

Low power digital UHF paging receiver

UAA2050T

GENERAL DESCRIPTION

The UAA2050T is a very low power UHF and VHF radio receiver circuit, primarily intended for use in paging receivers (27 MHz to 470 MHz) for wide-area digital paging systems employing direct FM non-return-to-zero (NRZ) frequency-shift keying (FSK) modulation.

Used in conjunction with the PCA5000T decoder for POCSAG paging systems, it offers an extremely advanced radio paging concept.

The radio receiver design is based on the offset receiver principle. The receiver provides fully filtered and squared data to drive the decoder and can be turned off completely by external inputs.

Features

- Low noise preamplifier ensuring high RF sensitivity
- Few external components required
- Low current consumption
- Wide operating supply voltage range
- Power on/off mode selectable via the enable input (RE)
- Low battery voltage detector
- Crystal controlled receiver frequency (AFC)
- Fully compatible with all FSK modulated systems (512 and 1200 bits/s)
- Uses low cost crystal

QUICK REFERENCE DATA

| parameter | condition | symbol | min. | typ. | max. | unit |
|-------------------------------------|-----------------------------------|------------------|------|------|------|--------------|
| Supply voltage range | | $V_P = V_{7-15}$ | 1.9 | — | 3.5 | V |
| Supply voltage for preamplifier | | $V_{23-24-15}$ | 1.0 | — | 3.5 | V |
| Total supply current | | I_{tot} | 2.25 | — | 3.76 | mA |
| Supply current OFF | | $-I_{OFF}$ | — | — | 1.0 | μ A |
| RF sensitivity (RMS value) | 1×10^{-2} bit error rate | EMF/2 | — | 0.18 | 0.25 | μ V |
| Preamplifier noise figure | note 1; $f = 470$ MHz | NF | — | 4.5 | — | dB |
| Operating ambient temperature range | | T_{amb} | -10 | — | +70 | $^{\circ}$ C |

Note to the Quick reference data

1. Including the transforming network.

PACKAGE OUTLINE

28-lead mini-pack; plastic (SO28; SOT136A).

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August 1989

1279

Low power digital UHF paging receiver

UAA2050T

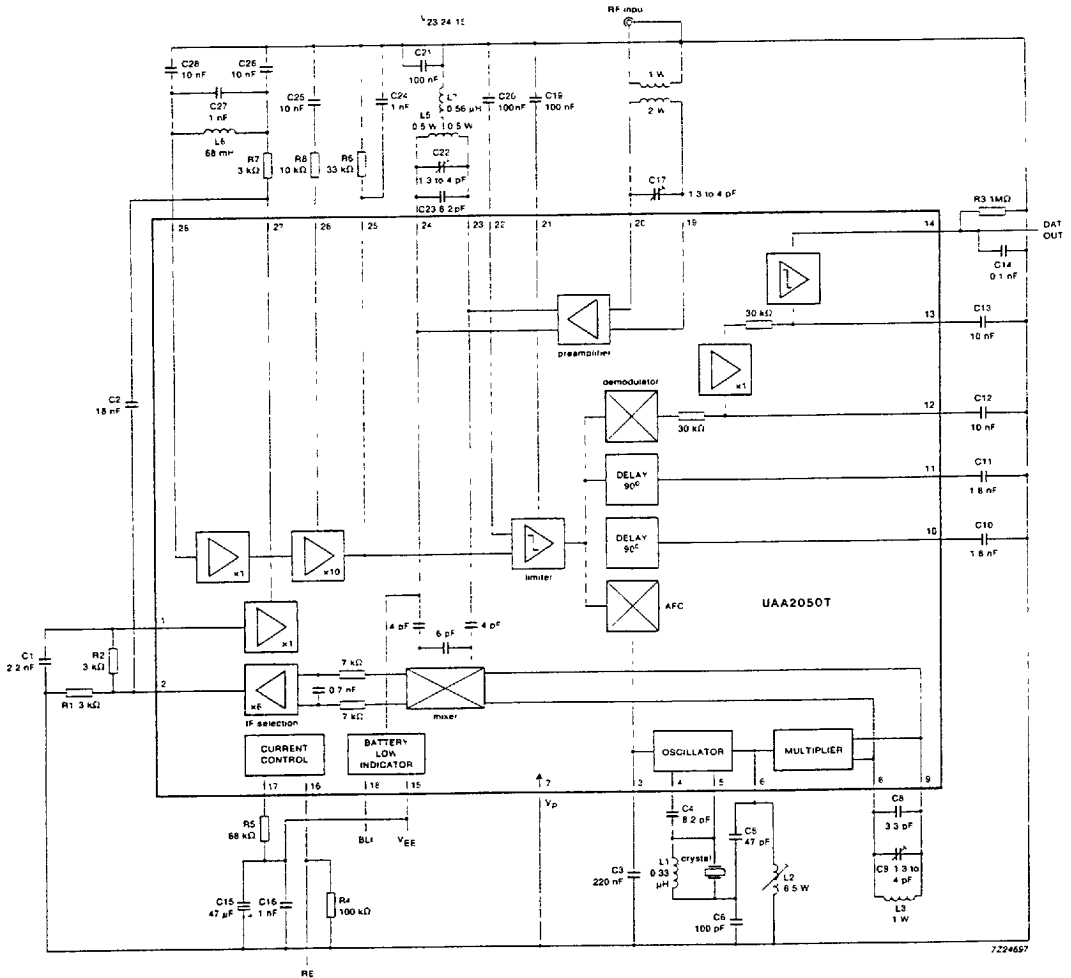


Fig.1 Block diagram (showing UHF external components).

