Estimating SignalStick Capacity

Ohmic Resistance

I took the resistivity of Nitinol from, Table III "SUMMARY OF PHYSICAL AND MECHANICAL PROPERTIES OF NOMINAL 55-NITINOL,"[1]
The resistivity (ρ) is about 80 microhm - cm.
The length of the antenna wire (L) is about 45.72 cm.
The wire diameter is about 1.524 mm; its cross section area (A) is about 0.01824 cm^2
The resistance is about 200500 microhms (0.20 ohms), calculated by

$$\begin{aligned} R_\Omega &= \frac{\rho L}{A} \\ &= 200500\, microhms \\ &= 0.20\Omega \end{aligned}$$

Power Converted to Heat

I considered the antenna impedance as 50 ohms (radiation resistance), consisting of the normal resistance and reactance components, which are much larger than the small ohmic resistance calculated in the section above. The current flowing in the antenna is controlled mainly by the impedance and the transmitter power. This current acting over the much smaller ohmic resistance produces heat. The current acting over the radiation resistance does not produce heat; that energy is used to produce electrical and magnetic fields: the transmitted power. See any number of available web-search results discussing this.[2]
The calculations look like this:

$$I = [\frac{P}{R_\Omega + R_r}]^{1/2}$$

$$P_{heat} = I^2 R_\Omega$$

Rate of Heat Transfer out of Wire

The two main modes of heat transfer out of the antenna are thermal radiation and convective heat transfer. For convective heat transfer, the rate of heat flow depends on the temperature difference between the air and the antenna, and on the air flow around the antenna. For radiation heat transfer, the rate depends on the temperature difference between the antenna and the surroundings. For estimates, I consider the temperature of the air and of the surroundings to be the same.

Convective Heat Transfer

For convective heat transfer in still air and for a vertical antenna, the rate of heat transfer is

$$\dot{Q} = h_c A (T_h - T_c)$$

where $h_c = 3.53[\frac{T_h - T_c}{L}]^{\frac{1}{4}}\ \frac{W}{m^2 K}$ for still air [3] and $h_c = 10$ to $100\ \frac{W}{m^2 K}$ for moving air of various speeds.[4]

[1] W.B. Cross, et al., Nitinol Characterization Study, NASA CR-1433, Goodyear Aerospace, Akron, OH, for Langley Research Center, 1969, p 3

[2] https://www.usna.edu/ECE/ee434/Handouts/EE302 Lesson 13 Antenna Fundamentals.pdf, for instance, p 13

[3] https://www.engineersedge.com/heat_transfer/convection_heat_transfer_coefficients_13855.htm

[4] https://www.engineersedge.com/heat_transfer/convective_heat_transfer_coefficients__13378.htm

Radiation Heat Transfer

For radiation heat transfer, heat flow out of the antenna depends on the surrounding temperature, the temperature of the antenna and the emissivity (ε)of the antenna covering (heat-shrink), about 0.9 for rubber and plastic materials.[5] The heat flow is calculated by

$$\dot{Q} = \varepsilon\sigma(T_h^4 - T_c^4)A$$

where the temperatures are in Kelvin ($0°C = 273.15K$), A is in m^2 and σ is 5.6703e-8 $\frac{W}{m^2K}$.

Balance of Power Input and Heat Rate Output

The power input as heat through the ohmic resistance of the antenna wire causes the wire to heat. As the temperature rises, the heat transfers out of the wire/shrink-tube by radiation into the surroundings, and by convection with the air. The convection and radiation equations may easily be solved for the wire temperature if each mode is considered separately. (Combining the heat flow and calculating the wire temperature is a little more complicated.) The solutions for the two modes are

for convection

$$T_h = [\frac{\dot{Q}L^{\frac{1}{4}}}{BA}]^{\frac{1}{1.25}}$$

and for radiation

$$T_h = [\frac{\dot{Q}}{\varepsilon\sigma A} + T_c^4]^{\frac{1}{4}}$$

where A is the total surface area of the antenna, and $\dot{Q}$ is equal to the ohmic power absorbed.

The radiation heat transfer is the primary controlling mode, and it's relative importance depends on the input power. The following example values use a 50% duty cycle (transmitting 50% of the time). At 1.0W input, ΔT is 0.8°C, considering only convection, and 0.1°C, considering only radiation. At 100W, ΔT is 33°C for convection and 11°C for radiation. Combined modes will drive the temperature lower than either mode alone.
To estimate a power capacity for the signal stick, it is necessary to choose a heating criterion. I would be comfortable with a rise in temperature of 18°F (10°C) if I'm transmitting half the time. This won't soften the heat-shrink appreciably. To be conservative, let's use just the radiation heat transfer. Transmitting 88W at 50% duty cycle results in 18°F temperature rise, considering only radiation. The actual temperature will be lower due to convection loss; when I get time I'll do the combined-loss calculations, and update this white paper! For now, I'm going to go with 100W at 50% duty cycle, with combined modes considered (and doing an educated guess on the amount of heat carried away by the combined modes).

Result: Capacity = 100W at 50% duty cycle.

[5] https://www.engineeringtoolbox.com/emissivity-coefficients-d_447.html