WIRELESS RELAY LOGIC CONTROL USING ENCODED 433 MHZ TX/RX MODULES (2 OUTPUT BITS PER PAIR).

The application is control of a space heater and a desktop lamp based on two (left and right) occupancy sensors (Infrared Motion Detection), time of day and seasonal temperature target. The logic is adjustable and uses timed off delays. The structure is open loop, but is deterministic in the manner of a wired connection. Wireless output signals are short pulses transmitted only when machine state changes.

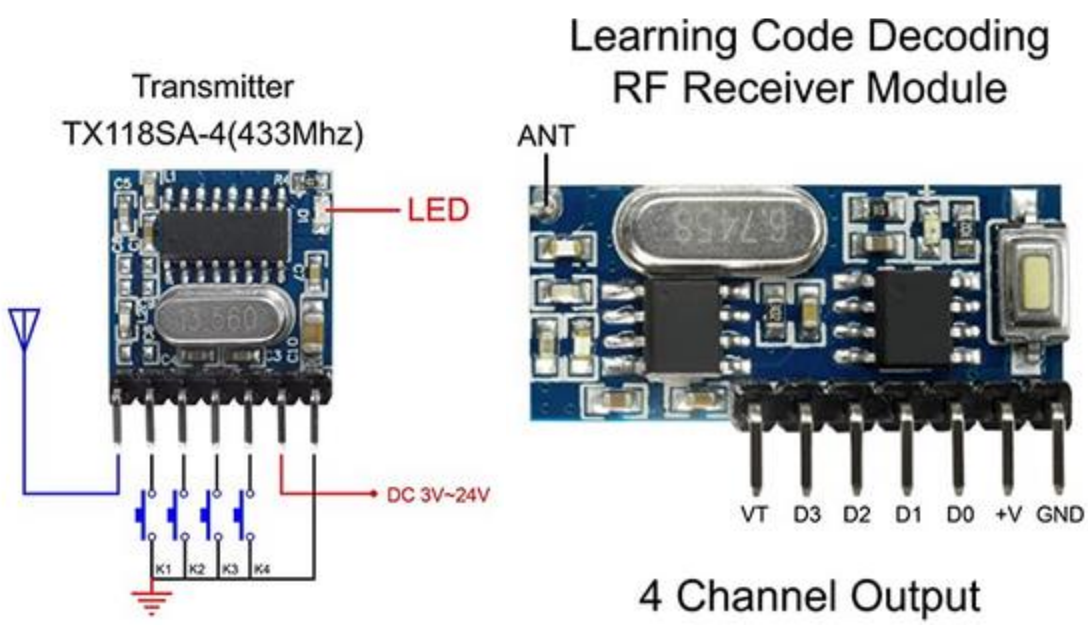
The TX/RX modules have 4 bits (channels) between them that can be used in three modes.

The first is a momentary mode where each bit can be separately set for the duration of the transmit pulse. Only one bit can be set a time and for a continuous TRUE logic condition, the pulse must be continuously transmitted. This is not advisable for the wireless spectrum environment and is not useful for state logic control without adding further hardware at the receiving end.

