REC-ERC-77-2

ELECTRONIC ISOLATION SIMULATOR FOR HYDRAULIC TURBINE GOVERNOR ALINEMENT

Engineering and Research Center

Bureau of Reclamation

January 1977

MS-230 (8-70)
Bureau of Reclamation

TECHNICAL REPORT STANDARD TITLE PAGE

1. REPORT NO. REC-ERC-77-2	2. GOVERNMENT ACCESSION NO.	3. RECIPIENT'S CATALOG NO.
4. TITLE AND SUBTITLE Electronic Isolation Simulator for Hydraulic Turbine Governor Alinement		5. REPORT DATE January 1977
		6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) L. E. Eilts		8. PERFORMING ORGANIZATION REPORT NO. REC-ERC-77-2
9. PERFORMING ORGANIZATION NAME AND ADDRESS Engineering and Research Center, Bureau of Reclamation, Denver, Colorado 80225		10. WORK UNIT NO.
		11. CONTRACT OR GRANT NO.
12. SPONSORING AGENCY NAME AND ADDRESS Same		13. TYPE OF REPORT AND PERIOD COVERED
		14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report describes the theory of governor alinement by the technique of simulated isolation. The design, assembly, circuit configuration, and external connections of an electronic isolation simulator for governor alinement testing are presented. Procedures for setting up and using the isolation simulator are outlined and typical governor responses obtained during simulated isolation tests are illustrated. The calculations and potentiometer setting determinations, prerequisite to this type of testing, are exemplified.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. *DESCRIPTORS*-- / governors / servomechanisms / regulation / electronic equipment / control systems / analog computers / dynamic tests / models / test procedures / field tests / hydroelectric powerplants.

b. *IDENTIFIERS*-- / *isolation simulator / governor alinement testing

c. *COSATI Field/Group* 09C *COWRR:* 0903

18. DISTRIBUTION STATEMENT *Available from the National Technical Information Service, Operations Division, Springfield, Virginia 22151.*	19. SECURITY CLASS (THIS REPORT) *UNCLASSIFIED*	21. NO. OF PAGES 9
	20. SECURITY CLASS (THIS PAGE) *UNCLASSIFIED*	22. PRICE

REC-ERC-77-2

ELECTRONIC ISOLATION SIMULATOR FOR HYDRAULIC TURBINE GOVERNOR ALINEMENT

by

L. E. Eilts

January 1977

Electric Power Branch
Division of General Research
Engineering and Research Center
Denver, Colorado

UNITED STATES DEPARTMENT OF THE INTERIOR * BUREAU OF RECLAMATION

ACKNOWLEDGMENTS

The electronic isolation simulator described in this report was designed and developed in the Electric Power Branch under the suspervision of C. L. Clemans, Chief, Electric Power Branch.

The author is indebted to F. R. Schleif, now retired from the Bureau of Reclamation, for initial development of the technique of simulated isolation for testing hydraulic turbines.

CONTENTS

FIGURES

LETTER SYMBOLS AND QUANTITIES

Symbol	Quantity
hp_{fs}	Turbine horsepower corresponding to full-scale watt transducer output
hp_{rated}	Turbine rated horsepower
I	Rotational moment of inertia
K	Gate to torque gain of the hydraulic turbine
MW_{fs}	Generator output power corresponding to full-scale watt transducer output
MW_{rated}	Rated generator output power
N	Rated speed in revolutions per minute
n	Normal governor speed signal
n'	Simulated speed signal
P_e	Electrical load (equivalent to electrical load torque at rated speed operating point)
P_m	Mechanical prime mover power (equivalent to prime mover torque at rated speed operating point)
ΔP	Incremental power
R	Net coefficient of regulation at rated load
R'	Net coefficient of regulation referred to T_m' integration time
R_c	Current transformer turns ratio
R_v	Potential transformer turns ratio
s	Laplace operator
T_a	Accelerating torque
$T_m,$	Mechanical starting time at rated load
T_m'	Mechanical starting time at the load corresponding to full-scale watt transducer output
T_w	Water starting time
WR^2	Total rotational inertia
Z	Gate position
ΔZ	Incremental gate position
ζ	Damping ratio
ω_n	Natural oscillation frequency

INTRODUCTION

The technique of simulating isolation[1] of a generating unit while it is operating on the system permits examining the stability of the governor for any loading consistent with the hydraulic head. The governor adjustments may thus be optimized for adequate stability at the least stable loading which is generally maximum load. Since the gate opening for maximum load varies with hydraulic head, the least stable operating point corresponds to the hydraulic head for which maximum load is obtained near full gate opening. If governor stability is optimized under these conditions, stability will be adequate over the operable range of hydraulic head and at all lower gate positions.

During simulated isolation tests, the speed of the generating unit does not actually change because it is held constant by the power system (except for the very small system speed and frequency deviations of perhaps ±0.02 Hz or 0.0003 per unit). Therefore, a signal representing the speed deviations which would occur if the unit were carrying an isolated load is developed by an analog computing unit or isolation simulator. The torque deviations which would accelerate or decelerate the inertia of the unit if it were carrying an isolated load are measured as power deviations from the unit to the system. The isolation simulator represents the inertia of the generating unit with an electronic integrator and develops, from the power deviations, a speed deviation signal which is delivered to the governor in addition to or in lieu of the actual speed signal. In addition, the simulator represents the speed-dependent losses or damping torques which are absent during these tests because speed actually does not vary. These effects are represented by a net coefficient of regulation which is comprised primarily of load damping (i.e., frequency-dependent electrical loads) and turbine self regulation. Because it is torque that serves to accelerate or decelerate the inertia, the net coefficient of regulation must represent speed- or frequency-dependent loads in terms of their torque contributions. Since torque is equal to power divided by angular velocity (or speed), the torque dependence of any load is given by its power dependence divided by frequency (or speed).

