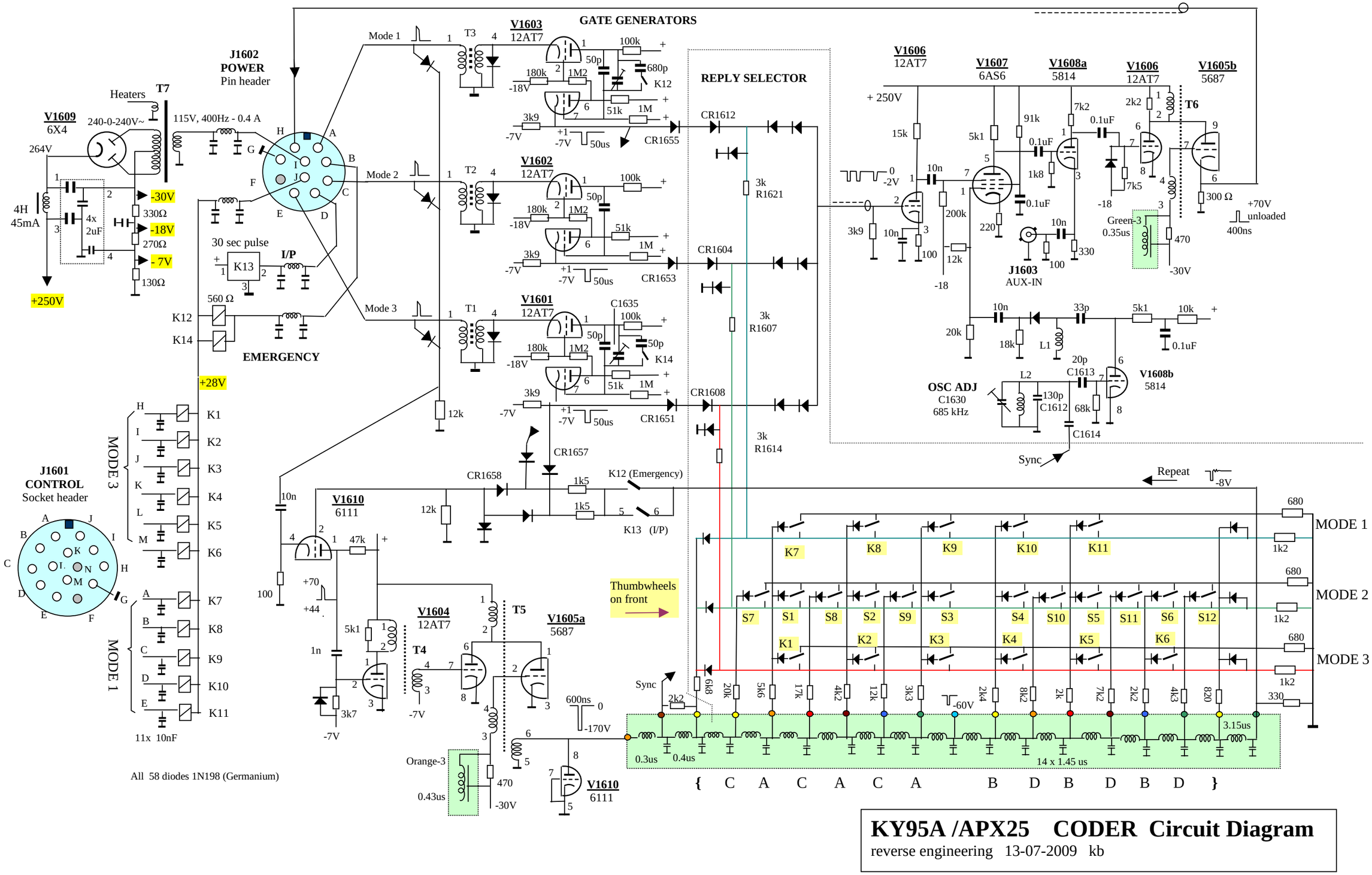
See page 2 for details



KY95A /APX25 CODER Circuit Diagram

reverse engineering 13-07-2009 kb

KY-95A /APX-25 Coder

The APX-25 IFF transponder dates from 1952, and has the following parts:

RT-279 /APX	Receiver/Transmitter
KY-95A/APX-25	Coder
C-1158 /APX	IFF (master) control box
C-1128/APX-25	SIF control box
AT-234 /APX	L-band blade antenna

The coder KY95 receives its power supply (115Vac and 28Vdc), as well as the decoded mode 1, 2 and 3 pulses ("challenges") from the RT279/APX unit via the 10-pin plug J1602 "power". The coded reply is sent back to the RT279 via this plug as well.

The 12-bit Mode-2 reply code is set on thumb wheels on the KY95A*, and is not accessible during flight. The 5-bit Mode1 and the 6 bit Mode 3 codes are set on the controlbox C1185/APX, which is connected to the coder via the 14-pole plug J1602 "control"
* In the KY95, the Mode-2 code is set with 12 tiny tumbler switches behind a cover.

Circuit description

The circuit is essentially a parallel-to-serial shift register, capable to output 3 different codes. Switches set the bits in each code. Which code depends on the input pin that gave the start pulse.

