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AUTOTAG-P TECHNICAL DATA & CIRCUIT DESCRIPTION

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1. BASE-STATION

1.1 Power Supply

L10/L12 and associated circuitry provide power supply filtering. For DC operation, C28 is replaced with a wire link, and D13/C43/U8 are populated.

1.2 Transmitter

The transmitter consists of a Colpitts oscillator, followed by an amplifier, a RF switch and variable attenuator and then the antenna connector.

Colpitts oscillator

Q1 is the oscillator transistor. C10 & C13 control feedback. Resonance is mainly determined by these and C11/L2. The oscillation is tapped above L2 and fed to the RF amplifier. The tapping ensures minimal loading of the oscillator by the amp (when switched on/off). The oscillator is switched on by holding TX ON high. This switches Q3 on, grounding the emitter of Q1. R9 determines oscillator current consumption and drive. F1 locks the frequency. C6 is a RF ground, helping to prevent RF from being injected onto the power line.

RF amplifier

Modulation is controlled via MODULATION. Q4-6 switch the RF amplifier on/off. Q5 is configured as a diode, and together with Q4 acts as a switch for the amplifier. V_{R14} follows V_{R11} at all times, thus acting as a current source to Q2. This configuration allows amp Q2 to be operated with the emitter grounded directly, with the current source preventing current variation due to V_{BE} changes. Direct grounding is required to provide the voltage swing for 10 mA output.

C7 & C2 provide a capacitive match to 50Ω. These together with C15 and L1 determine resonance. L4 & C8 act as harmonic suppression.

Attenuator /switch

Q8 is a temperature-compensated current source, which feeds attenuator diode D16 through RF chokes L13 & L14. Diode D1, together with the ¼-wave microstrip and D12, forms the antenna switch. It is controlled via ANT SWITCH / R15 / R12.

Antenna input

L3 & C9, as well as L9 and C5 are additional harmonic suppression. When tuning the Base-Station, C5 & C9 are the first trimmed for maximum transmit power, followed by C15. Once this is done the receiver capacitors C36 & C47 can be tuned for maximum sensitivity.

Antenna

This is a circularly-polarised patch antenna designed for use on FR4 substrate (standard PCB material).

Patches are by nature very high-Q devices, and this can result in matching problems, since etching and PCB tolerances can shift f_o. To counter this, it was designed to be relatively broadband in its response (±10MHz BW). This affects the polarisation and as such, becomes elliptical.

1.3 Receiver

The RF input is at D12. Resistors R29, R31 and R32 form the pi-attenuator. C33 matches the chip input to 50Ω. C36/L6 filters the input signal.

Chip Architecture

The signal is fed into a RF amp, the resonant collector circuit of which is C47/L8. From here the signal then goes into the mixer (through C42), where it is mixed with 433.6 MHz (generated from the crystal using the PLL). The output goes into an IF filter (through C46) and IF amplifiers. It then goes into an adaptive threshold, of which R34 & C35 form the level-following filter. The output of this is the data stream.

Varactor D14 together with C37/38/L7 forms the resonant circuit of a differential RF VCO. R33/36 form the bias control to the varactor, and R37/C48 in addition act as LP PLL loop filter. The output of the VCO is fed into the mixer as described above.

Note: The receiver IF is very low, centred at ±300kHz. This ensures that the image has to be in the operating band, reducing the chance of interference due to image frequency.

1.4 Microcontroller

Communications

Refer to the manual for a list of supported communications protocols.

U1 is deployed for RS232 communications. U2 is deployed for RS485 communications. Provision has been made for bi-directional communications.

Wiegand & Clock & Data communications protocols are standard, with the C&D Clock and C&D Data sharing the Wiegand pins. Wiegand data is obtainable at the collectors of Q10 and Q11.

The Relay, LED.s, buzzer, hardwired SYNC and Wiegand/C&D lines are all driven by open collector drivers.

External Trigger

U5 is the opto-isolator for the loop trigger input. The input is provided via an external relay closure.

2. TAG

2.1 Receiver

The receiver is permanently powered, operating at 4 - 5 uA (through R31). It is designed to receive OOK data signals at a data rate of up to +-280 Hz. This is limited largely by the gate capacitance of FETs Q1 & Q2, which together with the large resistors R16 & R11 creates a decay constant limiting HI-LO transition time.

The receiver antenna resonates with C17 & C18 at the centre frequency. D1, C5, R24 and associated components act as a crystal receiver (i.e. direct-conversion diode demodulator), converting the signal immediately to base-band. R27 & R24 also provide the forward-bias current to D1, ensuring minimum diode-drop, therefore maximum sensitivity.

The base-band signal is fed through DC block C11 into the first amplifier stage (Q7 and associated components). Gain of the amplifier is largely determined by C15 and R8, being approx. -R/Xc.

The stage is decoupled from the supply via R28/C22. Making R9 & R6 equal ensures:
- Enough voltage across R6 to reduce temperature effects
- Collector quiescent voltage is far enough from rails to prevent clipping.

This configuration is repeated three times.

Following the 3rd stage the signal is fed into a squaring circuit (Q4 / Q5 and associated componentry). Pulling the base of Q4 high sends the collector low and switches Q5 off. This drops the emitter voltage, causing Q4 to switch on harder. The output rams high, switching Q2 off and sending the data line (IC 1, pin 4) low. The reverse happens when the base goes low.

Q10 buffers the data input into ICI removing the signal when the ICI is powered down.

NB: The HI-LO transition at the receiver output is sharp compared to the HI-LO transition (suffers from RC discharge) and is therefore the sole transition used for data discrimination.

Q8, C19, R22 & R23 form a switch, used to control power to the rest of the circuit. The values here are largely determined by the configuration of the Base-Station transmission period. It is presently optimised for a gap between transmission bursts not exceeding ~400ms. If the gap becomes greater, the unit will switch off before being able to receive data.

C19 & R22 control the ON time of the uP circuit. R23 prevents FET (Q8) leakage from keeping the power ON permanently.

2.2 Transmitter

Current consumption whilst transmitting is approximately 1.8 mA.

This is a basic on-off keyed (OOK) Colpitts oscillator, with some added output filtering.

Q9 is in common-base configuration, with feedback provided by the C28/29 voltage divider. R19 & R20 are included to help reduce spurious radiation during switching.

L1, L2, and C29 and the antenna (TX_LOOP) form the primary components of the resonant circuit. L1 & C27 form a pi-filter. This has two functions. One is to reduce the spurious output and the other is to match the collector impedance to that of the antenna.

C6 & C7 are RF grounds. R35 may be de-soldered to aid fault-finding during manufacture.

The base of Q9 is grounded through SAW1 at resonance. Drive level is controlled by the ratio R17 and emitter resistor R34. Increasing R34 above 680 Ω would cause instability at low temperatures, due to increased V_{BE} and therefore lower I_E.

2.3 Microprocessor

When asleep, the device consumes <1uA. Running, this figure goes to ± 60 uA.

Crystal X1, together with C1 & C2, provides the timing for IC1 (PIC12LCE519). The PIC works well with the present CW206 watch crystal, but has given problems with others, especially surface-mount variants. Startup time in LP mode is in the order of +180ms.

The PIC is serially programmed via the serial connector.

Pins 5 & 6 are normally grounded through R32 & R33 respectively. They are used to call up one of 3 test routines during testing on the jig (see software description).

2.4 Power Supply

This is in the form of a single 200 mAh / 3V Lithium cell (CR2032). Under normal operating conditions, assuming the tag is woken 100 times a day, the life-span of the cell should be in the region of 3 years or more.