To rigorously simulate isolation, the simulated speed signal should be delivered to the governor in lieu of the normal speed signal. However, experience has shown that nearly identical results are obtained if the simulated speed signal is simply added to the normal speed signal which varies insignificantly during the testing. Summing the speed signals avoids the necessity of testing with the primary governor speed loop opened, thereby enhancing governor security.

An additional minor effect during simulation is the small second-order lag in the response of generator electrical power to a change of turbine torque. This lag results from the process of shifting the generator rotor and its inertia to a new position and electrical angle. The time constants are generally short, typically 0.08 to 0.16 second. While these lags could be compensated for in the simulator, computer studies have shown their influence to be quite small.

In the simulation of isolation, all other dynamic effects, including those of the water column, governor, valves, servomotor, and turbine gates, are included in actuality and the governor system response can be closely examined and adjusted.

ISOLATION SIMULATOR

The normal speed-governing control system is illustrated by figure 1. The control system effective while simulating isolation is shown by the block diagram of figure 2. The input system to the isolation simulator is a two-element, Hall-type watt transducer which will deliver a 1-mA output into 10 kΩ (10 V) for an input of 1 kW to the transducer. With current and potential transformer ratios of R_C and R_V, respectively, the overall calibration of the watt transducer becomes: 10 V = $R_C R_V/1000$ MW.

The isolation simulator is assembled in a 152- by 228- by 127-mm (6- by 9- by 5-in) chassis as illustrated in figure 3. Circuit details of the simulator electronics are shown in figure 4. The heart of the simulator circuit is operational amplifier A1 which is a unity gain amplifier when switch S4 is in the BAL position and an integrator of gain 2.5 (2.5 V/s output per volt of input) when switch S4 is in the INT position. Amplifier A1 is designed to deliver a computed speed signal of 60 V = 1 per unit or 1 V = 1 Hz to a recorder of impedance exceeding 10 kΩ. The integration rate of amplifier A1 is adjustable with the INTEGRATION RATE potentiometer whose dial setting ($2.4/T_m'$) is inversely related to the effective integration time of the inertia of the generating unit. The output of the watt transducer provides the input for amplifier A1 through terminals 1

[1] Schleif, F. R., and Angell, R. R., "Governor Tests by Simulated Isolation of Hydraulic Turbine Units," IEEE Power Apparatus and Systems, vol. PAS-87, No. 5, pp. 1263-1269, May 1968.

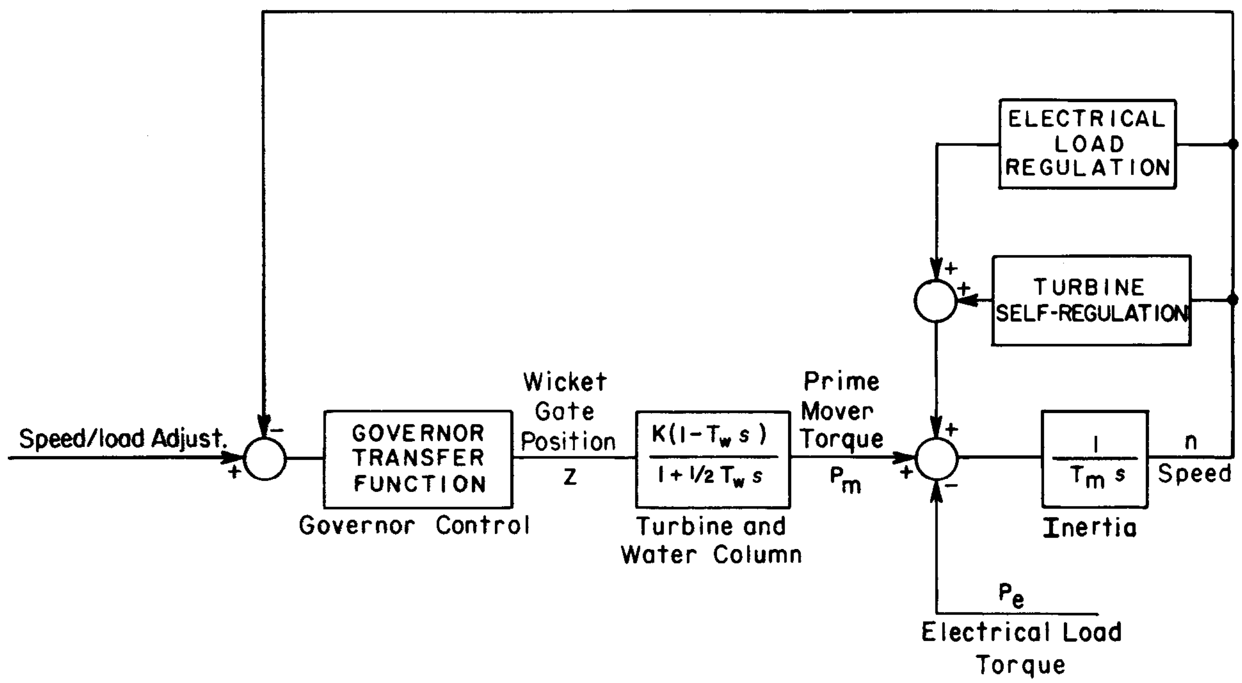
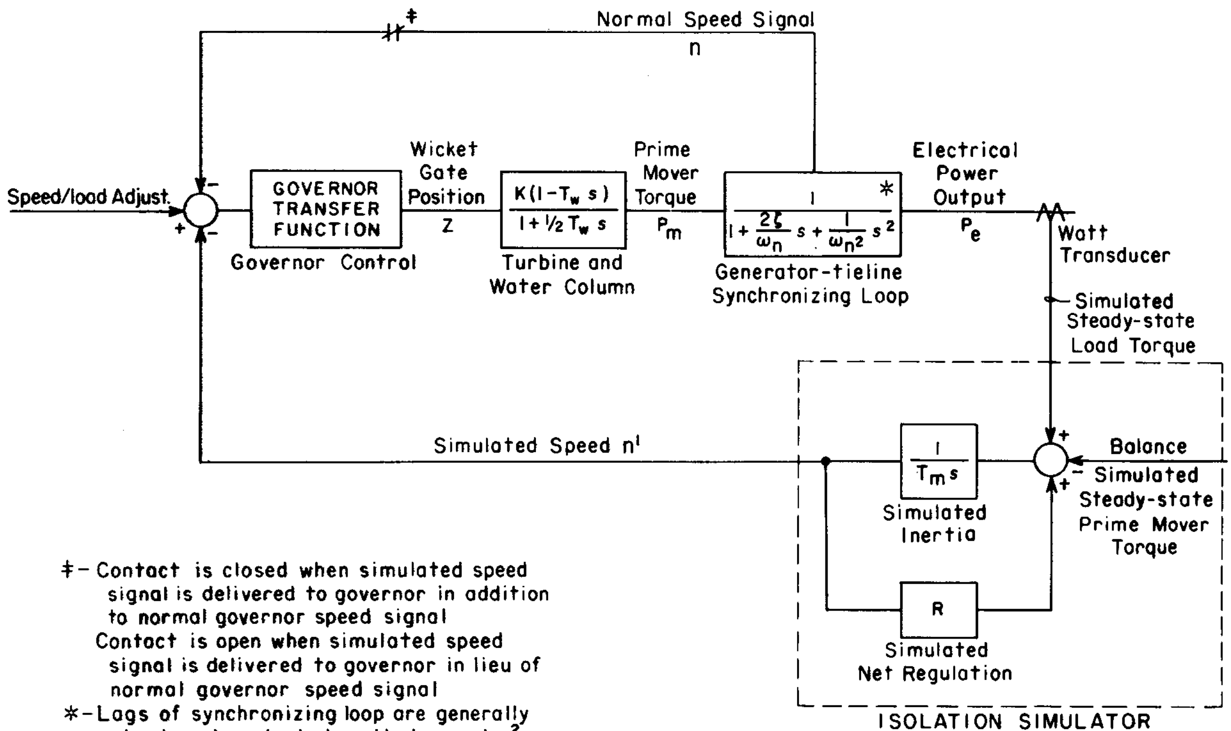


