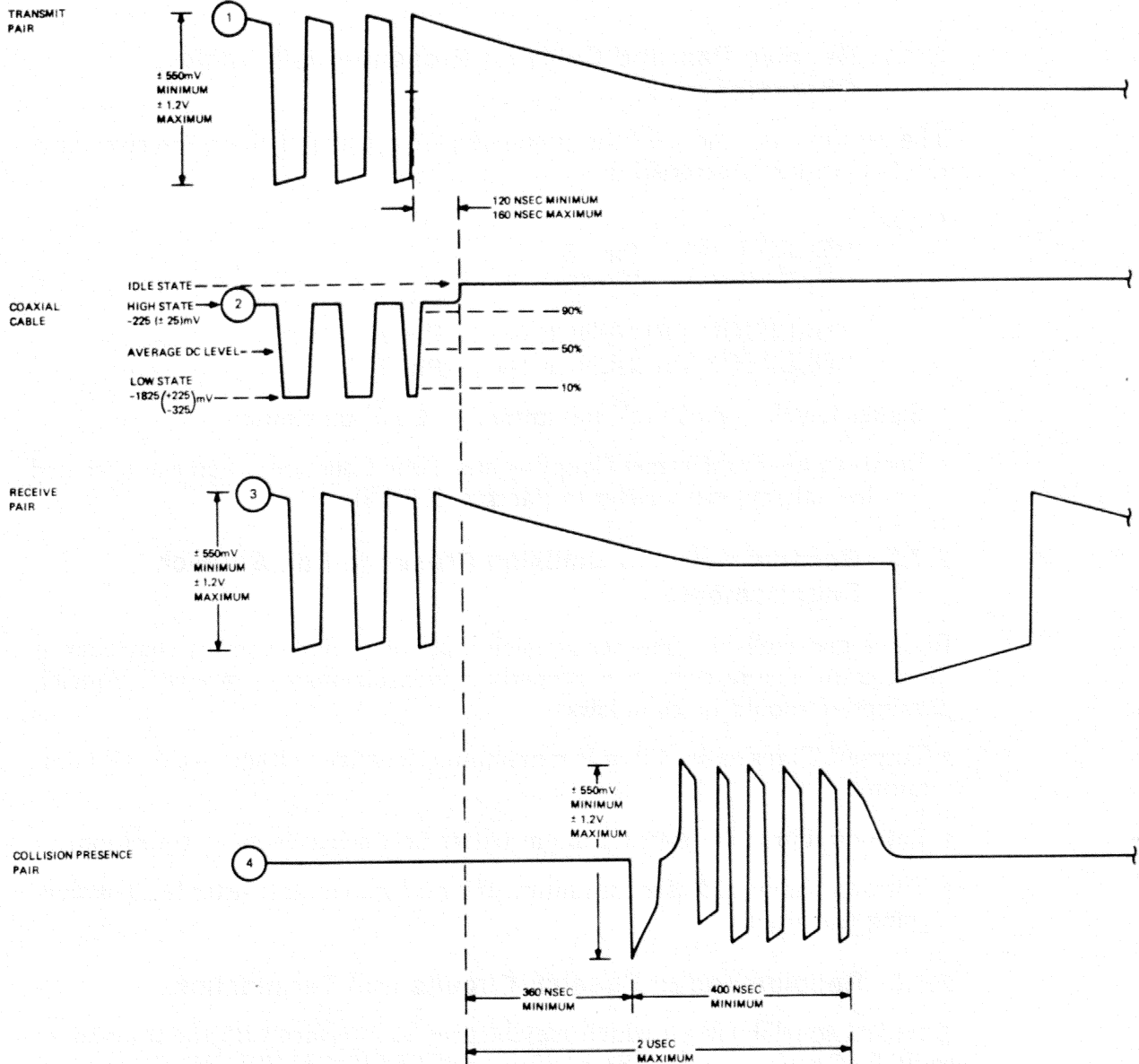
The waveform data presented in Figure 2-6 shows the transformer coupling effect and the timing characteristics of the transceiver outputs relative to the signals sent on the TRANSMIT (+) and TRANSMIT (-) signal line pair.



*TIMES SPECIFIED DO NOT INCLUDE PROPAGATION DELAY TIME
 NOTES
 FOR T_{r1} , T_{r2} (50% DUTY CYCLE): $|T_{c1} - T_{c2}| \leq 2$ NSEC
 FOR $T_{c1} \neq T_{c2}$: $|T_{r1} - T_{r2}| \leq 2$ NSEC

TK-8744

Figure 2-6: Interface Signal Waveforms



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Figure 2-6 (Cont.): Interface Signal Waveforms

2.7 Receive and Collision Presence Pairs

2.7.1 Receive Pair and Collision Presence Pair Output Characteristics

The receive pair and collision presence pair outputs of the transceiver have the following characteristics:

- Pins:

RECEIVE (+)	Pin 5
RECEIVE (-)	Pin 12
COLLISION PRESENCE (+)	Pin 2
COLLISION PRESENCE (-)	Pin 9
- Signal Levels: +/-550 mV minimum, +/-1.2 V maximum
- Receive Pair Transformer Coupling and Time Constant: (Same as specified for the transmit pair, Refer to Paragraph 2.6.3).

2.7.2 Receive Pair and Collision Presence Pair Squelch Requirements

Receive and collision presence squelch must be provided in the controller or repeater to ensure that only properly driven signals are received. Squelch parameters should be as follows:

- Turn-off Threshold: -175 mV maximum (Negative voltage), -400 mV minimum
- Turn-off Time: 50 nsec minimum (After first negative-going transition)
- Turn-on Time: 120 nsec minimum, 160 nsec maximum (After last positive-going transition)

2.7.3 Recommended Squelch Circuits and Termination

A typical squelch circuit which may be used to interface with the transceiver cable RECEIVE (+) and RECEIVE (-) or COLLISION PRESENCE (+) and COLLISION PRESENCE (-) signal line pairs is shown in Figure 2-2. The signal line pair inputs to the squelch circuit are properly terminated with the characteristic impedance of the transceiver cable (78 +/-5 Ohms). This termination is provided in the circuit by the 38.3 Ohm resistors across the signal line pair inputs.

2.7.4 Receive Waveform Data

The waveform data presented in Figure 2-6 shows the transformer coupling effect and the timing characteristics of the RECEIVE (+) and RECEIVE (-) signal line pair output of the transceiver relative to the signals sent on the TRANSMIT (+) and TRANSMIT (-) signal line pair and relative to the signals occurring on the coaxial cable.

2.7.5 Collision Presence Waveform Data

If a collision condition is detected, the transceiver sends a 10 MHz periodic waveform on the collision presence pair. The receiver may remain active during a collision, but the signal on the receive pair is not guaranteed valid; that is, the "data" on the receive pair should be ignored. Figure 2-7 shows typical waveforms and timing characteristics of the signal on the coaxial cable during simulated collision conditions and the resultant signals on the receive, and collision presence pairs.

A collision presence test signal is generated and sent on the collision presence pair at the end of each transmission. The timing characteristics of the collision presence test signal are shown in Figure 2-6.

2.8 Carrier Sense Requirements

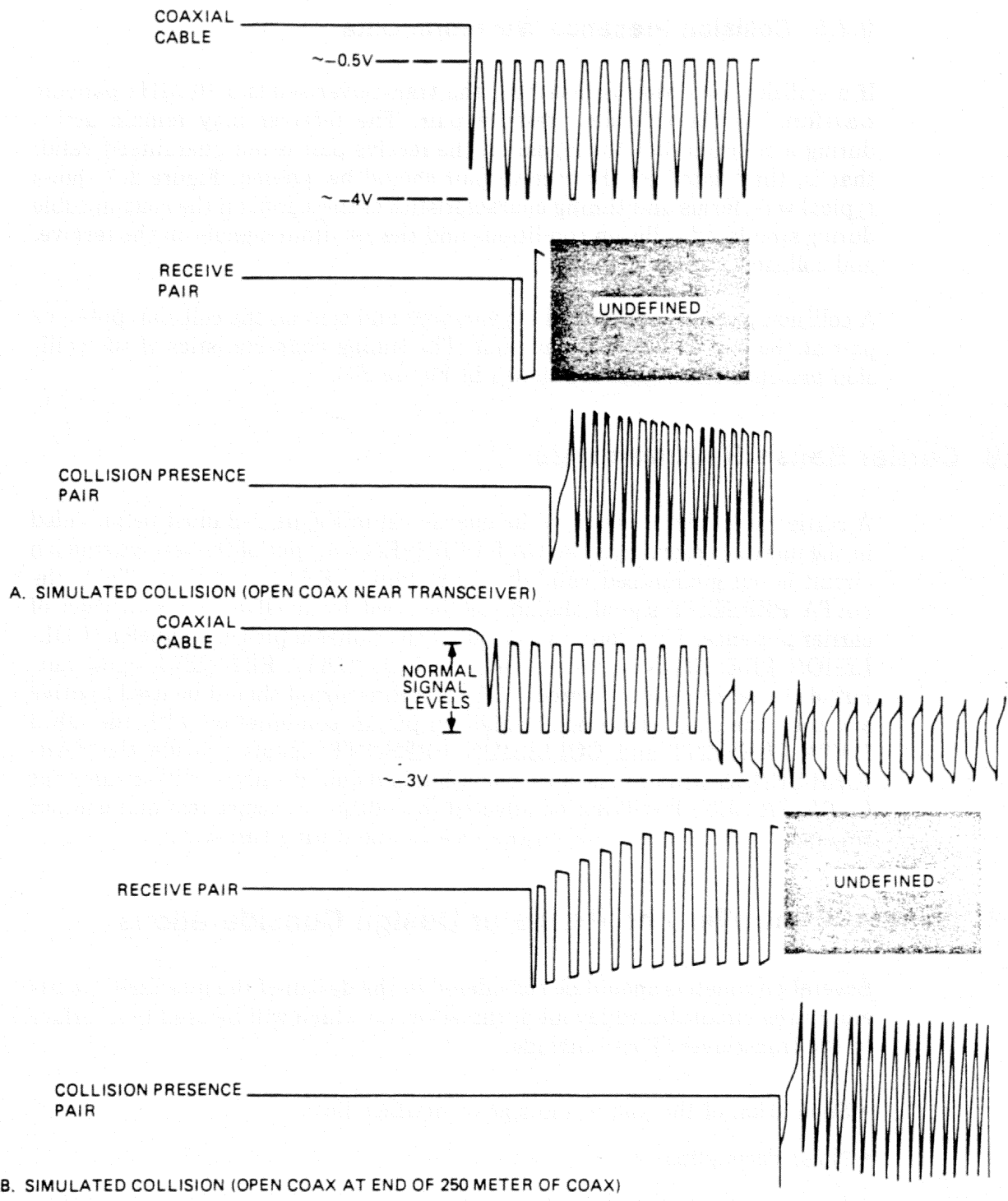
A carrier sense circuit such as the one shown in Figure 2-2 must be provided in the interface circuitry. The DATA PRESENT output of the receive squelch circuit is not guaranteed valid during certain collision conditions. Thus, the DATA PRESENT signal should not be used by itself as an indication of carrier presence. Therefore, the output of the collision presence squelch (COLLISION PRESENT) should be OR'd with the DATA PRESENT signal output of the receive squelch circuit. The resulting signal should be used to drive a 4 usec one-shot whose active high output in combination with the OR'd DATA PRESENT and COLLISION PRESENT signals provide the CARRIER SENSE signal. (The 4 usec oneshot is required since it will ensure that CARRIER SENSE will not be affected by collision presence test and will not respond to spurious glitches in the receive line during turn-off.)

2.9 General Controller and Repeater Design Considerations

Several parameters should be considered in the design of the interface circuits and in the circuit board layout of the device(s) which will be used to interface to the transceiver. These include:

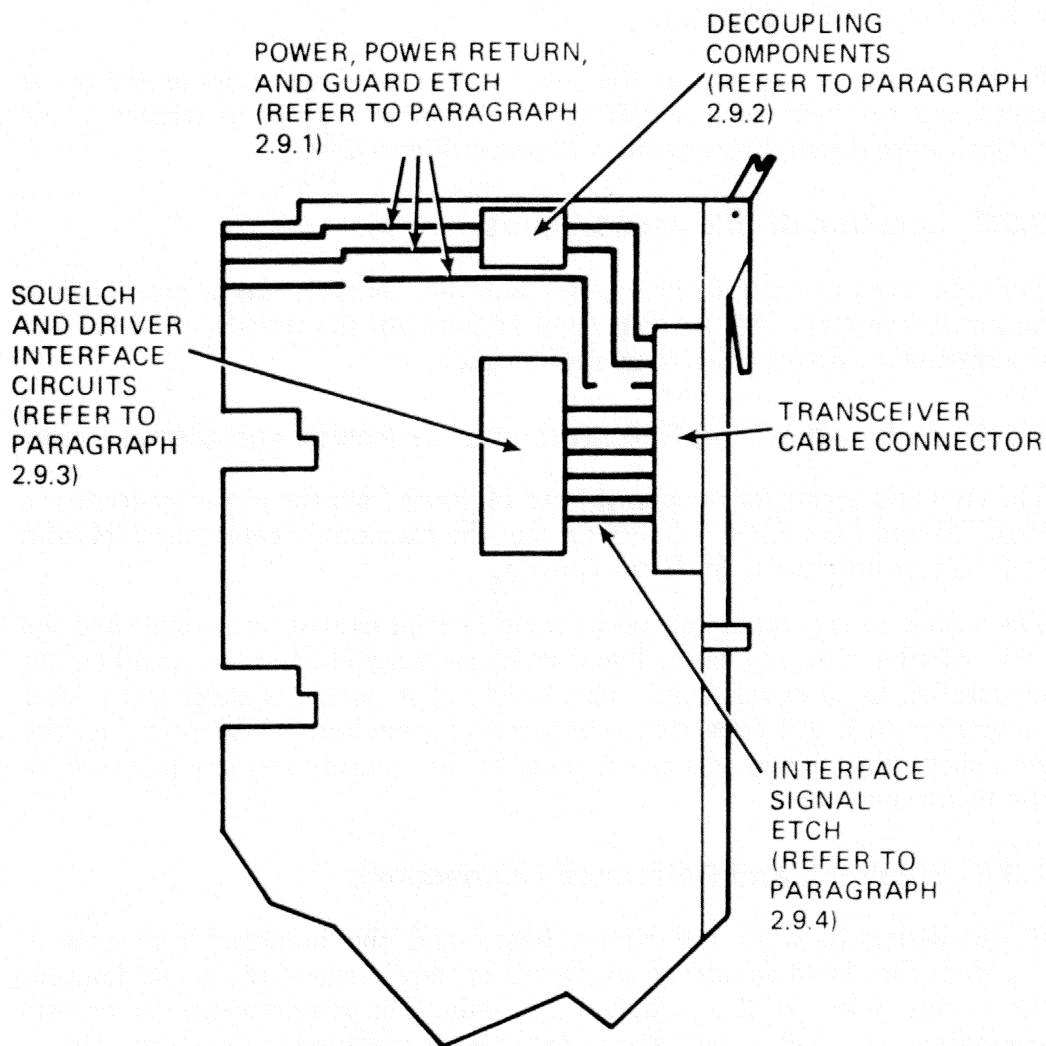
- Separation of the power and signal interface lines
- Noise decoupling
- Location of interface circuits
- Etch and wiring requirements for the power and signal lines
- Shielding and reference connections

Figure 2-8 shows a typical circuit board layout illustrating the parameters to be considered.



