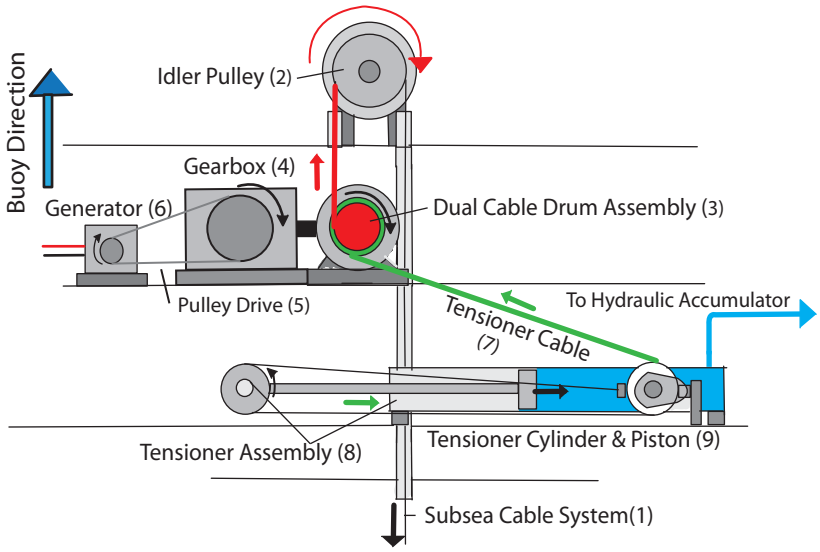
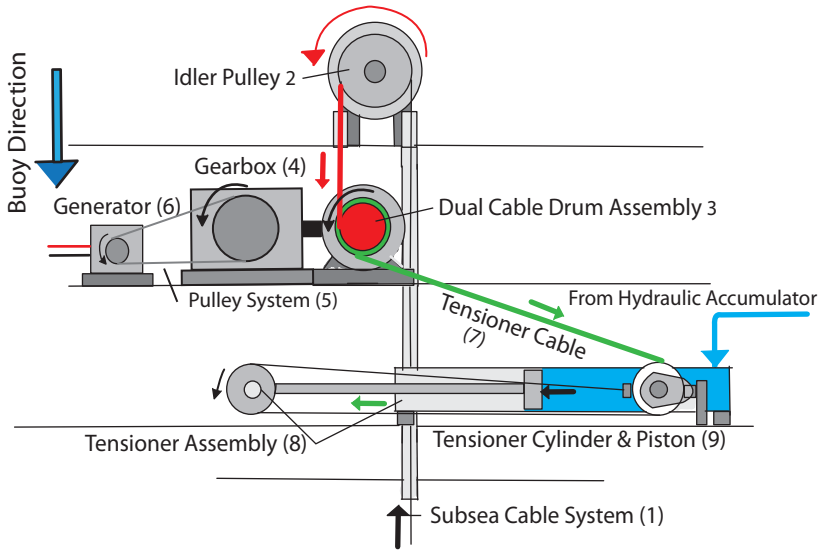
3-4 Watt WEC PTO Operation