Figure 1.—Normal speed-governing control system.



‡- Contact is closed when simulated speed signal is delivered to governor in addition to normal governor speed signal
Contact is open when simulated speed signal is delivered to governor in lieu of normal governor speed signal

*-Lags of synchronizing loop are generally short and neglected so that s and s^2 terms vanish.

Figure 2.—Simulated isolation control system.

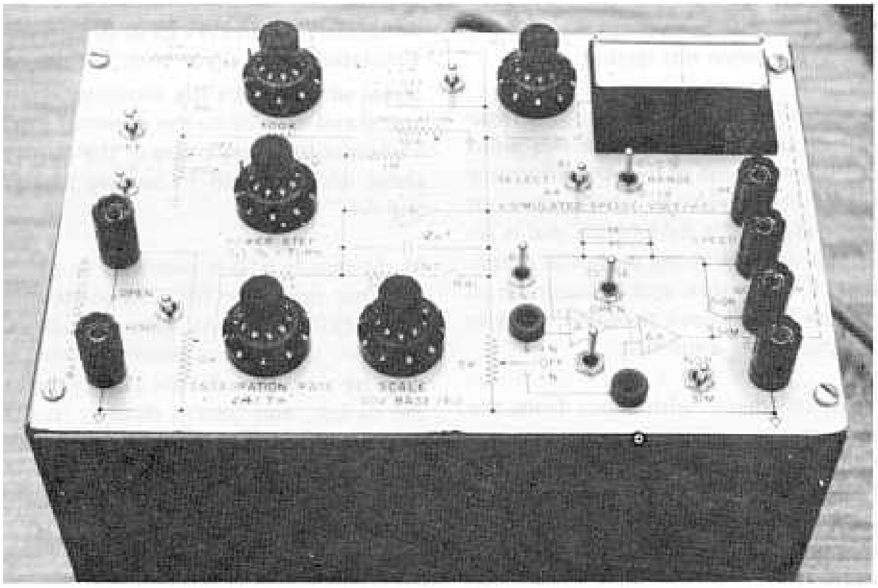


Figure 3.—Isolation simulator chassis. Photo P801-D-77566

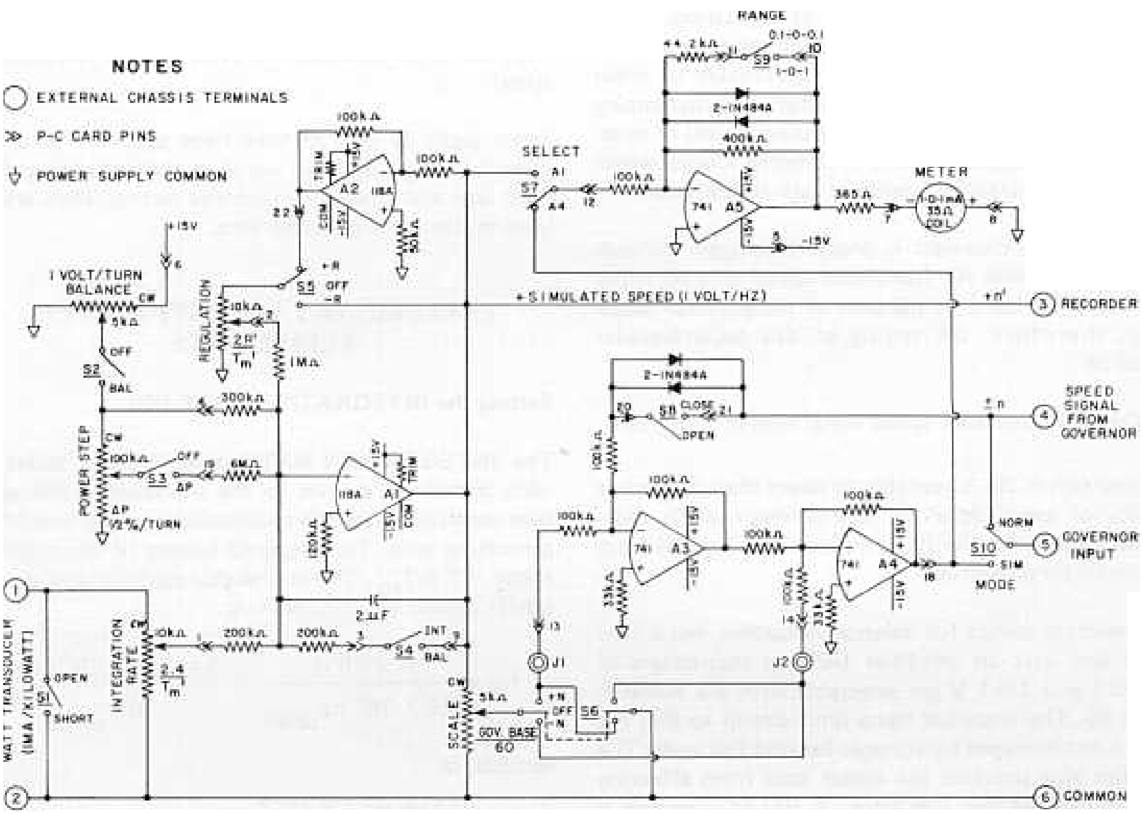


Figure 4.—Isolation simulator schematic.

and 2. A locking switch S1 has been provided to short the watt transducer output when not testing.

A BALANCE potentiometer with input from the regulated power supply is available to balance the input from the watt transducer to zero so that the integrator can operate upon only the deviations which represent acceleration or deceleration. The BALANCE dial is accurately calibrated and delivers at the output of amplifier A1 a voltage of 1 V per turn and a maximum of 10 V. A locking switch S2 has been provided in series with the balancing input to the amplifier.

A POWER STEP potentiometer with input from the BALANCE potentiometer is provided so that an adjustable increment of load can be applied to accelerate or decelerate the simulated inertia. This power step represents the acceptance or rejection of an incremental load. The potentiometer is calibrated so that each turn is equal to 0.5 percent of the operating point load. Switch S3 is provided to permit convenient insertion and removal of the power increment.

The net coefficient of regulation is set by the REGULATION potentiometer. It is scaled to permit representation of any net coefficient of regulation within the range of 0 to 2. The dial setting relation is $2\ R'/T_m'$. A three-position switch S5 is available to select either positive regulation (representative of undamping torques which decrease with increasing speed) or negative regulation (representative of damping torques which increase with increasing speed) or zero regulation.

A SCALE potentiometer is provided to scale the output from amplifier A1 (simulated speed on a 60 V/per unit = 1 V/Hz base) to the base of the governor speed signal; therefore, the setting of this potentiometer should be:

SCALE = (Governor speed signal base in volts)/60

Locking switch S6 is available to select the appropriate polarity of speed signal for the governor while maintaining a positive-polarity, simulated speed signal from terminal 3 for a recorder.

The meter, provided for balance indication, has a zero center and uses an amplifier (A5) so that ranges of 0.1-0-0.1 and 1-0-1 V are selectable with the RANGE switch S9. The amplifier has a limit circuit so that the meter is not damaged by voltages beyond full scale. The amplifier also prevents the meter load from affecting the accuracy of the simulator. A SELECT switch is available to permit monitoring the output of either amplifier A1 or A4.