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Figure 2-7: Interface Signal Waveforms: Collision Conditions



TK-9475

Figure 2-8: Controller or Repeater Circuit Board Layout Parameters

2.9.1 Separation of Power and Signal Interface Lines

Care should be exercised to maintain adequate separation between the etch used for power and the etch used for signals to prevent interference. Ideally, a guard etch run should be provided to isolate the power distribution pair from all other signals on the controller or repeater circuit board. The guard etch should be connected to the logic reference on the circuit board.

Neither the power nor power return line should be connected to the logic reference of the circuit board, to prevent common mode noise coupling.

2.9.2 Noise Decoupling

Filters should be provided on the power pair to minimize noise on the power input and to guard against switching noise produced by the transceiver. A typical noise decoupling circuit is shown in Figure 2-9.

2.9.3 Location of Interface Circuits

The interface circuits for each of the signal line pairs should be positioned to minimize the length of the etch required between the transceiver cable and the squelch or driver circuits as appropriate.

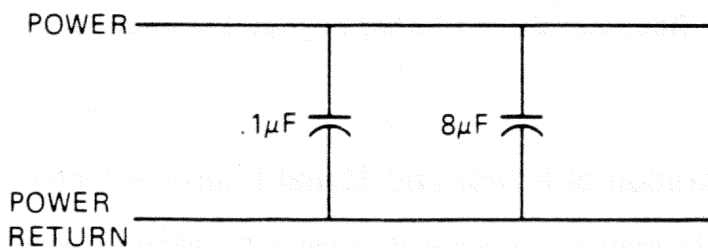
2.9.4 Etch and Wiring Requirements for Power and Signal Lines

The etch and wiring for the distribution of power from the power source to the POWER and POWER RETURN lines of the transceiver cable must conform to NFPA requirements for Class II wiring.

The wiring for the signal line pairs should be kept as short as possible and the wire pairs be of equal length. The etch for each signal line pair should be run in parallel, be of equal length, and layed out in such a manner as to avoid differences in board capacitance between the two lines of the pair (i.e., the etch should be treated as a continuance of the transmission line provided by the transceiver cable.

2.9.5 Shielding and Reference Connections

If the wiring between the circuit board and the bulkhead connector is shielded, the shield should be connected to the chassis of the device housing the circuit board at the bulkhead end only. The requirements for chassis grounding the shield of the transceiver cable are specified in Paragraph 2.4.



TK-9477

Figure 2-9: Noise Decoupling Circuit

Chapter 3

Circuit Description

A block diagram of the transceiver and its interface with the Ethernet coaxial cable and Ethernet transceiver cable is shown in Figure 3-1. As shown, the transceiver is made up of the following:

- Transmitter
- Receiver
- Collision Detector
- DC-to-DC Converter
- Isolation Transformers
- RF Shunt

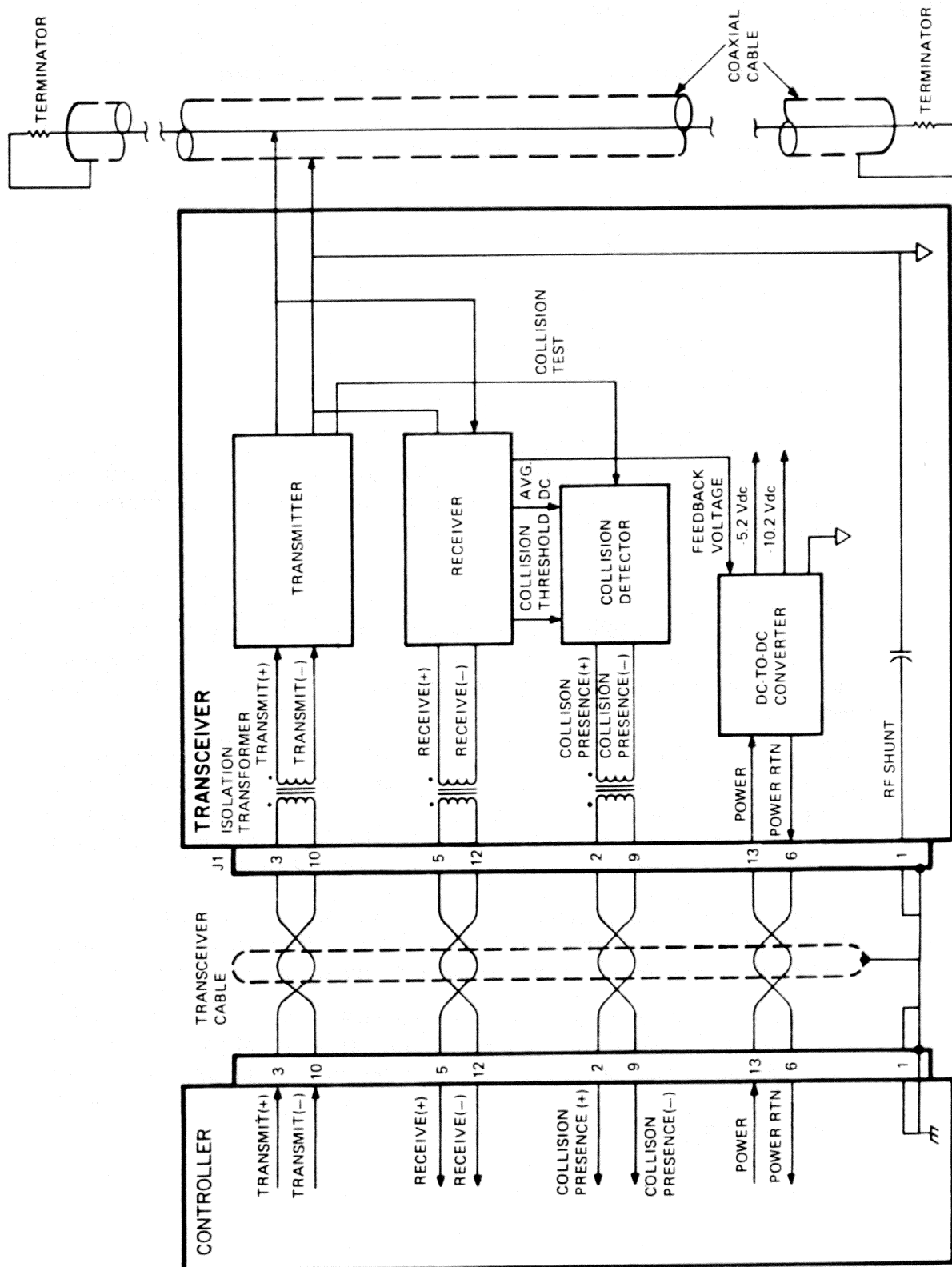
A description of the main functions performed by each of these circuits is provided in Table 3-1. The remainder of this section provides both functional and detailed descriptions of the major circuits.

Table 3-1: Main Functions of Transceiver Circuits

Circuit	Main Functions
TRANSMITTER	<p>Responds to the TRANSMIT (+) and TRANSMIT (-) signal inputs from the transceiver cable and transmits the signals on the coaxial cable.</p> <p>Limits the duration of each transmission to prevent the transmitter from becoming stuck on or continuously transmitting beyond the transmit time constraints.</p> <p>Initiates a test of the collision detector after each transmission to verify that the collision detector was operational during the transmission.</p> <p>Provides electrical protection between the transmitter and the coaxial cable to prevent a short circuit in the transmitter from shorting the coaxial cable.</p>

Table 3-1 (Cont.): Main Functions of Transceiver Circuits

Circuit	Main Functions
RECEIVER	<p>Responds to signals transmitted on the coaxial cable and couples the received signals to the RECEIVE (+) and RECEIVE (-) signal line pair of the transceiver cable.</p> <p>Monitors the average dc level of the signals on the coaxial cable to ensure that the detected signals are valid Ethernet signals before coupling the detected signals to the RECEIVE (+) and RECEIVE (-) signal line pair of the transceiver cable.</p> <p>Provides electrical protection between the receiver and the coaxial cable to guarantee that the failure mode at the receiver input will be an open circuit rather than a short.</p>
COLLISION DETECTOR	<p>Monitors the signals received from the coaxial cable to detect collision conditions (i.e., the condition where two or more transceivers are attempting to transmit simultaneously). If a collision is detected it sends an appropriate signal on the COLLISION PRESENCE (+) and COLLISION PRESENCE (-) signal line pair of the transceiver cable.</p> <p>Responds to the Collision Test input from the transmitter and sends an appropriate signal on the COLLISION PRESENCE (+) and COLLISION PRESENCE (-) signal line pair of the transceiver cable.</p>
DC-TO-DC CONVERTER	<p>Generates and regulates the operational voltages used by the transceiver from the power supplied on the POWER and POWER RETURN pair of the transceiver cable.</p>
ISOLATION TRANSFORMERS	<p>Maintain electrical isolation between the transceiver cable and the coaxial cable to prevent loop currents between Ethernet stations from corrupting the data communications capabilities of the Ethernet. (Electrical isolation is maintained at the POWER and POWER RETURN interface by the power transformer in the dc-to-dc converter.)</p>
RF SHUNT	<p>Prevents the buildup of large rf common mode voltages between the coaxial cable and the transceiver cable.</p>



TK-9339

Figure 3-1: H4000 Ethernet Transceiver: Functional Block Diagram

3.1 Transmitter Circuit Description

3.1.1 Transmitter Circuitry Functional Description

A block diagram of the transmitter is shown in Figure 3-2. As shown, the transmitter is made up of the following functional circuits:

1. Transmitter Squelch
2. Line Receiver/Buffer
3. Coaxial Cable Driver
4. Guard Circuits
5. Collision Test Generator

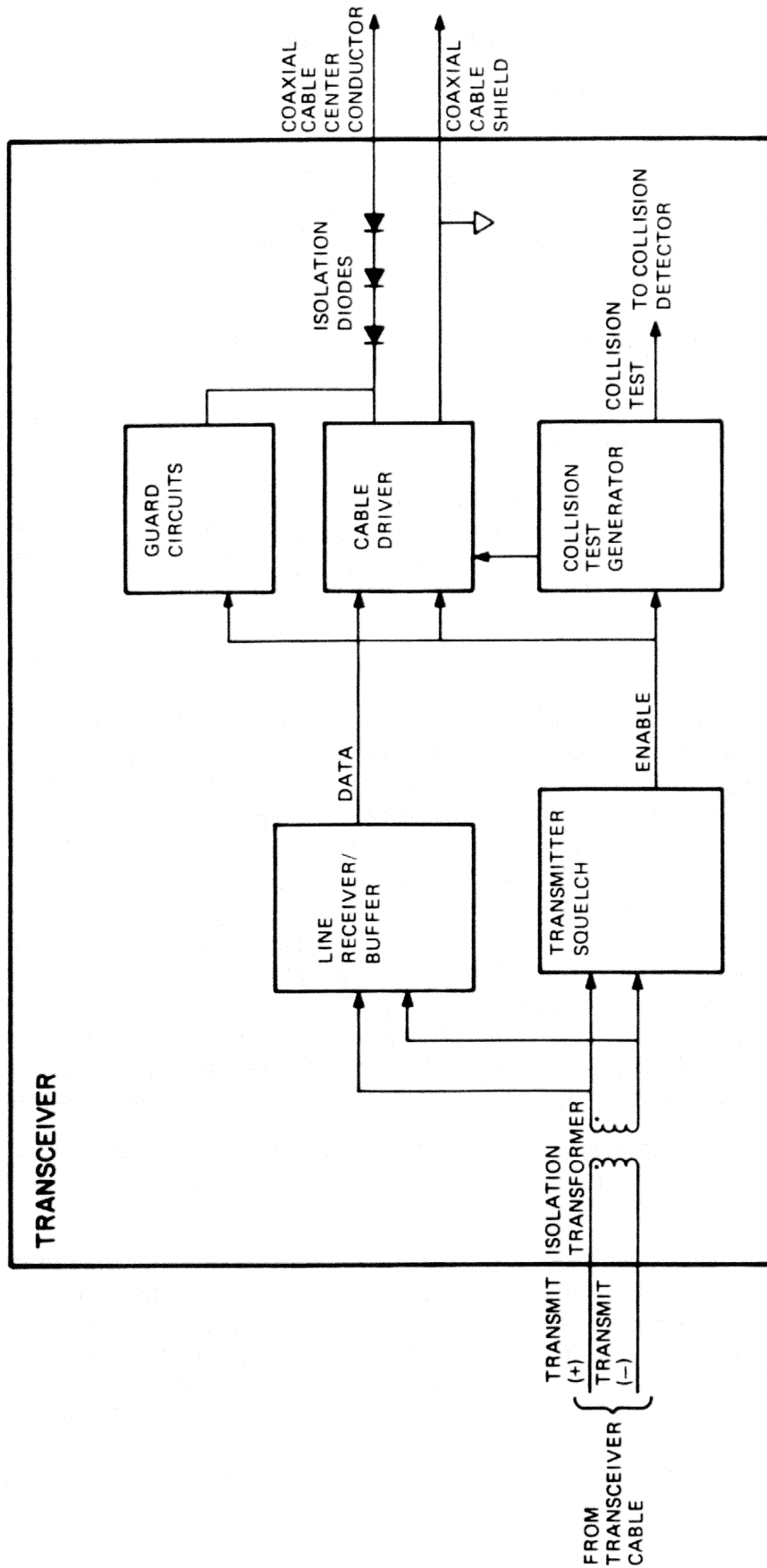
The TRANSMIT (+) and TRANSMIT (-) differential signal input from the transceiver cable is transformer coupled to the line receiver/buffer and transmitter squelch. The line receiver/buffer is a differential amplifier which drives the DATA signal input of the cable driver.

The transmitter squelch turns off only after the differential signal input has met specific threshold and timing requirements. When the transmitter squelch turns off, the ENABLE output enables the cable driver and the guard circuits. When the transmitter squelch turns on again, at the end of a transmission, the ENABLE output of the transmitter squelch turns on the collision test generator.

The cable driver responds to the changes in state of the DATA input from the line receiver/buffer and increases or decreases (as applicable) the amount of current drawn from the coaxial cable. The cable driver controls the rate of change in the current drawn from the coaxial cable and provides filtering to produce a controlled trapezoidal waveform on the coaxial cable.

The guard circuits are enabled at the same time that the cable driver is enabled. The guard circuits limit the amount of time that the transmitter may draw current from the coaxial cable during a single transmission.

The collision test generator is a 1 usec one-shot. When enabled by the ENABLE input, the collision test generator provides a current path by way of the COLLISION TEST signal line, which draws current through the low pass filter of the collision detection circuit. The current drawn through the low pass filter simulates a collision condition.



