Panasonic Analogue Proprietary Telephone (APT) Documentation V0.95

TechnicallyObsolete

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Contents

1 Introduction

This document is a collection of notes from reverse engineering the Panasonic APT ("Analogue Proprietary Telephone") communications interface.
This document aims to cover the following:

- Analogue Proprietary Telephones
- Voice Processing System (Analogue integration)
- DSS Consoles

2 Physical Layer

Line voltage may be either 40v (when the corresponding PBX port is configured for DSS mode) or 15v (when the PBX port is not configured in DSS mode). The KX-T7640 DSS console that I have seems to operate correctly at either voltage (it has a switching DC-DC converter), but phones should not be supplied with 40v (the phones I have use linear regulators for the logic supply).

Voice to and from the phone is handled exactly the same way as a conventional analogue phone line.

Data is transmitted in the form of pulses, amplitude around 2 V above or below the DC level. Data from the PBX to the phone is transmitted as a negative-going pulse, and data from phone to PBX is transmitted as a positive-going pulse.

A logic 1 is encoded by a 4µs pulse followed by a 28µs space, and a logic 0 is encoded by a 32µs space. The total time from the start of one packet to the start of the next is 64ms (measured on a KX-TDA30), but I've not seen any obvious issues even with much greater time between packets.

Note that the pulses are quite narrow, and there appears to be a moderate amount of jitter on the packets from the DSS console (but not in the packets from the PBX). To mitigate this, devices use an S/R latch, which is set each time a pulse appears (even if it is short), and cleared each time the microcontroller reads a bit. In the Sigrok plugin I wrote while reverse engineering this protocol, I sample for 2x the bit time instead.

At the start of a packet, the PBX generates a single pulse.

Then, the phone (or DSS console) sends 19 bits:

- one start bit which is always 1
- 16 data bits
- one parity bit, so that there are an even number of 1s (including start, parity and stop bits)
- one stop bit which is always 1

MSB (bit 18) is transmitted first and LSB (bit 0) last.

The PBX replies with 47 bits:

- one start bit which is always 1
- four address bits[1]
- 40 data bits
- one parity bit, so that there are an even number of 1s (including start, parity and stop bits)
- one stop bit which is always 1

MSB (bit 46) is transmitted first, and LSB (bit 0) last.

If the parity included in this message was correct, the phone will then reply with a single ACK bit.

[1] These are definitely address bits for DSS consoles, although I'm not certain that they're used as such on APTs. I suspect that some of the bits are used to enable/disable the speaker.

3 Bit Assignment

3.1 Phone to PBX

The 16 data bits from the phone are arranged as follows:

Table 1: Bit Mapping - Phone/DSS to PBX

Bit Within Frame	DataBit	Fn	
18	N/A	Start (Always 1)	
17	15	Button Press	[7]
16	14		[6]
15	13		[5]
14	12		[4]
13	11		[3]
12	10		[2]
11	9		[1]
10	8		[0]
9	7	Model ID	[3]
8	6		[2]
7	5		[1]
6	4		[0]
5	3	Program Mode?	1 = In Program Mode
4	2	Flash Button	1 = Flash Pressed
3	1	Hook Switch	1 = Off Hook
2	0	Always 1?	
1	N/A	Parity	
0	N/A	Stop (Always 1)	

Note that on startup, phones send a button code decimal 145 and DSS consoles do not. Additional details of the startup process can be found in section 5.

Observed model IDs are as follows:

Model	On Hook code[18:0]	DataBits[15:0]	Model ID[3:0]
T7720 (No LCD)	0x40007	0x0001	0x0
T7730 (1 Line LCD)	0x400C7	0x0031	0x3
T7735 (3 Line LCD)	????	????	????
T7736 (6 Line LCD)	????	????	????
T7740 (DSS Console)	0x402F5	0x00BD	0xB

NOTE: I'm not completely confident in these data points - more work is needed to capture model codings.