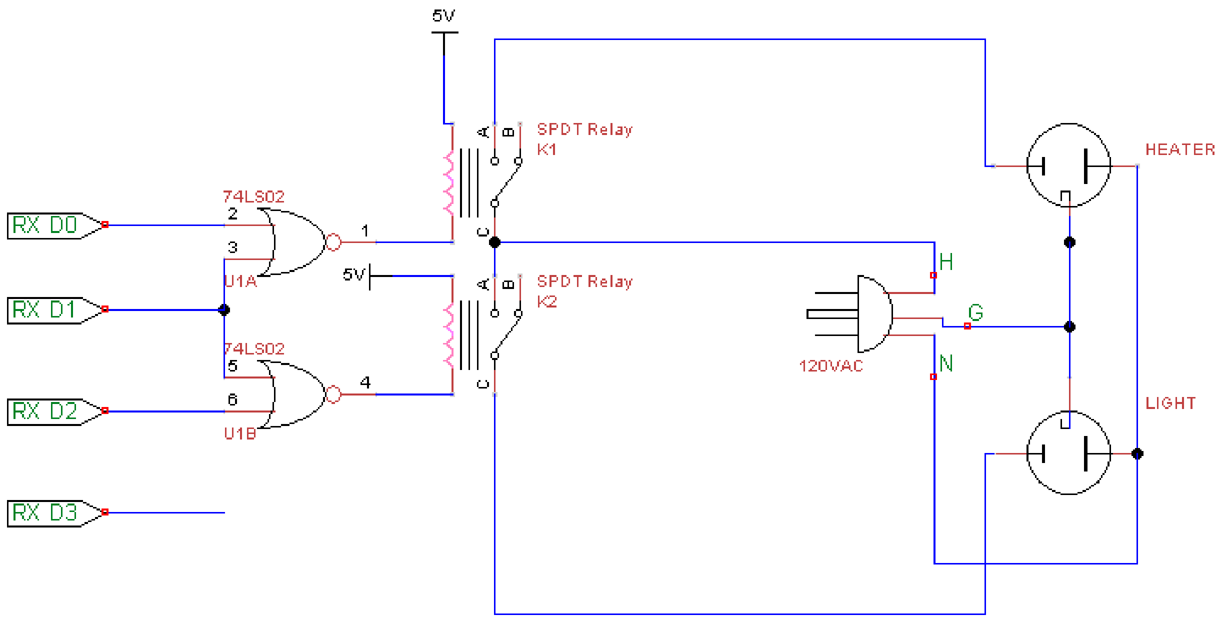
The second mode is latch toggle mode, where a TX pulse on each bit will toggle the corresponding RX latch at the other end. This is not deterministic in that the RX latch may get out of sync with the TX software machine state through power or communication failures and only human intervention can correct this unless some sort of feedback mechanism (another TX/RX pair) is implemented.

The third interlocking method is one bit channel set while all of the other bit channels are automatically reset at the RX end. This method precludes more than one bit channel being set at a time, again not useful for many logic applications. With some simple logic it can be made useful for logic control of 2 bits (devices), in all four bitwise states.

The following is the TX/RX pair system.



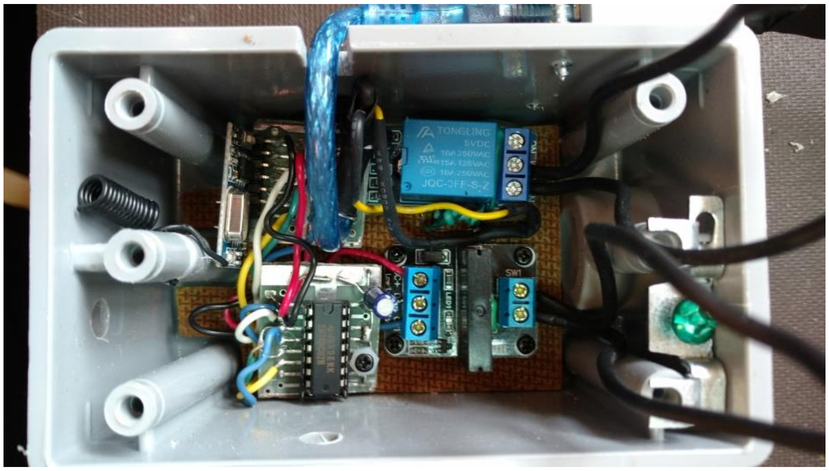
For a two bit logic system, the third method is put to use by adding two NOR gates to the RX outputs. The following is the circuit schematic for a RX 120VAC split receptacle box for two loads.

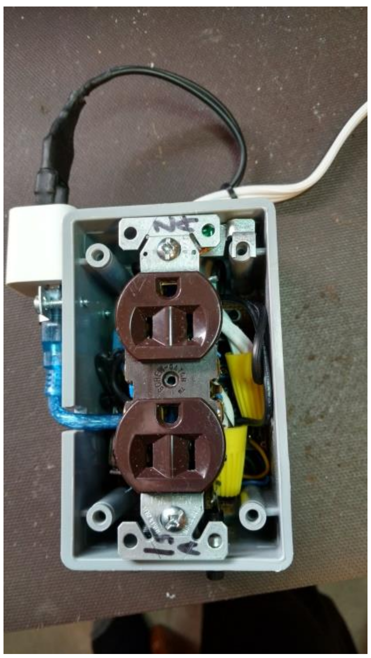


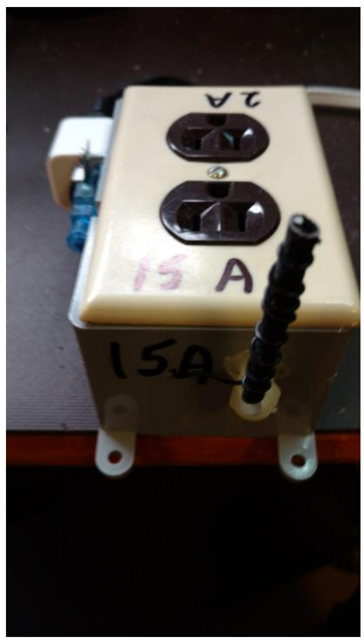
With this simple added logic, the four interlocked channels represent four possible output states for two Low True load relay devices, each independently on, both on or both off.