FIRST HALF OF WAVE PERIOD FIGURE 1



SECOND HALF OF WAVE PERIOD FIGURE 2

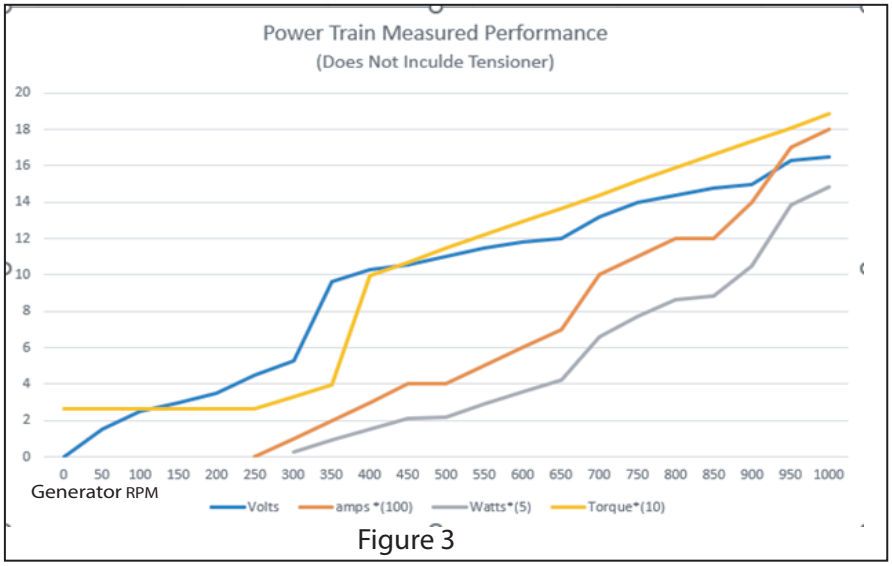


Figure 3

3-4 Watt WEC PTO Model Operation and Physical Description

The 3-4 watt power take off assembly (PTO)
Consists of three basic subsystems;

1. Subsea cable system and dual drum assembly
2. Generator and generator drive system
3. Gas over hydraulic tensioning system

First Half of the Wave Period

Subsea cable and dual drum assembly

The subsea cable system(1), in figure 1, consists of a cable that is connected to the seafloor at one end and after going over the idler pulley (2), wraps around and is connected to a1.56 inch diameter (D) cable drum, of the cable drum assembly (3). The vertical movement of the buoy, as the buoy transitions from a wave trough to a wave crest of a wave with a period of 5 seconds and a wave amplitude (A) of 3.95, inches, rotates the drum at a rate of 0 to 59 RPM*.

$$w = \left(\frac{2\pi}{T}\right)$$

$$V_{Max} = \left(w \cdot A \cdot 60\right)/12$$

$$*RPM_{Max} = \left(V_{Max}\right)/D$$

Generator and generator drive systems

The generator and generator drive system includes the 1.56 inch diameter dual cable drum assembly (3) , a flexible coupling, 1:20 ratio gearbox (4), 1.8: 1 ratio belt pulley drive (5) and a permanent magnet 5 watt generator (6) with a dual wound stator. Each of the two stator windings produce a variable voltage AC output. Each set of the generator windings is connected to an AC to DC rectifier. The DC output of each rectifier are joined together and connected to the 0-5 watt load, consisting of a set of LED lights. Physical measurements were taken by measuring the DC output voltage, load amps, and torque load (force applied to the subsea cable in pounds) across the generator operating RPM range. See Figure (3)

Second Half of the Wave Period

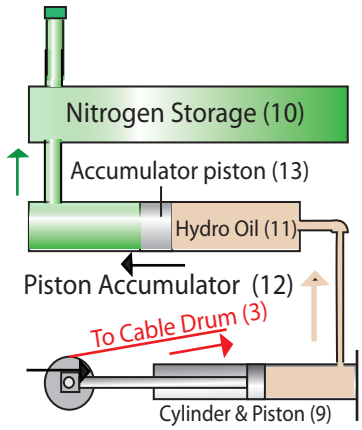
Tensioner cable and dual drum assembly

The tensioner cable (7), in figure 2, consists of a cable that is connected to the tensioner assembly (8) at one end and connected to and wraps around a 1.56 inch diameter cable drum, of the dual cable drum assembly (3) at the other end. As the vertical movement of the buoy, transitions from a wave crest to a wave trough, the tension on the subsea cable (1) relaxes. The cable tensioner assembly (8), through the tensioner cable (7) now rotates the drum at a rate of 0 to 59 RPM for a wave having a height of 7.9 inches and a period of 5 seconds. Rotation of the cable drum (3) by the tensioner cable (7) drives the generator (6) through the gearbox (4) and pulley system (5).