3.2 Summary

Command Name	Direction	Addr
Button Press 3.2.1	TE->PBX	N/A
LED Control 3.2.2	PBX->TE	0x8-0xF
LCD Update (full line) 3.2.3	PBX->TE	0x0
LCD Update (Single Char) 3.2.4	PBX->TE	0x5
Speaker Enable 3.2.5	PBX->TE	

3.2.1 Button Press

APT buttons are numbered as follows:

Table 2: Button press scancodes

Key	Reported button code (Decimal)
0	26
1	17
2	18
3	19
4	20
5	21
6	22
7	23
8	24
9	25
*	27
#	28
Flash/Recall	Not sent - Handled in ID
Transfer	32
Redial	33
Auto Answer / Mute	34
Speaker Phone	35
Program	36
Conference	64
Hold	65
Pause	66
FWD / DND	67
Auto Dial / Store	68
Message	70
Volume Up	Not Sent (handled locally)
Volume Down	Not Sent (handled locally)
Line 1	80
Line 2	81
Line 3	82
Line 4	83
...	
Line 11	90
Line 12	91
Intercom	95

3.2.2 LED Control

Each LED is controlled with a 4 bit value, and there are 10 LED controlled per address. The MSB of this value encodes the colour of the LED (`0=Green`, `1=Red`), and the three LSBs control the pattern: LED Mappings are as follows:

Table 3: LED control bits

0	Static Off
1	Static On
2	Slow Flash
3	Double Flash
4	Fast Flash
5	Not Used
6	
7	

Table 4: LED Mapping

LED	Address	Index (9 to 0)	DataBits[39:0]
Line 1	8	9	[39:36]
Line 2	8	8	[35:32]
Line 3	8	7	[31:28]
Line 4	8	6	[27:24]
Line 5	8	5	[23:20]
Line 6	8	4	[19:16]
Line 7	11?	3	[15:12]
Line 8	8	2	[11:8]
Line 9	15	7	[31:28]
Line 10	15	6	[27:24]
Line 11	15	5	[23:20]
Line 12	15	4	[19:16]
Intercom	8	1	[7:4]
Conference	12	1	[7:4]
FWD/DND	12	2	[11:8]
Auto Answer	12	3	[15:12]
Auto Dial	12	2?	[11:8]
Message Waiting	12?	1	[7:4]
Speaker Phone	15	3	[15:12]

3.2.3 LCD Control - Multicharacter

An LCD control command to a T7730 is shown below (note that @ is used in place of non printable ASCII characters, and that the LCD positions are numbered from `0xF` on the left to `0x0` on the right).

```
400E5 43F541C9BC03 Addr=00 Btn=0 LED=0xFD50726F00 LCD=00:Pro@
400E5 640000000203 Addr=09 Btn=0 LED=0x0000000080 LCD=00:@@@@
400E5 43299DC98401 Addr=00 Btn=0 LED=0xCA67726100 LCD=02:gra@
400E5 425DB4813803 Addr=00 Btn=0 LED=0x976D204E00 LCD=00:m N@
400E5 4191BCFDF803 Addr=00 Btn=0 LED=0x646F3F7E00 LCD=02:o?~@
400E5 40C480808001 Addr=00 Btn=0 LED=0x3120202000 LCD=00:   @
```

Table 5: Bit Mapping - LCD

DataBit	Fn	
39	Start Position	[3]
38		[2]
37		[1]
36		[0]
35	End Position	[3]
34		[2]
33		[1]
32		[0]
31	ASCII Char	[7]
30		[6]
29		[5]
28		[4]
27		[3]
26		[2]
25		[1]
24		[0]
23	ASCII Char	[7]
22		[6]
21		[5]
20		[4]
19		[3]
18		[2]
17		[1]
16		[0]
15	ASCII Char	[7]
14		[6]
13		[5]
12		[4]
11		[3]
10		[2]
9		[1]
8		[0]
7	ASCII Char	[7]
6		[6]
5		[5]
4		[4]
3		[3]
2		[2]
1		[1]
0		[0]