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Low power digital UHF paging receiver

UAA2050T

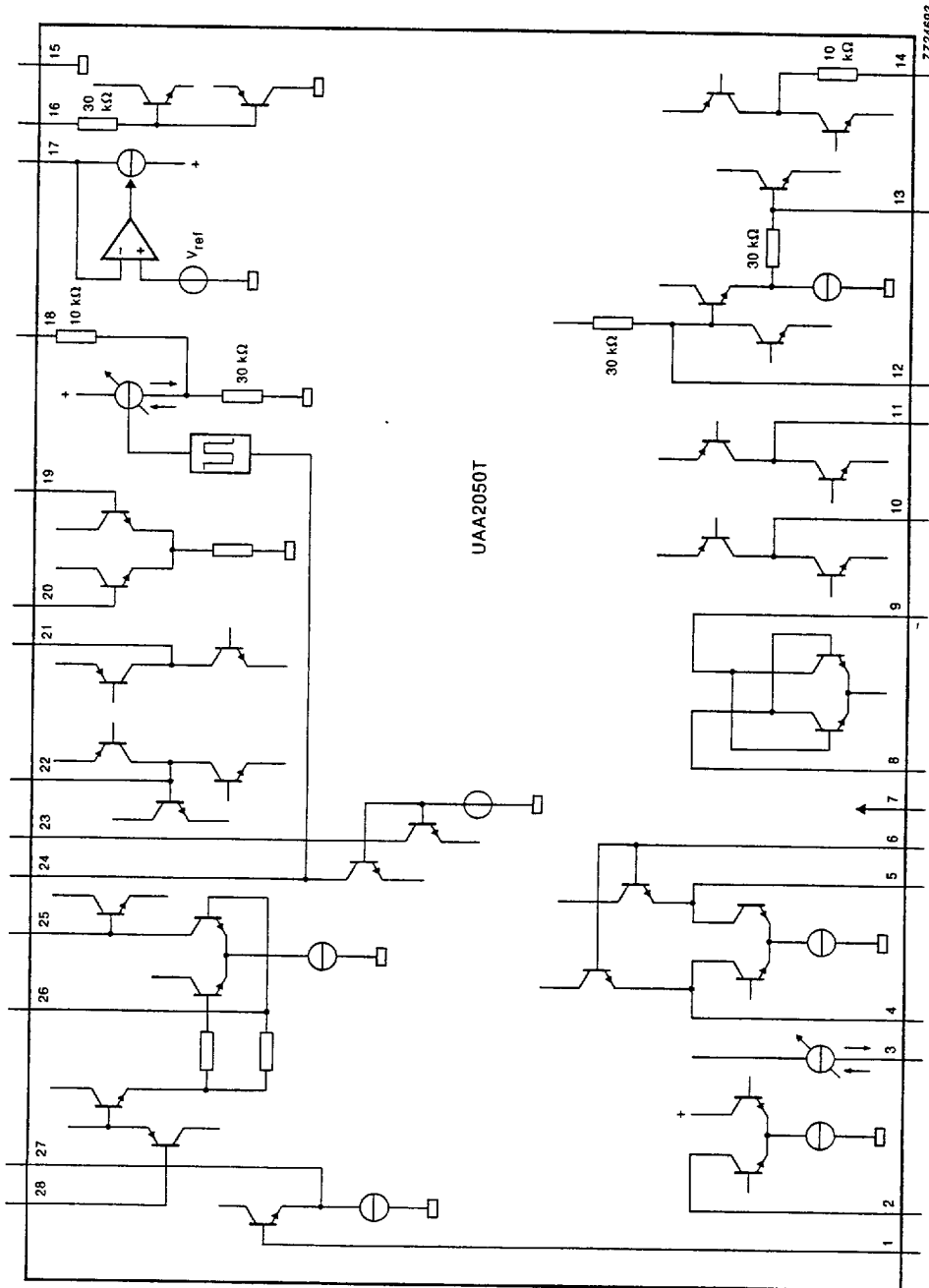


Fig.2 Pinning diagram and equivalent circuits.

Low power digital UHF paging receiver

UAA2050T

PINNING

| pin | mnemonic | description |
|-----|-----------------|-------------------------------------|
| 1 | IFF2 | IF filter 2 |
| 2 | IFF1 | IF filter 1 |
| 3 | AFC | AFC (test point 1) |
| 4 | OSC IN | oscillator input |
| 5 | OSC AFC | oscillator AFC range |
| 6 | OSC OUT | oscillator output |
| 7 | V _P | supply voltage (positive) |
| 8 | MC1 | multiplier coil |
| 9 | MC2 | multiplier coil |
| 10 | AFCD | AFC delay |
| 11 | DEM0DD | demodulator delay |
| 12 | DAT F1 | data filter 1 |
| 13 | DAT F2 | data filter 2 |
| 14 | DAT OUT | data output |
| 15 | V _{EE} | supply voltage (negative) |
| 16 | RE | receiver enable input |
| 17 | CC | current control input |
| 18 | BLI | battery low indicator output |
| 19 | PREAMP1 | preamplifier input 1 |
| 20 | PREAMP2 | preamplifier input 2 |
| 21 | LC2 | limiter decoupling 2 |
| 22 | LC1 | limiter decoupling 1 |
| 23 | MIX1 | mixer input 1 (preamplifier output) |
| 24 | MIX2 | mixer input 2 (preamplifier output) |
| 25 | LIM IN | limiter input (test point 2) |
| 26 | IFF5 | IF filter 5 |
| 27 | IFF3 | IF filter 3 |
| 28 | IFF4 | IF filter 4 |

Low power digital UHF paging receiver

UAA2050T

RATINGS

Limiting values in accordance with the Absolute Maximum System (IEC134)

| parameter | condition | symbol | min. | max. | unit |
|----------------------------------------------|-----------------------|------------------|-------|-------|------|
| Supply voltage | | $V_P = V_{7-15}$ | -0.3 | +5.0 | V |
| Supply voltage for preamplifier | | $V_{23,24-15}$ | -0.3 | +5.0 | V |
| Operating ambient temperature range | | T_{amb} | -10 | +70 | °C |
| Storage temperature range | | T_{stg} | -55 | +125 | °C |
| Electrostatic handling; human body model* | except pins 19 and 20 | V_{ESD} | -1000 | +1000 | V |
| | only pins 19 and 20 | V_{ESD} | -500 | +1000 | V |

* Equivalent to discharging a 100 pF capacitor through a 1.5 kΩ series resistor.

