1 THEORY OF OPERATION

1.1 General

The KAC 1052 Antenna Coupler is a component of a KHF 1050 HF Radio Communication system. It receives 200Wpep HF signals from the KPA 1052 Power Amplifier and feed the power to an aircraft antenna efficiently. Receiving signals from an antenna is provided to the KRX 1053 Receiver/Exciter via KPA 1052 Power Amplifier.

The unit is normally installed near an antenna inside of an aircraft fuselage for reducing feeder loss.

The unit is filled with dry Nitrogen and keeps it's internal pressure to prevent the RF networks from sparking caused by high voltage and low pressure.

The unit is composed of following circuit cards.

CBL-103	PS & INTERFACE
CDC-1083B	CPLR CONTROL
CCN-338	SENSOR & RLY DRV
CSC-590B	SHUNT CAP BOARD
CSC-591B	SERIES CAP BOARD
CSC-592B	COIL BOARD

CBL-103 PS & INTERFACE card is located at front panel and composed of power supply switching circuit, voltage regulators, and voltage-current converter for APC, RS422 interface driver and surge protection for interface signals. The card supplies 28V, 12V and 5V DC power to all circuit cards and has all interface connectors to communicate with another LRUs.

CDC-1083 CPLR CONTROL card is located between CBL-103 PS & INTERFACE card and shield assembly and composed of CPU, CPLD, EEPROM, analog interface, RS232C interface driver, reference voltage generator, pressure sensor, temperature sensor and voltage monitor. The card administers all operations to be needed and monitoring the state of the unit.

CCN-338 SENSOR & RLY DRV card is located between shield assembly and three RF boards and composed of impedance sensor, RF power level detector, 3dB attenuator, relay driver, bridge amplifier and part of relays for RF network determination. The card detects input impedance and provides them to the CDC-1083B CPLR CONTROL, converts serial relay signals to parallel relay signals and amplifies received signals and provides to the KRX 1053 Receiver/Exciter.

CSC-590B SHUNT CAP BOARD card is located between CSC-591B SERIES CAP BOARD and CSC-592B COIL BOARD card and composed of shunt capacitors and relays constituting the RF networks, arrestor and discharging resistor.

CSC-591B SERIES CAP BOARD card is located at right side of the unit and composed of series capacitors and relays constituting the RF networks. The capacitors are sometimes connected as shunt capacitor arm of the RF networks.

CSC-592B COIL BOARD card is located at left side of the unit and composed of inductors and relays constituting the RF networks. The inductors are connected as shunt inductor arm or series inductor arm of the RF networks.

Figure 1.1 shows overall simplified black diagram of KAC 1052 Antenna Coupler.