3.2.4 LCD Control - Single Character

The following sequence has been observed when dialling digits (to shift the contents of the display one position to the left, and append a new digit):

```
400C7 5583C0C40003 Addr=05 Btn=0 LED=0x60F0310000 LCD=00:@1@@
```

3.2.5 Speaker Control

Although not fully tested yet, I strongly suspect that bit 0 of the address is related to a ”speaker enable” bit.

```
Paging call active (speaker enabled, microphone disabled):
40105 740000000081 Addr=13 Btn=0 LED=0x0000000020
40105 640000000001 Addr=09 Btn=0 LED=0x0000000000


Paging call end (speaker disabled):
40105 600000000003 Addr=08 Btn=0 LED=0x0000000000
40105 700000000083 Addr=12 Btn=0 LED=0x0000000020

Sp Phone active (speaker enabled, microphone enabled):
40105 7C0000010081 Addr=15 Btn=0 LED=0x0000004020
40105 6C0000000041 Addr=11 Btn=0 LED=0x0000000010
```

3.3 DSS

In the PBX to DSS direction, each of the addresses controls 10 bi-colour LEDs. These are in a logical order, with buttons 1 to 10 being at address `0x8`, buttons 11 to 20 at `0x9` and so on. The same 4-bit mapping (as used for APT LEDs) detailed in Table 4 is applicable here.

The buttons returned from the DSS are also in a logical order, from decimal `1` to decimal `60`.

3.4 Bit Assignment - VM

Not yet reverse engineered

4 Appendix - Bit Mapping tables

4.1 Bit Mapping - PBX to DSS

Table 6: Bit Mapping - PBX to DSS

DataBit	Fn	
39	LED0	[3]
38		[2]
37		[1]
36		[0]
35	LED1	[3]
34		[2]
33		[1]
32		[0]
31	LED2	[3]
30		[2]
29		[1]
28		[0]
27	LED3	[3]
26		[2]
25		[1]
24		[0]
23	LED4	[3]
22		[2]
21		[1]
20		[0]
19	LED5	[3]
18		[2]
17		[1]
16		[0]
15	LED6	[3]
14		[2]
13		[1]
12		[0]
11	LED7	[3]
10		[2]
9		[1]
8		[0]
7	LED8	[3]
6		[2]
5		[1]
4		[0]
3	LED9	[3]
2		[2]
1		[1]
0		[0]

5 Startup

The following section contains some packet captures at startup. The first column is the data from phone (or DSS) to PBX, and the second column is data from PBX to phone, in both cases including start/stop/parity bits.

5.1 T7720 (No LCD)

```
40007 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
40007 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
40007 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
40007 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
40007 5C1000000001 Addr=07 Btn=0   LED=0x0400000000
64405 700000000001 Addr=12 Btn=145 LED=0x0000000000
40007 600000000003 Addr=08 Btn=0   LED=0x0000000000
40007 700000000083 Addr=12 Btn=0   LED=0x0000000020
40007 600000000003 Addr=08 Btn=0   LED=0x0000000000
40007 700000000083 Addr=12 Btn=0   LED=0x0000000020
40007 600000000003 Addr=08 Btn=0   LED=0x0000000000
40007 700000000083 Addr=12 Btn=0   LED=0x0000000020
```

5.2 T7730 (Single line LCD)

```
400CD 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
400CD 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
400CD 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
400CD 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
400CD 5C1000000001 Addr=07 Btn=0   LED=0x0400000000
644CF 600000000003 Addr=08 Btn=145 LED=0x0000000000
400CD 5403C0000001 Addr=05 Btn=0   LED=0x00F0000000
400CD 700000000083 Addr=12 Btn=0   LED=0x0000000020
400CD 600000000003 Addr=08 Btn=0   LED=0x0000000000
```