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1283

Low power digital UHF paging receiver

UAA2050T

DC CHARACTERISTICS

$V_P = 2.0\text{ V}$; $V_{23,24-15} = 1.1\text{ V}$; all voltages referenced to V_{EE} ; $T_{amb} = -10$ to $+55\text{ }^\circ\text{C}$; typical values measured at $T_{amb} = 25\text{ }^\circ\text{C}$; test circuit as Fig.4; L2 and L3 short-circuited; unless otherwise specified

| parameter | conditions | symbol | min. | typ. | max. | unit |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|------------------------|----------------------|--------------|--------------|---------------|
| Supply | | | | | | |
| Supply voltage | | $V_P = V_{7-15}$ | 1.9 | 2.0 | 3.5 | V |
| Supply voltage for preamplifier | $V_{23,24-15} \leq V_P$ | $V_{23,24-15}$ | 1.0 | 1.1 | 3.5 | V |
| Supply current | $V_{RE} \geq V_P - 0.6\text{ V}$ | I_7 | 1.9 | 2.5 | 3.2 | mA |
| Supply current for preamplifier | $V_{RE} \geq V_P - 0.6\text{ V}$ | $I_{23,24}$ | 0.35 | 0.45 | 0.56 | mA |
| Supply current OFF | $V_{RE} \leq 0.4\text{ V}$ | I_{OFF} | — | — | 1.0 | μA |
| Receiver enable (RE) | | | | | | |
| POWER-OFF MODE: | | | | | | |
| input voltage | | $V_{RE} = V_{16-15}$ | — | — | 0.4 | V |
| input current | $V_{RE} = 0.4\text{ V}$ | I_{16} | — | — | 1.0 | μA |
| POWER-ON MODE: | | | | | | |
| input voltage | | $V_{RE} = V_{16-15}$ | $V_P - 0.6\text{ V}$ | — | — | V |
| input current | $V_{RE} = 1.4\text{ V}$ | I_{16} | — | 1.0 | 5.0 | μA |
| Data output (DAT OUT) | | | | | | |
| Output voltage HIGH | $I_{14} = \pm 10\text{ }\mu\text{A}$ | V_{14-15} | $V_P - 0.7\text{ V}$ | — | — | V |
| Output voltage LOW | $I_{14} = \pm 10\text{ }\mu\text{A}$ | V_{14-15} | — | — | 0.5 | V |
| Battery voltage low indicator | | | | | | |
| Detection voltage | see Fig.3 | V_{DET} V_{DET} | 1.10 1.90 | 1.17 2.00 | 1.24 2.10 | V V |
| Output voltage HIGH | $1.0\text{ V} \leq V_{24-15} \leq 1.10\text{ V}$; $1.85\text{ V} \leq V_{24-15} \leq 1.90\text{ V}$; $I_{18} = \pm 7\text{ }\mu\text{A}$ | V_{OH} | $V_P - 0.5\text{ V}$ | — | — | V |
| Output voltage LOW | $1.24\text{ V} \leq V_{24-15} \leq 1.65\text{ V}$; $2.10\text{ V} \leq V_{24-15}$; $I_{18} = \pm 7\text{ }\mu\text{A}$ | V_{OL} | — | — | 0.5 | V |

Low power digital UHF paging receiver

UAA2050T

Note to the DC characteristics

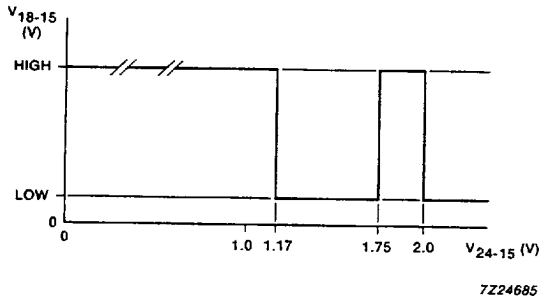
1. V_{18-15} goes HIGH if V_{24-15} is less than V_{DET} .

Fig.3 Typical battery low indicator thresholds.