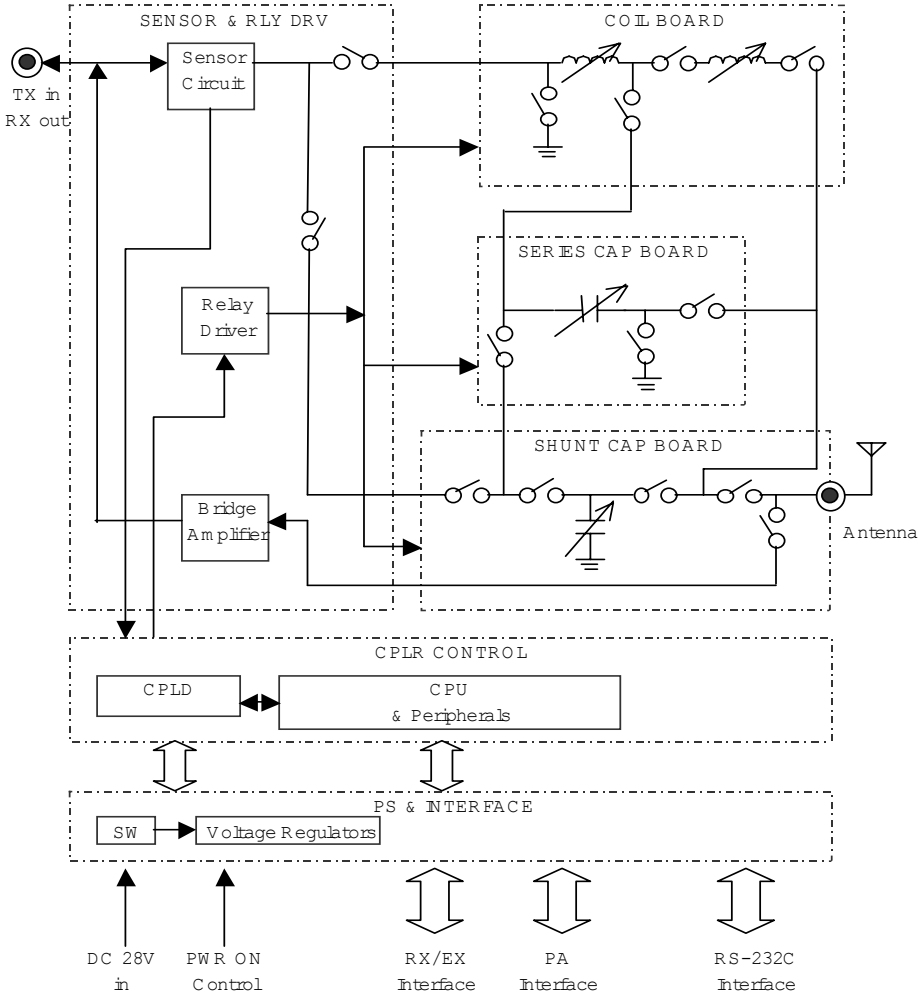


Figure 1.1 Overall Simplified Block Diagram of KAC 1052 Antenna Coupler

1.2 Construction

The mechanical configuration of the KAC 1052 Antenna Coupler is mainly composed of chassis assembly, two side plates, shield assembly, front bracket and rear bracket.

The chassis assembly is composed front panel, rear panel, top plate and bottom plate and these are welded together.

Both side plates seal chassis assembly tightly and enable to maintain internal circuit cards by removing from chassis assembly.

Shield assembly is composed of shield cap, shield plate and two support plates that isolate RF circuit and sensor circuit from digital noisy circuit such as CPU. For this purpose, the shield is located between CDC-1083B CPLR CONTROL card and CCN-338 SENSOR & RLY DRV card.

Front and rear bracket is used for fixing the unit to an aircraft fuselage with mounting tray.

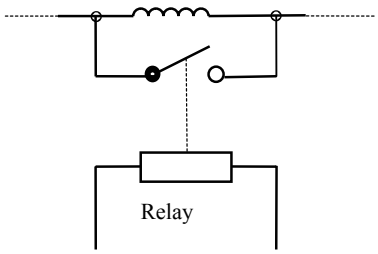
Outside of the unit has BNC connector, 37 pins sub D connector with one touch locking, 9 pins sub D connector, air valve and relief valve on the front panel and HN connector, ground terminal and vent plug on the rear panel. All these parts and side plates are airproof type to keep internal pressure level even if the unit is in low-pressure environment

The chassis assembly and side plates are designed to withstand internal high pressure of Nitrogen and severe vibrations of an aircraft.

1.3 RF Networks

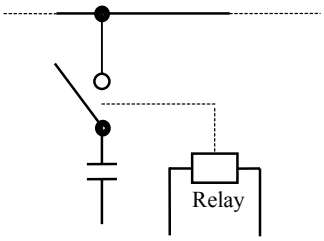
RF matching circuit of the unit is composed of three circuit arms, shunt capacitor, series capacitor and inductor circuit. Each arm is allocated for each card, CSC-590B SHUNT CAP BOARD, CSC-591B SERIES CAP BOARD and CSC-592B COIL BOARD.