The actual relays used for this project are shown below. The left image is a Solid State Relay (SSR), TRIAC output, rated at 120VAC 2A resistive load and used for the lamp load device. The right image is an SPDT Electro-Mechanical Relay, as portrayed in the above schematic and used for the space heater load device. Both relay inputs are 5V Low True signals, 74LS02 TTL compatible.

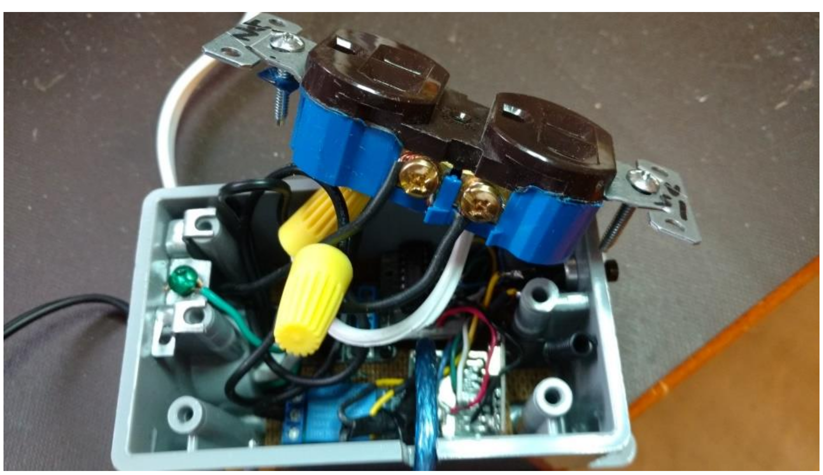
The following are some images of the RX end load distributing box with the two relays and the logic, as above, installed and ready for wiring to the 120VAC split receptacle plugs. 5V power is supplied by an USB style charger device, mounted externally. Note that the RX antenna is eventually mounted externally to avoid unwanted sporadic RX triggering caused within the box electrical environment.