5.3 T7740 (DSS console)

```
402F5 5403C0000001 Addr=05 Btn=0 LED=0x00F0000000
402F5 5403C0000001 Addr=05 Btn=0 LED=0x00F0000000
402F5 5403C0000001 Addr=05 Btn=0 LED=0x00F0000000
402F5 5403C0000001 Addr=05 Btn=0 LED=0x00F0000000
402F5 5C1000000001 Addr=07 Btn=0 LED=0x0400000000
402F5 600000000003 Addr=08 Btn=0 LED=0x0000000000
402F5 700000000001 Addr=12 Btn=0 LED=0x0000000000
402F5 600000000003 Addr=08 Btn=0 LED=0x0000000000
402F5 700000000001 Addr=12 Btn=0 LED=0x0000000000
402F5 600000000003 Addr=08 Btn=0 LED=0x0000000000
402F5 700000000001 Addr=12 Btn=0 LED=0x0000000000
402F5 5C1000000001 Addr=07 Btn=0 LED=0x0400000000
402F5 600000000003 Addr=08 Btn=0 LED=0x0000000000
402F5 700000000001 Addr=12 Btn=0 LED=0x0000000000
```

6 Appendix - Sample Packet captures / Waveforms

Figure 1: Sample packet capture (overview)

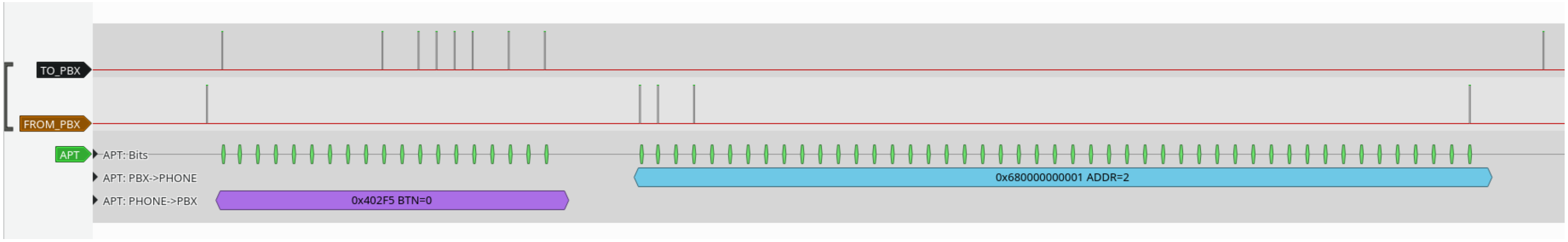


Figure 2: Sample packet capture (To PBX)

