**DATASETS: ALGORITHM FOR VOLTAGE STABILITY CONTROL IN A POWER SYSTEM NETWORK WITH INTEGRATED MICROGRID**

## 1. IEEE 9 BUS SINGLE LINE DIAGRAM IN RTDS

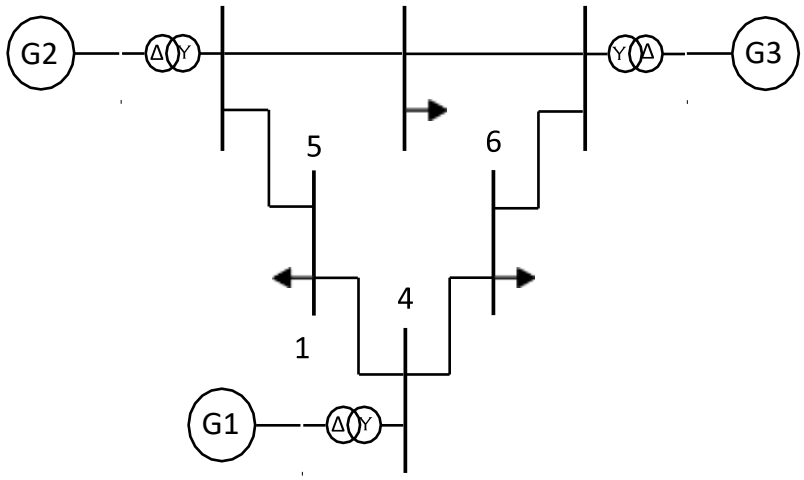


**Figure 1:** IEEE 9 bus system

## 2. RSCAD/RTDS SYSTEM DATA

**Table 1: RSCAD Power Flow Data expressed in 100 MVA**

| BUS | Type | V (pu) | PG (MW) | QG (MVAr) | PL (MW) | QL (MVAr) |
|---|---|---|---|---|---|---|
| 1 | SLACK | 1.040 ∠0.0° | 71.6 | 27.0 | - | - |
| 2 | P-V | 1.025 ∠9.3° | 163.0 | 6.7 | - | - |
| 3 | P-V | 1.025 ∠4.7° | 85.0 | -10.9 | - | - |
| 4 | P-Q | 1.026 ∠-2.2° | - | - | - | - |
| 5 | P-Q | 0.996 ∠-4.0° | - | - | 125.0 | 50.0 |
| 6 | P-Q | 1.013 ∠-3.7° | - | - | 90.0 | 30.0 |
| 7 | P-Q | 1.026 ∠3.7° | - | - | - | - |
| 8 | P-Q | 1.016 ∠0.7° | - | - | 100.0 | 35.0 |
| 9 | P-Q | 1.032 ∠2.0° | - | - | - | - |

**Table 2: IEEE 9 bus Line data in RSCAD**

| From BUS | To BUS | R (pu) | X (pu) | B (pu) |
|---|---|---|---|---|
| 4 | 5 | 0.0100 | 0.0850 | 0.1760 |
| 4 | 6 | 0.0170 | 0.0920 | 0.1580 |
| 5 | 7 | 0.0320 | 0.1610 | 0.3060 |
| 6 | 9 | 0.0390 | 0.1700 | 0.3580 |
| 7 | 8 | 0.0085 | 0.0720 | 0.1490 |
| 8 | 9 | 0.0119 | 0.1008 | 0.2090 |

**Table 3: Transformer Data**

| From BUS | To BUS | R (pu) | X (pu) | Tap Ratio[1] |
|---|---|---|---|---|
| 1 | 4 | 0.0 | 0.0576 | 1.0 |
| 2 | 7 | 0.0 | 0.0625 | 1.0 |
| 3 | 9 | 0.0 | 0.0586 | 1.0 |