Delay line

Regardless of mode, any input pulse is applied to the input of a tapped delay line after being shaped to 0.4us wide and 170V high.
The delay line has 17 sections: 0.3µs, 0.4µs, then 14 sections 1.45µs, and finally 3.15 µs.
The characteristic impedance of the line is 1k. Internally, the delay line has subsections of approx. 0.15µs, each approx. 0.15mH/150pF. This makes a total of 190 inductors and 190 capacitors in a hermetically sealed box. The series resistance per section is 17 Ω.
The damping is severe; at the end of the delay line only an 8V pulse remains. Resistors in series with each tap make the output pulses equal.
Two short delaylines for pulse shaping are in the same sealed box as well.

Diode selector

The pulse on each tap can be switched to the output to form the output pulse pattern. The complete mode 1, 2 and 3 replies are made simultaneously. To keep the load on each tap constant, change-over type switches are used, like these rather exotic octal thumbwheel switches.

The coder was designed in 1951, only a few years after the invention of the transistor and the mature use of germanium as a semiconductor material. Yet, early 1N198 gold-bonded germanium diodes are used. This diode can block 80V, can conduct 4mA continuous, or 100mA pulsed. The selector circuits have a low impedance, and leakage in (hot) diodes is not directly a problem. The ringing from the delay line, especially in the Emergency mode, is more a problem, leading to random pulse replies in my set.

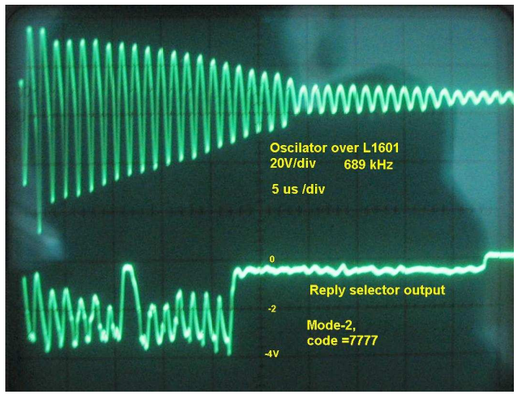
Gate generators

To decide which response from the tapped delay line must be used, the Coder must remember which pin on J1602 ("Mode") started the process.
The mode 1, 2 or 3 challenge is remembered during 47us in the monostable circuit around V1603, V1602 or V1601. Once any one of them is triggered, any other triggers are blocked for 100us in the RT279.

During the monstable time (one shot), the reply for the requested mode is transferred to the output.
During the pulse of the one shot, its output is –7V, and its output diodes do not conduct. Outside the pulse (or without one), the cathode current flows in the two output diodes and the diode to ground in the reply selector, shorting any signal from the delayline to ground.
The mode 1 and mode 3 one shot time is extended to 100µs when "Emergency" is selected by the pilot.

Reply selector

The pulse trains for mode 1, 2 or 3 are gated with the output pulse of the respective one shots.
The pulses from the reply selector are only 2V pk, that's all what is left from the 170V pulse that once entered the delay line.
Shown below (lower trace) is this signal, recorded at a Mode-2 challenge, the thumbwheels set at 7777 to produce all 12 data pulses, and the leading and trailing bracket pulses. The end of the (47µs) gate pulse is just visible at the far right of the oscilogram.



Output pulse shaper

The pulses from the reply selector are amplified, and gated with a 690kHz clock signal. This clock signal comes from a slightly damped resonant circuit, triggered by a short pulse from the first tap in the delay line. This results in sharp equidistant pulses, rather than the small, unequal rounded pulses from the reply selector.
The final output stage has a blocking oscilor, a circuit that produces short pulses by regenerative feedback. The output triode is a high current type, allowing 500mA peak cathode current for 0.5us.

I/P mode

Another novelty in the APX-25 is the Identify Position (I/P) function which repeats the reply code when the pilot pushes the transmit switch on his microphone. The double reponse produces an extra blob on the radar near the main echo, so the air traffic controller can see with whom he is talking. To make shure that the I/P is visible on the radar, the I/P mode must be present for at least one revolution of the ground radar antenna.
An extension to 30 sec is made by relay K13 in the coder. This sealed unit inside the KY95 had originally a circuit with a tube, but later versions had a early transistor in it.
The contact of relay K13 feeds the output pulse of the delay line back to the input during the mode 1 or mode 3 one shot time, so the complete pattern is made once more. Because the mode one-shots have a pulse width of 47 µs, the first repeat is transferred to the output.
The 690kHz clock oscillator is re-triggered as well, and should be adjusted especially for good pulse forming in case of such a repeated pattern. The distance between the closing bracket pulse of the first replay and the opening bracket pulse of the repeated reply should be exactly 3 clock cycles.

Emergency mode

When the master switch on the APX-25 control panel is turned to the "Emergency" position, the mode1 or mode 3 replies are repeated even 4 times. The method is the same as with the I/P trick, but the Mode 1 and Mode 3 one-shot times are extended to 100us instead of the normal 47µs.
Mode 2 has no repeats at all.

Power supply

All power is supplied from the RT 279.
This is **28V dc** at 0.65A max when mode1 =37 and mode 3= 77, and emergency is selected, then all 13 relays are energized, each 50mA

The **115Vac** / 320-1760Hz, usually 400Hz draws 0.4A, that is 46VA and 40W: 24W for heaters and 15W for circuitry idling. When pulsing at the highest speed (4kHz), the consumption is nearly the same.

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