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# Satellite dish antenna control for distributed mobile telemedicine nodes

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**ABSTRACT**

The positioning control of a dish antenna mounted on distributed mobile telemedicine nodes (DMTNs) within Nigeria communicating via NigComSat-1R has been presented. It was desired to improve the transient and steady performance of satellite dish antenna and reduce the effect of delay during satellite communication. In order to overcome this, the equations describing the dynamics of the antenna positioning system were obtained and transformed into state space variable equations. A full state feedback controller was developed with forward path gain and an observer. The proposed controller was introduced into the closed loop of the dish antenna positioning control system. The system was subjected to unit step forcing function in MATLAB/Simulink simulation environment considering three different cases so as to obtain time domain parameters that characterized the transient and steady state response performances. The simulation results obtained revealed that the introduction of the full state feedback controller provided improved position tracking to unit step input with a rise time of 0.42 s, settling time of 1.22 s and overshoot of 4.91%. With the addition of observer, the rise time achieved was 0.39 s, settling time of 1.31 s, and overshoot of 10.7%. The time domain performance comparison of the proposed system with existing systems revealed its superiority over them.



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## 1. INTRODUCTION

Satellite antennas are essential components of mobile telecommunication systems. Large amount of data representing telephone traffic, radio signals, and television signals are carried by satellites. The application of satellite has become increasingly common and an integral part of everyday life as can be seen in many homes and offices with various forms of antennas that are employed for receiving signal from satellites located far distance away from the earth [1]. Satelllite communications certainly offer the most vital technology that enables communication without selecting location and time [2].

Communication via satellite has become a famous process in all field of human endeavour including health sector, where distributed mobile telemedicine nodes (DMTNs) communicating via satellite are used to provide remote healthcare delivery. The DMTNs are communicating dish antenna networks. Telemedicine simply means the the use of information and communication technology (ICT) to provide healthcare delivery and sharing of medical knowledge over a distance [3]–[6]. In Nigeria, it is one of the primary assignment of the Nigerian's communication satellite (NigComSat-1R) that is aimed at improving remote diagnosis and providing cost efficient and good healthcare delivery [3], [6].

As a result of the distribution and mobility nature of telemedicine system in addition to the large land mass of Nigeria, huge delay in propagation occurs during satellite communication between parabolic antennas, which can cause poor quality or instability in system performance if not addressed. Hence, a system that will compensate for this time delay variableness is expected to provide good positioning as well as fast, accurate and precise line of sight (LOS) operation in terms of robust tracking [6]. In order to compensate for this, conventional and robust proportional-integral-derivative (PID) controllers have been used to provide command and positioning control of mobile temedicine dish antenna network mounted on vehicles to point and lock to NigComSat-1R by [7], [8]. For DMTNs within Nigeria when communication is via NigComSat-1R, the effect of PID controller on positioning control of dish antenna perforamnce has been examined [3]. The performance response of PID compensated mobile satelllite dish antenna network used in telemedicine within Nigeria has been improved in [9] by adding a low pass filter (LPF) in the input of the antenna positioning control system. The performance characteristics of dish antena system in distributed telemedicne mobile network has been simulated by adding a compensator in [10]. For distributed mobile telemedicine nodes, the effect of different controllers on performance of dish antenna Positioning system has been examined in [11].

Actually, different control strategies have been implemented to position dish antenna for satellite communication. A control system for realizing stable position of antenna in the presence of external disturbance was developed in [12]. The use of random data generated for antena control servo system has been done in [13]. Positioning control of deep space antenna based on weighted cultural artificial fish swarm algorithm optimized PID controller has been presented in [14]. Satellite antenna systems using PID tuned compensator that will provide robustness and effective tracking for direct current servo-based antenna and positioning control system for servo based ground station satellite antenna have been presented in [15], [16]. The use of least square method (LSM) to tune the optimal level signal value (LSV) so as to solve the problem of antenna alignment in point-to-point communition was performed by [17]. An active position compensator has been developed in [18] for large beam waveguide antenna subject to wind disturbance. Deshpande and Bhavikatti [19] antenna azimuth control system has been tuned by two algorithms. Azimuth position control has been achieved in [20] based on gradient and Lyapunov strategies to adaptively tune differential amplifier using model reference adaptive control (MRAC). Fractional order lead compensator has implemented for antenna azimuth position [21].