Low power digital UHF paging receiver

UAA2050T

AC CHARACTERISTICS (UHF)

For AC test procedures refer to section "TEST INFORMATION". $V_P = 2.0\text{ V}$; $V_{23,24-15} = 1.1\text{ V}$; all voltages referenced to V_{EE} ; $T_{amb} = -10$ to $+55\text{ }^\circ\text{C}$; typical values measured at $T_{amb} = 25\text{ }^\circ\text{C}$; test circuit as Fig.4 and printed-circuit board layout as Fig.7; test signal: $f = 469.200\text{ MHz}$; deviation = $\pm 4.5\text{ kHz}$; modulation = 256 Hz rectangular; channel spacing = 25 kHz ; unless otherwise specified

| parameter | conditions | symbol | min. | typ. | max. | unit |
|--------------------------------------|------------------------------------------------------------------------------------------------|----------------|------|------|------|------------------------|
| UHF sensitivity range (RMS value) | note 1; 1×10^{-2} bit error rate $T_{amb} = -10$ to $+70\text{ }^\circ\text{C}$ | EMF/2 | - | 0.18 | 0.25 | μV |
| | | EMF/2 | - | -122 | -119 | dBm |
| | | EMF/2 | - | - | -116 | dBm |
| Adjacent channel selectivity | $T_{amb} = -10$ to $+70\text{ }^\circ\text{C}$ | aa | 60 | 67 | - | dB |
| | | aa | 50 | - | - | dB |
| Co-channel selectivity | | ac | 8 | - | - | dB |
| Spurious response rejection | | as | 55 | 58 | - | dB |
| Intermodulation response | | IM | 50 | 60 | - | dB |
| Blocking | $\Delta f \geq \pm 4\text{ MHz}$ | EMF | 80 | 83 | - | $\text{dB}\mu\text{V}$ |
| AFC lock-in range | | $\pm \Delta f$ | 3 | - | - | kHz |
| Preamplifier | see Fig.9 | | | | | |
| Noise Figure | note 2 | NF | - | 4.5 | - | dB |
| Third order intercept point | | IP3 | - | -20 | - | dBm |
| Available power gain | | G_p | - | 6 | - | dB |
| 1 dB compression point (RMS value) | | EMF/2 | - | 10 | - | mV |
| VHF RF sensitivity range (RMS value) | see Fig.10; $f =$ 173.95 MHz ; $1 \times$ 10^{-2} bit error rate | EMF/2 | - | 0.14 | - | μV |
| | | EMF/2 | - | -124 | - | dBm |
| | | EMF/2 | - | - | - | |

Notes to the AC characteristics

1. A simple digital method of performing an approximate bit error rate (BER) measurement with a counter is shown in Fig.5. At high signal levels ($10\text{ }\mu\text{V}$) the counter should read the exact frequency of the data input to the signal generator (256 Hz). As the signal level is reduced, errors occur at the receiver output and effectively changes the output frequency read by the counter (error duration is nearly always less than one bit length). The input signal level (V_{ref}) is reduced until the bit error rate is $\leq 1 \times 10^{-2}$ (5 bit errors for 512 bit/s system). The frequency from the data output signal will change from 256 Hz (512 bit/s system) to 261 Hz . This RF-level is the reference for the following tests (V_{ref}).
2. Including the transforming network.

Low power digital UHF paging receiver

UAA2050T

TEST INFORMATION

Tuning procedure for AC tests

1. After performing the DC tests, prepare the device for AC testing (as shown in Fig. 4).
2. Connect pin 3 to a voltage source of $V_{3-7} = -0.5$ V. Measure the multiplier frequency with a counter or spectrum analyzer connected to the link winding of L3. Tune L2 to set the crystal oscillator to a frequency of:

$$\frac{\text{Received frequency} + 2.2 \text{ kHz}}{5} (\pm 100 \text{ Hz})$$

For a received frequency of $f = 469.200$ MHz, the oscillator frequency (f_{osc}) = 93.840 MHz.

3. Remove the test voltage source and turn on the signal generator ($f = 469.200$ MHz; deviation = ± 4.5 kHz; rectangular 256 Hz modulation; RF input level = 1 mV).

Note During the following tests the RF signal generator level should be reduced as the receiver is tuned, to ensure the peak-to-peak output voltage at pin 25 lies between 20 mV and 100 mV.

4. Tune C9 (multiplier) to obtain a peak audio output voltage on pin 25.
5. Tune C22 (Mixer input) to obtain a peak audio output voltage on pin 25.
6. Disconnect the frequency counter from the multiplier output. Measure the voltage at pin 3 and check if it is within the range of -0.48 V to -0.52 V. If it is outside this range then adjust L2 (oscillator) until it is within the limits.
7. Check with an oscilloscope that clean data is appearing on the data output (pin 14) and proceed with the AC tests.

Low power digital UHF paging receiver

UAA2050T

Test conditions

The data output signal corresponds to the sensitivity definition.

Where:

f_1 is the modulated test signal
 f_2 is the unmodulated test signal
 f_{cs} is the channel spacing (25 kHz)
 V_1 is the signal generator 1 output
 V_2 is the signal generator 2 output
 V_{ref} is defined in 'Notes to the AC characteristics'.

1. Adjacent channel selectivity (see Fig.6);
 - generator 1: modulated test signal; $V_1 = V_{ref} + 3\text{ dB}$
 - generator 2: unmodulated test signal; $V_2 = V_1 + 60\text{ dB}$ ($f_2 = f_1 \pm \Delta f_{cs}$).
2. Co-channel selectivity (see Fig.6);
 - generator 1: modulated test signal; $V_1 = V_{ref} + 3\text{ dB}$
 - generator 2: unmodulated test signal; $V_2 = V_1 - 8\text{ dB}$ ($f_2 = f_1 \pm 3\text{ kHz maximum}$).
3. Spurious response rejection (see Fig.6);
 - generator 1: modulated test signal; $V_1 = V_{ref} + 3\text{ dB}$
 - generator 2: unmodulated test signal; $V_2 = V_1 + 55\text{ dB}$ ($f_2 = 100\text{ kHz to } 1\text{ GHz}$; $|f_2 - f_1| \geq 2\Delta f_{cs}$).
4. Intermodulation response (see Fig.6);
 - generator 1: modulated test signal; $f_1 = 469.2\text{ MHz} \pm 2 \times n \times \Delta f_{cs}$ $n = 1\text{ to } 4$.
 - generator 2: unmodulated test signal; $f_2 = 469.2\text{ MHz} \pm n \times \Delta f_{cs}$. $n = 1\text{ to } 4$.