Each arm is composed of 12 to 13 elements that are combination of capacitors or inductors and switching relays in order to realize both sufficient resolution at the upper limit frequency and wide coverage range at the lower limit frequency. Each capacitor or inductor is connected or disconnected by relays. Figure 1.2 shows the way of change over by relay in inductor and capacitor elements. Values of these elements are set to increase by binary system. For example, if the capacitance value of C101 is 1, the relative capacitance value of C102, C103 will be 2 and 4 in principle. Combined inductance or combined capacitance of arm is the sum of all applied elements.



When relay is OFF, inductor is applied.
When relay is ON, inductor is short circuited and does not affect circuit.

Inductance Element



When relay is ON, capacitor is applied.
When relay is OFF, capacitor is not connected and does not affect circuit.

Capacitance Element

Figure 1.2 Change over by Relay of Circuit Elements

Refer to Figure 1.3 RF Matching Network of KAC 1052 Antenna Coupler.

CSC-590B SHUNT CAP BOARD has parallel connected 13 shunt capacitor elements and three network determination relays. The maximum capacitance is approximately 5600pF.

CSC-591B SERIES CAP BOARD has parallel connected 13 series capacitor elements and three network determination relays. The maximum capacitance is approximately 1500pF.

CSC-592B COIL BOARD has series connected 12 inductor elements and three network determination relays. The maximum inductance is approximately 48uH.

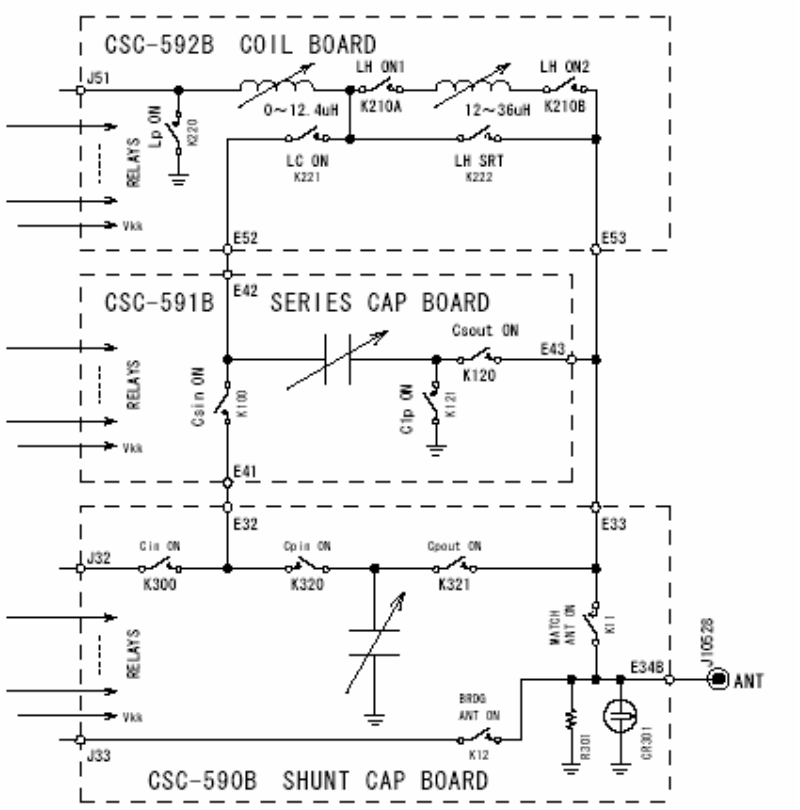
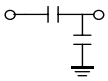
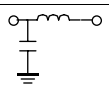
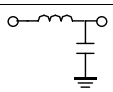
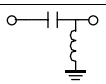
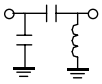
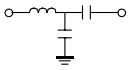
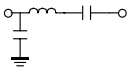
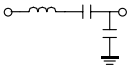
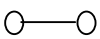


Figure 1.3 RF Matching Network of KAC 1052 Antenna Coupler

The unit has many circuit configurations that enable wide matching impedance region. Combinations of network determination relays set the circuit configuration. Available circuit configurations are listed on Table 1.1. The unit tries to set the most efficient circuit among these configurations during tuning sequence.