In this paper, a satellite dish antenna positioning control system for DMTNs communicating via NigComSat-1R that is located in International Telecommunication Union (ITU) region at 42.5° East [3], [8], [22] is examined. A full state feedback controller is proposed to compensate for time delay effect and evaluate the positioning performance response of satellite dish antenna in DMTNs within Nigeria. Full state feedback controller has been chosen in this paper because it provides the best performance compared to other control technique in terms of oscillation and settling time [23], it can solve the problem of systems with time-varying state space representation [24] or systems with multiple operating conditions as well as those with multiple inputs and multiple outputs signal requirement [25], it offers flexibility of shaping the dynamics of closed loop system to meet the desired specifications [26]. It should be noted that the goal of this paper is to control or move the position of a dish antenna in a mobile telemedicine node in less than or equal to 4 s and with very much reduced settling time and improved satellite signal tracking while overcoming the effect of time delay during communication.

## 2. SYSTEM DESIGN

The main tools used in this paper are the MATLAB codes and the Simulink embedded blocks, which were used for the modelling and simulations. The MATLAB codes were used to determine the controllability matrix, observability matrix, the gain of the control law (or feedback gain matrix), the forward path gain, and the gain of the observer. These values were then entered as parameters including the calculated state matrix, input matrix and output matrix, in embedded Simulink blocks used in the modelling and simulations. The delay dynamic was represented with the variable time delay block of the Simulink. Also in this section, the approach adopted in modelling of the system is presented. The first approach was to study the dynamic models of the existing system in transfer function (frequency domain representation) of the plant and time delay. In order to present the method used in this study, a block diagram describing the operation of each stage of the proposed system is shown in Figure 1.

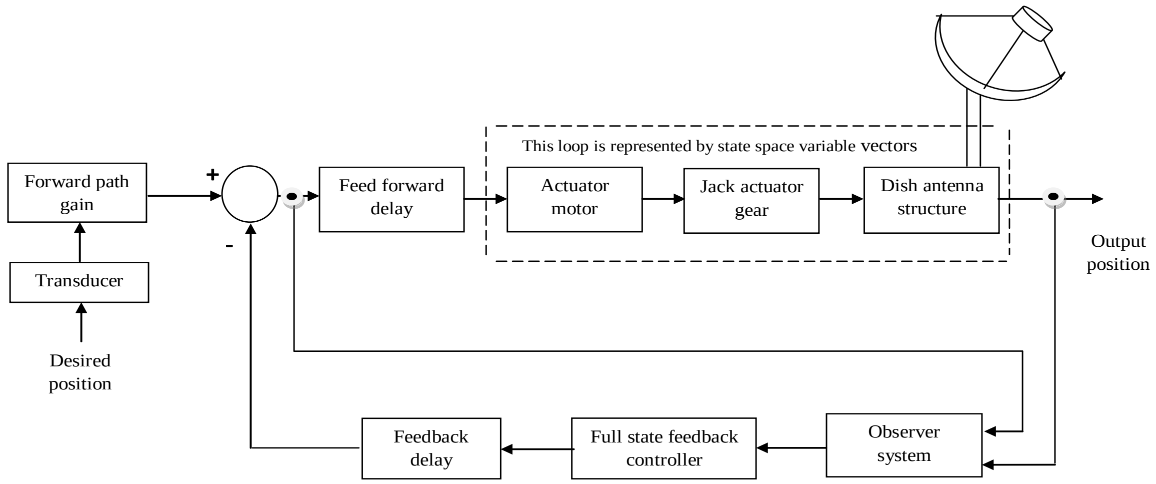


Figure 1. Block diagram description of the proposed system

### 2.1. Transfer function model of system

The system transfer function was determined taking into consideration the dynamic equations of dish structure and jack actuator. The dynamic of the dish structure was determined experimentally in terms of the parameters of the dish structure moment of inertia, damping coefficient and spring constant, and similarly for the jack actuator dynamics 3. Therefore, the dynamic equation for the dish antenna is by [9]:

$$I_A \frac{d^2\theta_A}{dt^2} + B_A \frac{d\theta_A}{dt} + \tau_A \theta_A = \tau_A \theta_g \tag{1}$$

the Laplace transform of (1) assuming zero initial conditions [9]:

$$G_p(s) = \frac{\theta_A(s)}{\theta_g(s)} = \frac{\tau_A/I_A}{s^2+(B_A/I_A)s+(\tau_A/I_A)} \tag{2}$$