**Table 4: Generator Data-1 (100 MVA Base)**

| GEN | BUS | Xa (pu) | Xd (pu) | Xd' (pu) | Xd" (pu) | Xq (pu) | Xq' (pu) | Xq" (pu) |
|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 0.01460 | 0.1460 | 0.0608 | 0.06 | 0.1000 | 0.0969 | 0.06 |
| 2 | 7 | 0.08958 | 0.8958 | 0.1198 | 0.11 | 0.8645 | 0.1969 | 0.11 |
| 3 | 9 | 0.13125 | 1.3125 | 0.1813 | 0.18 | 1.2578 | 0.2500 | 0.18 |

**Table 5: Generator Data-2 (100 MVA Base)**

| GEN | BUS | Ra (pu)[2] | Tdo' (s) | Tdo" (s) | Tqo' (s) | Tqo" (s) | H (s) | D(pu/pu) |
|---|---|---|---|---|---|---|---|---|
| 1 | 5 | 0.000125 | 8.96 | 0.01 | 0.310 | 0.01 | 23.64 | 0.0 |
| 2 | 7 | 0.000125 | 6.00 | 0.01 | 0.535 | 0.01 | 6.40 | 0.0 |
| 3 | 9 | 0.000125 | 5.89 | 0.01 | 0.600 | 0.01 | 3.01 | 0.0 |

**Table 6: Exciter Data-1 (IEEE Type DC1A)**

| GEN | KA | TA | VRmin | Vrmax | KE | TE | KF | TF |
|---|---|---|---|---|---|---|---|---|
| 1 | 20.0 | 0.2 | -5.0 | 5.0 | 1.0 | 0.314 | 0.063 | 0.35 |
| 2 | 20.0 | 0.2 | -5.0 | 5.0 | 1.0 | 0.314 | 0.063 | 0.35 |
| 3 | 20.0 | 0.2 | -5.0 | 5.0 | 1.0 | 0.314 | 0.063 | 0.35 |

**Table 7: Exciter Data-2 (IEEE Type DC1A*)***

| GEN | EX1 | S(EX1) | EX2 | S(EX2) |
|---|---|---|---|---|
| 2 | 3.3 | 0.6602 | 4.5 | 4.2662 |
| 3 | 3.3 | 0.6602 | 4.5 | 4.2662 |
| 4 | 3.3 | 0.6602 | 4.5 | 4.2662 |

**Table 8: Governor Data (TGOV1)**

| GEN | R | T1 | Vmax | Vmin | T2 | T3 | Dt |
|---|---|---|---|---|---|---|---|
| 1 | 0.05 | 0.05 | 5.00 | -5.00 | 2.1 | 7.0 | 0.0 |
| 2 | 0.05 | 0.05 | 5.00 | -5.00 | 2.1 | 7.0 | 0.0 |
| 3 | 0.05 | 0.05 | 5.00 | -5.00 | 2.1 | 7.0 | 0.0 |

**Table 9: Power consumption per load in RSCAD**

| Load | Bus | P [MW] | Q [Mvar] |
|---|---|---|---|
| Load A | Bus 5 | 125 | 50 |
| Load B | Bus 6 | 90 | 30 |
| Load C | Bus 8 | 100 | 35 |

