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# Investigated Performance of Davidson Model for DVB-T2 Propagation in Medium and Small Urban Area

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**Abstract:** This study investigates the efficiency of Davidson Path Loss Model in order to apply for use in the DVB-T2 propagation network design for medium and small urban areas in southern Thailand. The data being collected from the electric field strength while broadcasting of two channels within urban areas of Hadyai, Songkla Province are used for the path loss analysis. The result through a comparison on the efficiency of an old Davidson Model and a calibrated Root Mean Square Error (RMSE) model along with an efficiency index of Relative Error (RE) shows that the old Davidson Model is closer to the measured data than the calibrated ones. The statistics also demonstrates that the RE of the old Davidson Model is at the least when being compared with the RE of both the calibrated and the Hata Models. The old Davidson Model is therefore, the most accurate and the most optimized for the design of the propagation network.

**Key words:** DVB-T2 propagation, calibration methods, path loss model, calibrated, propagation

## INTRODUCTION

In order to conduct the broadcasting prediction that enables to appropriately cover the areas, a path loss model is necessary for the planning on a design of the wireless communication network. The capability in using the suitable transmitted power can lead to a cost saving performance on the network equipment, subsequently, the path loss model being used for the research must be of the most accurate one.

When the path loss model is practically used, errors are found due to the differences of the surroundings of each area, especially an urban area of high density of buildings that show more errors than a suburban or rural area. Thus, researchers present their work of adapted path loss models that are optimized for the specific area for example Obot *et al.* (2011) presents the calibration and the optimization of the Hata Model for an urban area of southern Thailand (Chebil *et al.*, 2011; Roslee and Kwan, 2010) the optimization of Lee and Hata Models in a suburban area of Malaysia. RMSE statistic value is applied for the calibration in order to obtain the accuracy for the area while root mean square error, relative error, standard deviation, etc. are used for the efficiency index of the adapted models.

Table 1: Songkla provincial DVB-T2 station transmission

| Channel | Frequency (MHz) | Brand transmitter | Model | Power (kW) |
|---|---|---|---|---|
| CH42 | 642 | HARRIS | UAX-2000T2HE | 1.3 |
| CH46 | 674 | NEC | DTL-10/1R0S | 1.0 |

This study investigates the efficiency of Davidson Path Loss Model and compares with the model calibration while the efficiency index is performed by using the statistic values of a relative error. Part two of the article consists of a description of the research data collection and its signal equipment while part three explains the model analysis and its calibration, part four is the findings and the last part contains the research conclusion.

**Data collection:** The measurement on the electrict field strength of an airing TV signal is conducted at 2 channels of CH42: the frequency of 642 MHz and CH46: the frequency of 674 MHz where the distance from the transmitted station is 2-7 km in Hadyai urban area. The area covering the DVB-T2 station in songkla province is located on Mt. Corhong at the latitude of 7 0'57.95" and the lontitude of 100 31'12.17" with the vertical of the land and the tranmitted antenna of 432 m. The DVB-T2 transmitter details is described in Table 1 and Fig. 1 show a structure on the system connection of DVB-T2 transmitted stations. The DVB-T2 network providers

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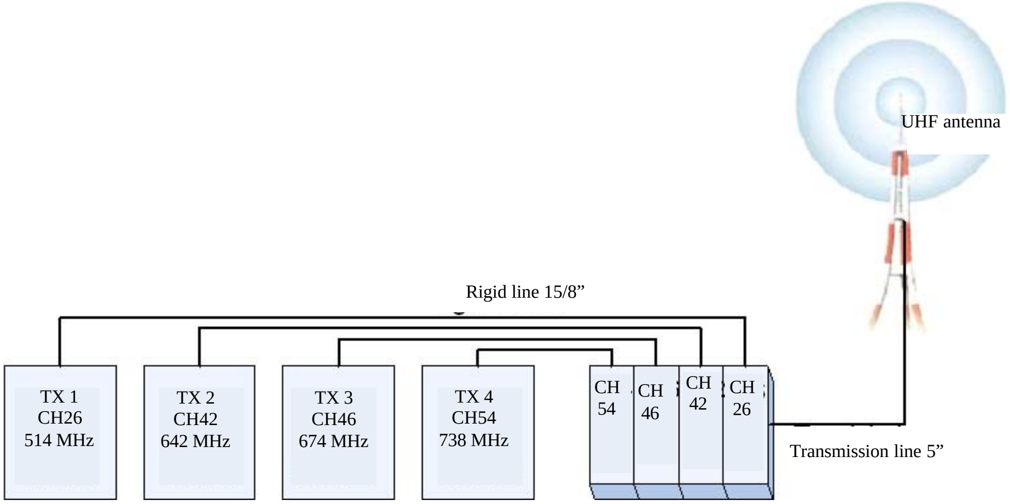