where $\theta_A$ is dish angular displacement, $\theta_g$ is gear output shaft angular displacement, $I_A$ is the moment of inertia of dish structure (140.60 kgm$^2$), $B_A$ represents the damping coefficient (126.78 Nms/rad), $\tau_A$ is the tortional spring stiffness (317.5 Nm/rad). Thus (2) becomes [7]:

$$G_p(s) = \frac{2.2578}{s^2+0.9016s+2.2578} \tag{3}$$

the transfer function of actuator motor and the gear ratio dynamic, $K_g$ are expressed in [7] as:

$$G_m(s) = \frac{0.075}{s(1+0.015s)} \tag{4}$$

$$K_g = \frac{1}{30} \tag{5}$$

The time delays for the forward path $G_{d1}(s)$, and feedback path $G_{d1}(s)$, are expressed as transfer functions by [3]:

$$\left.\begin{aligned} G_{d1}(s) &= e^{-T_1 s} \\ G_{d2}(s) &= e^{-T_2 s} \end{aligned}\right\} \tag{6}$$

where $T_1$ and $T_2$ are the feed forward time and feedback time in seconds respectively. Assuming $T_1 = T_2, = T$ then (6) can be expressed as in [3]:

$$G_{d1}(s) = G_{d2}(s) = G_d(s) = e^{-Ts} \tag{7}$$

The minimum and maximum time delays were determined to be 0.2469 s and 0.2502 s [3]. However, a value T = 0.25 s was used in this paper. The closed loop diagram of the system with the transfer functions of actuator motor, $G_m(s)$, dish antenna structure, $G_p(s)$, the gear ratio, $K_g$, feed forward time delay, $G_{d1}(s)$, and feedback time delay $G_{d2}(s)$ with unit gain feedback sensor is shown in Figure 2.

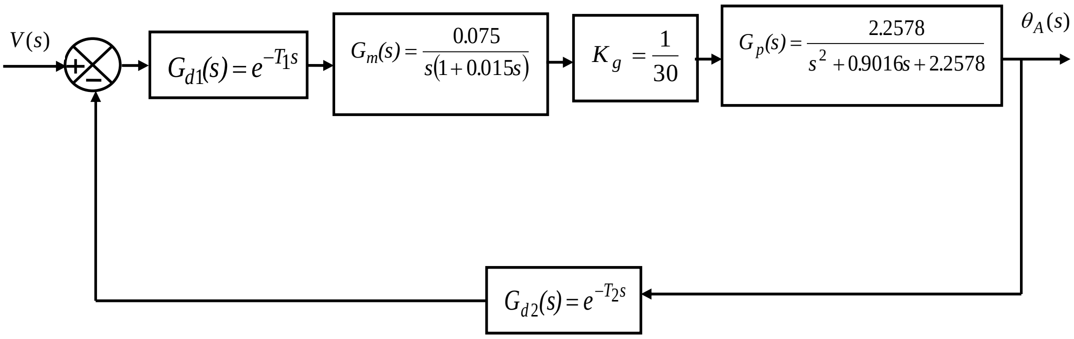


Figure 2. Block diagram of closed system

The open loop transfer function without considering the time delay and the closed loop transfer function with time delay compensation for the system are by [3], [7] as in (8) and (9).

$$\frac{\theta_A(s)}{V(s)}=\frac{3.76}{s^4+67.56s^3+62.36s^2+150.52s} \tag{8}$$

$$\frac{\theta_A(s)}{V(s)}=\frac{3.76e^{-Ts}}{s^5+67.56s^4+62.36s^3+150.52s^2+3.76e^{-Ts}} \tag{9}$$

where $V(s)$ is the input voltage and that is represented as the reference forcing step input.

### 2.2. State space model

Implementing a full sate feedback controller requires that that the variables of the system be represented in terms of state space model. Therefore, the transfer function (8) is transformed into an equivalent state variable equation is this subsection. Generally, a linear state space system is by:

$$\dot{x}=Ax+Bu \tag{10}$$

$$y=Cx+Du \tag{11}$$

where *A*, *B*, *C*, and *D* are the state matrix, input matrix, output matrix, and direct transition matrix. Expressing (8) as in (12) and assuming zero initial conditions, the space equation for the system is as shown in (13) and (14):

$$\frac{Y(s)}{U(s)}=\frac{3.76}{s^4+67.56s^3+62.36s^2+150.52s} \tag{12}$$

$$\begin{bmatrix}\dot{x}_1\\\dot{x}_2\\\dot{x}_3\\\dot{x}_4\end{bmatrix}=\begin{bmatrix}0&1&0&0\\0&0&1&0\\0&0&0&1\\0&-150.52&-62.36&-67.56\end{bmatrix}\begin{bmatrix}x_1\\x_2\\x_3\\x_4\end{bmatrix}+\begin{bmatrix}0\\0\\0\\3.76\end{bmatrix}u(t) \tag{13}$$