Output voltages of both generators increase with the same level, until a data output signal corresponding to the sensitivity definition is reached. The level must be 50 dB above the $V_{ref} + 3\text{ dB}$ level.
5. Blocking (see Fig.6);
 - generator 1: modulated test signal; V_1 (EMF) = 3 dB μ V
 - generator 2: unmodulated test signal; V_2 (EMF) = 80 dB μ V ($f_2 = f_1 \pm \Delta f$; $\Delta f \geq 4\text{ MHz}$)
6. AFC lock-in-range (see Fig.5);
 - generator 1: modulated test signal; $V_1 = V_{ref} + 3\text{ dB}$ ($f_1 = 469.2\text{ MHz} \pm 3\text{ kHz}$)

Low power digital UHF paging receiver

UAA2050T

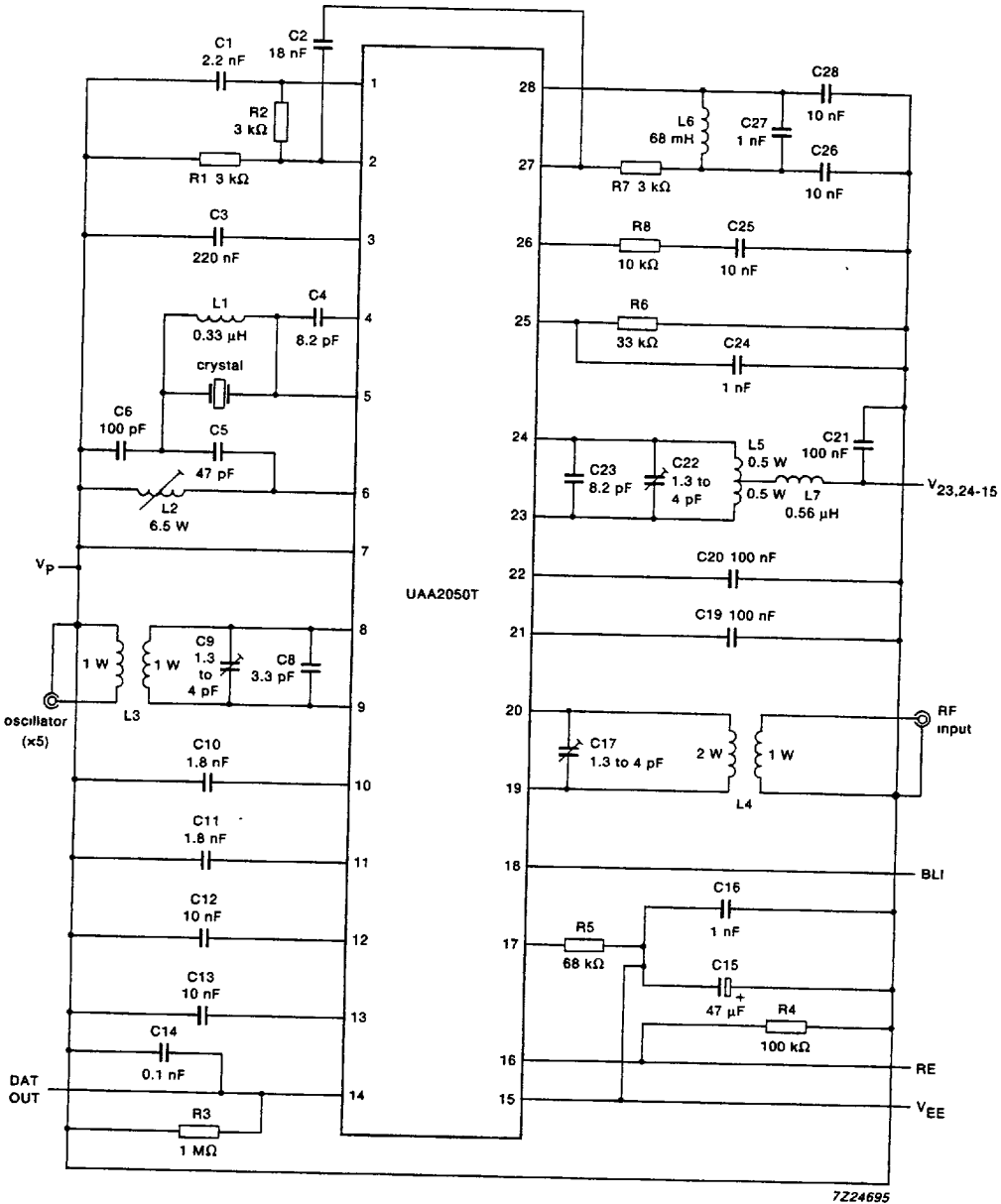


Fig.4 Test circuit (UHF).

Low power digital UHF paging receiver

UAA2050T

Crystal data

Test frequency for the receiver chip is 469.2 MHz, crystal frequency is 93.838 MHz.

Static capacitance C0 (max.) = 4 pF

Dynamic capacitance C1 = 0.4 fF ± 20%

Dynamic resistance R1 (max.) = 75 Ω

Temperature drift = ±5 × 10⁻⁶.

Inductors

L3, L4 and L5: wound with 0.9 mm silvered wire, without pot or core and diameter of 4.5 mm.