Fig. 1: A structure on the system connection of DVB-T2 transmitted stations

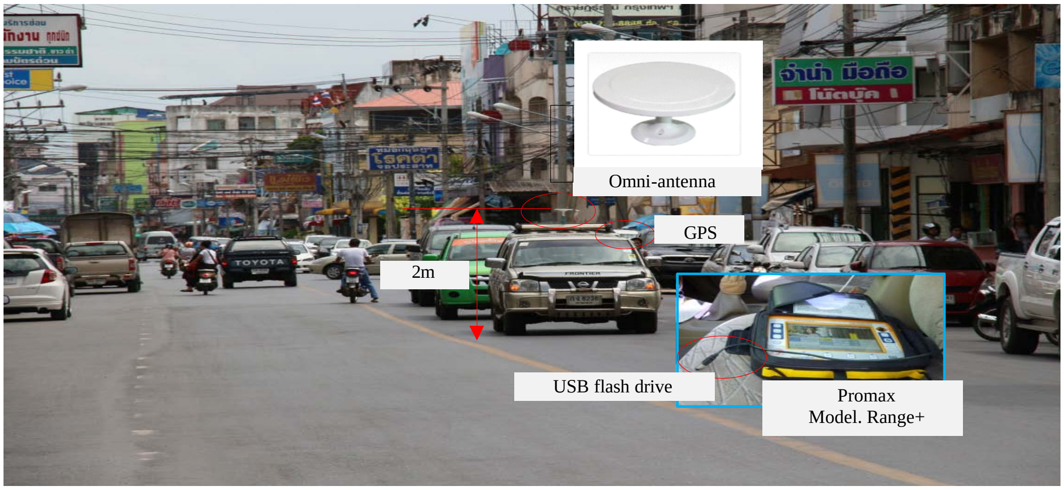

Fig. 2: The DVB-T2 signal measurement tool in urban Hadyai, Songkla Province

install the TV transmission within the same station in order to mutually utilize a transmission line and an antenna. The TV transmission is connected with a combiner system where its loss value is ($Cl_1$) 0.55 dB; the loss value in the transmitted antenna is ($Cl_2$) 1.186 dB; the transmitted antenna rate ($G_t$) is 18.35 dBi. The relation of the received signal power ($P_r$) and the signal path loss value (L) can be described as:

$$L(dB) = (EIRP + G_r) - P_r \quad (1)$$

$$EIRP = P_t + G_t - Cl_1 - Cl_2 \quad (2)$$

The signal measurement is performed by using DVB-T2 PROMAX, HD RANGER+Model which consists of a GPS and a USB Drive as value recording while the received antenna is Omni-directional, Spectrum. Co.Ltd, Korea, Omni-Saturn Model with the rate ($G_r$) of -3 dBi which are installed on top of a pick-up with 2 m from the ground. The measurement method is done through a drive test function of its signal power collection tool at every 2 sec on the urban density of both sides of the streets where the speed limit is 20 km/h. The measurement tools and the installation are shown in Fig. 2, whereas Fig. 3 is the test drive streets for the data collection.