$$y=[1\quad 0\quad 0\quad 0][x_1\quad x_2\quad x_3\quad x_4]^T \tag{14}$$

where:

$$A=\begin{bmatrix}0&1&0&0\\0&0&1&0\\0&0&0&1\\0&-150.52&-62.36&-67.56\end{bmatrix}, B=\begin{bmatrix}0\\0\\0\\3.76\end{bmatrix}, C=[1\quad 0\quad 0\quad 0], D=0.$$

## 3. METHOD

In this section, the necessary approaches to designing a full state feedback controller are presented. These approaches include: determining controllability and observability of the system, designing the control law with the feedback gain, *K*, the forward path gain, and observer design.

### 3.1. Controllability and observability

The first step to designing a full state controller is to determine the controllability and observability of the system. The equations for determining the controllability matrix and observability matrix are by:

$$C_{matrix} = [B \quad AB \quad A^2B \quad \ldots. \quad A^{n-1}B] \tag{15}$$

$$O_{matrix} = [C \quad CA \quad CA^2 \quad \ldots. \quad CA^{n-1}]^T \tag{16}$$

solving (14) and (15) as shown in:

$$C_{matrix} = \begin{bmatrix} 0 & 0 & 0 & 0 \\ 0 & 0 & 4 & 300. \\ 0 & 3.76 & -254 & 16900 \\ 3.76 & -254.0256 & 16927 & 1128300 \end{bmatrix}, \text{Rank} = 4,\ O_{matrix} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}, \text{Rank} = 4.$$

### 3.2. Design of control law

A full state variable feedback is a pole placement design technique whereby all desired poles are selected at the beginning of the design process. In order to begin with the design of the control law, Figure 3 is presented, it is initially assumed that the reference input is zero, and hence the control law is simply by:

$$u = -Kx \tag{17}$$

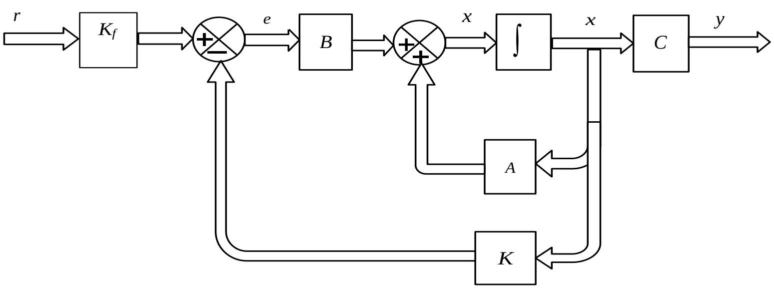


Figure 3. Structure of full state feedback control system

where, $u, K, x$ are the control input, feedback gain, and state variable. Substituting (17) into (10):

$$\dot{x} = (A - BK)x, \tag{18}$$

the eigenvalues of $(A - BK)$ are determined in order to obtain the elements of the forward path gain, *K* by:

$$K = [K_1 \quad K_2 \quad K_3 \quad K_4] \tag{19}$$

therefore, the eigenvalues,$\lambda_i$ (where $i = 1, 2, 3, 4$) are shown in:

$$(A - BK) = \begin{bmatrix} 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ -3.76K_1 & -150.52 - 3..76K_2 & -62.36 - 3.76K_3 & -67.56 - 3.76K_4 \end{bmatrix} \tag{20}$$

$$det[\lambda I - (A - BK)] = \begin{vmatrix} \lambda & -1 & 0 & 0 \\ 0 & \lambda & -1 & 0 \\ 0 & 0 & \lambda & -1 \\ 3.76K_1 & 150.52 + 3.76K_2 & 62.36 + 3.76K_3 & \lambda + 67.56 + 3.76K_4 \end{vmatrix} = 0 \tag{21}$$

Solving (21) as shown in:

$$\lambda^4 + \lambda^3(67.56 + 3.76K_4) + \lambda^2(62.36 + 3.76K_3) + \lambda(150.52 + 3.76K_2) + 3.76K_1 = 0 \quad (22)$$

choosing a desired characteristic (23) by:

$$E_{ch} = (\lambda^2 + 2\zeta\omega_n\lambda + \omega_n^2)\,(\lambda^2 + a\lambda + b) \quad (23)$$