2.5-4 Watt WEC PTO Operation

Gas over hydraulic tensioning system

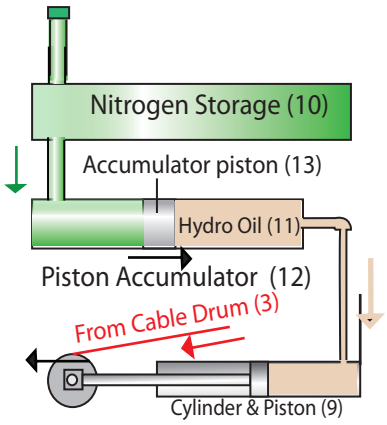
3-4 Watt Tensioner System
First Half of Wave Period



Cable Tensioner Assembly (8)

Figure 4

3-4 Watt Tensioner System
Second Half of Wave Period



Cable Tensioner Assembly (8)

Figure 5

The model cable tension assembly (8) consists of two .63 in diameter X 3.3 inch stroke cylinder piston assemblies (9). The piston accumulator (12) consists of a 2 inch diameter X 8 inch long cylinder with an internal sliding piston. The nitrogen storage (10) consists of one 2.5 in diameter X 8 inch long cylinder. The piston accumulator (12) contains 25% by volume nitrogen gas at 60 psi (6.28 cu. inches), and the nitrogen storage (10) contains 39.27 cu. inches at 60 psi. The pressure drop of the hydraulic oil over the full stroke of the cylinder and piston (9), (2.56 cu. inches) results in a pressure drop on the hydraulic oil (11) ($P_1V_1 = P_2V_2$) of 2.04 psi.
The relative constant pressure on the hydraulic oil (11) allows the cable tension assembly (8) to act like a spring, absorbing energy during the first half of the wave period and returning that energy to the system during the second half of the wave period. With the system operating at a hydraulic/nitrogen pressure of 60 psi a force of 37.4 pounds is applied to tensioner cable (7) during the first and second half of the wave period.

Figure 6

First Half of the Wave Period

Subsea cable and dual drum assembly of the subsea cable system (1), in figure 1 and 2, consists of a cable that is connected to the seafloor at one end , that after going over the idler pulley (2), wraps around and connects to a 1.56 inch diameter cable drum, of the cable drum assembly (3) at the other end. The vertical movement of the buoy, as the buoy transitions from a wave trough to a wave crest with a period of 5 seconds and a wave height of 7.9, inches, rotates the dual cable drum assembly (3) at a rate of 0 to 59 RPM. The rotation of the cable drum not only drives the generator (4) but also compresses the cable tensioner assembly (8) as shown in Figures 1 and 4. The piston in the cylinder & piston (9) pushes hydraulic oil (11) back into the piston accumulator (12). The piston accumulator (12) maintains a constant pressure on the hydraulic oil (11) as a result of the nitrogen pressure on the opposite side of the accumulator piston (13).

Second Half of the Wave Period

Subsea cable and dual drum assembly

The subsea cable system (1), in figure 1 and 2, consists of a cable that is connected to the seafloor at one end, that after going over the idler pulley (2), wraps around and is connected to a 1.56 inch diameter cable drum, of the cable drum assembly (3). Force on the subsea cable system (1) is relaxed when the vertical movement of the buoy transitions to a wave crest from a wave trough. As the force on the subsea cable assembly (1) relaxes, force on the tensioner cable (7), as the result of the cable tensioner assembly (8) extending, causes the dual cable drum assembly (3) to rotate. With a wave having a period of 5 seconds and a wave height of 7.9, inches, the dual cable drum assembly (3) will rotate at a rate of 0 to 59 RPM. (see figure 2 and 5). The rotation of the cable drum assembly (3) drives the generator (4) as shown in Figure 2. When the tension on the subsea cable assembly (1) relaxes, the accumulator piston (13) in the piston accumulator (12) pushes hydraulic oil (11) into the cable tension assembly (8) cylinder & piston (9), causing the cable tension assembly (8) to extend. The piston accumulator (12) maintains a constant pressure on the hydraulic oil (11) as a result of the nitrogen pressure on the opposite side of the accumulator piston (13), as explained in figure 6.