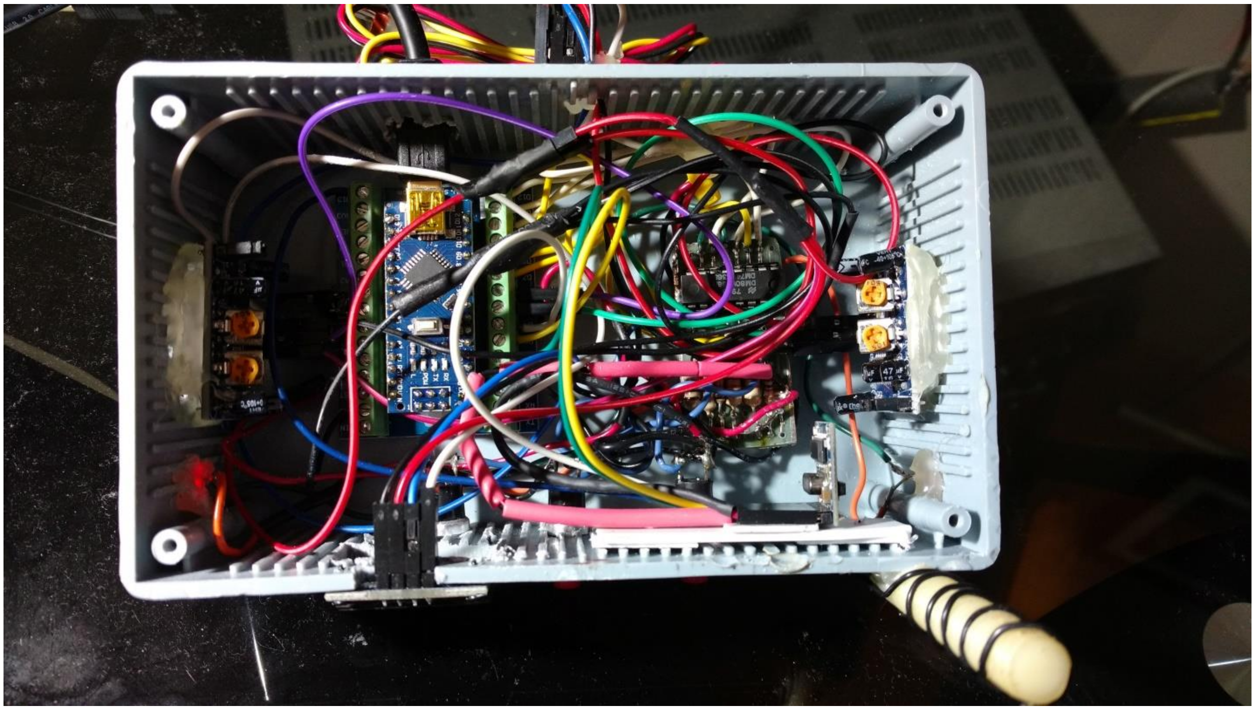


External Antenna



Split Receptacle

The TX end box contains the logic processor, the temperature (BMP 280) and infrared motion detection sensors, OLED display, TX module with an externally mounted antenna and Real Time Clock (RTC).



The controller box is mounted on the left side of a work bench. The right motion detector indicates the bench area is occupied while the left motion detector (hidden in this picture) indicates the digital piano area is occupied. The RX load box is seen below on the floor and the heater beneath the piano is on.

The left (piano area) motion detector is on, as indicated by the LED.

The following running displays are seen consecutively on the OLED display, at 10 second intervals.

The first display shows the control mode ('T' for temperature control) and temperature target (21 Deg C). It shows that both the heater and light outputs are on ('H' and 'L') and that there is 10 minutes left in the minimum on time regardless of occupancy. The line below ('T') shows the time of day from the RTC along with the on state of the left motion detector ('L'). The line below this (C') shows the number of temperature control minutes for the day so far and the on state of the right motion detector.

The second display adds the current measured temperature to the first line as above.

The three buttons are for adjusting control parameters, including control mode ('T' for temperature AND light control or 'L' for ONLY light control), temperature target and minimum control on time (in minutes) following an occupancy event.

The control can also be disabled (the first line will show a ‘D’ instead of the output states) for a given number of hours during the day. The user can enter the range of hours (starthour : endhour) for control to be enabled through the button menu system as well. This feature was meant to avoid spurious temperature control during the night, for example, as triggered by a nearby mechanical refrigeration unit.

CONTROL LOGIC AND USER INTERACTION

The following is a description of the control logic during enabled hours. Right side (bench area) occupancy will always turn the light on and enable the temperature control (heater is on if the measured temperature is less than the temperature target minus a deadband of 0.5 degC or the heater is off if the measured temperature is greater than the temperature target plus a deadband of 0.5 degC). The light will turn off if the right side becomes unoccupied (there is some small delay due to the motion detector sensor itself). The heater temperature control will be disabled after the minimum time delay set by the user, if the right side space becomes unoccupied. The left side occupancy (piano area) behaves the same as above for the temperature control but it does not provide for any light control.