L1 = 0.33 μH chip inductor (at 25 MHz minimum value of Q = 12)

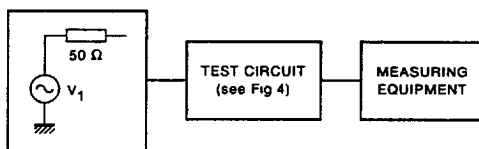
L2 = 6.5 turns

L3 = 1 turn

L4 = 2 turns

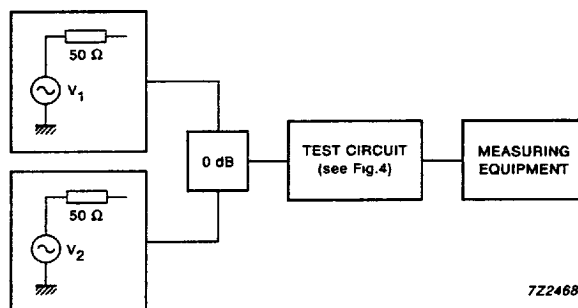
L5 = 1 turn

L6 = inductor, Philips microchoke (at 10 kHz minimum value of Q = 10)



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Fig.5 Test figure A.

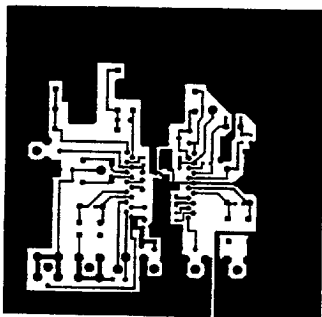


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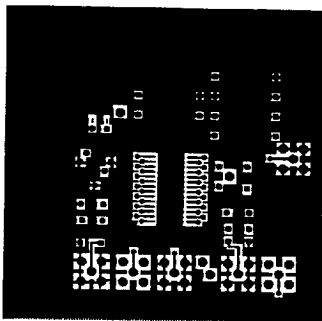
Fig.6 Test figure B.

Low power digital UHF paging receiver

UAA2050T



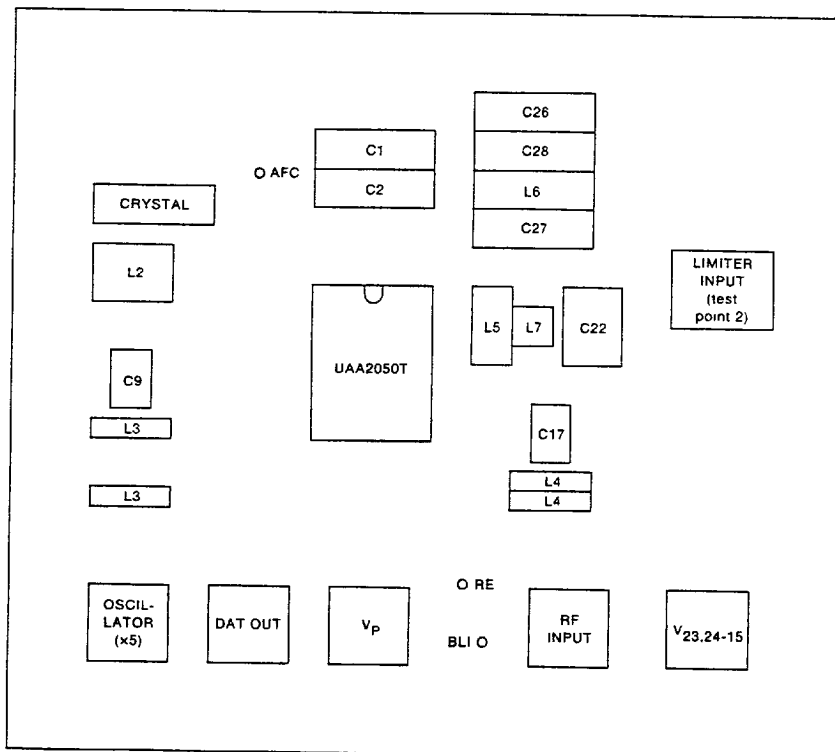
(a) underside



(b) top side

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Fig. 7 Printed-circuit board for UHF range (see Fig.4).



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Fig. 8 Printed-circuit board for UHF range (component arrangement).

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Low power digital UHF paging receiver

UAA2050T

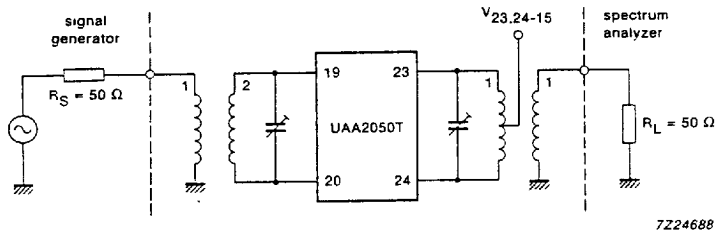


Fig.9 Test circuit for the preamplifier.