TK-9352

Figure 3-2: Transmitter: Functional Block Diagram

3.1.2 Transmitter Circuitry Detailed Description

Isolation Transformer

The isolation transformer at the input of the transmitter circuit (Figure 3-3) couples the differential signal on the TRANSMIT (+) and TRANSMIT (-) signal line pair of the transceiver cable to the inputs of the transmitter squelch and line receiver/buffer. Transformer coupling provides electrical isolation between the transceiver cable and the coaxial cable. The isolation transformer, E15A, has a magnetizing inductance of 30 μ H \pm 10%. The secondary of E15A is terminated differentially by R1 and R2 (shown as part of the transmitter squelch circuit). R1 and R2 match the impedance of the load with the impedance of the transceiver cable.

Line Receiver/Buffer

The line receiver/buffer, E4(3), is a differential amplifier which amplifies the signals from the secondary of the transformer. The active high output of the line receiver/buffer drives the DATA input to the cable driver. Resistors, R17 and R18, at the active low output are used for load matching of the active high and low outputs.

Transmitter Squelch

The transmitter squelch provides noise immunity for the transmitter by ensuring that the transmitter cable driver is turned on only when valid Ethernet signals are present on the TRANSMIT (+) and TRANSMIT (-) signal line pair. The initial turn-off threshold of the transmitter squelch is set at -350 mV (nominal), -400 mV (minimum). The transmitter squelch responds to signals which exceed, in the negative direction, the turn-off threshold and is turned off after the signal input has exceeded the turn-off threshold for a period of between 50 and 100 nsec. After the transmitter squelch has been turned off, the squelch threshold is lowered to -150 mV (nominal), which ensures that the transmitter squelch does not turn on prematurely. The transmitter squelch turns on between 120 and 160 nsec after the last positive transition occurs on the TRANSMIT (+) and TRANSMIT (-) signal line pair. When the transmitter squelch turns on, the initial threshold is re-established.

When the transmitter squelch turns off, it enables the cable driver. When the transmitter squelch turns on, it inhibits the cable driver and enables the collision test generator.

The transmitter squelch (Figure 3-3) consists of two differential amplifiers, E4(1) and E4(2). Before the transmitter squelch is turned off, the active low output of E4(2) -denoted by the inverting output- is high and the active high output is low. This condition causes diode D1 to be forward biased and diode D2 to be reverse biased. When D1 is forward biased, current flows through R1 and the secondary of E15A in parallel with R2, through R4, and R5 in parallel with R6 and D1, which establishes a dc offset between the inputs of E4(1). This dc offset results in a threshold requirement for E4(1) of -350 mV (nominal), -400 mV (minimum). E4(1) turns on when the differential signal input from the secondary of the isolation transformer exceeds the threshold voltage requirement. When E4(1) turns on, it amplifies the input signal to the extent

that it exceeds the threshold voltage. Thus, E4(1) turns on when the input signal is negative and turns off when the input signal is positive. When E4(1) turns on, it starts charging capacitor C2 through R9 and R10. C2 in combination with R9 and R10 determine the squelch turn-off time constant. To charge C2 to the point where it will cause E4(2) to turn on requires that E4(1) be turned on for a cumulative period of between 50 and 100 nsec. Note that due to the turn-on requirements of E4(1), C2 cannot be fully charged during the first 50 nsec transition of the input signal.

When E4(2) turns on (i.e., the transmitter squelch turn-off threshold requirements have been met), the output of E4(2) changes state. When E4(2) changes state, the active low output of E4(2) goes low, reverse biasing diode D1. The active high output of E4(2) goes high, which forward biases diode D2. This provides the dc offset at the input of E4(1) which changes the threshold voltage requirement to -150 mV (nominal).

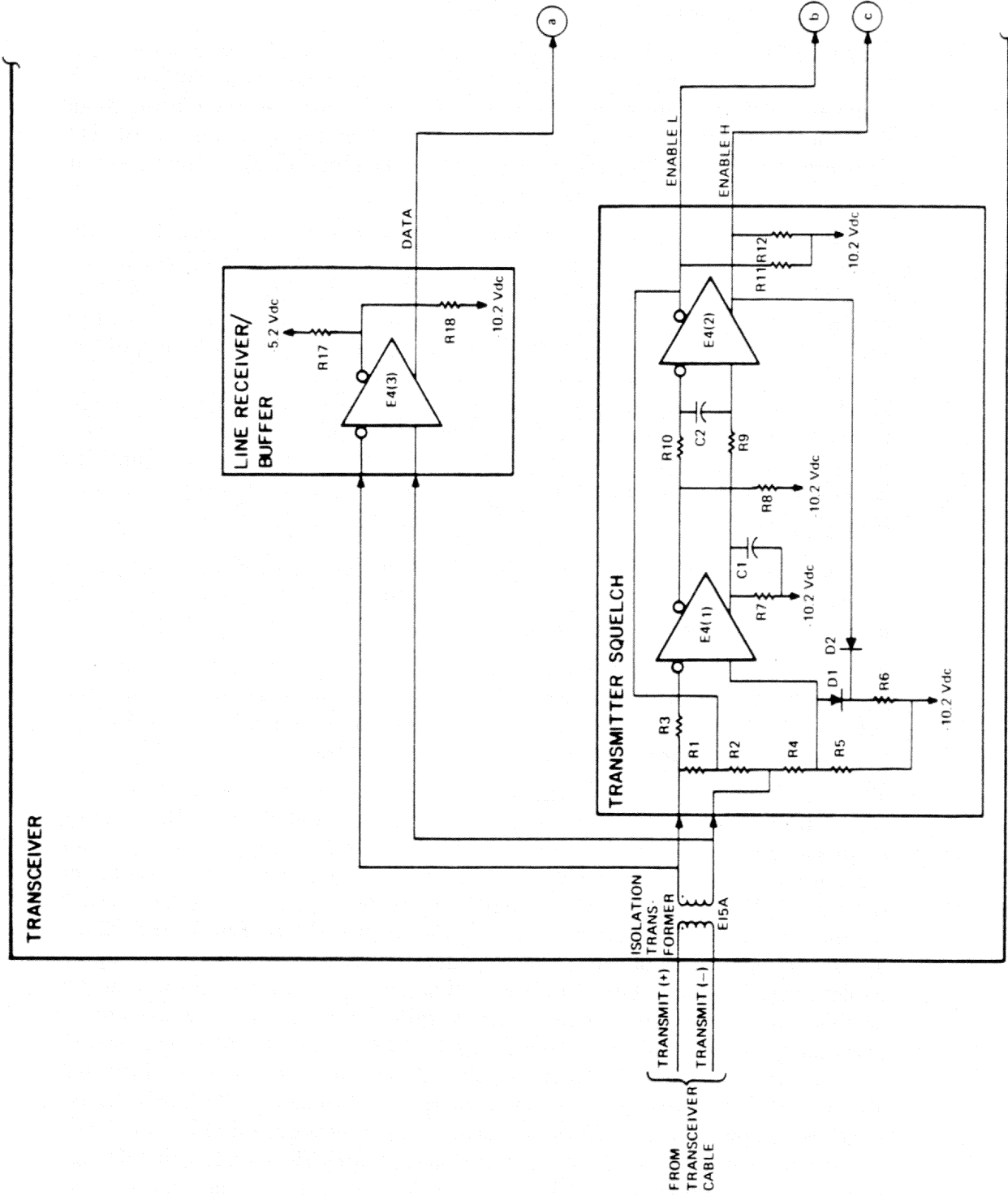
The transmitter squelch turn-on time constant is established by C1 and R7. C1 is instantly charged and recharged each time E4(1) is turned on. During E4(1) off time (i.e., during the positive portion of the input signal), C1 discharges through R7. In an Ethernet environment, the last transition sent on the TRANSMIT (+) and TRANSMIT (-) signal line pair will be positive going. Thus, E4(1) turns off and C1 discharges through R7. The time constant of C1 and R7 ensures that E4(2) will turn off between 120 and 160 nsec after the last transition sent on the TRANSMIT (+) and TRANSMIT (-) signal line pair. When E4(2) turns off, the outputs of E4(2) change state, and the initial threshold requirements of the transmitter squelch are re-established.

Cable Driver

The cable driver (Figure 3-3) consists of a current source (E7), coaxial cable drivers (E5(1) through E5(4)), a delay line (DL1), and output filters (C10 in combination with R40, R41, and R42, and C11).

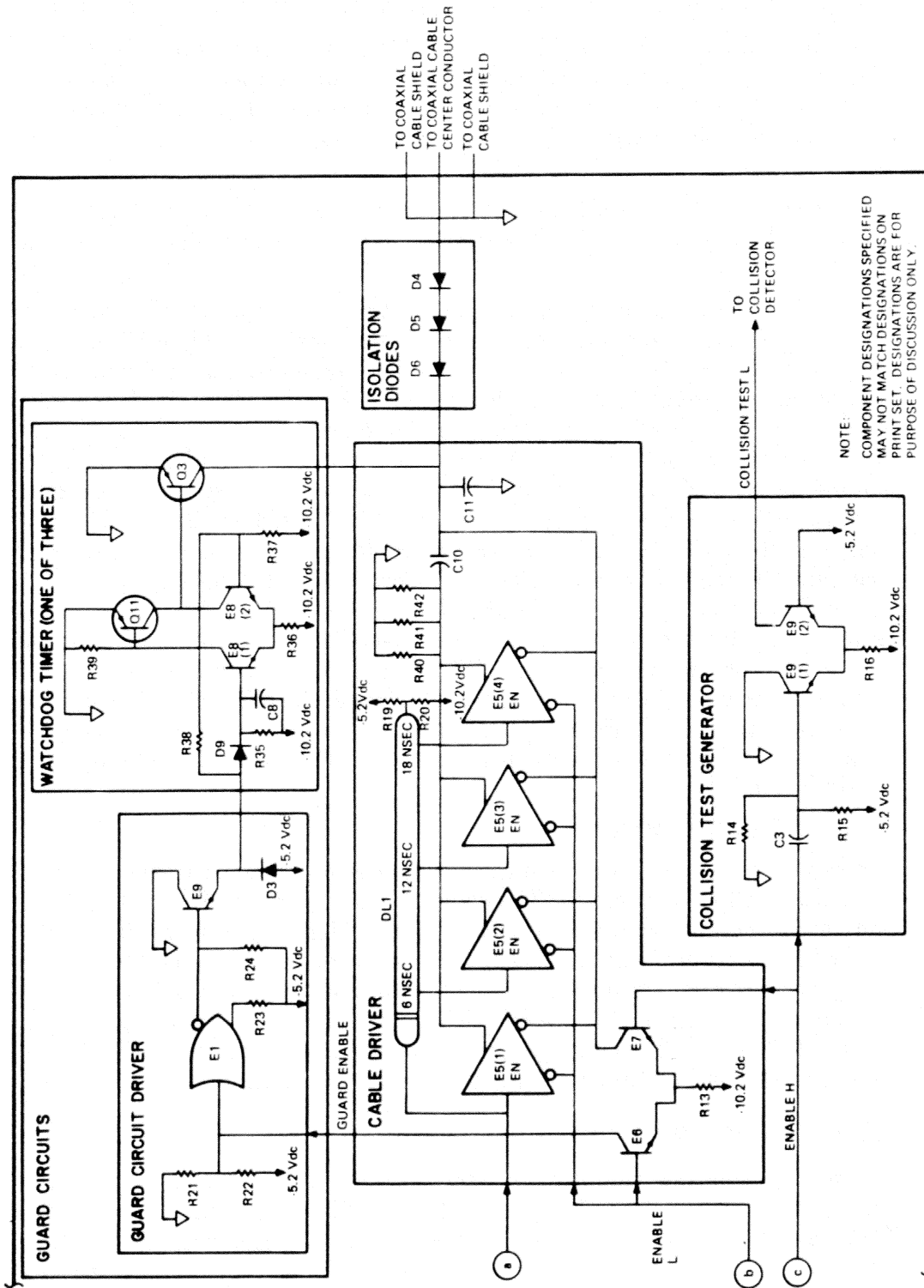
E7, the current source, is emitter coupled with E6. When the transmitter squelch is on, E6 is held on and E7 is held off. When the transmitter squelch is turned off, E6 is turned off and E7 is turned on. When E7 is turned on, it provides the bias current source for the coaxial cable.

The coaxial cable drivers (E5(1) through E5(4)) are enabled by the transmitter squelch. The coaxial cable drivers and delay line (DL1) form a staircase generator. Each transition in the DATA input from the line receiver/buffer is sent to the input of the first cable driver, E5(1), and to the delay line, DL1. Taps at the 6, 12, and 18 nsec outputs of DL1 are sent to each of the three succeeding stages of the cable driver, E5(2), E5(3), and E5(4). Thus, the four stages of the staircase generator are turned on or off (as applicable) in succession at 6 nsec intervals. The outputs of each of the four stages of the cable driver are connected in parallel to produce an increasing or decreasing staircase ramp in the total current drawn through the coaxial cable (i.e., the dc offset current plus the combined current drawn by each of the four stages of the cable driver). The staircase ramp produced by the cable drivers is filtered to produce a linear ramp output. Filtering is provided by two 5 nsec poles: one pole consists of C10 in combination with R40, R41, and R42; the second pole is formed by C11 in combination with the 25 ohm impedance of the coaxial cable.



TK 9350

Figure 3-3: Transmitter: Functional Schematic Diagram



TK 9351

Figure 3-3 (Cont.): Transmitter: Functional Schematic Diagram

Guard Circuits

The guard circuits impose a constraint on the maximum amount of time that the transmitter can drive the coaxial cable during a single transmission. Should the transmitter become stuck on because of a fault in the controller or transceiver, the guard circuits, upon time out (20 msec minimum, 150 msec maximum) will crowbar the output of the cable driver. This reverse biases the isolation diodes, effectively removing the transmitter from the coaxial cable.

The guard circuits (Figure 3-3) consist of a guard circuit driver and triply redundant watchdog timers. Because the configuration and operation of the three watchdog timers are similar, only one of the watchdog timers is shown in Figure 3-3 and discussed in the following paragraphs.

The guard circuit driver is enabled when E6 and E7 in the cable driver change state. When E6 turns off, E1 in the guard circuit driver turns on. E1 provides the control for the emitter follower (E9). When E1 turns on, it starts the watchdog timer.