Selection is made by taking a damping ratio $\zeta = 0.69$ for minimal overshoot, a settling time, $T_s = 1\ s$ and natural frequency, $\omega_n = 5.77$, while the constants a, b, are chosen as (16, 100) respectively. Substituting these values in (23):

$$E_{ch} = \lambda^4 + \lambda^3(7.963 + a) + \lambda^2(33.293 + 7.963a + b) + \lambda(33.293a + 7.963) + 33.293b \quad (24)$$

In (22) and (24) as shown in:

$$67.56 + 3.76K_4 = 7.963 + a \quad \Rightarrow K_4 = -11.60$$

$$62.36 + 3.76\mathrm{K}_3 = 33.293 + 7.963\mathrm{a} + \mathrm{b} \quad \Rightarrow K_3 = 52.75$$

$$150.52 + 3.76\mathrm{K}_2 = 33.293 + 7.963\mathrm{a} + \mathrm{b} \quad \Rightarrow K_2 = -313.4$$

$$3.76\mathrm{K}_1 = 33.293\mathrm{b} \Rightarrow K_1 = 885.5$$

thus, (19) can now be expressed as in (25), and the control law in (17) is now presented as in (26):

$$K = [885.5 \quad 313.4 \quad 52.75 \quad -11.60] \quad (25)$$

$$u = [885.5 \quad 313.4 \quad 52.75 \quad -11.60]x \quad (26)$$

With the control law designed, the full state feedback control loop can now be implemented, but the problem of using the full state feedback gain, $K$, alone is that the chances of tracking the desired input is not certain. Hence, to solve this problem, a forward path gain $K_f$ is designed as shown in Figure 3. Considering Figure 3, the control command can be expressed by:

$$u = K_f r - Kx \quad (27)$$

where $r$ is the desired or reference input. Substituting (27) into (10):

$$\dot{x} = (A - BK)x + BK_f r \quad (28)$$

the value of $K_f$ is calculated to be 885.5.

### 3.3. Design of observer

Figure 4 is an illustration of state feedback employing an observer, and the mathematical theory of calculating and selecting observer gains is subsequently presented. Observers are designed as part of full state feedback control system when it is not possible to measure all the states of the plant or can only be partially measured or reducing the number of measured states will be cost effective. Hence, the observer state equation can be described from Figure 4 as shown in (29) and (30).

$$\hat{\dot{x}} = A\hat{x} + Bu + L(y - \hat{y}) \quad (29)$$

$$\hat{y} = C\hat{x} \quad (30)$$

where $u = K_f r - K\hat{x}$, and $L$ is the gain of the observer by:

$$L = [L_1 \quad L_2 \quad L_3 \quad L_4] \quad (31)$$

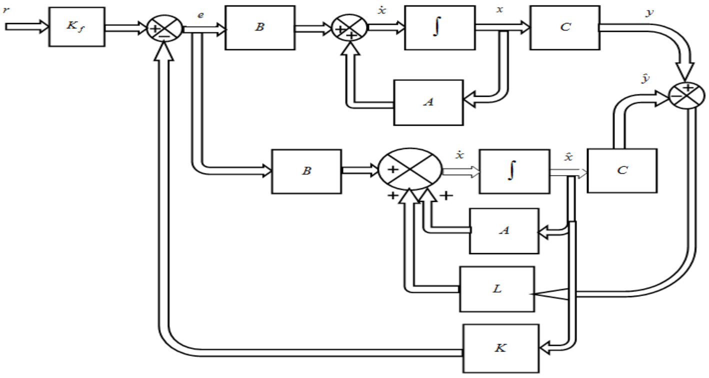


Figure 4. Full state feedback with observer

The objective of an observer is to reduce the error between the actual and the estimated states to zero. That is error, $e = x - \hat{x} \rightarrow 0$. Therefore:

$$\dot{e} = \dot{x} - \dot{\hat{x}} = Ax + Bu - (A\hat{x} + Bu + L(y - \hat{y})) = (A - LC)(x - \hat{x}) \quad (32)$$

$$\dot{e} = (A - LC)e \quad (33)$$

The poles, $p_1, p_2, p_3, p_4$ of the system can be obtained by solving the characteristics by (24) to determine the eigenvalues. Hence, substituting the values of *K*, in (25) into (24):

$$\lambda^4 + 23.944\lambda^3 + 260.7\lambda^2 + 1328.904\lambda + 3329.48 = 0 \quad (34)$$

solving (34):

$\lambda_1 = p_1 = -7.9915 + 6.0318j$, $\lambda_2 = p_2 = -7.9915 - 6.0318j$, $\lambda_3 = p_3 = -3.9805 + 4.1676j$, $\lambda_4 = p_4 = -3.9805 - 4.1676j$. The values of the gains of *L* are computed using the MATLAB expression: $L = place(A', C', 10 * p)$and this: $L = [2000 \quad 14400 \quad 345500 \quad 9030600]$.