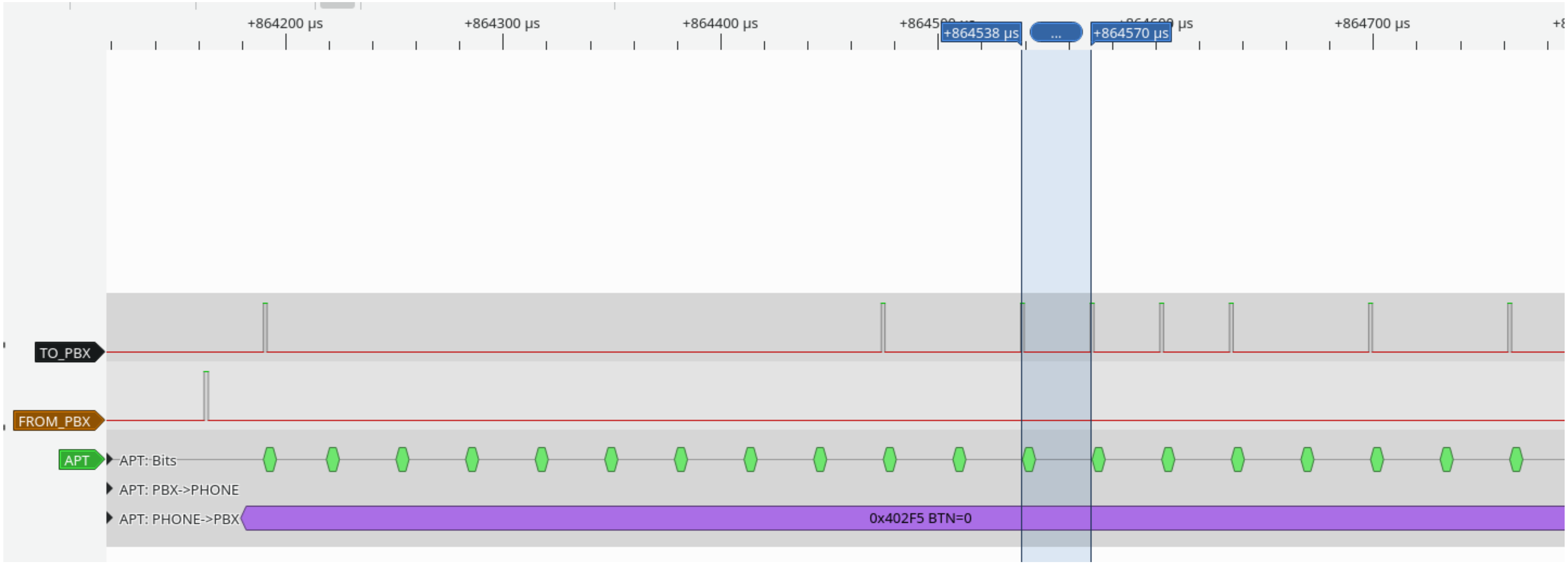


Figure 3: Sample packet capture (From PBX)