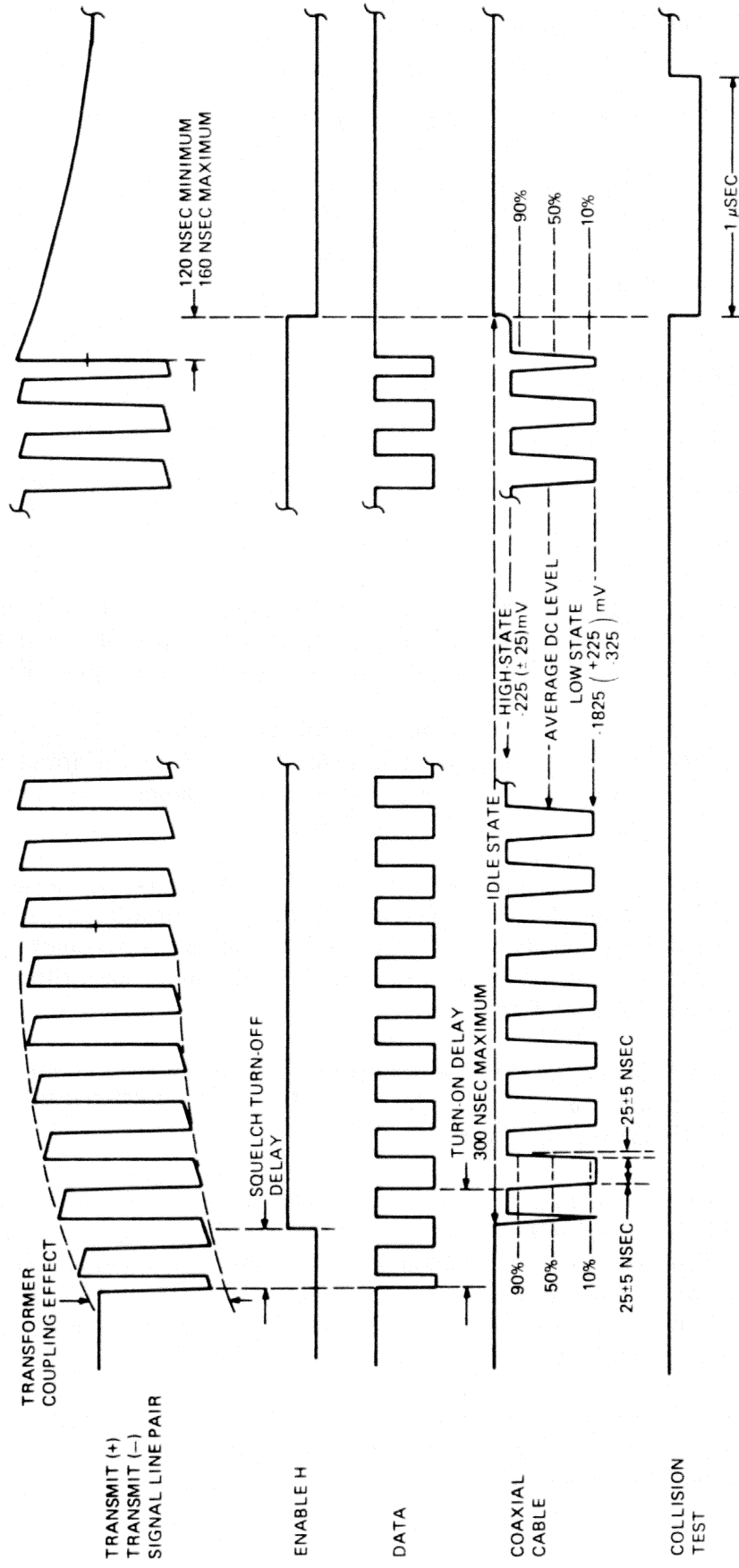
Before the guard circuit driver is enabled, the input from the guard circuit driver causes E8(1) to be held off and E8(2) to be held on. While E8(1) is off, Q11 is held off. While E8(2) is on, Q3 is held on. When the guard circuit driver is enabled, the input to the watchdog timer drops by about 0.8 V, causing E8(1) to turn on, E8(2) to turn off, and diode D9 to become reverse biased. While E8(1) is on, Q11 is held on, which shunts the base and emitter of Q3, holding Q3 off. When D9 becomes reverse biased, C8 starts discharging through R35 as well as through E8(1) and R36 toward -10.2 Vdc. The discharge time of C8 (between 20 and 150 msec) provides the transmit time constraint. When C8 has discharged sufficiently to lower the potential at the base of E8(1) to a level below the threshold at the base of E8(2), E8(1) turns off and E8(2) turns on. E8(1) turning off causes Q11 to turn off. E8(2) turning on and Q11 turning off turns on Q3. When Q3 turns on, it shorts the output of the cable driver to the return. Because the emitter to collector voltage drop of Q3 is less than the combined voltage drops of diodes D4, D5, and D6, the cable driver (if enabled) draws current through Q3 rather than through the coaxial cable.

Collision Test Generator

The collision test generator is turned on at the end of each transmission to simulate a collision condition. The collision test generator (Figure 3-3) functions as a one-shot which is triggered by the high to low transition of the ENABLE H output of the transmitter squelch. C3 at the input of the collision test generator differentiates the high to low transition of the ENABLE H input to turn off E9(1) and turn on E9(2) for a period of approximately 1 usec. While E9(2) is on, it provides a current source to the low pass filter in the collision detector circuitry to simulate a collision condition.

3.1.3 Transmitter Timing

A diagram showing the timing relationship of the signals sent to the transmitter on the TRANSMIT (+) and TRANSMIT (-) signal line pair, the TRANSMIT ENABLE output of the transmitter squelch, the DATA output of the line receiver/buffer, the filtered output of the cable driver, and the COLLISION TEST output of collision test generator is presented in Figure 3-4.



TK-9343

Figure 3-4: Transmitter: Timing Diagram

3.2 Receiver Circuit Description

3.2.1 Receiver Functional Operation

A block diagram of the receiver is shown in Figure 3-5. As shown, the receiver is made up of the following functional circuits:

1. Input Buffer
2. Low Pass Filter
3. Threshold Setting Network
4. Receiver Squelch
5. Band Pass Filter
6. Receive Amplifier and Driver

The signal from the coaxial cable is coupled to the receiver input buffer through a fusible resistor. The input buffer drives two filters with the signal from the coaxial cable: the low pass filter and the band pass filter.

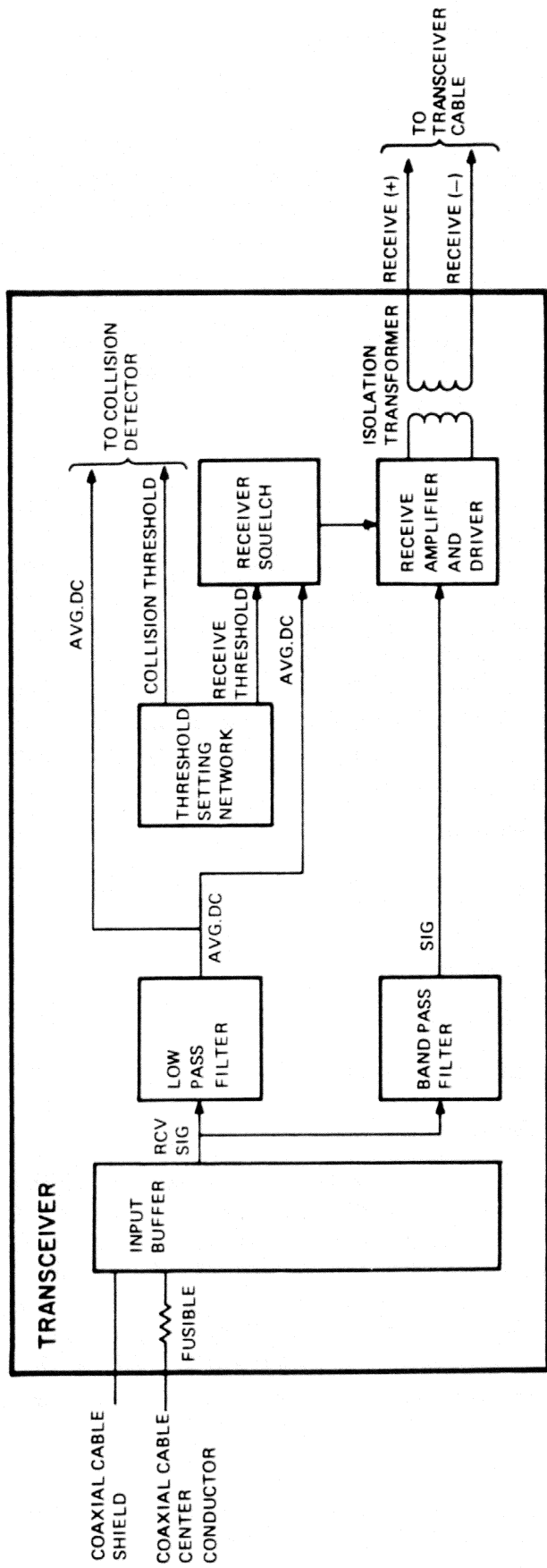
The low pass filter removes the ac component of the input signal, producing an output which represents the average DC level of the input signal. The output of the low pass filter goes to the receiver squelch and to the collision detector.

The band pass filter has two purposes: first, it limits the bandwidth of the receiver to that bandwidth corresponding to proper Ethernet signals. Secondly, it compensates for timing distortion in the received signal introduced by the coaxial cable. The output of the band pass filter goes to the receive amplifier and driver.

The threshold setting network is a precision current source and voltage divider which provides precisely regulated RECEIVE THRESHOLD and COLLISION THRESHOLD outputs.

The receiver squelch compares the output of the low pass filter with the RECEIVE THRESHOLD output of the threshold setting network to determine if the signals on the coaxial cable are valid Ethernet signals. When the output of the low pass filter is more negative than the RECEIVE THRESHOLD, indicating the presence of Ethernet signals, the receiver squelch enables the receive amplifier and driver.

The receive amplifier and driver, when enabled by the receiver squelch, amplify the input from the band pass filter and drive the isolation transformer at the output of the receiver.



TK-4337

Figure 3-5: Receiver: Functional Block Diagram

3.2.2 Receiver Detailed Operation

Coaxial Cable Protection

Coaxial cable protection is provided by a fusible resistor (R43, Figure 3-6) in the base circuit of the input buffer. R43 is fusible to guarantee that the failure mode of the resistor will be an open circuit rather than a short.

Input Buffer

The input buffer responds to the signal input from the coaxial cable and drives the low pass and band pass filters. The input buffer (Figure 3-6) consists of a current source, R51, R52, and E8(1), and an emitter follower, E6(1), configured as a unity gain amplifier.

Low Pass Filter

The low pass filter removes the ac component of the signal input to produce an output which represents the average dc level of the signal on the coaxial cable. The low pass filter (Figure 3-6) consists of a two pole Butterworth low pass filter (R44, R45, C12, C13, and E7(1)), and a single pole filter (C14 and R48). The two pole Butterworth is critically damped with a cutoff frequency of 1 MHz. The single pole filter following E7(1) also has a cutoff frequency of 1 MHz. The output of the low pass filter is voltage which represents the average DC level of the signal on the coax cable minus the V_{be} drops in the input buffer emitter follower, E6(1), and the Butterworth filter emitter follower, E7(1). E9(1) provides the current source for E7(1).

Threshold Setting Network

The threshold setting network (Figure 3-6) consists of the following functional circuits:

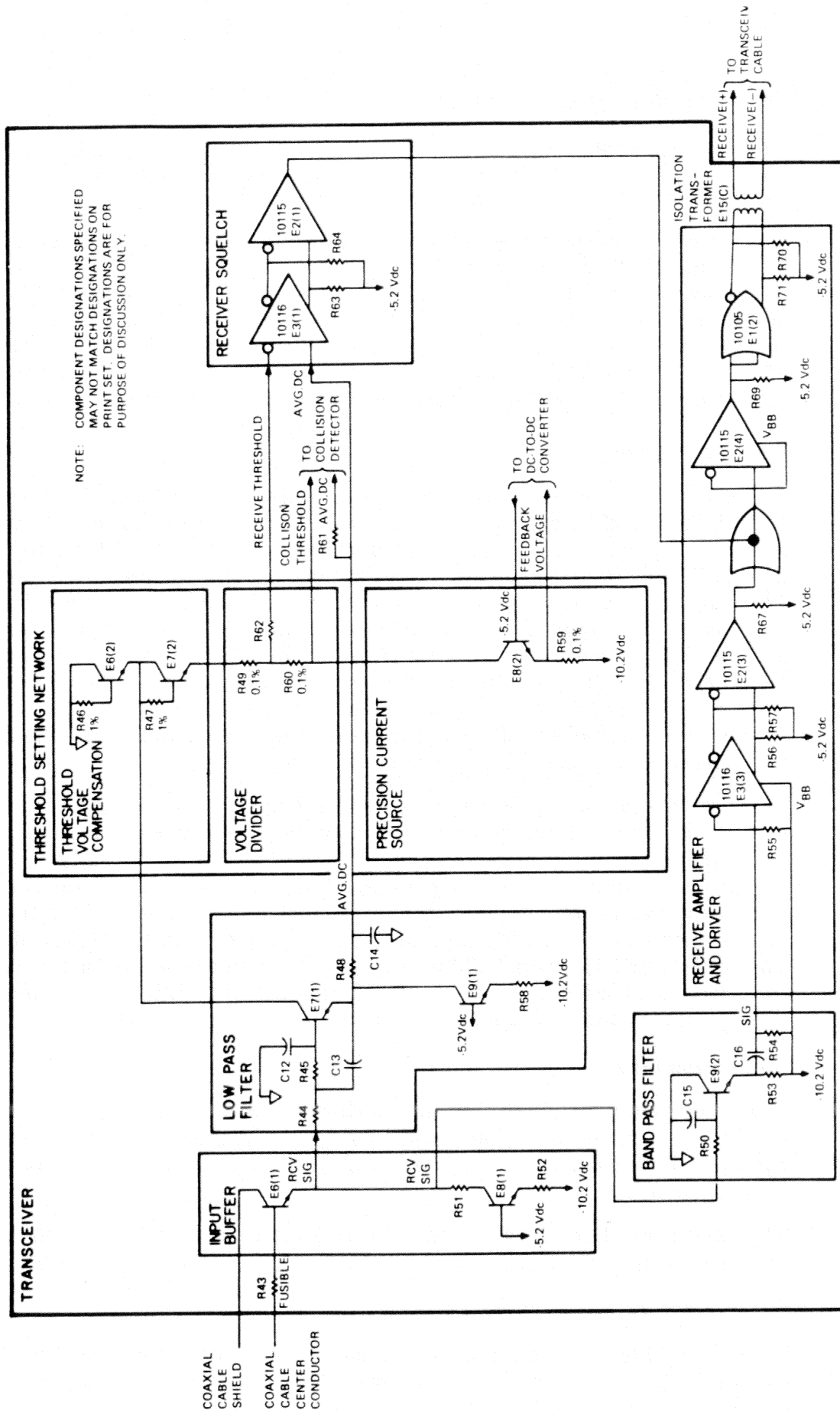
1. Precision Current Source
2. Voltage Divider Network
3. Voltage Compensation Network

Precision Current Source

The precision current source (Figure 3-6) consists of E8(2) and R59. The FEEDBACK VOLTAGE output of the current source is used to regulate the -5.2 Vdc output of the dc-to-dc converter. Thus, the FEEDBACK VOLTAGE is guaranteed to be 4.3 Vdc \pm 1 % above the -10.2 Vdc output of the dc-to-dc converter. Therefore, the emitter current of E8(2) is regulated to within \pm 1.1 % (i.e., 1 % for the regulation tolerance of the dc-to-dc converter and 0.1 % for R59, the resistor which develops the FEEDBACK VOLTAGE). The collector current of E8(2) is the emitter current minus the base current of E8(2).

Voltage Divider

The voltage divider (Figure 3-6) develops the RECEIVE THRESHOLD and the COLLISION THRESHOLD levels used by the receiver squelch and collision detector. The voltage divider consists of R49 and R60, which have tolerances of \pm 0.1 %.