Table 1.1 RF Circuit Configurations of KAC 1052 Antenna Coupler

No	Circuit	Schematic	Ls on	Lp on	LC on	LH1	LH2	LHSR	Cin on	Cs on1	Cs on2	C1p	Cp in	Cp out	Note
1	Cp-Cs			O		O			O	O	O		O		
2	Cs-Cp			O		O			O	O	O			O	
3	Cp-Ls		O			X	X	X	O				O		
4	Ls-Cp		O			X	X	X						O	
5	Cs-Lp			O				O	O	O	O				
6	Cp-Cs-Lp			O		X	X	X	O	O	O		O		
7	Lp-Cs-Cp			O	O				O	O	O			O	
8	C1p-Ls -C3p		O			X	X	X	O	O		O		O	
9	Ls-Cp-Cs		O		O					O	O		O		
10	Cp-Ls-Cs		O		O				O		O		O		
11	Ls-Cs-Cp		O		O						O			O	
12	THRU			O		O			O				O	O	

Note 1: O: ON X: At least one relay ON

Note 2: “Ls on” relay is located on CCN-338 SENSOR & RLY DRV card

1.4 Sensors

The unit has following sensors; impedance sensors, pressure sensor, temperature sensor and power supply voltage sensor. The impedance sensors are located on CCN-338 SENSOR & RLY DRV and others are on CDC-1083B CPLR CONTROL.

The impedance sensors are divided into magnitude detector, phase detector, angle detector, resistance (R) detector, conductance (G) detector and VSWR detector. Figure 1.4 shows block diagram of the impedance sensors in the CCN-338 SENSOR & RLY DRV.

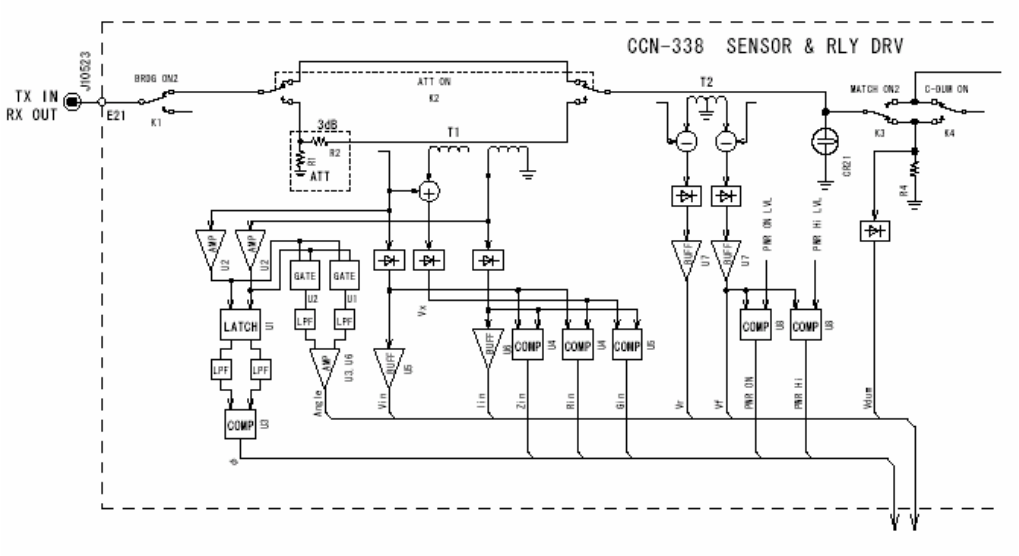


Figure 1.4 Block Diagram of Impedance Sensors

The magnitude (Zin) detector judges magnitude of line impedance. The detector compares the magnitude of line voltage with that of current. If magnitude of line voltage is smaller than line current, in other words line impedance is smaller than 50 Ohm, the signal "Zin<Zo" will be low.

The phase detector judges the phase of line impedance. The detector detects phase difference between line voltage and current. If line voltage lag line current, in other words line impedance is capacitive, the signal "PH<0" will be low.

The angle detector generates DC voltage proportional to the phase difference between line voltage and line current. The signal has no polarity and it will be 5Vdc at maximum phase difference 90 deg.