## 3. PHOTOVOLTAIC CONTROL DESIGN IN RTDS

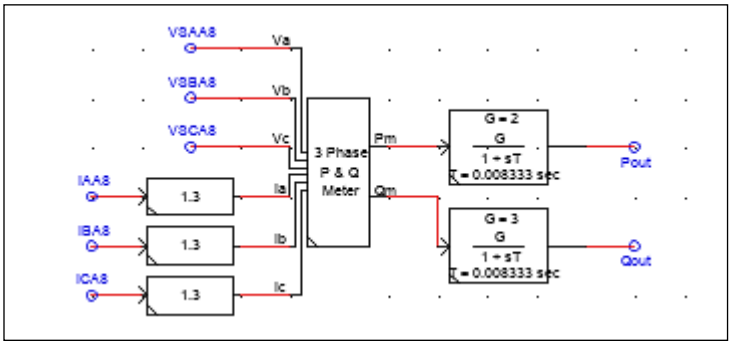


**Figure 1: Power measurement at VSC**

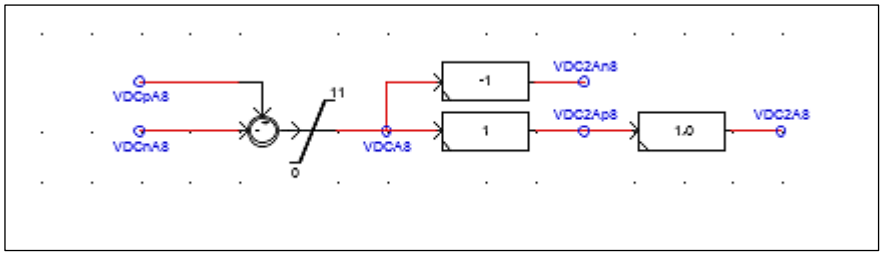


**Figure 2: Logic to control the limit of PV voltage**

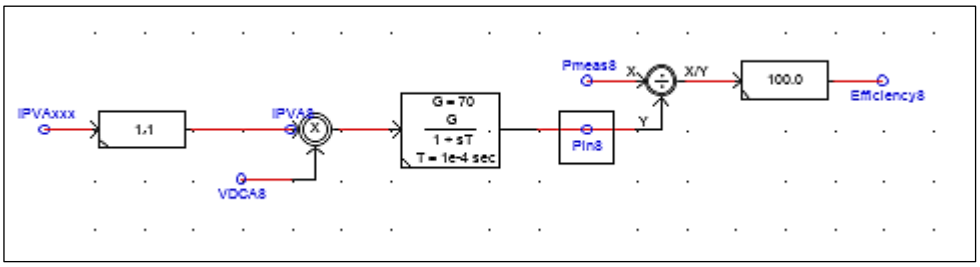


**Figure 3: PV efficiency measurement logic**

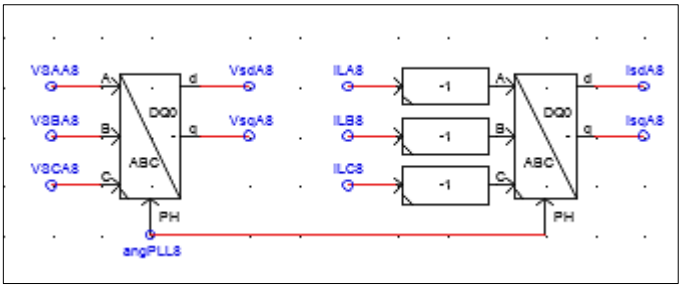


**Figure 4: ABC to dq frame terminal logic**

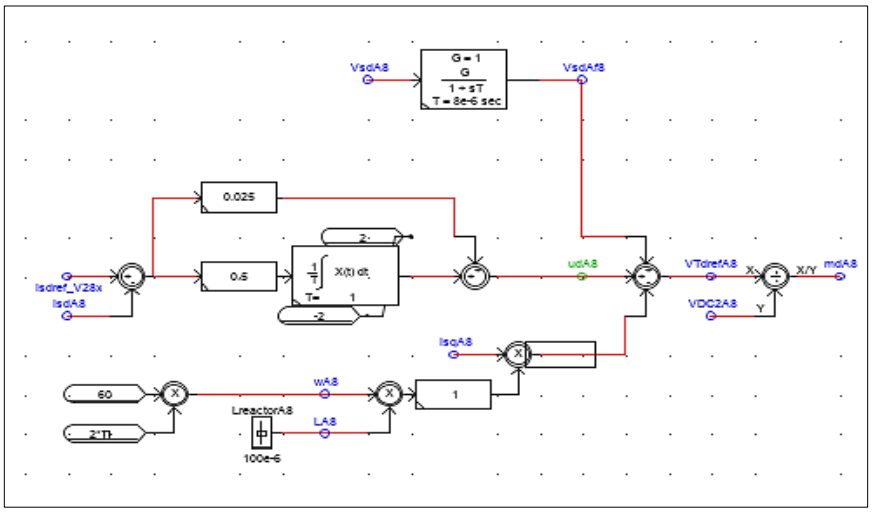


**Figure 5: Inner loop dq current control**

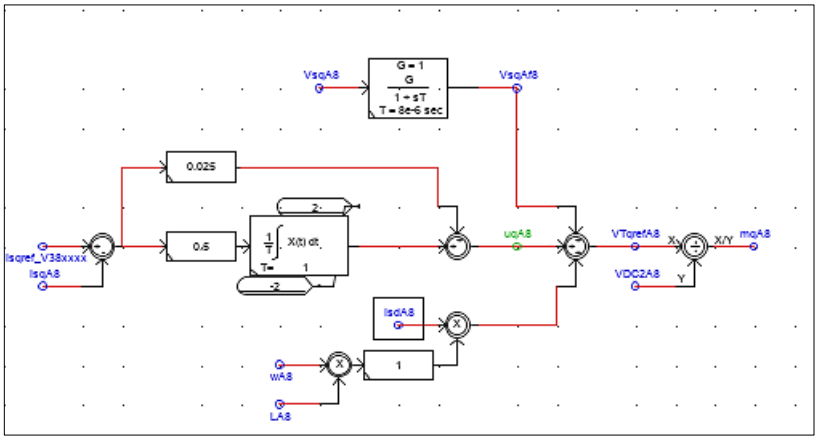


**Figure 6: Inner loop dq current control**

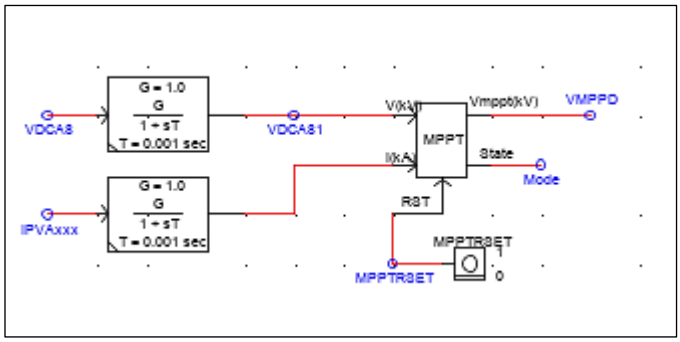


**Figure 7: MPPT outer loop control**

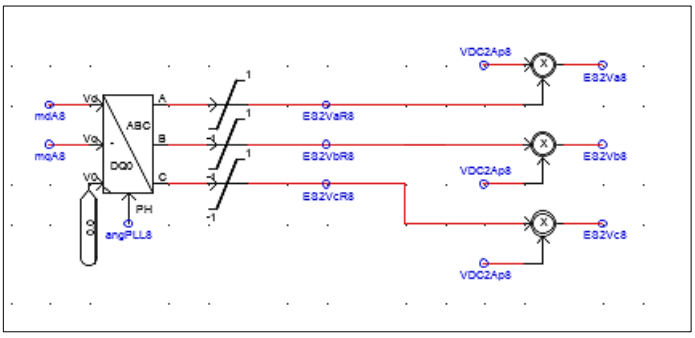


**Figure 8: A reference wave generator**

## 4 VOLATGES PROFILES

### 4.1 voltage Profiles under disturbances.

**Table 4 1: Real-time results under disturbance compared to results under normal conditions.**

| Modified 9 bus system base case simulation results in RSCAD/RTDS | | | Modified 9 bus system results after disturbance in RSCAD/RTDS | |
|---|---|---|---|---|
| **Bus** | **u, Magnitude [p.u.]** | **TYPE** | **Bus** | **u, Magnitude [p.u.]** |
| 1 | 1.030 | SLACK | 1 | 1.025 |
| 2 | 0.9946 | P-V | 2 | 0.9704 |
| 3 | 1.018 | P-V | 3 | 0.9878 |
| 4 | 1.012 | P-Q | 4 | 00.9872 |
| 5 | 0.9777 | P-Q | 5 | 0.9199 |
| 6 | 0.9984 | P-Q | 6 | 0.9463 |
| 7 | 1.001 | P-Q | 7 | 0.9598 |
| 8 | 0.9957 | P-Q | 8 | 0.9442 |
| 9 | 1.020 | P-Q | 9 | 0.9744 |