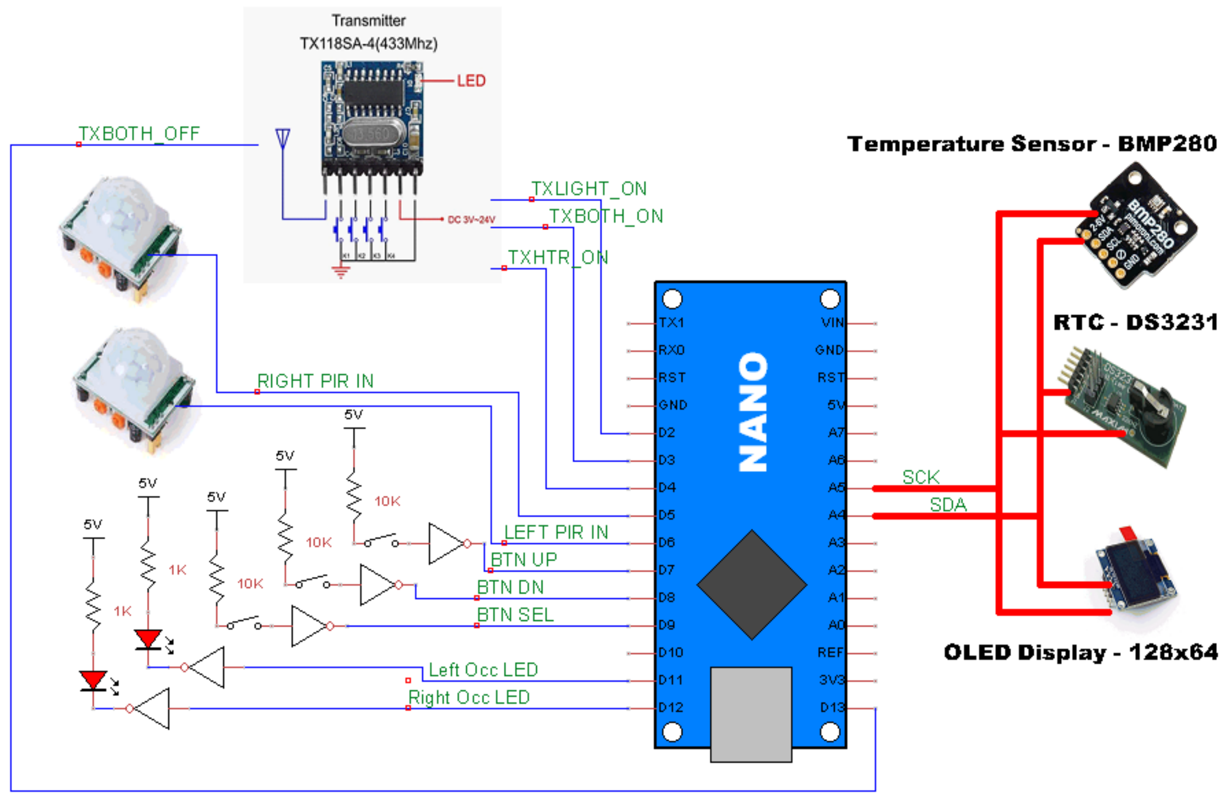
The user menu buttons behave as follows. The right button increments values (default is target temperature) within strict limits, while the middle button decrements values (default is target temperature). The left button puts the display in a ‘special menu’ editing mode. Pressing it will cycle through four values: control mode (‘T’ or ‘L’) , minimum control time in minutes and the starting and ending hours of the day for control enabling. On the final press of this button, the above values, plus the temperature target, are saved in EEPROM for loading at processor startup. All entered values are range limited per a set of values.

CONTROLLER CIRCUIT

The following is the circuit schematic for the controller.

The four TX outputs are wired per the following pair mappings: K1->D0, K2->D1, K3->D3,K4->D2. Note the mis-ordering of the last two pairs by the TX/RX devices. The Passive Infra-Red (PIR) sensors use a high true signal when occupancy motion is detected. These devices have potentiometers to adjust range sensitivity and delay time after an occupancy trigger. Inverter gates were used to drive the Left and Right Occupancy LEDs which report the PIR sensor state. Leftover gates were used to sense the user button switches. (Otherwise directly connect the switches to the Nano inputs with internal pullups.)

The temperature sensor, real-time clock and OLED display are all connected through the I2C bus using the two serial signals SDA (data) and SCK (clock).



Software Notes

The software user the hardware Timer1 to interrupt the background loop() processing. The foreground Interrupt Service Routine (ISR) simply schedules sensor measurement, control logic and OLED display updates in multiples of 10 second intervals. All of the above processing is done outside the ISR in the background loop. The foreground and background synchronize and communicate through global values.

The sensing of user input buttons uses a software switch de-bounce method. The OLED display update routine has two modes: static user input and dynamic control data. The control output sequence uses a 100 millisecond pulse length for transmitting the bit channel to the receiver. Transmission only occurs when a state change (2 output bits with 4 states) happens.

Time of day is tracked by the ISR and the number of minutes of control output ON state is also tracked. The control minutes are reset at midnight and at 6AM the time of day is updated using the real-time clock. The ISR also enables and disables control as specified by the user time of use hours.

Control parameters (user defined) are stored in EEPROM and are loaded up at startup, along with the time of day. The editing feature of user values has been generalized to allow for easy expansion to editing additional parameters by just adding to data lists (no code). However, only integer values are accommodated in this version.