The resistance detector judges magnitude of real part line impedance. The detector compares the sum of the line voltage and current with the magnitude of line voltage. If the real part of line impedance is smaller than 50 Ohm, the signal "Rin<Zo" will be low.

The conductance detector judges magnitude of real part line admittance (conductance). The detector compares the sum of the line voltage and current with the magnitude of line current. If the line conductance is smaller than 1/50 Siemens, the signal "Gin>Go" will be high.

The VSWR detector detects forward voltage (Vf) and reflected voltage (Vr) of line. Each voltage is compared each other to generate VSWR signals on the CDC-1083B CPLR CONTROL card. The signal "Vf" is also used to generate "PWR ON" and "PWR Hi" signals. The "PWR ON" signal informs the CPU that RF power level is valid and enables tuning operation. The "PWR Hi" signal informs the CPU that RF

power level is too high to tune and enables detune detection.

The pressure sensor detects internal absolute pressure of the unit. The device U42 outputs differential DC voltage “Vo+” and “Vo-” proportional to the pressure followed by the high input impedance differential amplifier composed of U43 and U44A. The gain of the differential amplifier is designed that the output voltage will be approximately 4Vdc with 30-psia pressures. This voltage is provided to CPU and converted digital value to detect pressure-warning level. The comparator U44B detects low-pressure alarm and informs CPU via CPLD as “PRESS ALM”. The alarm level is set to approximately 11.9 psia.

The temperature sensor detects internal temperature of the unit. The device R428 varies its resistance sensitively to temperature and shunt resistors R426 and R427 linearize the resistance. The output voltage of the amplifier U45A is approximately proportional to absolute temperature and will be approximately 2Vdc at 400degree K. This voltage is provided to CPU and converted digital value to compensate the pressure value to it at room temperature.

The power supply voltage sensor monitors the combined voltage of 12Vdc and 5Vdc used in the unit. The combined voltage is provided to CPU and converted digital value. If the 12Vdc and /or 5Vdc are failed, CPU detects power supply alarm.

1.5 Bridge Amplifier

The Bridge Amplifier is mounted on CCN-338 SENSOR & RLY DRV. The amplifier amplifies received signal fed from antenna and provides the signal to the KRX 1053 Receiver/Exciter via KPA 1052 Power Amplifier.

Figure 1.5 shows the block diagram of Bridge Amplifier. The amplifier is composed of single NPN transistor and transformer used for feedback circuit. The impedance transformer is inserted at its input circuit to convert the impedance from 50 Ohm to about 400 Ohm. The approximate gain of the amplifier is 9 to 12 dB at the frequency range from 2 to 30MHz. The internal oscillator and output level detector are incorporated to detect the failure of the amplifier. The frequency of the oscillator is approximately 4MHz.

To protect the amplifier, the input circuit is connected to ground and output is connected to internal 50 Ohm resistor when the unit and/or other side system is in transmitting state.

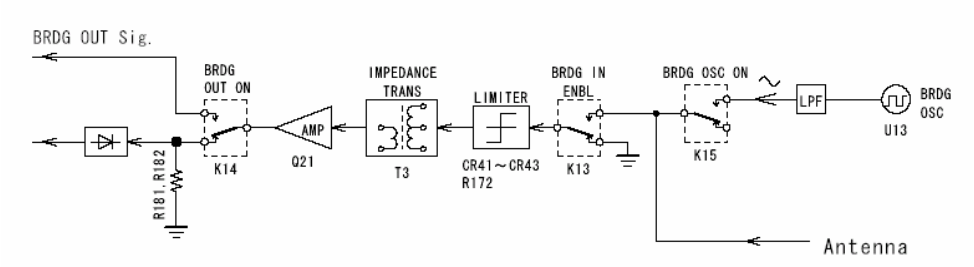


Figure 1.5 Block Diagram of Bridge Amplifier

1.6 CPLR Control (CDC-1083B)

1.7 Interface (CBL-103 PS & INTERFACE)

1.8 Power Supply