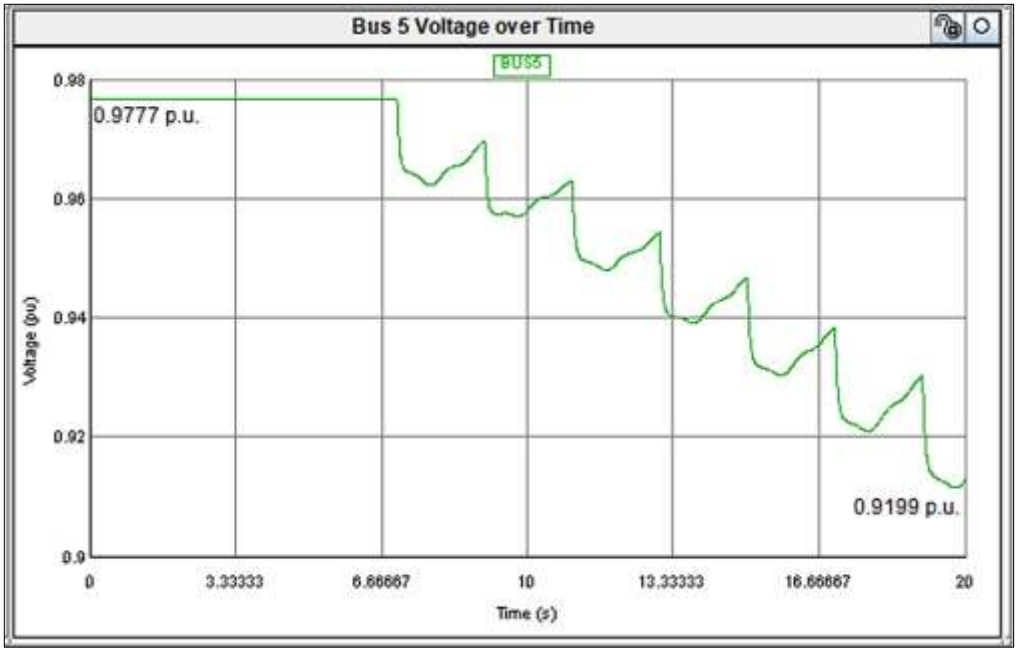


**Figure 4 1: Voltage drop at bus 6 due to disturbance caused by 35% increase of load demand**

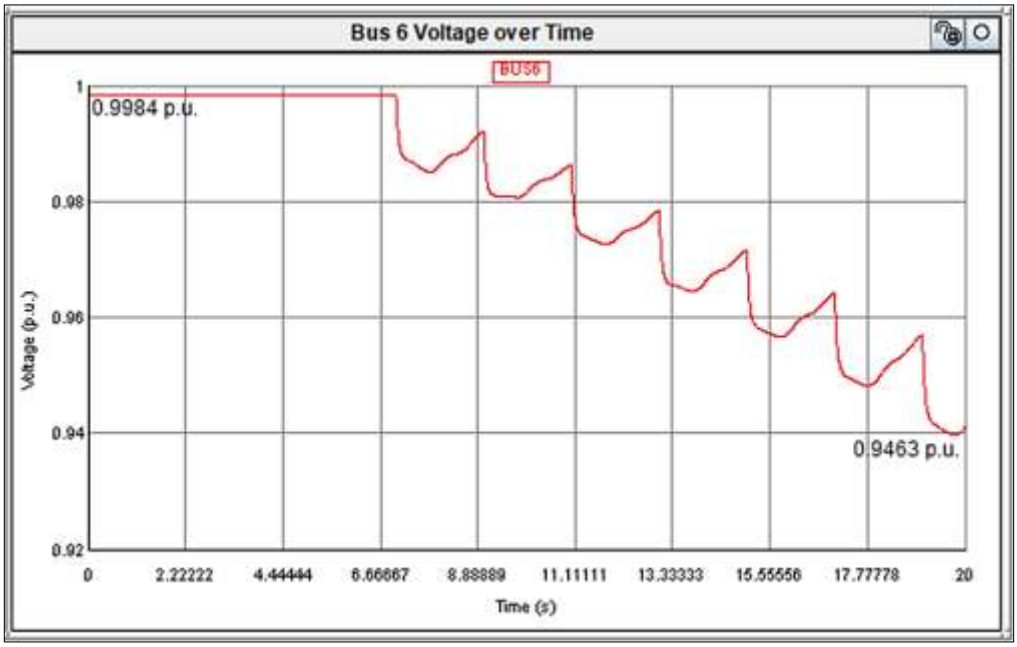


**Figure 4 2: Voltage drop at bus 6 due to disturbance caused