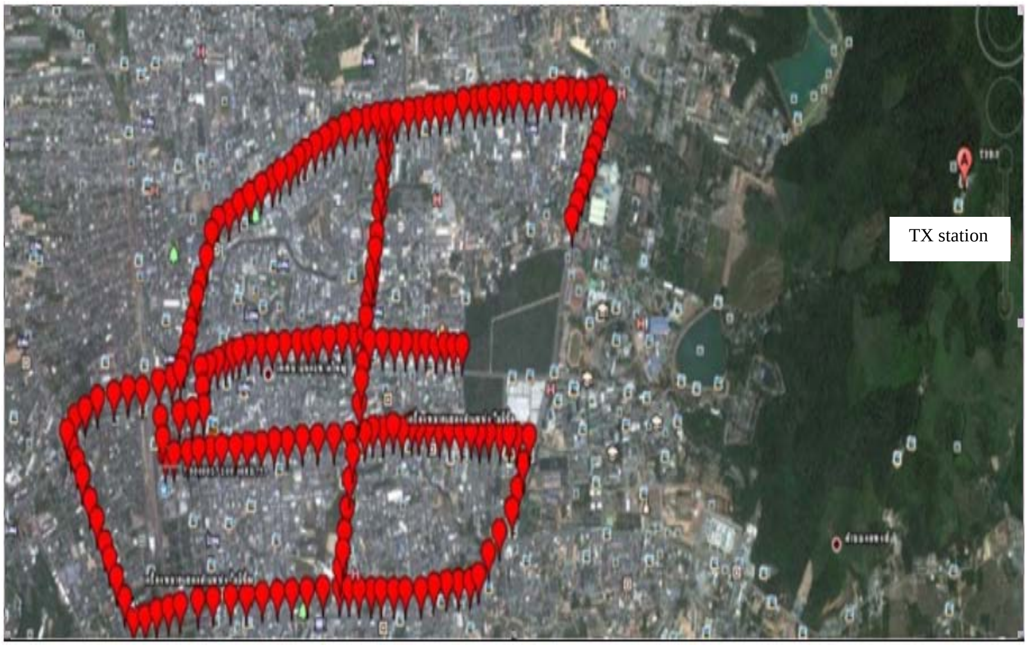

Fig. 3: Drive test signal measurement streets in urban Hadyai, Songkla Province

## MATERIALS AND METHODS

### Model analysis

**Hata Model:** Hata Path Loss Model (Hata, 1980) varies its equations based on different characters of the areas, i.e., urban, suburban and rural as followed:

$$L(dB) = 69.55+26.16\log f_c-13.82\log h_t+(44.9-6.55\log h_t)\log R-E \tag{3}$$

An urban area of a large size:

$$E = 3.2[\log(11.7554h_m)]^2-4.97f_c \geq 400\text{ MHz} \tag{4}$$

$$E = 8.29[\log(1.54h_m)]^2-1.1,\ f_c \leq 200\text{ MHz} \tag{5}$$

An urban area of medium and small sizes:

$$E = [1.1\log f_c - 0.7]h_m - [1.56\log f_c - 0.8] \tag{6}$$

A suburban area:

$$L(dB) = 69.55+26.16\log f_c-13.82\log h_t+(44.9-6.55\log h_t)\log R-2[(\log\frac{f_c}{28})^2+5.4] \tag{7}$$

A rural area:

$$L(dB) = 69.55+26.16\log f_c-13.82\log h_t-4.78(\log f_c)^2+18.33\log f_c+40.94 \tag{8}$$

Where:

$f_c$ = The research frequency with a unit of MHz

$R$ = The distance between the transmitted station and the receiving machine with a unit of kilometer

$h_t$ = The height of the transmitted antenna with a unit of meter

$h_m$ = The height of the received antenna with a unit of meter

**Davidson Model:** Davidson Path Loss Model (Faruk *et al.*, 2013) is developed based on Hata Model and its Equation is written as:

$$L_D(dB) = L_{Hata}(dB)+A(h_t, d_{km})-S_1(d_{km})-S_2(h_t, d_{km})-S_3(f_{MHz})-S_4(f_{MHz}, d_{km}) \tag{9}$$

Where:

$L_{hata}$ = Hata Path Loss Model that its value is obtained from Eq. 3

$A(ht, d_{km})$ and $Sl (d_{km})$ = The distance correction factors

$S2(h_t, d_{km})$ = The correction factors of the transmitted antenna vertical

$S_3 (f_{MHz})$ and $S_4(f_{MHz}, d_{km})$ = The frequency correction factors

All correction factors show a unit of decibel and the equations can be described as:

$$A(h_t, d_{km}) = \begin{cases} 0;\ d < 20\ \text{km} \\ 0.62317(d-20)[0.5+0.15\log \\ (h_t/121.92)];\ 20\ \text{km} \leq d \leq 300\ \text{km} \\ 0.62317(d-20)[0.5+ \\ 0.15\log(h_t/121.92)]; \\ 20\ \text{km} \leq d \leq 300\ \text{km} \end{cases} \tag{10}$$

$$S_1(d_{km}) = \begin{cases} 0;\ d < 20\ \text{km} \\ 0;\ 20\ \text{km} \leq d \leq 64.38\ \text{km} \\ 0.174(d-64.38);\ 64.38\ \text{km} \\ \leq d \leq 300\ \text{km} \end{cases} \tag{11}$$

$$S_2(h_t, d_{km}) = 0.00784\left|\log(9.98/d)\right| (h_t-300); h_t < 300\ \text{m} \tag{12}$$

$$S_3(f_{MHz}) = f_c/250\log(1500/f_c) \tag{13}$$

$$S_4(f_{MHz}, d_{km}) = [0.112\log(1500/f_c)] (d-64.38); d > 64.38\ \text{m} \tag{14}$$

**Calibration:** The calibration of both Hata Path Loss Model and Davidson Path Loss Model is conducted by using RMSE and its equation is written as: The calibration of Hata Path Loss Model:

$$L(dB) = 69.55+26.16\log f_c-13.82\log h_t+ (44.9-6.55\log h_t)\log R-[1.1\log f_c-0.7]h_m- [1.56\log f_c-0.8]+RMSE \tag{15}$$

The calibration of Davidson Path Loss Model:

$$L_D(dB) = L_{Hata}(dB)+A(h_t, d_{km})-S_1(d_{km})- S_2(h_t, d_{km})-S_3(f_{MHz})-S_4(f_{MHz}, d_{km})+RMSE \tag{16}$$

