**Intellitune**

**2. Design Requirements/Constraints**

Intellitune is an automatic antenna tuning unit (ATU) for use in a ham radio setup, where it fits between the radio transmitter and the antenna. Traditionally, a ham operator would manually tune the impedance of the network so that the transmitter could operate at maximum efficiency. The Intellitune aims to eliminate this time consuming process by automatically tuning the network, allowing the user to operate the radio faster and with more ease. Once tuned, the transmitter will operate near its peak efficiency for the given setup, enabling the user to transmit a cleaner signal with less interference. In order to successfully implement this project, there are certain constraints to which the design must abide. Section 2.1 provides a description of five technical constraints, followed by section 2.2, which elaborates on five practical constraints.

**2.1. Technical Design Constraints**

Table 2.1 describes the technical specifications that the Intellitune must meet upon completion.

**Table 2.1. Technical Design Constraints**

|  |  |
| --- | --- |
| Name | Description |
| Power Rating | Intellitune must be capable of handling 2.5 kW of transmitting power |
| Frequency Bandwidth | Tuning circuitry must be able to pass through specified frequencies with low attenuation. |
| Tuning Speed | The tuning system must complete impedance matching within fifteen seconds |
| Latch Sampling | Microprocessor (MCU) must read the output of the latch and perform calculations to determine proper impedance correction |
| Impedance Matching | The Intellitune must provide a tuning network that is capable of matching impedances from 12-1600 ohms |

**2.1.1. Power Rating**

The Intellitune must be capable of functioning at a transmitting power of 2.5 kW in single sideband (SSB) and continuous wave (CW) operating modes. This rating places the Intellitune in a strategic position among competitors, most of which are not capable of operating at such high power. Only the components in direct connection with the transmission line will transmit the full power. The Intellitune will tie into the transmission line fed from the radio transmitter, after which it will connect to the variable inductor and variable capacitor. A single relay will be used to switch the capacitor onto each side of the inductor. Therefore, each part aforementioned shall be rated to a minimum of 2.5 kW. In addition, connections between each the stepper motor and their respective reactive component, either the variable inductor or variable capacitor, must have proper insulation/protection to prevent transmission power from flowing through the the control circuit.

**2.1.2. Frequency Bandwidth**

The Federal Communications Committee (FCC) allocates specific frequencies in the RF spectrum for varying applications. The spectrum allocated to amateur radio is described in 47 CFR 97.301 [1]. The Intellitune must be able to operate at all specified frequencies without significant attenuation. Since the impedance of an antenna changes as a function of frequency, the tuning components must be able to match the impedance of an antenna over the specified frequency spectrum.

**2.1.3. Tuning Speed**

The Intellitune must complete the tuning process in a maximum time of 15 seconds. Tuning time must be kept within that limit to satisfy MFJ standards and match impedance faster than the manual tuning process. The stepper motors play the largest role in accomplishing this task. There must not be any miscommunication between the motor drivers and the microprocessor; any miscommunication may lead to a higher VSWR reading, thus reducing the transmission efficiency. Furthermore, the stepper motors must adjust the variable inductor and capacitor via a physical connection between the shafts. This connection must be sturdy to prevent slippage so that the motor does not lose reference to the values of the reactive components.

**2.1.4. Latch Sampling**

The MCU must read 16 digital signals from the latch to determine the correct tuning component values. The variable reactive components will be changed based off of the value calculated from the inputs from the latch. Thus, the entire tuning process hinges on interpreting the digital signals correctly with the MCU. The sampling interval must be at a rate which allows for quick response to changes in the latch output, while allowing enough time to perform necessary calculations.

**2.1.5. Impedance Matching**

The Intellitune must provide a matching network capable of regulating the impedance observed by the signal source. It will be designed to match a 50 ohm output transmitter, transceiver, or amplifier to any antenna with an impedance ranging from 12 to 1600 ohms. Standard coaxial cables used for radio transmission typically have an intrinsic impedance of 50 ohms, so matching this amount minimizes the reflected radio frequency (RF) power in the system. If the antenna’s impedance is not matched, low power transfer and poor transmission quality will be observed at the transmitter/transceiver. This will directly affect the radio operator’s experience, causing frustration and grief.

**2.2. Practical Design Constraints**

Table 2.2 describes the practical design constraints that must be followed in order for a successful execution of the final product.

**Table 2.2. Practical Design Constraints**

|  |  |  |
| --- | --- | --- |
| Type | Name | Description |
| Health and Safety | Physical Safety of the User | The front panel of the product must be safe for human contact. |
| Manufacturability | Size | Size must be compact and comparable to previous antenna tuning units. |
| Sustainability | Longevity | The device must have a long life before requiring maintenance. |
| Economic | Price | The retail cost of this product must be comparable to currently available tuning units. |
| Environmental | Heat dissipation | The enclosure must be safe to touch after operating at max power |

**2.2.1. Health and Safety**

Ensuring user safety is critical, and the autotuner must not pose any potential risks since the Intellitune must be capable of handling a 2.5 kW load. This high load presents the risk of electrocution so it must ensure that all potentially dangerous current is grounded. The Intellitune must be placed in a durable yet lightweight enclosure to accommodate this. During operation, the enclosure should be properly grounded and separated from the transmission feedline so that the user can safely make contact with the front panel.

**2.2.2. Manufacturability**

The size of the tuning unit must be suitable to fit in ham radio work stations. Ham radio users typically set up their radio equipment on a desk, workbench, etc., so the Intellitune cannot be oversized such that it will not fit in a typical setup. The current and comparable MFJ-9982 model measures 13” x 7” x 15.72” [2]. The Intellitune employs similar components so the final product should remain within two inches of these dimensions, in each direction, to provide a compact automatic tuner.

**2.2.3. Sustainability**

The Intellitune must have a longer lifespan between maintenance than previous models. A large number of relays are used in the MFJ-998 model which traditionally wear out and require service more frequently than other parts [2]. By design, the final product will only utilize one relay in order to limit the amount of failures it may cause.

**2.2.4. Economic**

The tuning unit must have a comparable price to other similar tuners in order to attract customers. Tuners capable of handling high loads tend to be expensive, but the Intellitune will be contrary by providing automatic tuning up to 2.5 kW at a lower price. Our product will be using little additional hardware in comparison to similar models, so we would not have to spend much on additional components. Additionally, the in house manufacturing can ensure to keep costs lower.

**2.2.5. Environmental**

The Intellitune must be capable of dissipating the rated power without rapid heating. The enclosure shall be safe to touch after operating at maximum power. If heating were to occur, the risk of fire from contact with the ATU would reduce the safety of the unit. In addition, the enclosure must be robust enough to sustain minor bumps or collisions with other equipment when moved.

**References:**

[1] LII / Legal Information Institute. (2018). 47 CFR 97.301 - Authorized frequency bands.. [online] Available: https://www.law.cornell.edu/cfr/text/47/97.301 [Accessed 19 Sep. 2018].

[2] MFJ Enterprises Inc., Starkville, MS, USA, “Tuners, Antenna Tuners,” Available: <http://www.mfjenterprises.com/Categories.php?sub=0&ref=5> . [Accessed 16 Sep. 2018].