by 35% increase in load demand**

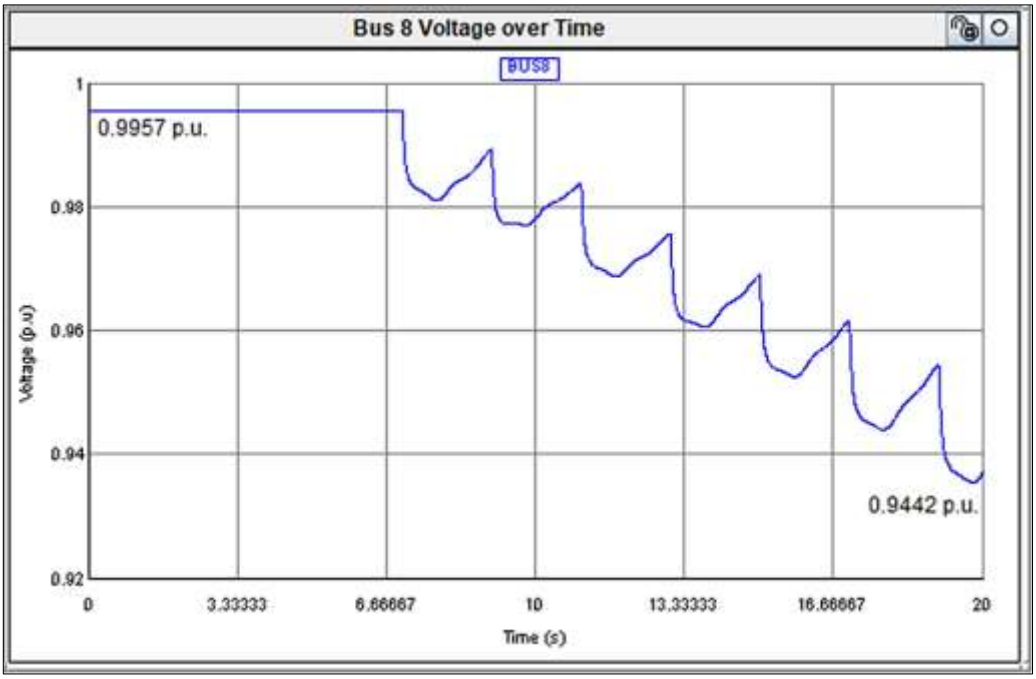


**Figure 4 3: Voltage drops at bus 6 due to disturbance caused by a 35% increase in load demand**

### 4.2 Voltages profiles after PV integration

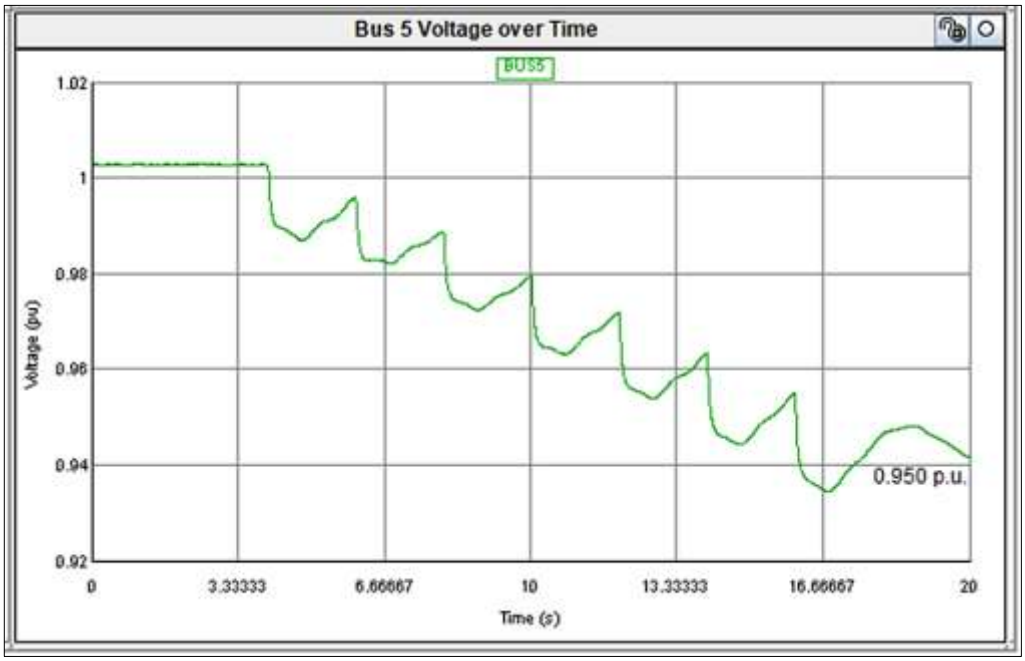