TK-0140

Figure 3-6: Receiver: Functional Schematic Diagram

Threshold Voltage Compensation

The threshold voltage compensation is used to shift the RECEIVE THRESHOLD and COLLISION THRESHOLD voltage levels to compensate for the V_{be} drops in the input buffer and the low pass filter.

The threshold voltage compensation (Figure 3-6) consists of E6(2) and E7(2). Note that, E6(2) in the threshold compensation circuit is provided on the same substrate as E6(1) in the input buffer; thus, the V_{be} drops of the components are matched. Additionally, the base resistance of E6(2) is matched to the base resistance of E6(1), to provide matching base current. Similarly, E7(2) in the threshold compensation circuit is matched to E7(1) of the low pass filter to provide a matching voltage drop in the threshold outputs.

Receiver Squelch

The receiver squelch ensures that the receiver and driver is enabled only when valid ETHERNET signals are present on the coaxial cable. The receiver squelch compares the AVG. DC input from the low pass filter with the RECEIVE THRESHOLD input from the threshold setting network. When the low pass filter has charged the AVG. DC input to the RECEIVE THRESHOLD level, the output of the receiver squelch enables the receive amplifier and driver. The delay characteristics of the low pass filter determine in part the threshold requirements of the receiver (i.e., the signals on the coaxial cable must be present for between 300 and 600 nsec before the AVG. DC output becomes charged sufficiently to exceed the turn-off voltage threshold of the receiver squelch).

The receiver squelch (Figure 3-6) consists of a comparator, E3(1), and amplifier, E2(1). E3(1) is a comparator which turns on when the AVG. DC input has charged to a level more negative than the RECEIVE THRESHOLD. E2(1) is an amplifier for the comparator. This amplifier speeds up the rise time of the comparator output to reduce the probability of noise bursts at the output of the receiver during the transition from squelch on to squelch off. The output of E2(1) is wire OR'd in the high state with the receive amplifier; thus, when the receiver squelch is turned off, the output of E2(1) goes low and the receive amplifier and driver is enabled.

Band Pass Filter

The band pass filter limits the bandwidth of the SIG input to the receive amplifier and driver to the bandwidth of Ethernet signals. Additionally, the band pass filter compensates for timing distortion in the input introduced by the coaxial cable.

The band pass filter consists of an 8.2 nsec low pass filter, R50 and C15, a unity gain amplifier, E9(2), and a 150 nsec high pass filter, R54 and C16.

Receive Amplifier and Driver

When enabled by the receiver squelch output, the receive amplifier and driver amplifies the input from the band pass filter and drives the isolation transformer at the receiver output.

The receive amplifier and driver (Figure 3-6) consists of four amplifier stages, E3(3), E2(3), E2(4), and E1(2). The rise time at the output of each stage is either the rise time at the input divided by the nominal gain or 2.2 nsec, whichever one is greater. As shown in Figure 3-6, the output of the second amplifier stage is wire OR'd with the receiver squelch to inhibit the receiver output until the receiver squelch is turned off. The output of the fourth amplifier stage E1(2), drives the isolation transformer at the receiver output. The isolation transformer couples the output of the receiver to the RECEIVE (+) and RECEIVE (-) differential signal line pair of the transceiver cable.

3.2.3 Receiver Timing

A timing diagram showing the relationship between the Ethernet signal on the coaxial cable, the AVG. DC level output of the low pass filter, the output of the receiver squelch, the SIG output of the band pass filter, and the resulting signal on the RECEIVE (+) and RECEIVE (-) outputs of the transceiver is presented in Figure 3-7.

3.3 Collision Detection Circuit Description

3.3.1 Collision Detection Circuitry Functional Operation

A block diagram of the collision detection circuitry is shown in Figure 3-8. As shown, the collision detection circuitry is made up of the following functional circuits:

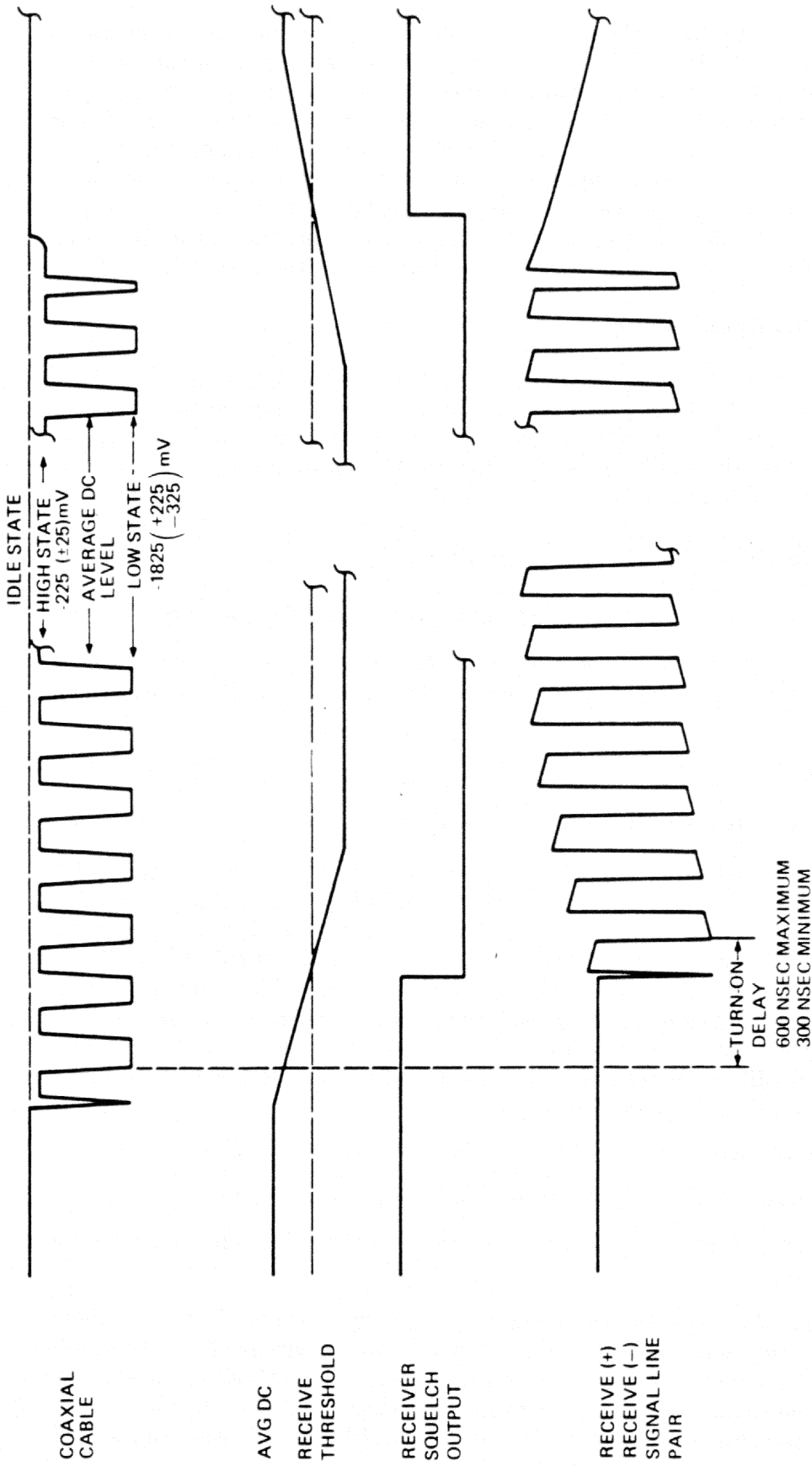
1. Collision Detector
2. Collision Presence Oscillator and Driver

The collision detection circuitry compares the AVG. DC output of the low pass filter of the receiver with the COLLISION THRESHOLD input from the threshold setting network of the receiver. When the AVG. DC input to the collision detector becomes more negative than the COLLISION THRESHOLD, the collision detector turns on. When the collision detector turns on, it turns on the collision oscillator and driver, which then drives the isolation transformer. The isolation transformer couples the collision oscillator output to the COLLISION PRESENCE (+) and COLLISION PRESENCE (-) signal line pair of the transceiver cable.

The collision detection circuitry is enabled during two conditions:

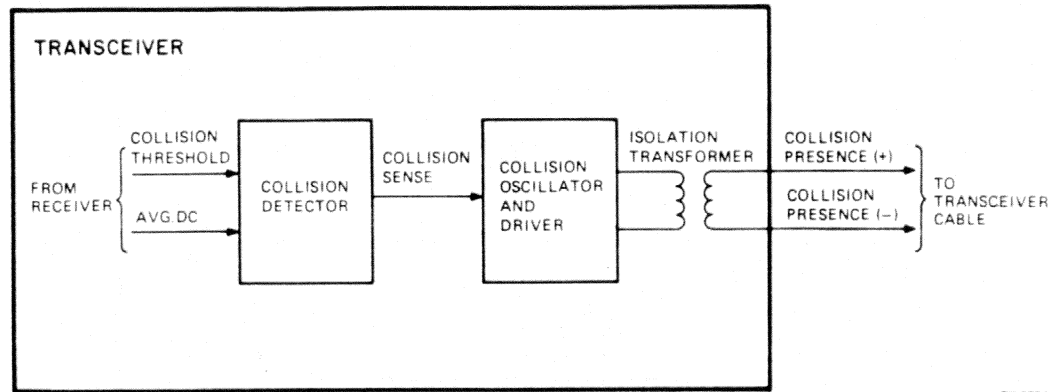
1. The presence of a collision condition on the coaxial cable.
2. At the end of each transmission as a test of the collision detection circuitry.

During simultaneous transmissions by two or more transceivers, the signal being transmitted on the coaxial cable will be more negative than the amplitude of the signal expected from a single transceiver. Thus, the average dc level of the signal on the coaxial cable will cause the AVG. DC input to the collision detector to exceed the COLLISION THRESHOLD, causing the collision detector to turn on.



TK-9344

Figure 3-7: Receiver: Timing Diagram



TK-9334

Figure 3-8: Collision Detector: Functional Block Diagram

At the end of each transmission, the transmitter generates a COLLISION TEST signal which causes the AVG. DC input to exceed the COLLISION THRESHOLD, causing the collision detector to turn on for a limited duration.

3.3.2 Collision Detection Circuitry Detailed Operation

A schematic diagram of the collision detector is presented in Figure 3-9. This diagram also includes the low pass filter which is part of the receiver. The low pass filter is included to show the collision test operation.

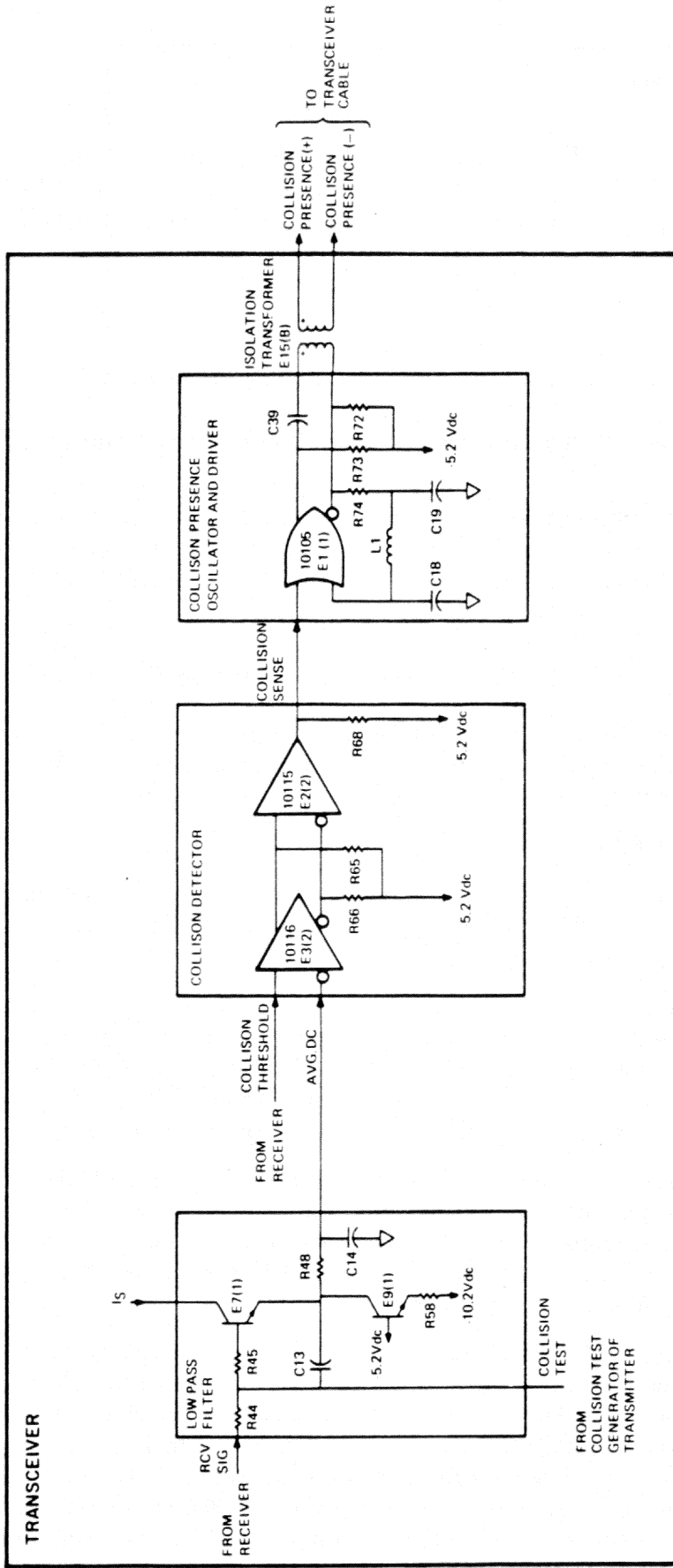
Low Pass Filter

There are two inputs to the low pass filter: RCV SIG, the signal from the input buffer of the receiver; and COLLISION TEST, the signal from the collision test generator in the transmitter.

During a collision condition (i.e., two or more transceivers attempting to transmit simultaneously), the output of the low pass filter charges toward the average dc level of the signal on the coaxial cable. The delay characteristics of the low pass filter provides a turn-on delay for the collision detection circuitry of 900 nsec (maximum) after the collision condition is present.

During test of the collision detection circuitry, the COLLISION TEST input to the low pass filter is present for approximately 1 usec after the transceiver has stopped transmitting. The low pass filter responds to the COLLISION TEST signal input to produce an AVG. DC output, which simulates the dc level output expected during a collision.

The COLLISION TEST input establishes a current path through the low pass filter without drawing current through the coaxial cable. This current path causes the AVG. DC output to charge to a dc level more negative than the COLLISION THRESHOLD level, causing the collision detector to turn on. The delay of the low pass filter in response to the COLLISION TEST input causes the collision detector to turn on within 360 nsec (minimum) after the end of a transmission, to remain on for a period of 400 nsec (minimum), and to turn off within 2 usec (maximum) after the end of a transmission.