Amplifiers A3 and A4 serve to sum the properly scaled, simulated speed signal with the normal governor speed signal which enters the simulator chassis through terminal 4 and returns to the governor input via terminal 5. The amplitude and phase of the normal governor speed signal are unaltered in passing through amplifiers A3 and A4.

Mode switch S10 is provided to transfer from normal governor operation (NORM position) to simulated isolation (SIM position). With switch S10 in the NORM position, the normal governor speed signal merely enters the simulator chassis at terminal 4, passes through the switch, and returns directly to the governor input through terminal 5. Transfer to the SIM position routes the output of amplifier A4 (the sum of the normal governor speed signal and the simulated speed signal) to the governor input via terminal 5. This switch permits returning quickly to normal governor operation should problems arise during testing.

Switch S8 is provided to permit complete isolation from the normal governor speed signal so that only the simulated speed signal is delivered to the governor. The diodes across switch S8 insure that the normal speed signal is automatically reinserted should it deviate more than 0.5 V from its nominal value of zero volts at rated speed.

Input jacks J1 and J2 have been provided to permit insertion of an auxiliary signal to the governor to facilitate step and frequency response testing. They are not used in simulated isolation tests.

PRELIMINARY POTENTIOMETER ALINEMENTS

Setting the INTEGRATION RATE Dial

The INTEGRATION RATE potentiometer scales the watt transducer output to the simulated speed signal base consistent with the mechanical starting time of the generating unit. The required setting of the potentiometer is $2.4/T_m'$. The mechanical starting time at rated power output (T_m) is given by:

$$T_m = \frac{N^2 (WR^2)}{1.6 \times 10^6\ hp_{rated}} = \frac{0.462\ N^2 (WR^2) \times 10^{-9}}{MW_{rated}}$$

seconds, or

$$T_m = \frac{10.96\ N^2\ I \times 10^{-9}}{MW_{rated}} \quad \text{seconds}$$

The mechanical starting time corresponding to full-scale watt transducer output (T_m') is:

$$T_m' = \frac{N^2 (WR^2)}{1.6 \times 10^6 \; hp_{fs}} = \frac{0.462 \; N^2 \; (WR^2) \times 10^{-9}}{MW_{fs}}$$

seconds, or

$$T_m' = \frac{10.96 \; N^2 \; I \times 10^{-9}}{MW_{fs}} \quad \text{seconds}$$

Therefore, T_m' and T_m are related as the machine rating and the full-scale watt transducer output; i.e.:

$$\frac{T_m'}{T_m} = \frac{\text{machine megawatt rating}}{\text{megawatts for full-scale watt transducer output}}$$