**Figure 4.4: Voltage recovering at bus 5 when PV action is simulated for 20 second**

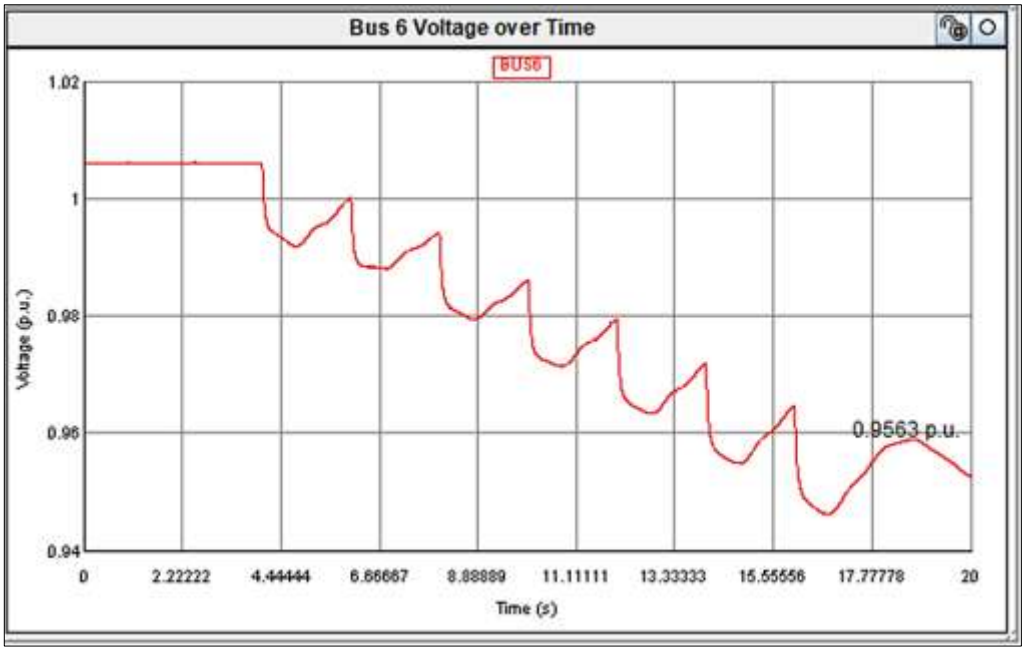


**Figure 4.5: Voltage recovering at bus 6 when PV action is simulated for 20 second**