NOTE: COMPONENT DESIGNATIONS SPECIFIED
MAY NOT MATCH DESIGNATIONS ON
PRINT SET. DESIGNATIONS ARE FOR
PURPOSE OF DISCUSSION ONLY

FK-9316

Figure 3-9: Collision Detector Functional Schematic Diagram

Collision Detector

The collision detector (Figure 3-9) consists of a comparator E3(2) and an amplifier E2(2). E3(2) begins to turn on when the AVG. DC input becomes more negative than the COLLISION THRESHOLD input, which is -1536 mV (nominal). E2(2) is an amplifier for the comparator. This amplifier speeds up the rise time of the comparator output. When the output of the comparator begins to change state, the output of amplifier E2(2), COLLISION SENSE, goes low, which enables the collision presence oscillator and driver.

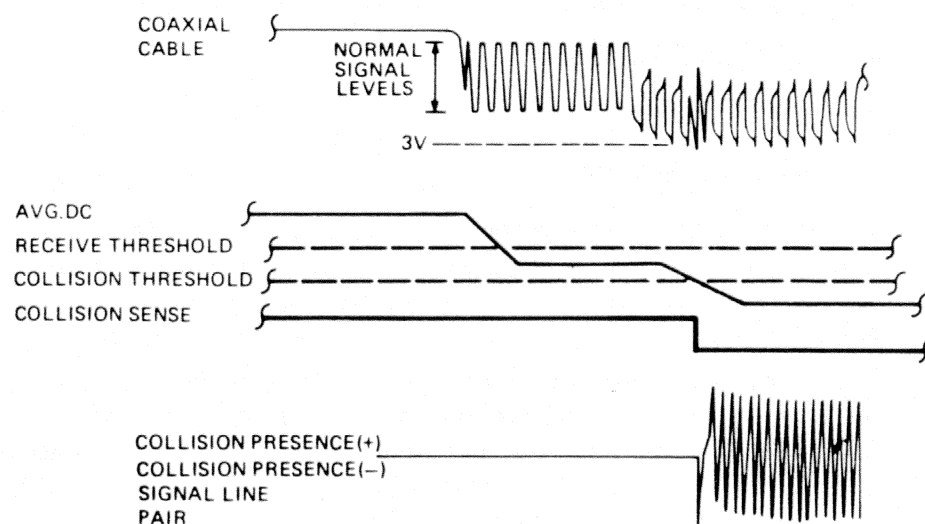
Collision Presence Oscillator and Driver

The collision presence oscillator and driver (Figure 3-9) consist of an amplifier, E1(1), with an RLC network in the feedback loop. When enabled by a low COLLISION SENSE input, the output of the amplifier drives the COLLISION PRESENCE (+) and COLLISION PRESENCE (-) outputs with a 10 MHz periodic waveform.

3.3.3 Collision Detection Circuit Timing

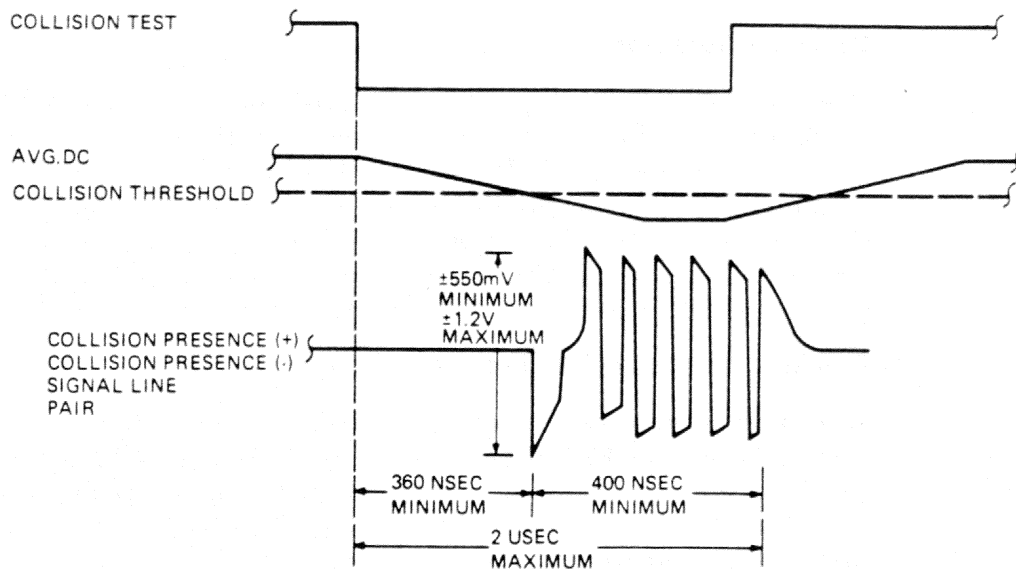
A timing diagram showing the relationship between the signal on the coaxial cable during a simulated collision condition, the AVG. DC output of the low pass filter, the COLLISION SENSE output of the collision detector, and the resulting signal on the COLLISION PRESENCE (+) and COLLISION PRESENCE (-) outputs of the transceiver is presented in Figure 3-10.

A timing diagram showing the relationship between the COLLISION TEST signal input from the collision test generator, the resulting AVG. DC output of the low pass filter, and the signal on the COLLISION PRESENCE (+) and COLLISION PRESENCE (-) outputs of the transceiver is presented in Figure 3-11.



TK-9353

Figure 3-10: Collision Detector Timing: Simulated Collision Condition



TK-9354

Figure 3-11: Collision Detector Timing: Collision Test Condition

3.4 DC-to-DC Converter Circuit Description

3.4.1 DC-to-DC Converter Functional Operation

A block diagram of the dc-to-dc converter is shown in Figure 3-12. As shown, the dc-to-dc converter is made up of the following functional circuits:

1. Turn-on and Start-up Control
2. Power Switch
3. Duty Cycle Control
4. Differential Amplifier
5. Optical Coupler
6. -5.2 Vdc Regulator

The turn-on and start-up control inhibits turn-on of the dc-to-dc converter until the voltage level of the POWER input meets start-up requirements. The turn-on and start-up control also establishes the start-up frequency of the power switch until the dc-to-dc converter can achieve free running operation.

During start-up; the operating frequency of the power switch is established by the duty cycle control in conjunction with the turn-on and start-up control. After the dc-to-dc converter has achieved free running operation, feedback from the primary of the power transformer, T2, is used to establish the operating frequency of the power switch.

The duty cycle control in conjunction with the feedback amplifier and optical coupler controls the duty cycle of the power switch, and thus the -10.2 Vdc output of the dc-to-dc converter.

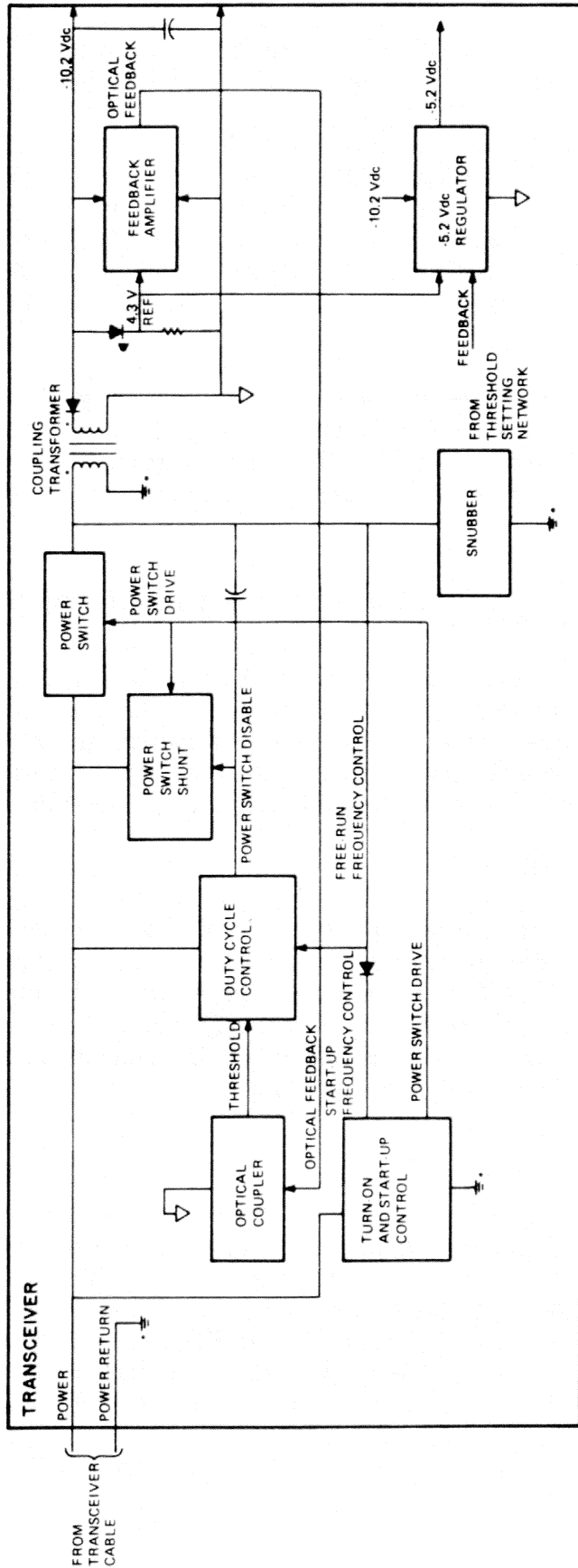


Figure 3-12: DC-to-DC Converter: Functional Block Diagram

When the power switch is turned on, it asserts the POWER input to the primary of the coupling transformer. When the power switch is turned off, it interrupts the POWER input to the primary of the coupling transformer.

The current flow in the secondary winding during power switch off time is used to generate the -10.2 Vdc output of the dc-to-dc converter. The -10.2 Vdc output is regulated by varying the duty cycle of the power switch. The feedback amplifier and optical coupler determine the THRESHOLD input to the duty cycle control. Adjusting the THRESHOLD input allows either a longer or shorter duty cycle of the power switch as required to maintain the -10.2 Vdc output.

The -5.2 Vdc output of the dc-to-dc power converter is generated from the -10.2 Vdc output and is regulated relative to the -10.2 Vdc output. The -5.2 Vdc output is regulated by FEEDBACK from the threshold setting network of the receiver to maintain a precise current flow through the threshold setting network.

3.4.2 DC-to-DC Converter Detailed Operation During Start-Up

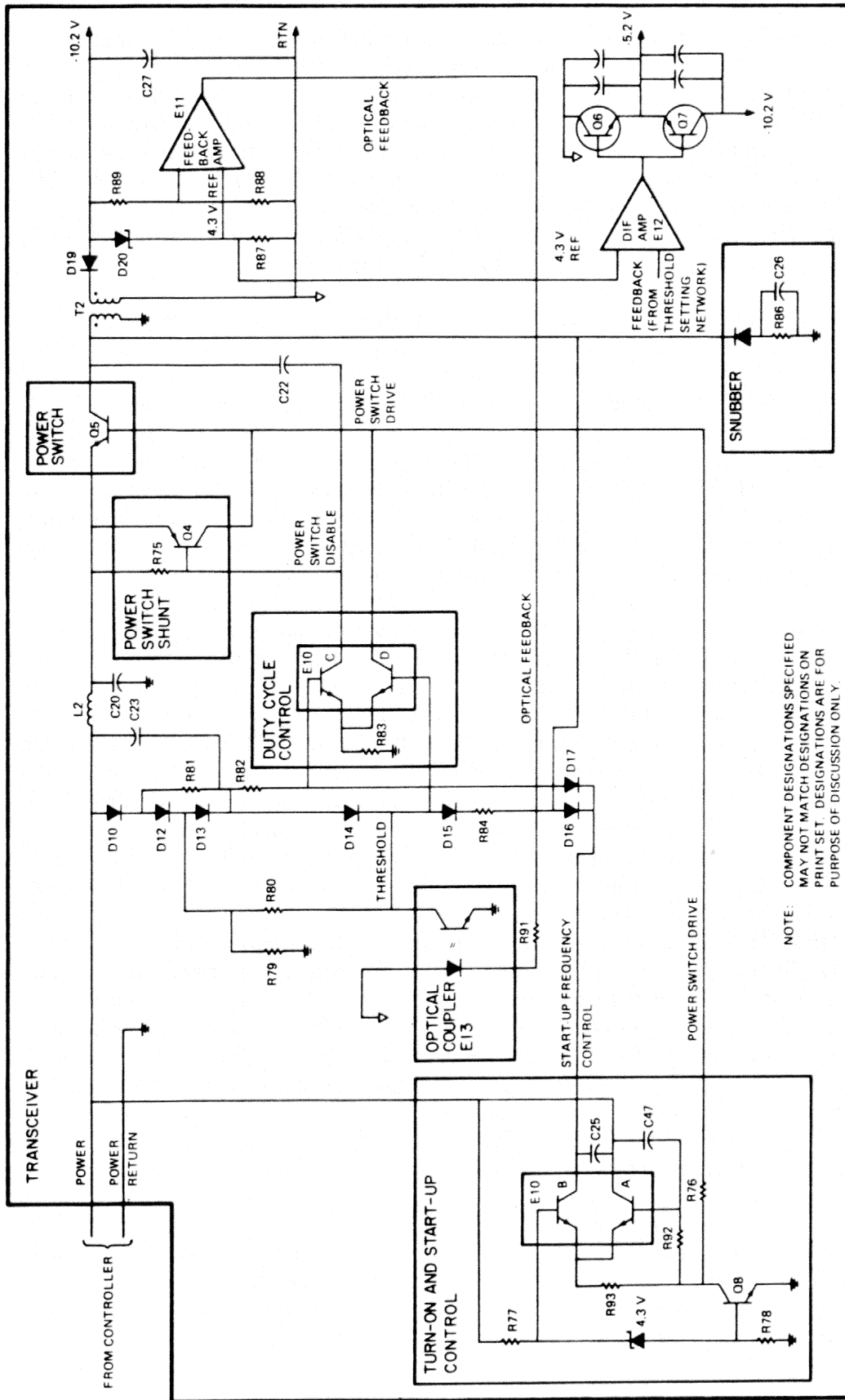
When the input POWER is first asserted to the dc-to-dc converter, The start-up control section (See Figure 3-13) controls turn-on and turn-off of the dc-to-dc converter, provides the drive for the power switch, and establishes the operating frequency of the power switch until the output capacitor has been charged sufficiently to allow the dc-to-dc converter to free-run.

Turn-On and Turn-Off

The dc-to-dc converter is turned on and off by Q8 of the turn-on and start-up control. Q8 is turned on whenever the level of the POWER input is greater than approximately 6.4 Vdc, and is turned off whenever the input POWER level goes below approximately 6.4 Vdc. When Q8 is turned on, it provides the POWER SWITCH DRIVE to the power switch, Q5, and enables the start-up control section of the turn-on and start-up control.

Start-Up Control

During initial start-up of the dc-to-dc converter, the operation of the duty cycle control and the power switch is controlled by the start-up section of the turn-on and start-up control. The start-up control is made up of two sections of E10 (labeled E10(A) and E10(B) in Figure 3-3). When Q8 of the start-up control is biased on, it biases E10A on. While E10A is on, it holds E10B off. When E10A is turned on, capacitor C47 starts discharging toward ground through R92 and Q8. C47 and E10A form a delay which holds E10A on and E10B off until C47 has discharged to the threshold voltage at the base of E10B (approximately 5 V). The delay time provided by E10A and C47 is approximately 400 msec.