Low power digital UHF paging receiver

UAA2050T

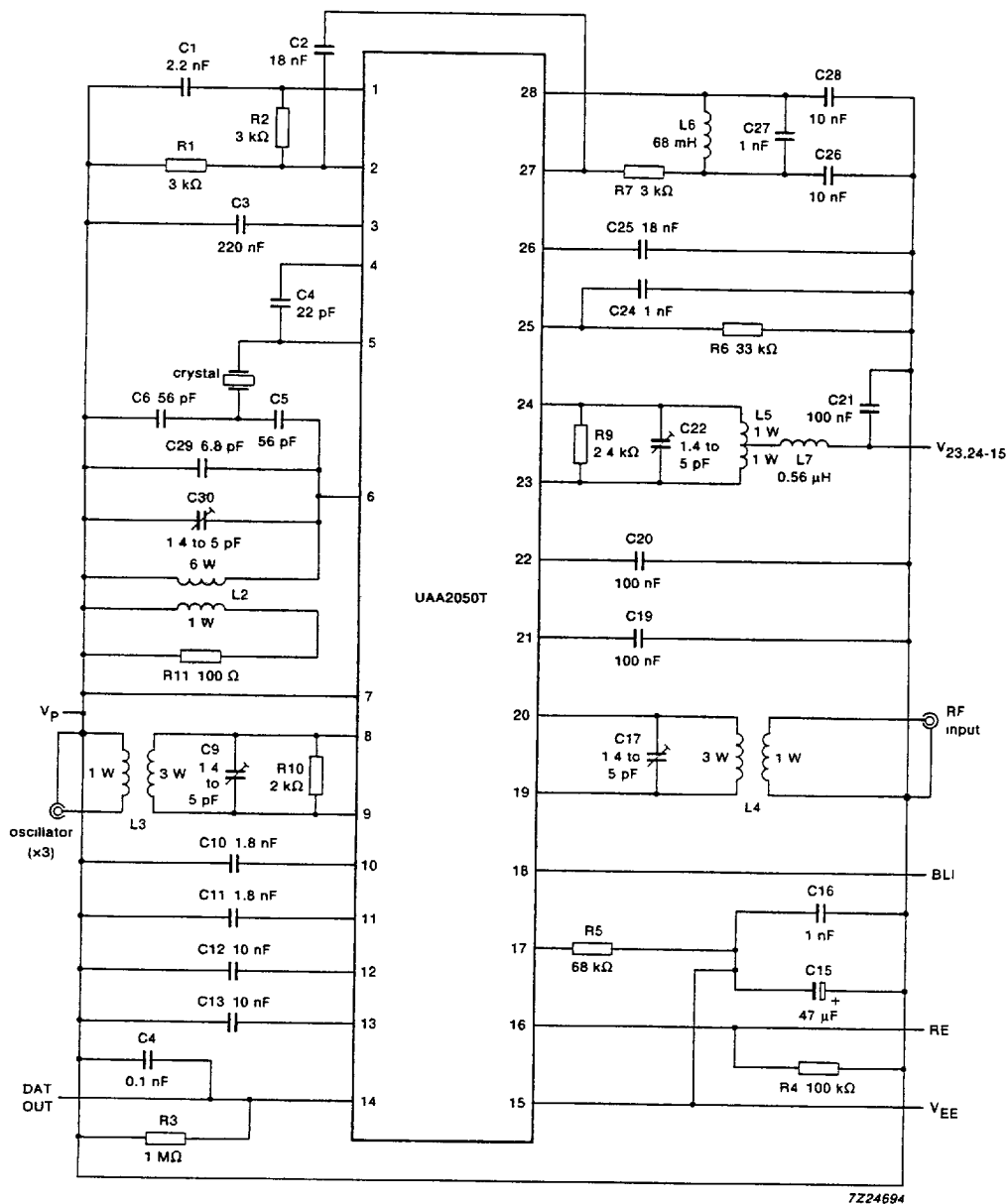


Fig.10 Test circuit (VHF).

Low power digital UHF paging receiver

UAA2050T

Crystal data

Test frequency for the receiver chip is 173.95 MHz, crystal frequency is 57.9859 MHz.

Inductors

L2, L3, L4 and L5: wound with 0.3 mm enamelled copper wire on Toko 4.5 mm diameter former, without pot or core. Screening cans are also used.

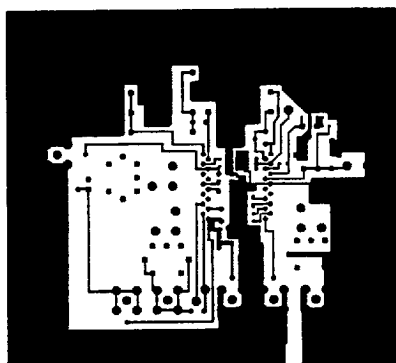
L2 = 6 turns, 2 turns per groove; link winding, 1 turn over the centre of the other winding

L3 = 3 turns, 1 turns per groove; link winding, 1 turn at the bottom of the former

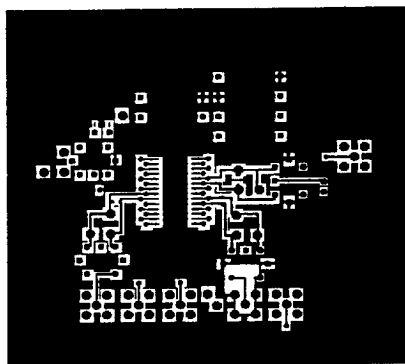
L4 = 3 turns, 1 turns per groove; link winding, 1 turn at the centre of the other winding

L5 = 2 turns

L6 = inductor, Philips microchoke (at 10 kHz minimum value of $Q = 10$)



(a) underside



(b) top side

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Fig. 11 Printed-circuit board for VHF range (see Fig.10).