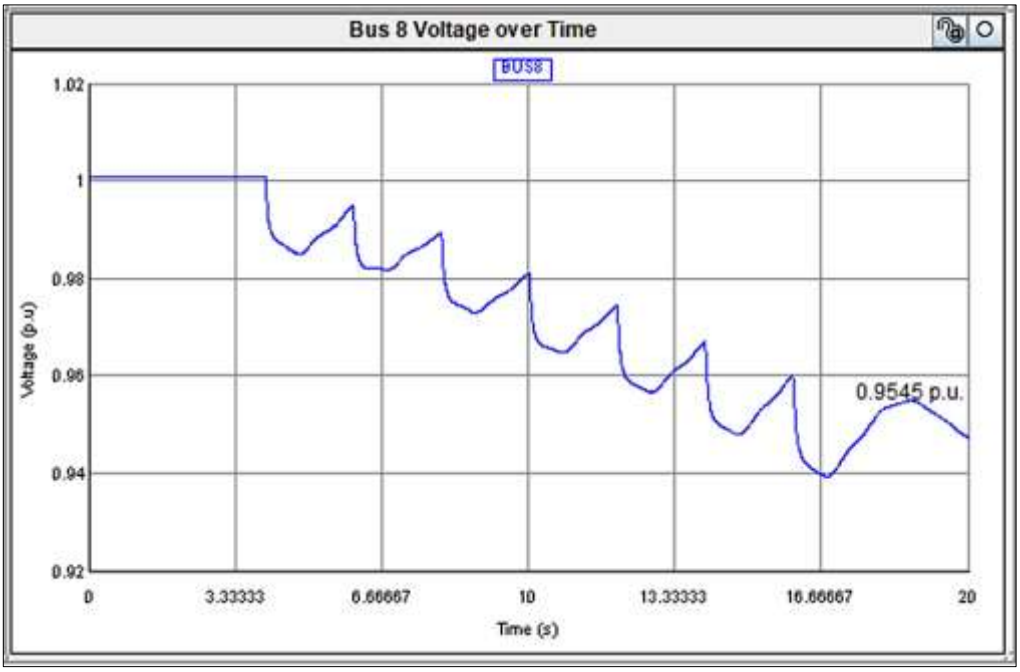


**Figure 4.6: Voltage recovering at bus 8 when PV action is simulated for 20 second**

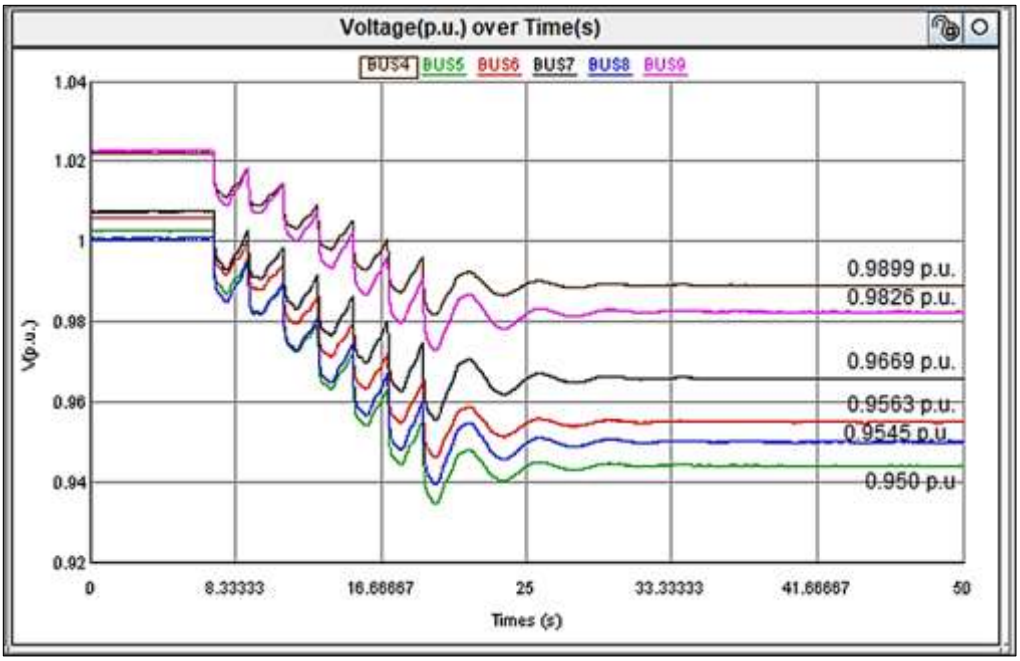


**Figure 4.7: Voltage recovery of all buses due to PV penetration**