Setting the SCALE Dial

The SCALE potentiometer scales the simulated speed signal from amplifier A1 (60 V/per unit) to be compatible with the governor speed signal base. Thus, this potentiometer should be set to the value:

$$\text{SCALE} = \frac{\text{governor speed signal base in volts/per unit}}{60}$$

Setting the REGULATION Dial

The REGULATION potentiometer represents the net coefficient of regulation (R). It is the sum of the normalized contributions to accelerating torque resulting from speed variations (i.e., $R = \Sigma \, \partial T_a/\partial n$). Regulation is generally derived from two principle sources: (1) turbine self regulation, which is typically 0 to −1; and (2) electrical load regulation, which generally lies in the range of −2 to +1. Certainly if the individual components of regulation are known, they may be summed to provide a valid, realistic net coefficient of regulation (R). Unfortunately, accurate values are seldom available (particularly for load regulation) and one must choose an appropriate value for R. One suitable choice is R = 0, which is representative of a resistive load (R = +1.0), and a familiar turbine coefficient of self regulation (R = −1.0). A more conservative (generally slower) governor alinement is necessary if $R > 0$ and a less conservative (generally faster) alinement is permitted if $R < 0$.

The setting of the REGULATION potentiometer is $2R/T_m$ or $2R'/T_m'$, where R' and R are related as T_m' and T_m, namely by the ratio:

$$\frac{\text{machine megawatt rating}}{\text{megawatts for full-scale watt transducer output}} = \frac{R'}{R}$$

The three-position switch S5 for selecting ±R has a center off position which is convenient for setting R = 0. A sample calculation of the potentiometer settings prerequisite to testing by simulated isolation is presented in the appendix.

ISOLATION SIMULATOR CONNECTIONS

With the generating unit loaded to the operating point for which the tests are to be performed (usually 90 to 95 percent gate or full load), connect the isolation simulator as indicated by the simulator schematic diagram (fig. 4), and the connection block diagram (fig. 5). Note that the governor speed loop must be opened and connected to the isolation simulator terminals 4 and 5 where it is reclosed through mode switch S10. To open the primary governor speed loop, the governor should be locked, transferred to the auxiliary valve, or the unit shut down. Following closure of the speed loop through terminals 4 and 5 of the simulator chassis, proper governor control should be demonstrated by moving the speed/load adjustment and observing correct gate response. The watt transducer is connected to terminals 1 and 2 and the COMMON terminal 6 should be connected to the governor COMMON. Switch S6 of the simulator should be in the OFF position, switch S10 should be in the NORM position, and switch S8 should be in the CLOSE position. A recorder should be connected to the simulator unit at terminal 3 to record the speed deviation transients. A second recorder channel to record turbine gate movements is desirable though not essential.

TEST PROCEDURE

1. Set the INTEGRATION RATE, SCALE, and REGULATION potentiometers to values calculated in the preceding section. Place switch S6 in the +N or −N position as required to be consistent with polarity of the governor speed signal.

2. Open switch S1 to operate and close switches S2 and S4 to BAL. Adjust the BALANCE dial to null the simulator output voltage to zero as indicated by the meter with SELECT switch S7 in the A1 position and RANGE switch S9 in the 0.1-0-0.1 position. Switch S3 should be in the OFF position.

3. Open switch S4 to the INT position and adjust the BALANCE potentiometer, if necessary. Move the meter SELECT switch S7 to the A4 position to insure

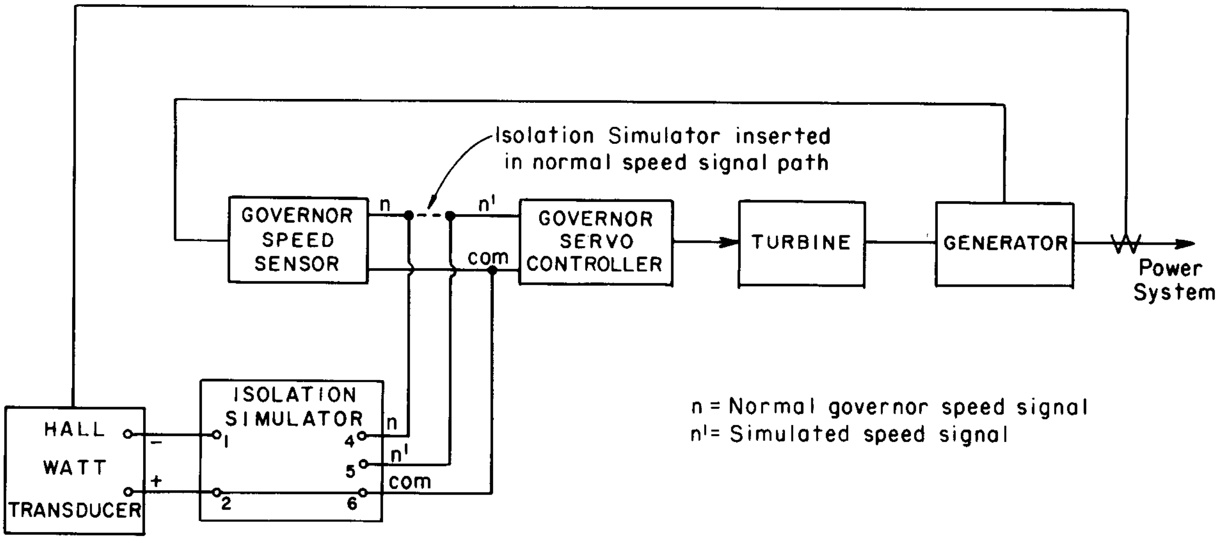


Figure 5.—Connection diagram for simulating isolation.

that its output is properly balanced. Move mode switch S10 to the SIM position. The generator then will be operating under simulated isolation. The turbine gates (position) should remain reasonably steady. (About 0.01 per unit of gate wander may result from backlash in the turbine gate shifting mechanism.)