Low power digital UHF paging receiver

UAA2050T

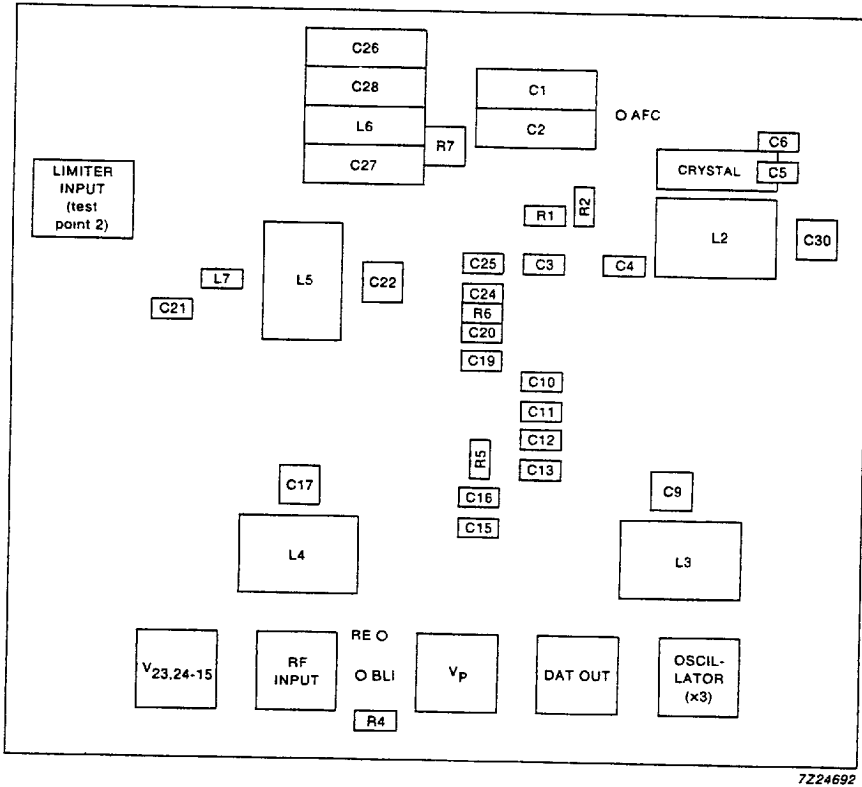
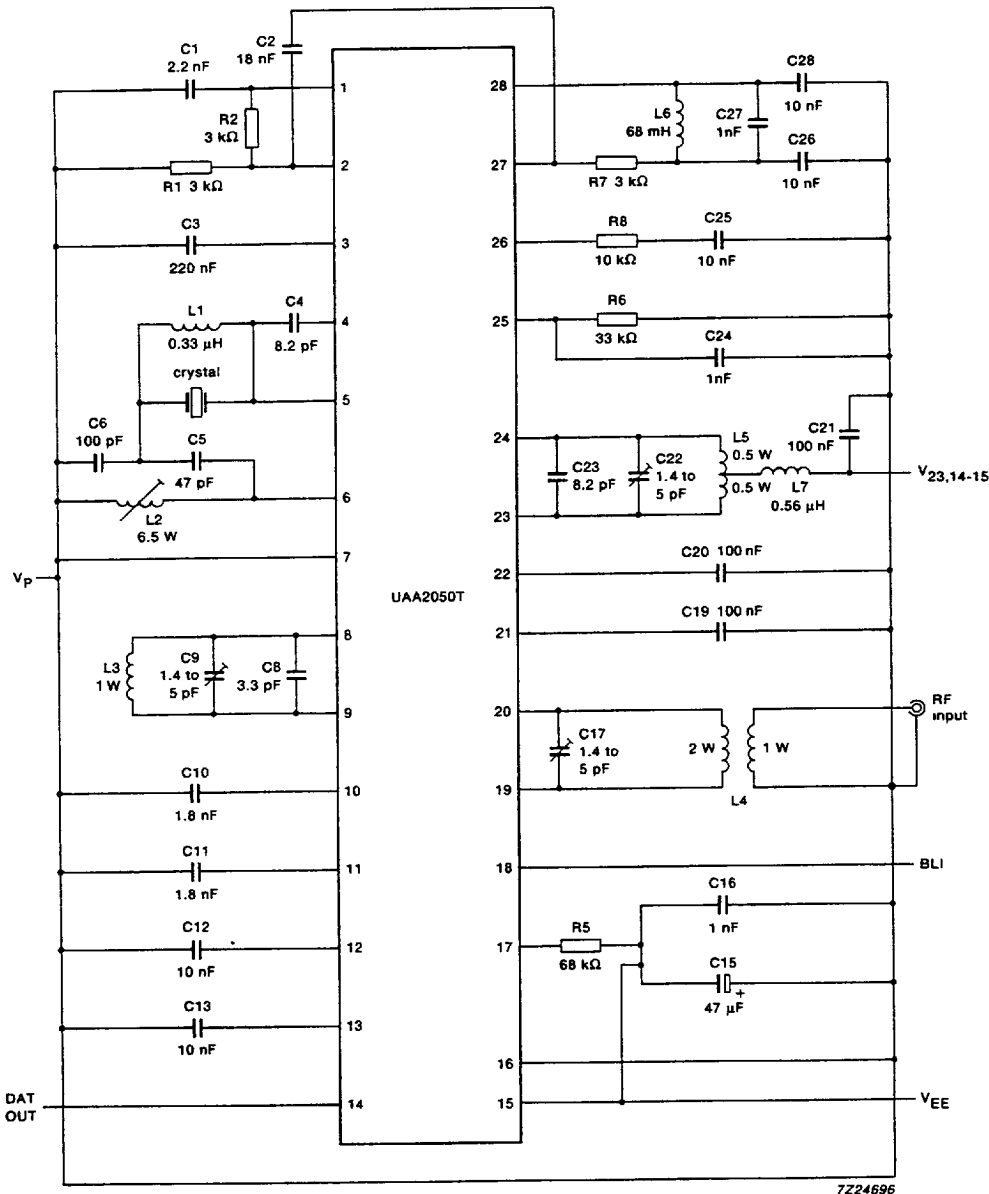


Fig. 12 Printed-circuit board for VHF range (component arrangement).

Low power digital UHF paging receiver

UAA2050T

APPLICATION INFORMATION



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Fig.13 Application diagram (UHF).

Note to Fig.13

For information concerning the crystal oscillator and inductors, refer to Fig.4.

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