The statistical RMSE value can be obtained from the following Eq. 17:

$$RMSE = \sqrt{\frac{\sum(PL_m-PL_{model})^2}{N-1}} \tag{17}$$

Where:

$Pl_m$ = The path loss value obtained from the measurement

$Pl_{model}$ = The path loss value obtained from the model

N = The amount of the data points obtained from the signal measurement where 2300 points of each channel are selected for this research

**Statistical investigation:** An investigation to compare the efficiency index of the path loss models is performed through the use of a RE statistical value from Eq. 18:

$$\delta = \frac{|PL_m-PL_{model}|}{|PL_m|} \tag{18}$$

The $P_m$s the path loss value obtained from the measurement and $Pl_{model}$ is the path loss value obtained from the model.

## RESULTS AND DISCUSSION

**Analytical findings:** The RMSE result from the measured data as shown in Table 2 is the RMSE value of Davidson Path Loss Model showing CH42 = 6.72 and CH46 = 6.66 dB which are lesser than the value of Hata Path Loss Model of CH42 = 11.07 and CH46 = 10.16 dB. Therefore, primarily Davidson Model is more accurate than Hata Model. Table 3 compares the results of relative errors between an old Davidson Model an old Hata Model and a calibrated Davidson Model, a calibrated Hata Model where the result shows that the RE of the calibrated Hata Model is lesser than the old Hata Model while the RE of the old Davidson Model is lesser than the calibrated one. The comparison result of all models discloses that the RE of the old Davidson Model is at the lowest. Figure 4 and 5 demonstrate that the old Davidson Model is closer to the measured data than other compared models.

Table 2: The result of root mean square error

| | Root mean square error (dB) | |
|---|---|---|
| Frequency (MHz) | Davidson | Hata |
| CH42 (642) | 6.72 | 11.07 |
| CH46 (674) | 6.66 | 10.16 |

Table 3: The comparison of relative error

| | Relative error (dB) | | | |
|---|---|---|---|---|
| Frequency (MHz) | RMSE-Davidson | Davidson | RMSE-Hata | Hata |
| CH42(642) | 0.0352 | 0.0155 | 0.0154 | 0.0682 |
| CH46(674) | 0.1283 | 0.0007 | 0.0189 | 0.0582 |
| CH46(674) | 0.1283 | 0.0007 | 0.0189 | 0.0582 |

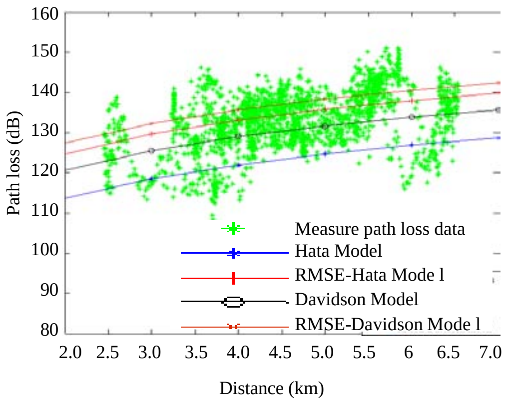

Fig. 4: The comparison of path loss models for CH42; the frequency of 642 MHz

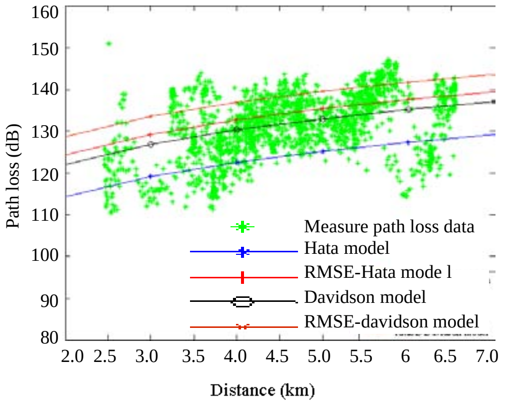

Fig. 5: The comparison of path loss models for CH46; the frequency of 674 MHz

## CONCLUSION

This study investigates the efficiency of Davidson Path Loss Model and compares with the calibrated model as well as the old Hata Model through the data collection of electric field strength while airing of two channels in urban Hadyai, Songkla Province. The model calibration is through the statistic values of Root Mean Square Error (RMSE) while Relative Error (RE) is used for the model efficiency. The comparison result reveals that the old Davidson Model is closer to the measured data than the calibrated one. The statistic value also shows that the RE of the old Davidson Model is at the least upon being compared with other models. It can be concluded that the old Davidson Path Loss Model is the most accurate and the most suitable for use in the propagation network design for medium and small urban areas in Southern Thailand.

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