4. Set the POWER STEP potentiometer to the desired load increment. A small step of possibly 1 percent may be desired initially. The calibration of this potentiometer is 0.5 percent/turn. Move switch S3 to the ΔP position. This will simulate application of about 0.01 per unit additional load. The speed signal should temporarily sag. Gate position should increase 1 or 2 percent at first, then shortly stabilize at less than 1 percent increase. After proper operation has been demonstrated, the POWER STEP potentiometer should be increased to 3 to 5 percent to obtain a good response significantly larger than the random wander. The load increment now can be inserted and removed conveniently by operating switch S3. When the switch is closed, the gates should open in response to the sag in simulated speed. When the switch is opened, the gates should close in response to the speed rise. A typical record obtained from an electrohydraulic governor during simulated isolation is shown in figure 6.

The governor parameters may now be optimized for the particular operating point. To aid the optimization process, figure 7 illustrates the influence of each adjustment of a double-derivative governor upon the response of the speed signal.

Note: Unit loading cannot be changed while under control of the isolation simulator except by the BALANCE dial. A change of the governor SPEED/LOAD ADJUST control would be compensated by the isolation simulator. To change loading, the unit must be released from the simulator by returning switch S4 to BAL and switch S10 to NORM.

5. With mode switch S10 in NORM and S4 in BAL, unit loading may be changed to any desired operating point. To simulate isolation at the new operating point, rebalance the simulated speed signal to zero with BALANCE dial, place switch S4 in the INT position, and switch S10 in the SIM position to place the generator again under simulated isolation control. Check governor stability by operating the ΔP switch S3. The generating unit should be more stable at reduced gate openings. Stability at any gate position or load level may be checked as desired. (For test and adjustment of stability at no load, simulated isolation is not applicable).

6. When testing is completed, the generating unit is removed from the isolation simulator by placing switch S4 in BAL and mode switch S10 in the NORM position. The governor then should be locked, transferred to auxiliary valve, or the unit shut down to reconnect the primary governor speed loop. Following reconnection of the speed loop, proper gate response to the governor SPEED/LOAD ADJUST control should be verified.

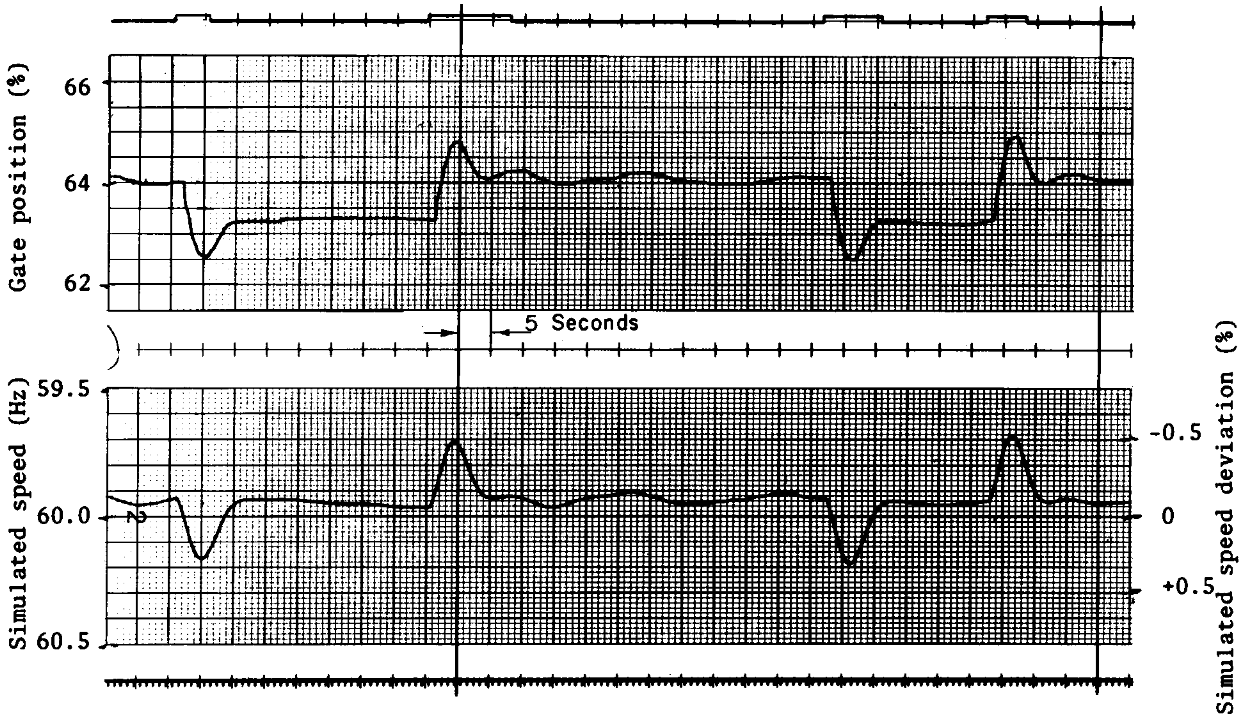


Figure 6.—Response of an electrohydraulic governor to load increments of 1.5 percent (9 MW) while carrying 600 MW of simulated isolated load — Grand Coulee Unit G19 — 24 September 1975 — Net head = 102 m.