T-4-5138

Figure 3-13: DC-to-DC Converter: Functional Schematic Diagram

During this delay time, the initial zero voltage across C25 holds diodes D16 and D17 reverse biased. Thus, during the start-up delay time, the biasing for the duty cycle control, which ensures that the power switch Q5 remains off during the start-up delay time, is provided by the current flow from the POWER input through D10, D12 through D15, R84, and the primary of T2. This current path sets the bias for E10C at one diode drop above the bias for E10D. This biasing holds E10C on and E10D off. While E10C is on, it provides the base drive to the power switch shunt, Q4, which holds Q4 on and Q5, the power switch, off. This prevents input POWER from being asserted to the primary of transformer, T2, during initial start-up.

After Approximately 400 msec, when C47 has discharged to the 5V threshold at the base of E10B, E10A turns off and E10B turns on. When E10B turns on, C25 starts charging toward ground through E10B, R93, and Q8. When C25 starts charging toward ground, diode D17 becomes forward biased. Thus, as C25 is charging toward ground, the voltage at the base of E10C decays at the rate of charge of C25. When the voltage at the base of E10C has been reduced to the THRESHOLD input to E10D, E10C turns off and E10D turns on. When E10C turns off, it removes the base drive from the power switch shunt, Q4, causing Q4 to turn off and the power switch, Q5, to turn on. When Q5 turns on, it asserts the POWER input to the primary of T2.

The amount of time that the power switch remains on is dependent on the charge time of C23. When the input POWER is asserted to the primary of T2, C25 charges to one diode drop below the input POWER dc level through diode D16. This causes diodes D15 and D17 to become reverse biased. When D17 becomes reverse biased, C23 starts charging through R81, which starts raising the voltage input at the base of E10C from one diode drop below the THRESHOLD input to E10D toward one diode drop above the THRESHOLD input. The time required for C23 to raise the voltage level at the base of E10C to a level greater than the THRESHOLD input to E10D is the amount of time that the power switch, Q5, remains on. When the charge of C23 has raised the voltage level at the base of E10C to a level greater than the THRESHOLD voltage level input to E10D, E10C turns on and E10D turns off. When E10C turns on, it provides the base drive to the power switch shunt, Q4, causing Q4 to turn on and Q5 to turn off. When Q5 is turned off, the POWER input is removed from the primary of T2 and C25 again starts charging through E10B, R93, and Q8 toward ground. While C25 is charging toward ground, diodes D15 and D17 again become forward biased. When C25 has charged sufficiently to lower the voltage at the base of E10C below the THRESHOLD input to E10D, E10C again turns off, causing Q4 to turn off and Q5 to turn on, which re-asserts the input POWER to the primary of T2.

After the input POWER has been asserted to the primary of the coupling transformer and the power switch has been turned off, the collapsing magnetic flux developed in the coupling transformer causes current flow in the secondary winding. The current flow in the secondary winding drives the -10.2 Vdc output and charges the -10.2 Vdc output capacitor.

After current flow in the secondary winding ceases, the induced voltage in the transformer collapses, causing the voltage across the primary, which was held negative by the current flow in the secondary, to return toward zero volts. This positive voltage swing at the primary of the coupling transformer is asserted to the base of the power switch shunt through a coupling capacitor. During initial start-up of the dc-to-dc converter, this positive voltage swing is of insufficient magnitude to turn off the power switch shunt. However, after the output capacitor has been charged sufficiently, this positive voltage swing causes the power switch shunt to be turned off and the dc-to-dc converter becomes free running.

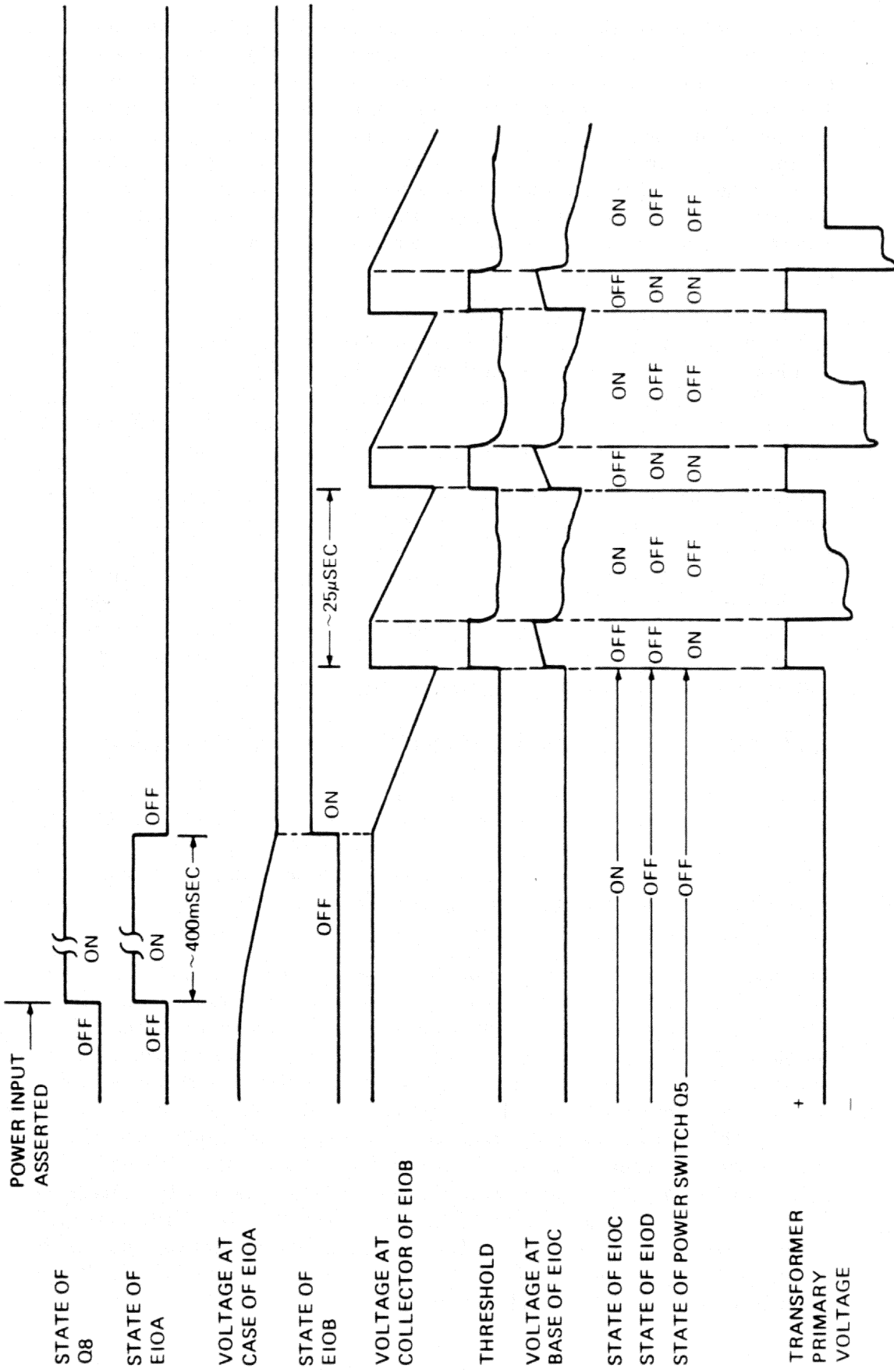
The operation of the dc-to-dc converter remains under control of the turn-on and start-up control until the output capacitor has been charged sufficiently to allow the dc-to-dc converter to free-run. Once the dc-to-dc converter becomes free running, the start-up control will not have any effect on the duty cycle control since the free running frequency (approximately 150 kHz) is much higher than the start-up frequency (approximately 40 kHz).

A timing diagram showing the operation of the dc-to-dc converter during start-up is presented in Figure 3-14. As shown, the basic operating frequency of the power switch during start-up is approximately 40 kHz. Figure 3-14 also shows that with each recurrence of power switch operation, the positive voltage transition in the primary of T2, when current flow in the secondary winding ceases, becomes greater. When this voltage becomes sufficient enough to retrigger the power switch, then the operation of the dc-to-dc converter changes to a free-running mode of operation.

3.4.3 DC-to-DC Converter Detailed Operation During Free-Run

The dc-to-dc converter is switched automatically to the free-run mode after the output capacitor has been charged sufficiently to provide enough of a positive transition at the primary winding to shut off the power switch shunt when current flow in the secondary winding has terminated. This positive transition is coupled through coupling capacitor C22 to the base of the power switch shunt, Q4, causing Q4 to turn off, and the power switch, Q5, to turn on.

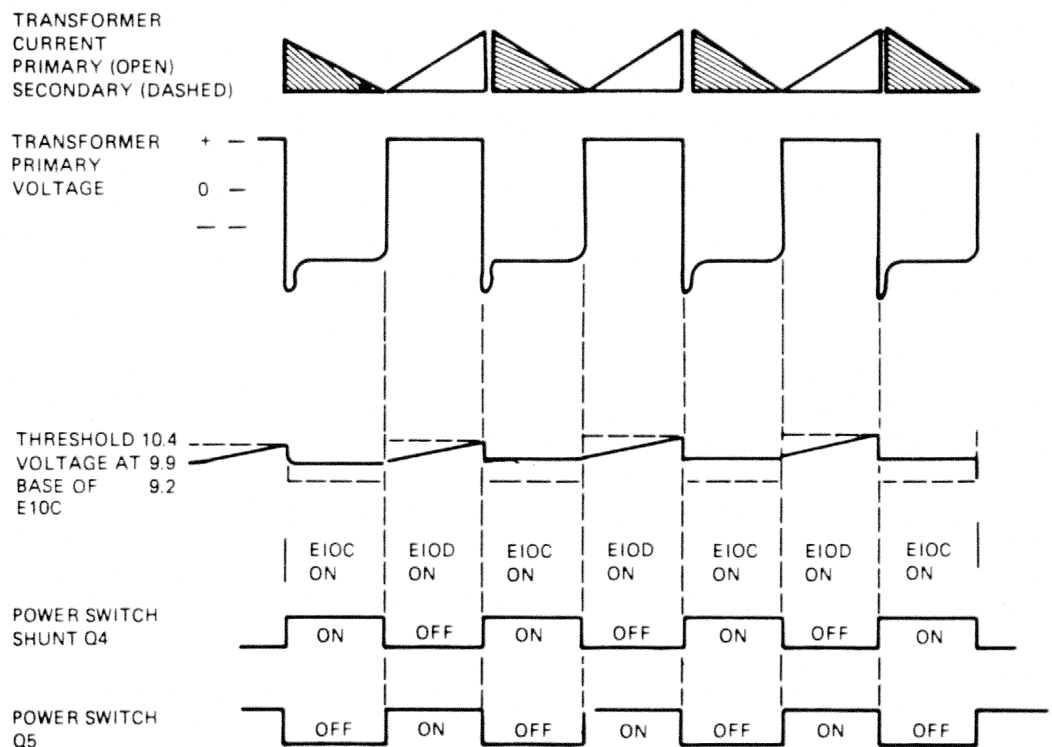
The positive transition at the primary of T2 also back biases diode D15 in the biasing network of the duty cycle control. When D15 becomes back biased, the THRESHOLD level input to the duty cycle control is controlled by the optical coupler. While D15 was forward biased, C23, which controls the voltage level input to E10C of the duty cycle control, was discharged back to a level which is one diode drop above the THRESHOLD level input to the duty cycle control. This ensures that E10C remains on during the secondary current flow time. However, when diode D15 becomes back biased, the THRESHOLD input assumes a primary level which is one diode drop above the charge on C23. Thus, E10D is turned on and E10C is turned off. When E10C is turned off, it removes the base drive from Q4, which ensures that Q4 will remain off and Q5 will remain on until C23 charges to the level of the THRESHOLD input to E10D of the duty cycle control.



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Figure 3-14: Operational Sequence: DC-to-DC Converter During Start-Up

When C23 has charged to the THRESHOLD level, E10C is turned on and E10D is turned off. When E10C is turned on, it provides base drive to Q4 which causes Q4 to turn on. When Q4 is turned on, it causes Q5 to turn off. When Q5 is turned off, current flow in the primary of T2 ceases and current flow in the secondary commences. When the current flow in the secondary of T2 ceases, the induced voltage in T2 collapses causing a positive transition at the primary of T2. This transition restarts the free-run operation of the dc-to-dc power converter. The frequency at which the input POWER is asserted to the primary of T2 is dependent on the voltage level of the POWER input, but runs at approximately 150 KHz. Figure 3-15 shows a timing diagram outlining the operation of the dc-to-dc converter during free-run.



TK-9335

Figure 3-15: Operational Sequence: DC-to-DC Converter During Free-Run

Chapter 4

Repair Instructions

4.1 Repair Operations

1. Removal and Replacement of the Transceiver Module
2. Removal and Replacement of the Transceiver

NOTE

The transceiver may be re-used (removed and re-installed) provided that the pins used to make contact with the coaxial cable center conductor have not been broken or bent and the braid contacts of the transceiver are replaced before the transceiver is re-installed.

4.2 Transceiver Module Removal Procedure

To remove the transceiver module from the transceiver, perform the following procedure.

1. Release transceiver cable slide latch (See Detail A, Figure 4-1) and disconnect transceiver cable connector (Item 4) from transceiver.