With the observer gain obtained, the proposed full state feedback controller using forward path gain and an observer (FSFB+Obsv) is implemented in MATLAB/Simulink environment as shown in Figure 5.

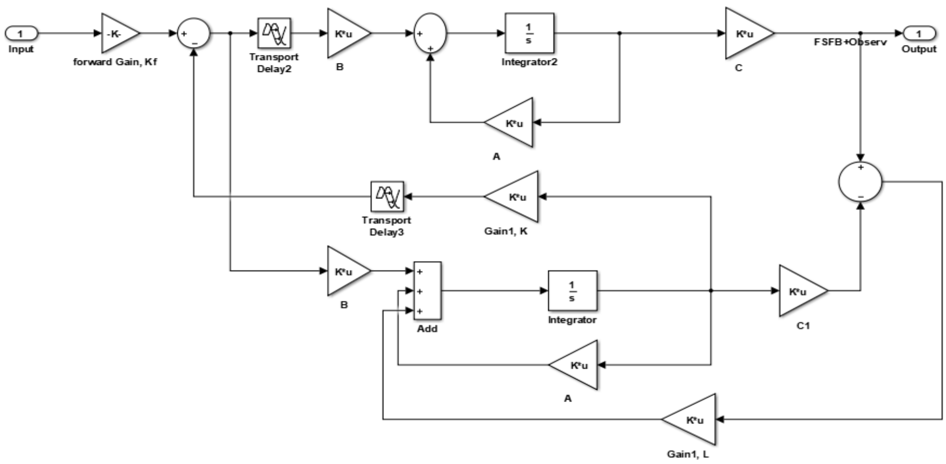


Figure 5. Simulink model of proposed dish antenna position control system

## 4. RESULTS AND DISCUSSION

### 4.1. Results

The simulation results of the position control of dish antenna for distributed mobile telemedicine nodes using state feedback controller designed in MATLAB/Simulink environment are presented in this section. The simulation is conducted base on five scenarios with respect to unit step forcing input. These scenarios are: step response performance without the control law (uncompensated system) in Figure 6, step response performance with feedback gain only (FSFB without FG) in Figure 7, step response performance with feedback gain and forward gain (FSFB with FB) in Figure 8, step response performance of full state feedback plus observer (FSFB+Obsv) in Figure 9, and lastly is the step response performance comparison with previous system in Figure 10. Table 1 is the numerical summary of the simulation plots. The expression in (35) is used to compute the percentage improvement of the proposed FSFB+Obsv against existing system.

$$\text{Improvement} = \left(\frac{\text{Previous value} - \text{New value}}{\text{Previous value}}\right) \times 100 \quad (35)$$