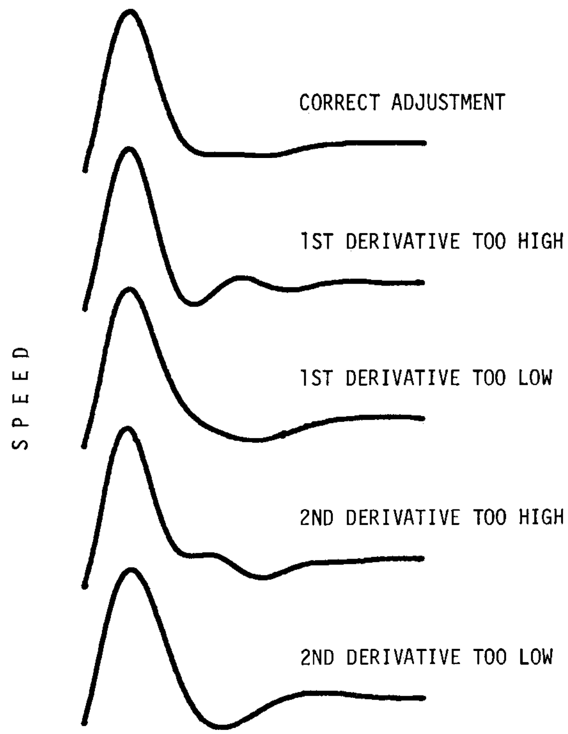


Figure 7.—Speed transients developed by analog computer illustrating the effect of each parameter adjustment of a double-derivative electronic governor.

TESTS AND ALINEMENT OF MECHANICAL GOVERNORS BY SIMULATED ISOLATION

Tests and alinement of mechanical governors can be conveniently performed with the isolation simulator provided a torque motor or electromechanical transducer is inserted in the floating lever system to interface the electronic isolation simulator to the mechanical speed-control linkage.

Variations in the Simulation Procedure

1. In the case of a mechanical governor, there is no electrical governor speed signal, thus no connection to terminal 4 of the isolation simulator chassis.

2. Since the normal governor speed signal is obtained mechanically from the ballhead motor and is not removed, testing is always done with the simulated speed signal added to the normal speed signal via the torque motor (or electromechanical transducer) linkages.

3. Prior to simulating isolation, the polarity and calibration of the torque motor input must be determined so as to choose the appropriate position for switch S6 and to set the SCALE potentiometer properly. This may be accomplished by applying a small positive d-c signal (ΔV) to the torque motor driver and noting the

resultant gate deviation (ΔZ) including sign. The governor base is then given by the following equation:

Governor electrical speed base in volts/per unit =

$$\left(\frac{\Delta V \text{ in volts}}{\Delta Z \text{ in per unit}}\right)\left(\frac{-1}{\text{permanent droop}}\right)$$

Switch S6 should be set to +N for positive governor bases and −N for negative governor bases. The SCALE potentiometer should be set to the absolute value of the governor base in volts/per unit divided by 60.

Excepting variations 1 through 3 above, the procedure for simulating isolation of a mechanical governor follows that outlined in the preceding sections.

A record obtained while simulating isolation of a mechanical governor is shown in figure 8.

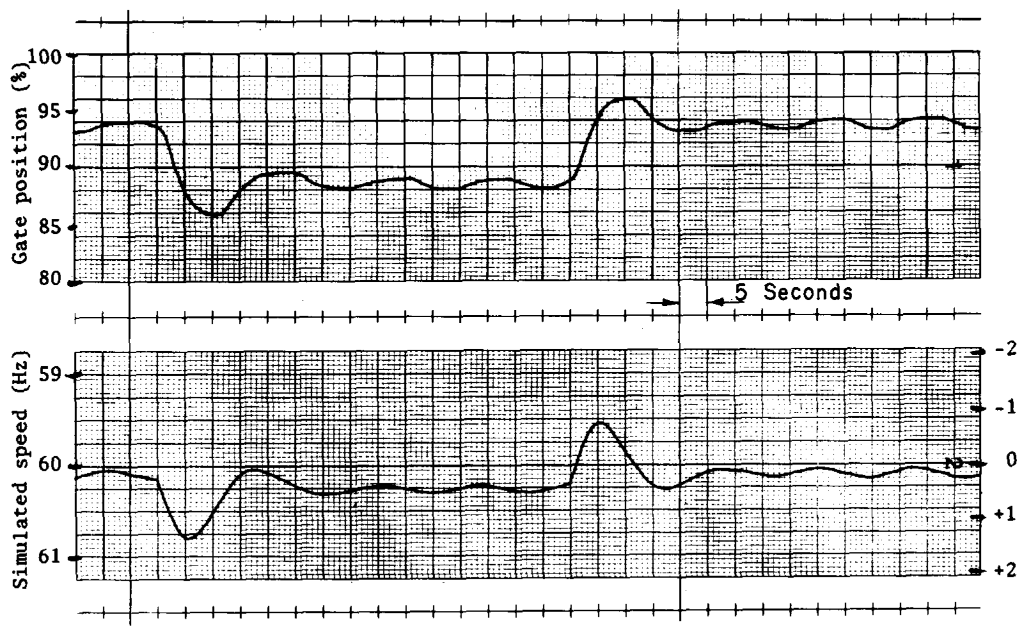


Figure 8.—Response of a mechanical governor to load increments of 4 percent (4 MW) while carrying 100 MW of simulated isolated load — Grand Coulee Unit G17 — 19 May 1976 — Net head = 87.2 m.

APPENDIX

SAMPLE ISOLATION SIMULATOR PRELIMINARY SETTINGS

Rated data, preliminary calculations, potentiometer settings, and switch positions for simulated isolation of generating unit G19 at Grand Coulee Third Powerplant.