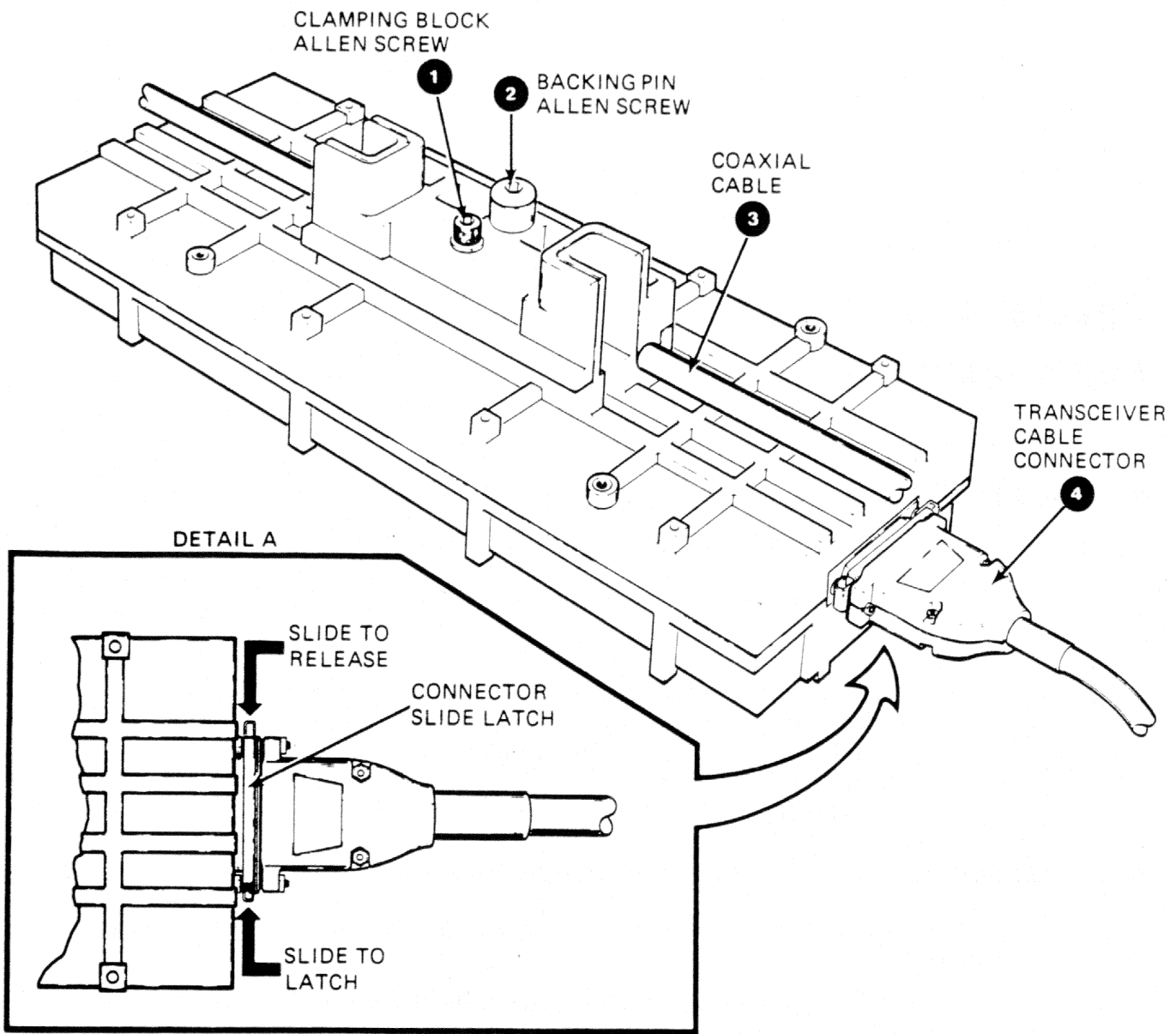
NOTE

The screws which secure the backshell (Item 4, Figure 4-2) to the main housing (Item 1) are captive screws. Do not remove the screws from the backshell.

CAUTION

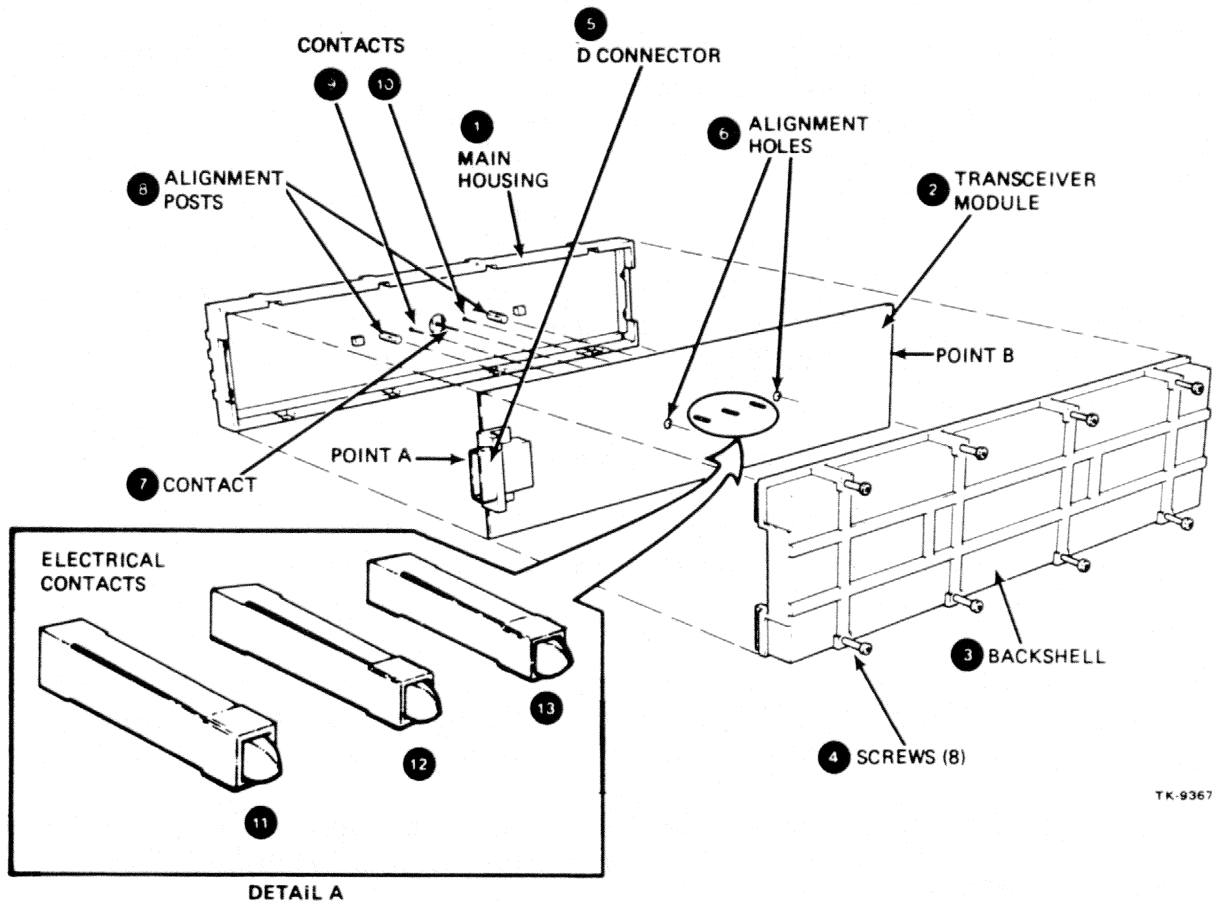
In Step 2, transceiver module (Item 2) may fall out of main housing (Item 1) when removing the backshell (Item 3) from the main housing.

2. Loosen the eight screws (Item 4, Figure 4-2) securing the backshell (Item 3) to the main housing (Item 1), and remove backshell from main housing.
3. Grasp transceiver module (Item 2) at points labeled A and B in Figure 4-2, and using equal pressure at points A and B, lift the transceiver module out of the main housing.



TK-9369

Figure 4-1: Coaxial Cable and Transceiver Cable Connections



TK-9367

Figure 4-2: Physical and Electrical Connections Between the Main Housing, Backshell, and Transceiver Module

4.3 Transceiver Module Installation Procedure

To install the transceiver module into the transceiver, perform the following procedure.

1. Inspect electrical contacts (Items 7, 9, and 10, Figure 4-2). Inspect as follows:

Inspect	Requirement	Corrective Action
Item 7	Contact not bent or broken.	Replace transceiver.
Items 9 and 10	Contacts not bent or broken and present.	Install new contacts. Refer to Paragraph 4.6.

NOTE

The transceiver module D connector (Item 5, Figure 4-2) may be positioned at either end of the transceiver. Correct positioning is determined by locating the side of the transceiver to which the transceiver cable will be attached.

2. Position transceiver module (Item 2, Figure 4-2) with component side away from main housing (Item 1) and with the transceiver module D connector (Item 5) positioned as required.

CAUTION

Until backshell (Item 3) is installed in step 6 of this procedure, it is possible that the transceiver module may fall out of the main housing if not physically held in place.

CAUTION

Use care when pressing transceiver module into place to avoid bending or breaking the electrical contacts (Items 7, 9, and 10, Figure 4-2).

3. Align transceiver module alignment holes (Item 6) with main housing alignment posts (Item 8), and using equal pressure at points A and B shown in Figure 4-2, press transceiver module onto alignment posts.
4. While holding transceiver module in position, inspect transceiver module to main housing electrical connections shown in Detail A of Figure 4-2. Inspect as follows:

Inspect	Requirement	Corrective Action
Item 7,	Contact extends to the bottom of the transceiver module connector (Item 12, as shown in exploded view of Figure 4-2.)	Replace transceiver.
Items 9 and 10	Contacts extend to the bottom of the transceiver module connectors (Items 11, and 13 of Figure 4-2).	<p>If main housing is not attached to coaxial cable, the two braid contacts (Items 9 and 10) may have been pushed out when the transceiver module was installed: This condition may be corrected by pressing upon the braid contacts which extend above the main housing (See Figure 4-3) until the contacts are properly positioned.</p> <p>If transceiver main housing is attached to coaxial cable lift the transceiver module out of the main housing in accordance with Paragraph 4.2, Step 3; then replace defective braid contacts (Refer to Paragraph 4.6).</p>

5. Align opening on end of backshell (Item 3, Figure 4-2) with the end of the transceiver module on which the D connector is located.
6. Place backshell in position on the main housing and tighten (torque to 6 ft/lbs) the 8 self tapping screws (Item 4).

4.4 Transceiver Removal Procedure

To remove the transceiver from the coaxial cable, perform the following procedure:

1. Release transceiver cable slide latch (Detail A, Figure 4-1) and disconnect transceiver cable connector (Item 4) from transceiver.
2. Using the allen wrench supplied in the Installation Kit (H4090-KA), loosen the backing pin allen screw (Item 2, Figure 4-1) by turning it approximately three turns in a counterclockwise direction. Do not remove backing pin allen screw from clamping block (Item 4, Figure 4-3).

CAUTION

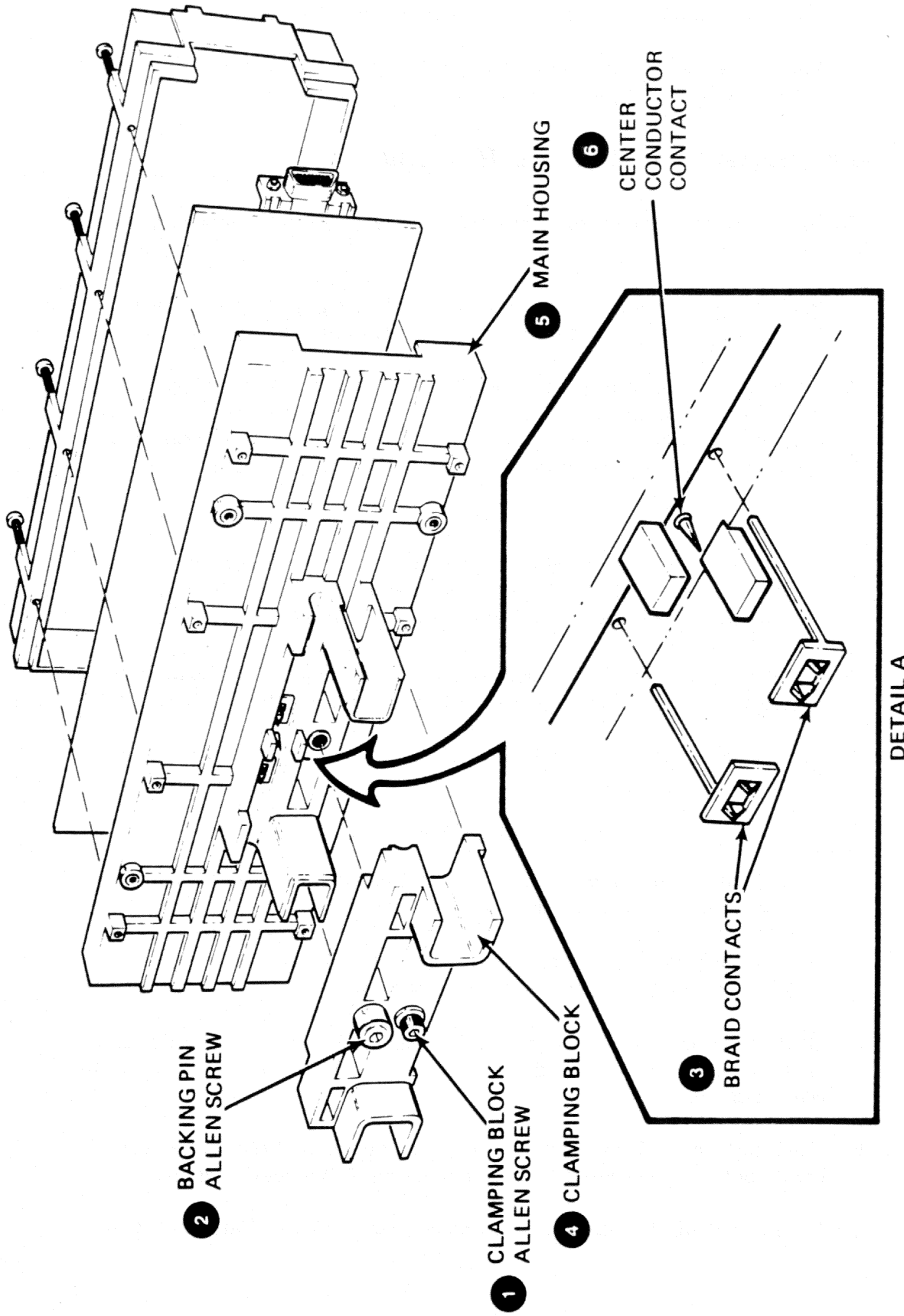
Support the main housing while performing steps 3 through 5. If not supported, transceiver may prematurely separate from clamping block and coaxial cable and may damage transceiver.

3. Using the allen wrench, loosen the clamping block allen screw (Item 1, Figure 4-1) until it disengages from the main housing (Item 5, Figure 4-3).
4. Remove clamping block (Item 4, Figure 4-3) from the main housing (Item 5).

CAUTION

In step 5, as soon as coaxial cable is removed from main housing, remove braid contacts from coaxial cable. Do not allow braid contacts to come in contact with any metal surfaces before they are removed. Failure to remove braid contacts may result in temporary failure of the network.

5. Gently lift the coaxial cable (Item 3, Figure 4-1) out of the main housing cable tray and remove braid contacts (Item 3, Figure 4-3) if attached to coaxial cable.
6. Using tape, cover predrilled holes in coaxial cable and the area where the braid contacts penetrated the outer covering of the coaxial cable.
7. Install new braid contacts in the transceiver. (Refer to Paragraph 4.6.)



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Figure 4-3: H4000 Transceiver: Detailing Clamping Block Removal and Braid Contacts Removal and Installation

DETAIL A

4.5 Transceiver Installation

1. Install the transceiver at the black bands marked on the Ethernet coaxial cable.

If a transceiver had been located at the selected band marking and removed, then install the transceiver 10 cm to either side of the marking.

2. Install the transceiver on the coaxial cable.

The coaxial cable must be preconditioned by drilling two holes through the outer jacket and shield of the coaxial cable. The tools, fixture, and instructions for preconditioning the coaxial cable and installing the transceiver are contained in Installation Kit, H4090-KA.

4.6 Braid Contacts Replacement Procedure

If transceiver main housing is attached to the coaxial cable, remove the transceiver in accordance with the instructions provided in Paragraph 4.4, then perform the following procedure:

1. Obtain two new braid contacts from Installation Kit, H4090-KA.
2. Remove defective or used braid contacts from main housing by lifting braid contacts directly out of main housing (See detail A of Figure 4-3).
3. Install new braid contacts as shown in Detail A of Figure 4-3.