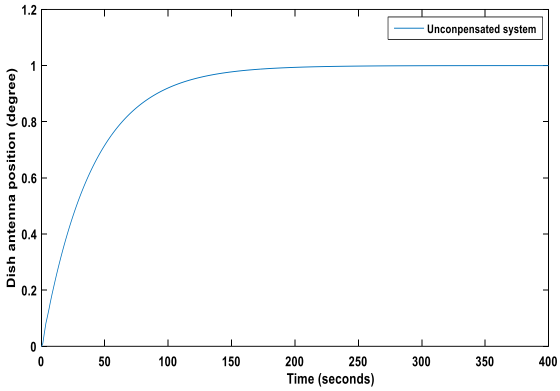


Figure 6. Step response of uncompensated system

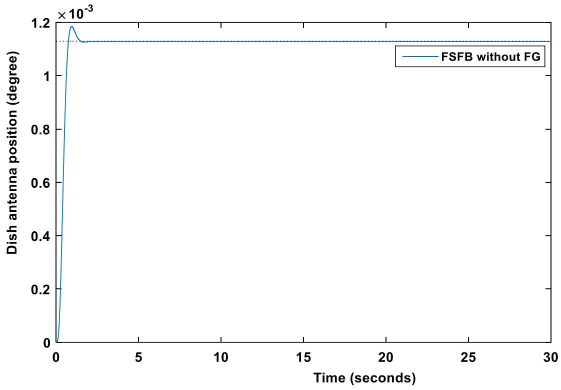


Figure 7. Step response with full state feedback gain only

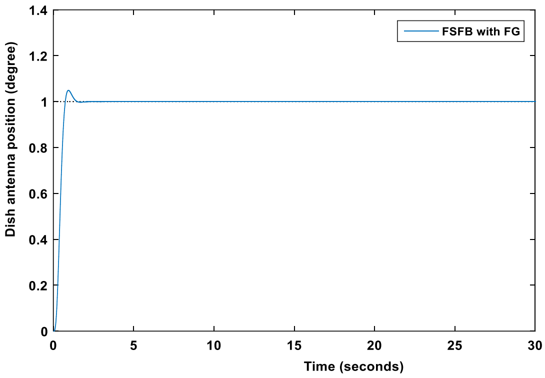


Figure 8. Step response with full state feedback with forward gain

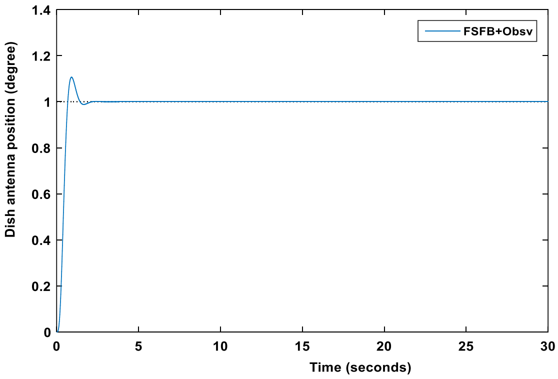


Figure 9. Step response with full state feedback plus observer

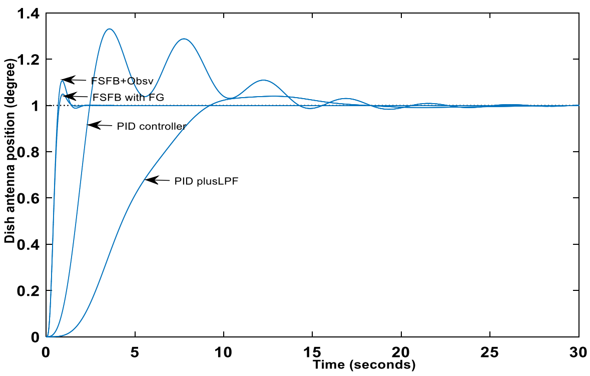


Figure 10. Step response comparison of different controllers

Table 1. Summary of numerical performance analysis for different control scenarios

| System condition | Rise time (s) | Settling time (s) | Time to peak overshoot (s) | Overshoot (%) | Response to a step input | Remark |
|---|---|---|---|---|---|---|
| Uncompensated | 87.1 | 155 | 300 | 0 | Able to track desired input but sluggish due to time delay | Unsatisfactory |
| FSFB without FG | 0.42 | 1.22 | 0.945 | 4.91 | Not able to track desired input | Unsatisfactory |
| FSFB with FG | 0.42 | 1.22 | 0.945 | 4.91 | Able to track desired input | Satisfactory |
| FSFB + Obsv | 0.39 | 1.31 | 0.931 | 10.7 | Able to track desired input | Satisfactory |
| PID controller | 1.4 | 17.6 | 3.57 | 33.1 | Able to track desired input | Needs overshoot and settling time improvement (still suffers from instability) |
| PID plus LPF | 5.54 | 15.3 | 10.67 | 3.98 | Able to track desired input | Needs rise time and settling time improvement |