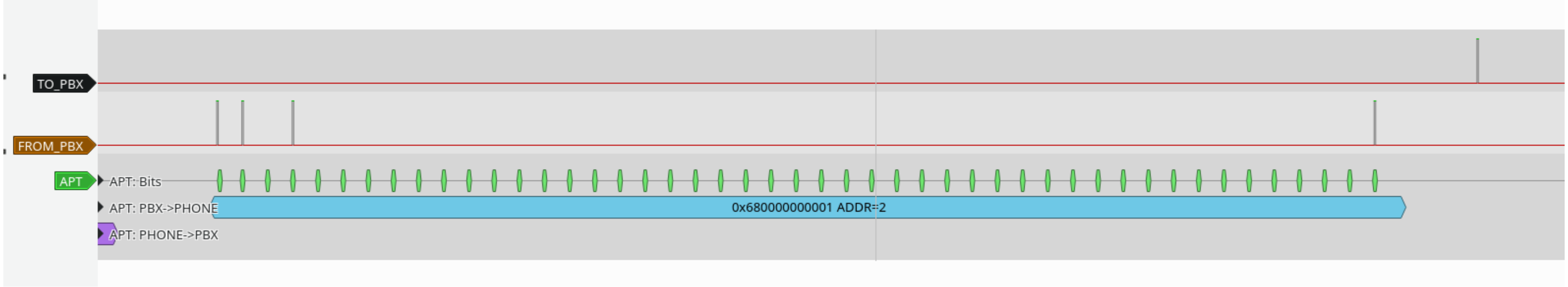
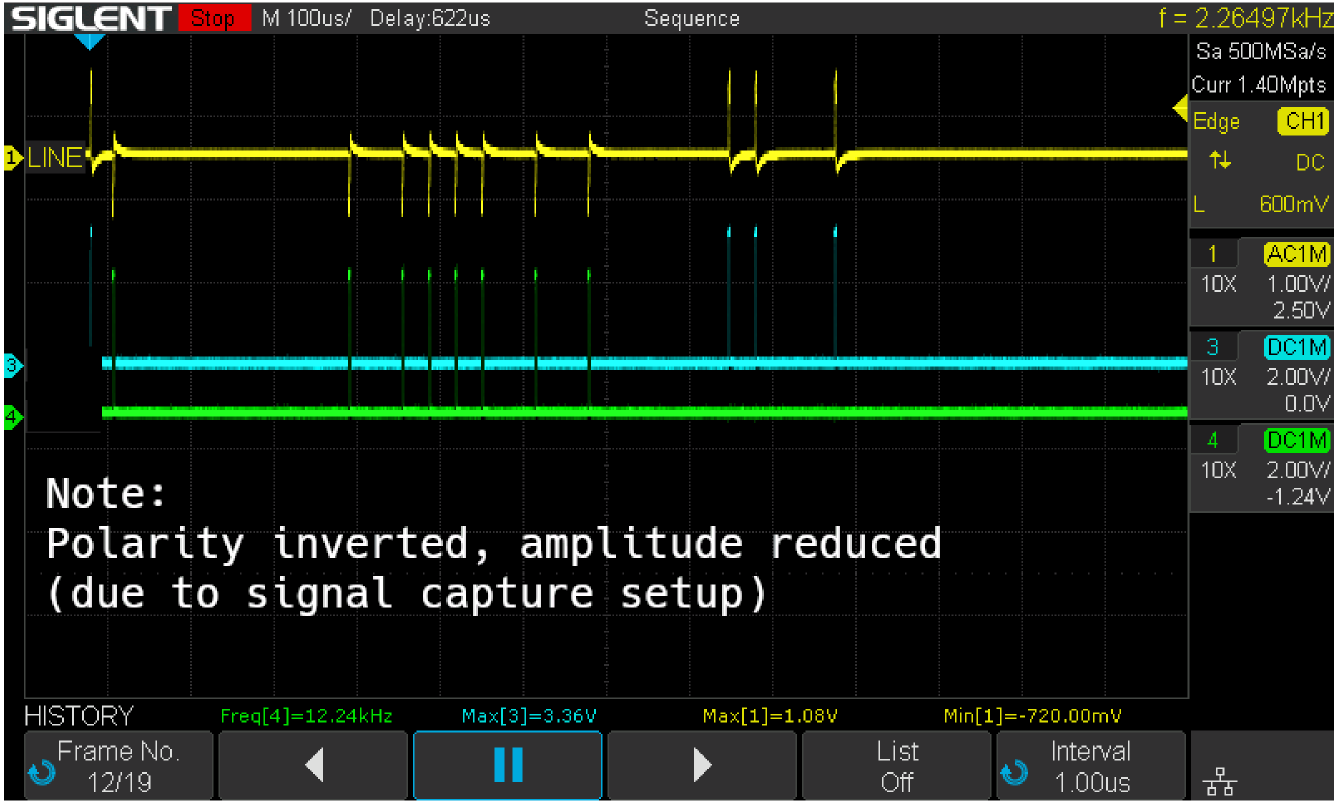


Figure 4: Sample packet capture (Oscilloscope trace)



Note:
Polarity inverted, amplitude reduced
(due to signal capture setup)

7 APT Model Coding

The KX-T7720, KX-T7730, KX-T7735 and KX-T7750 share a common PCB and software (note, this list does not include the KX-T7736).

Q109 has integrated pulldown resistors. If fitted, pins 34 and pins 33 of IC1 are pulled down. If Q109 is not fitted, and R152 is fitted, then pin 34 is floating, and pin 33 is pulled up to VCC.

The part number for IC1 in the KX-T7736 is `C2ABEE000018` rather than `C2ABEE000013` in the other models, so I suspect it is the same IC but with different firmware.

Table 7: KX-T77x Model Coding

Model	R152	R153	R154	R155	RA1	Q109
KX-T7720 No LCD	100k			100k		
KX-T7730 (1 line LCD)				100k	47k	Present
KX-T7735 (3 line LCD)			100k		47k	Present
KX-T7750 No LCD, no Speakerphone	100k	100k		100k		

8 Appendix - Change History

- 2023-08-10 V0.9 Initial Document version
- 2023-10-23 V0.95 Major update to APT section