R_c = 30 000/5 A = 6000:1
R_v = 15 000/120 V = 125:1
Rated load = 600 MW
Governor speed base = − 10.0 V/per unit
$WR^2 = 2.54 \times 10^9$ lb•ft²
$I = 0.107 \times 10^9$ kg•m²
Full-scale load = $R_c R_v/1000$ = 750 MW
Rated speed, N = 72 r/min

1. $$T_m = \frac{0.462\, N^2\, (WR^2) \times 10^{-9}}{MW_{rated}} = 10.13 \text{ seconds}$$

1′. $$T_m = \frac{10.96\, N^2\, I \times 10^{-9}}{MW_{rated}} = 10.13 \text{ seconds}$$

2. $$T_m' = \frac{0.462\, N^2\, (WR^2) \times 10^{-9}}{MW_{fs}} = 8.11 \text{ seconds} = T_m \frac{MW_{rated}}{MW_{fs}}$$

2′. $$T_m' = \frac{10.96\, N^2\, I \times 10^{-9}}{MW_{fs}} = 8.11 \text{ seconds}$$

3. $$\text{INTEGRATION RATE setting} = \frac{2.4}{T_m'} = 0.296$$

4. SCALE setting = Governor base in volts/per unit ÷ 60 = 0.166. Since the speed signal polarity is negative, switch S6 is placed in the − N position.

5. REGULATION potentiometer setting:

Turbine self regulation =	− 1.0
Composite load regulation =	0.0
Net regulation, R =	− 1.0

$$R' = R \frac{MW_{rated}}{MW_{fs}} = -0.800$$

$$\text{REGULATION setting} = \frac{2R}{T_m} = \frac{2R'}{T_m'} = 0.197$$

Since net regulation is negative, switch S5 is placed in the − R position.

6. BALANCE potentiometer setting for 600-MW operating point:

Watt transducer output at 600 MW =

$$10\text{ V}\left(\frac{600\text{ MW}}{750\text{ MW}}\right) = 8\text{ V}$$

Output from INTEGRATION RATE potentiometer at 600 MW =

$$\left(\frac{2.4}{T_m'}\right) \cdot (\text{Watt transducer output}) = 2.37\text{ V}$$

Since the BALANCE potentiometer output at 1 V/turn must balance the output of the INTEGRATION RATE potentiometer at the operating point, the BALANCE potentiometer setting should be nominally 0.237.

ABSTRACT

This report describes the theory of governor alinement by the technique of simulated isolation. The design, assembly, circuit configuration, and external connections of an electronic isolation simulator for governor alinement testing are presented. Procedures for setting up and using the isolation simulator are outlined and typical governor responses obtained during simulated isolation tests are illustrated. The calculations and potentiometer setting determinations, prerequisite to this type of testing, are exemplified.

ABSTRACT

This report describes the theory of governor alinement by the technique of simulated isolation. The design, assembly, circuit configuration, and external connections of an electronic isolation simulator for governor alinement testing are presented. Procedures for setting up and using the isolation simulator are outlined and typical governor responses obtained during simulated isolation tests are illustrated. The calculations and potentiometer setting determinations, prerequisite to this type of testing, are exemplified.

ABSTRACT

This report describes the theory of governor alinement by the technique of simulated isolation. The design, assembly, circuit configuration, and external connections of an electronic isolation simulator for governor alinement testing are presented. Procedures for setting up and using the isolation simulator are outlined and typical governor responses obtained during simulated isolation tests are illustrated. The calculations and potentiometer setting determinations, prerequisite to this type of testing, are exemplified.

ABSTRACT

This report describes the theory of governor alinement by the technique of simulated isolation. The design, assembly, circuit configuration, and external connections of an electronic isolation simulator for governor alinement testing are presented. Procedures for setting up and using the isolation simulator are outlined and typical governor responses obtained during simulated isolation tests are illustrated. The calculations and potentiometer setting determinations, prerequisite to this type of testing, are exemplified.

REC-ERC-77-2
Eilts, L E
ELECTRONIC ISOLATION SIMULATOR FOR HYDRAULIC TURBINE GOVERNOR ALINEMENT
Bur Reclam Rep REC-ERC-77-2, Div Gen Res, Jan 1977, Bureau of Reclamation, Denver, 9 p, 8 fig, 1 ref, app.

DESCRIPTORS— / governors / servomechanisms / regulation / electronic equipment / control systems / analog computers / dynamic tests / models / test procedures / field tests / hydroelectric powerplants

IDENTIFIERS— / *isolation simulator / governor alinement testing

REC-ERC-77-2
Eilts, L E
ELECTRONIC ISOLATION SIMULATOR FOR HYDRAULIC TURBINE GOVERNOR ALINEMENT
Bur Reclam Rep REC-ERC-77-2, Div Gen Res, Jan 1977, Bureau of Reclamation, Denver, 9 p, 8 fig, 1 ref, app.

DESCRIPTORS— / governors / servomechanisms / regulation / electronic equipment / control systems / analog computers / dynamic tests / models / test procedures / field tests / hydroelectric powerplants

IDENTIFIERS— / *isolation simulator / governor alinement testing

REC-ERC-77-2
Eilts, L E
ELECTRONIC ISOLATION SIMULATOR FOR HYDRAULIC TURBINE GOVERNOR ALINEMENT
Bur Reclam Rep REC-ERC-77-2, Div Gen Res, Jan 1977, Bureau of Reclamation, Denver, 9 p, 8 fig, 1 ref, app.

DESCRIPTORS— / governors / servomechanisms / regulation / electronic equipment / control systems / analog computers / dynamic tests / models / test procedures / field tests / hydroelectric powerplants

IDENTIFIERS— / *isolation simulator / governor alinement testing

REC-ERC-77-2
Eilts, L E
ELECTRONIC ISOLATION SIMULATOR FOR HYDRAULIC TURBINE GOVERNOR ALINEMENT
Bur Reclam Rep REC-ERC-77-2, Div Gen Res, Jan 1977, Bureau of Reclamation, Denver, 9 p, 8 fig, 1 ref, app.

DESCRIPTORS— / governors / servomechanisms / regulation / electronic equipment / control systems / analog computers / dynamic tests / models / test procedures / field tests / hydroelectric powerplants

IDENTIFIERS— / *isolation simulator / governor alinement testing