### 4.2. Discussion

The simulation result in Figure 6 clearly shows from the step response performance that the uncompensated system suffers from the effect of time delay, which largely affects the rise time and settling time as the value of these time domain parameters are very high. Thus, looking at Table 1, the system shows promising performance in terms of peak overshoot (0%), but this benefit is defeated because it will take a long time (87.1 s) for the system to respond to input signal requiring the dish antenna to be positioned, and even after responding it takes 155 s to reach a steady state or stabilizes for efficient line of sight communication (with respect to tracking desired position, which in this case is unit step input) in telemedicine node operation. Figures 7-9 are the simulation plots of three different cases for full state feedback positioning control of dish antenna in telemedicine node. The application of the control law with feedback gain only was not able to ensure the tracking of unit step input but reached a final value of 0.00113 degree as shown in Figure 7. Though the time domain performance parameters seem very promising as shown in Table 1 (FSFB without forward path gain), the control of the dish antenna in this case cannot provide efficient satellite communication for proper telemedicine node services. This is unsatisfactory because the desired position for better satellite communication is not realized using the full state feedback controller in this scenario. With the introduction of a forward path gain, the performance of full state feedback controller was enhanced as a result; the desired position was tracked while achieving a rise time of 0.42 s, settling time of 1.22 s, and peak overshoot of 4.91% as shown in Table 1 (FSFB with FG). It suffices to say that by adding the forward path gain the full state feedback controller can effectively position dish antenna at the desired location for improved and quality satellite communication in mobile telemedicine node. Also, the addition of observer (FSFB+Obsv) improved the system performance response to unit step input as shown in Figure 9 by providing a rise time of 0.39 s, settling time of 1.31 s and overshoot of 10.7% Table 1 in addition to offering an efficient tracking and positioning of the dish antenna for effective LOS communication.

In order to validate the effectiveness of the proposed system in this paper, its step response performance is compared with existing systems proposed by [3], [9]. The existing systems used PID controller and PID plus LPF aided control technique to improve the tracking performance of a DMTNs studied in this research. The performance comparison of the existing systems and the proposed full state feedback control system are shown in Figure 10. The step response performance characteristics in time domain for both existing and proposed systems are presented in Table 1 such that PID controller proposed in [3] yielded a rise time of 1.4 s, settling time of 17.6 s, peak time of 3.57 s, and overshoot of 33.1%, while PID plus LPF [8] yielded rise time of 5.54 s, settling time of 15.3 s, peak time of 10.67 and overshoot of 3.98% respectively. It can also be said from the numerical values of the simulation results in Table 1 that system with proposed full sate feedback plus observer controller has both better transient and steady states response than the system with either PID controller or the system with LPF aided PID controller because of the lower value of system time domain performance response parameters. The only time domain parameter that makes the PID plus LPF appears to outperform the proposed system is the percentage overshoot, which is 3.98% against 10.7%. However, there will be no negative effect caused by this on the proposed system response as it would have risen and settled before the LPF aided PID control system even rises considering the step response in Figure 10 and the rise time and settling time as shown in Table 1. Generally, the major observation regarding the performance of the proposed FSFB+Obsv is that it provided very fast response to satellite communication for the antenna positioning system in terms of reduced rise time (0.39 s), which is 99.6% improvement against the rise time (87.1 s) of the uncompensated system, 72.1 % improvement against the rise time (1.4 s) of PID controller and 93% improvement against the rise time (5.54 s) of PID plus LPF. Also, the proposed strategy offered very much urgent stabilization of the antenna positioning system in terms of reduced settling time (1.31 s), which is 99.2% improvement against the settling time (87.1 s) of the uncompensated system, 92.6 % improvement against the settling time (1.4 s) of PID controller and 91.4% improvement against the settling time (5.54 s) of PID plus LPF.

## 5. CONCLUSION

Simulations have been conducted and it was observed that a state feedback controller using forward path gain and an observer successfully allowed the dish antenna plant to follow step angle inputs represented by a step function. Since the dish antenna at the node is usually used to send or receive medical information by the mobile telemedicine nodes, the quality of performance of such satellite tracking antenna will depend mainly on how effective the position of the antenna can be controlled. This means that good communication with satellite by antenna node in the telemedicine network depends on the ability to position the antenna to urgently locate and track satellite signal and maintain desired LOS for improved signal transmission and reception. This is only achievable when dish antenna is properly positioned with the aid of enhanced control strategy. In this paper, quality LOS was taken to mean the ability of dish antenna to track unit step input with fast response time of less than or equal to 4 s and stabilizing at a very much reduced time (settling time). In respect to this, the full state feedback controller with forward gain and an observer proposed was able to provide improved position control system for dish antenna in terms of effective tracking of unit step input. It also ensures enhanced performance in terms of quality and timeliness in sending or receiving of healthcare information based on the fast (or better transient) response time achieved considering the improved rise time, settling time and percentage overshoot and zero steady state error provided by the proposed system. Authors are currently working on intelligent control algorithm for the system and suggest that other prospective control strategies such as optimal controllers be employed in future study.

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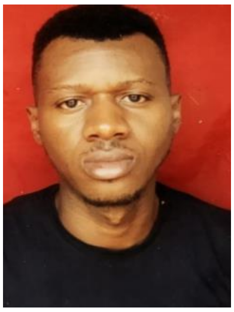

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